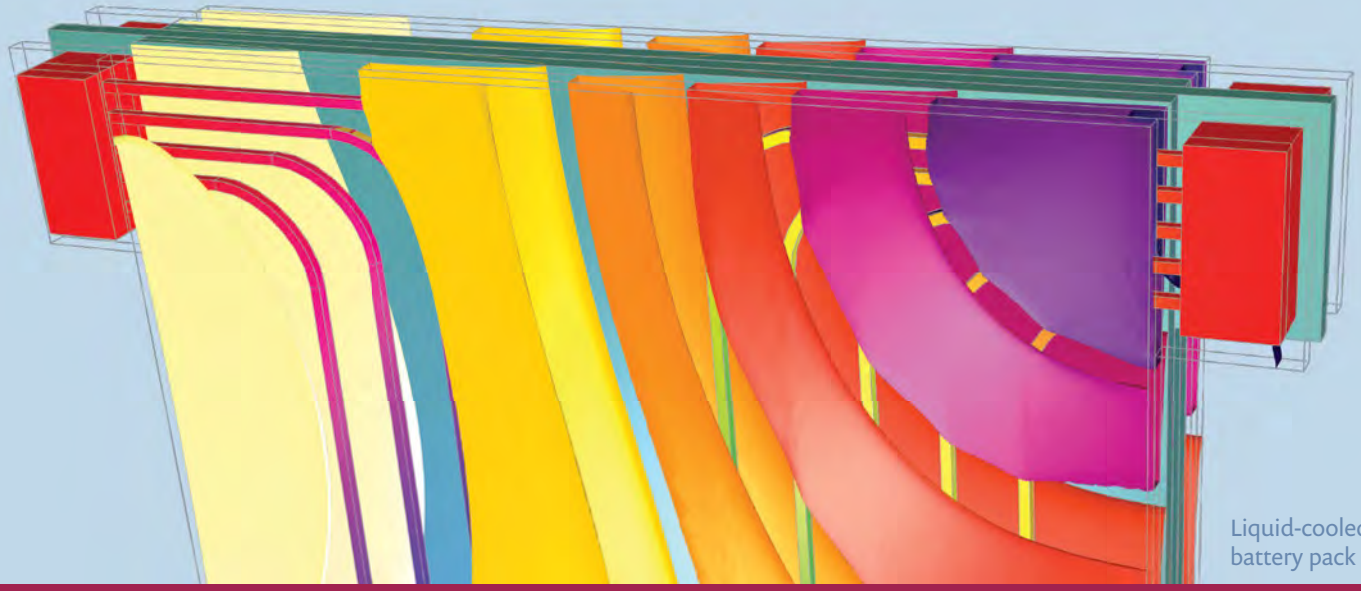

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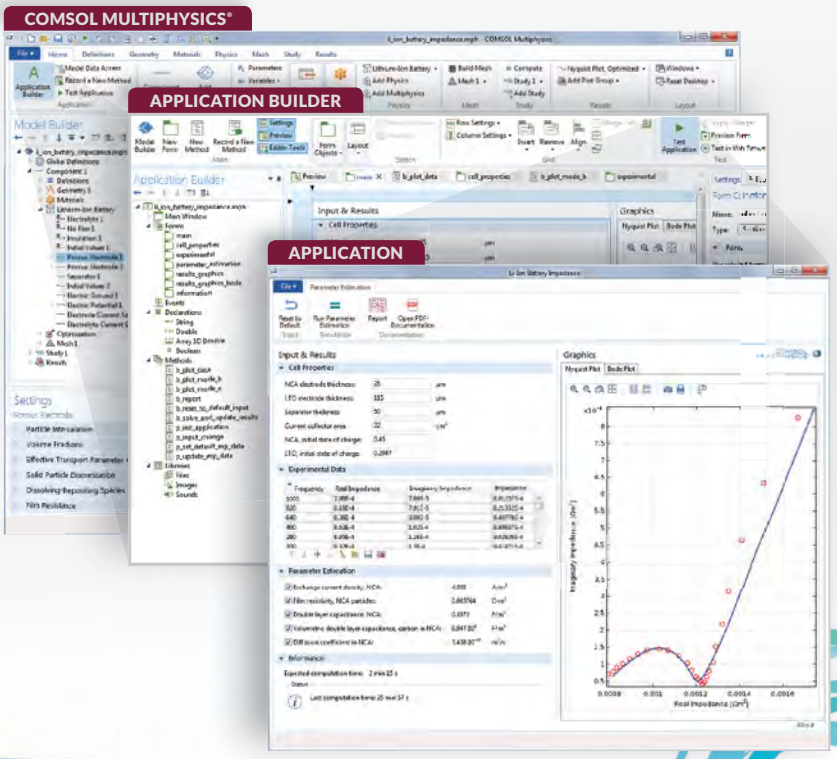

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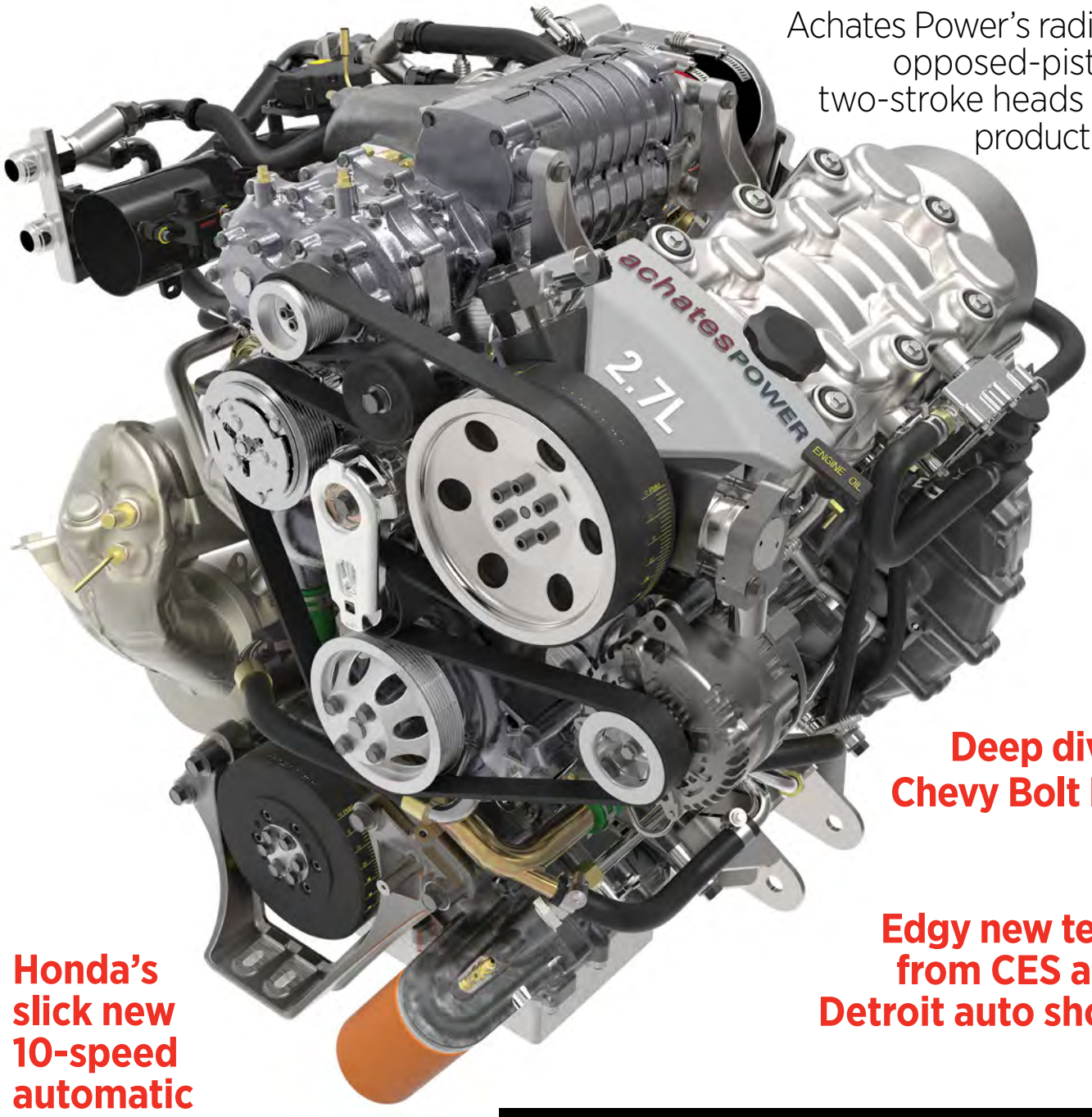
ICE's new life?

Achates Power's radical opposed-piston two-stroke heads for production



Deep dive: Chevy Bolt EV

Edgy new tech from CES and Detroit auto show

Honda's slick new 10-speed automatic

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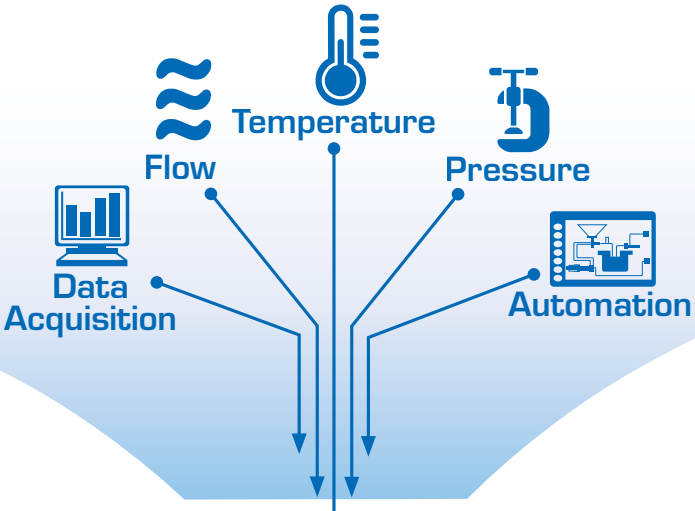

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ON THE COVER

Achates Power's new 2.7-L 3-cylinder OP compression-ignition 2-stroke engine in its latest iteration, fully dressed and wearing a close-coupled catalyst. Image courtesy Achates Power, Inc.

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Automotive Engineering®, February 2017, Volume 4, Number 2. *Automotive Engineering* (ISSN 2331-7639) is published in January, February, March, April, May, June, August, September, October, and November by Tech Briefs Media Group, an SAE International Company ®, 261 Fifth Avenue, Suite 1901, New York, NY 10016 and printed in Mechanicsburg, PA.

Annual print subscription for SAE members: first subscription, $15 included in dues; additional single copies, $30 each North America, $35 each overseas. Prices for nonmember subscriptions are $115 North America, $175 overseas. Periodicals postage paid at New York, and additional mailing offices. POSTMASTER: Please send address changes 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.
(ISSN 2331-7639 print)
(ISSN 2331-7647 digital)

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EDITORIAL

Question mark or exclamation point?

Editor-in-chief Lindsay's Brooke's illuminating account of the production-readiness of the **Achates Power** opposed-piston engine (see p. 16) seems an appropriate kind of punctuation mark for the auto industry's current state of developmental and political flux.

The problem is, English doesn't have a punctuation symbol that combines exclamation point and question mark—and I think it's time we create one. Consider:

• At a moment when every major automaker and supplier is talking almost exclusively about two parallel engineering goals—vehicle electrification and automated driving—the on-the-road reality isn't exactly aligned. Achates is prepping the first series-production alternative powertrain since the rotary engine. Just weeks prior to Achates' news of its engine's pending production, a newswire story from Japan confirmed rumors that had kicked into high gear in the powertrain community: **Mazda** appears ready to launch a compression-ignition gasoline (CIG) engine for 2018 deployment.

Several automakers and suppliers have in the past decade devoted considerable resources to the development of CIG—often also referred to as homogenous-charge compression-ignition, or HCCI—but those efforts (and investments?) seem to have been sidetracked as the public and regulators turned a more-favoring eye to electrification.

• And what are we to think of diesel? The consensus is that **Volkswagen** once-and-for-all grenaded diesel's precarious (in the U.S.) future, if new diesel-hostile emissions initiatives in Europe aren't enough. Yet at January's Detroit auto show (see p. 27), **Ford** shoved a serious and contradictory stake in the ground by announcing a diesel-engine option coming this year for the light-duty F-series pickup, the best-selling nameplate in the country. Also at the Detroit show, **GM** announced diesel power for its 2018 GMC Terrain compact crossover.

• Juxtapose those Detroit-show IC happenings with this: **Chevrolet**'s Bolt, a battery-electric vehicle, was named the North American Car of the Year at the show. A couple of weeks earlier at this year's Consumer Electronics Show (CES, p. 22), I and other journalists rode in a prototype of the Air, an ambitiously engineered electric luxury sedan from **Lucid Motors.** The company plans a factory in Arizona and has shouldered past an ever-changing shortlist of big-talking EV start-ups as the front-running rival to **Tesla**.

• Speaking of CES, it's now being suggested by some that the automotive element of the show has reached peak excitation. One popular thesis: Although recent CESs have been rife with electric and autonomous concepts and demonstrations, actual consumer interest may begin to wane without showroom product to back up gee-whiz promises (i.e. SAE Level 4-5 automated driving) that simply aren't "just around the corner."

• It's difficult to ignore how the policies of the new Trump Administration also play into the seismic industry transitions shaping before our eyes. The new President has been obvious in his desire to influence auto-industry strategies—and in a paradox that only fuels the "which horse are we backing?" confusion of the times—the industry's lobbying group, knowing the incoming administration's stated disdain for government overreach, openly petitioned for relaxation of the aggressive Corporate Average Fuel Economy (CAFE) fuel-efficiency standards that have dominated automotive engineering since President Obama finalized the rules in 2012. The **EPA**'s response: It fast-tracked the review period in an effort to make the standards law before President Trump took office.

This might be one of the most clearly delineated periods of transition in the industry, because we know, maybe better than ever, what's possible. Suddenly less clear is what's *probable*. Is that one definition of "disruption?"

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SUPPLIER EYE

Are you prepared for greater electrification?

The hottest debate within the global vehicle industry is the pace of adoption of vehicle electrification. It's been raging for the past decade and continues to ignite bets, arguments and new forecasts. Don't I know it!

For an OEM to shift increasing levels of human and capital resources towards the development and production of battery, motors, power control and associated software technologies and away from the existing combustion-engine infrastructure, alters their future competitive stature. Foremost among the several "balls in the air" related to electric propulsion is compliance with rising global CO_2 standards in most major markets. But over the next decade, greater electrification also will require increasing shifts and investment in infrastructure. And, importantly, it also is a key enabler for greater subsystem (steering, HVAC) efficiency, adoption of automated driving formats and shared mobility.

Four key markets with rising vehicle emission regulations—the U.S., China, the EU and Japan—account for better than 75% of the global light vehicle market. With the onset of global vehicle and propulsion platforms over the past two decades, the benefits of economies of scale to competitiveness are obvious. Having one flexible platform to cover millions of units of production far exceeds any benefits from multiple regional efforts. Though the inflection of CAFE and greenhouse-gas standards in the U.S. may be of some question over the short term, global OEMs have to design to the highest common denominator—no matter what any individual country does.

As vehicle emission regulations become more stringent, engineers and product planners need to examine the compliance options and obstacles facing the industry. Within the propulsion world the "low-hanging fruit"—direct injection, turbocharging, variable valve control and cylinder deactivation—has, for the most part, been picked. It's on the road. OEMs and suppliers are now focusing on what had been "higher-hanging" (and costlier) technologies: variable-compression-ratio systems, lean-burn/HCCI combustion strategies and even new approaches such as opposed-piston two-stroke engines that are multi-fuel capable. Add in increased transmission ratios or CVTs to deliver the power and greater focus on aerodynamics and friction reduction and it's clear that the industry is pulling out all the stops.

Michael Robinet
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Suppliers involved in propulsion and its ancillaries will face tremendous change in technologies, timelines and system sourcing.

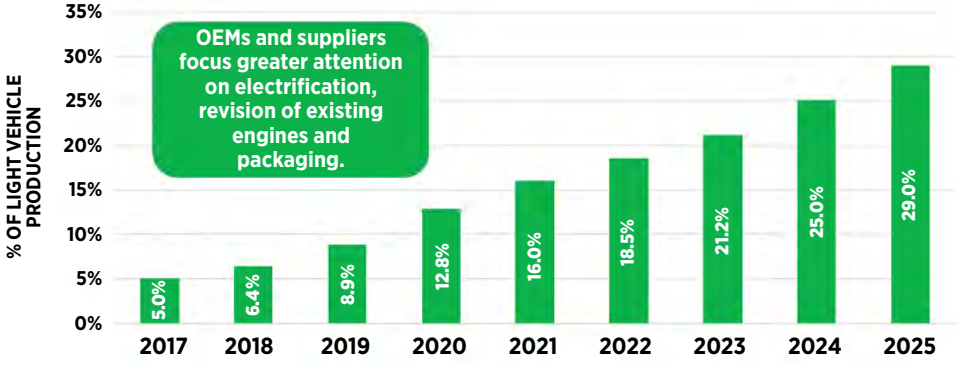
Meanwhile, electrification has only driven changes to the industry's periphery. But this will soon change, as shown in a recent forecast by **IHS Markit** (see chart). The industry is bracing for significant shifts in resource allocation and therefore the competitive landscape for OEMs and suppliers. The ICE will increasingly receive less design and investment—the capital pie is only so large. The number of new engine plants dedicated to ICEs already is in decline. While advanced ICEs will remain vital for hybrids and specific vehicle segments for decades to come, the OEMs are already marking their territory in advance.

Suppliers involved in propulsion as well as the ancillary systems will face tremendous, rapid change in technologies, timelines and system sourcing. Electrification will carry with it greater need to control all systems to optimize efficiency. OEMs will be requesting increased mechatronics, sensor integration and consolidation of ECUs. They'll also be looking for new materials and manufacturing processes, mostly on a global scale.

Is your organization prepared for what's ahead? ■

Global Propulsion

Mild/Full Hybrid, Battery-Electric and Fuel Cell Formats Rise



Over the next decade greater electrification will require increasing shifts and investment in infrastructure. (IHS Markit data)

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SAE STANDARDS NEWS

Attacking the cybersecurity threat

SAE Standards News provides an update on the vital activities in the SAE Global Ground Vehicle Standards development process, engaged by more than 800 ground-vehicle committees comprised of volunteers from global industry stakeholders and SAE GVS staff who support the committee work.

Jennifer Shuttleworth
Associate Editor
Jennifer.Shuttleworth@sae.org

SAE GVS committees are fully engaged on a growing number of cybersecurity topics.

Hot topics among product developers don't get much hotter than cybersecurity. "We have quite a few things [on that subject] in the pipeline," noted Tim Weisenberger, Project Manager, Technical Programs, Ground Vehicle Standards.

First SAE Cyber committee: The scope of SAE's first cybersecurity committee—focused on Vehicle Electrical Systems Security—encompasses on-board vehicle electrical systems that affect vehicle control, or otherwise act contrary to the occupants' interests if the systems are manipulated by an attacker. The committee brings together experts from the automotive and cybersecurity industries for information sharing, Weisenberger said. It has one work in progress (WIP) in the active Vehicle Electrical Hardware Security task force.

This team is developing a recommended practice for security methods and tools for protecting vehicle electrical-system hardware. They're examining existing best practices for hardware security approaches from both the cybersecurity and automotive industries. The resulting document will derive security approaches for use cases such as theft protection, authentication for secure booting and software flashing and secure storage of data. The task force's work also includes hardware-security recommendations for the silicon industry.

Security best-practices guide: SAE J3061 recommends best practices for building security into the product development lifecycle. Following its publication in 2016, the Vehicle Cybersecurity Systems Engineering Committee quickly began work to build standards with J3061 as the foundation. Their two active task forces are developing a best practice to serve as a framework for industry to examine security testing methods and tools for vehicle hardware and software security. Weisenberger told *AE* that the standard will be vendor-agnostic.

The committee aims to develop a classification scheme for the automotive industry to use in threat analysis and risk assessment, to identify discrete integrity levels, he said. It is also examining how Automotive Cybersecurity Safety Integrity Levels relate to the safety-integrity levels from **ISO** 26262, a functional safety standard.

Attacking the cyber threat to DSRC: Multiple SAE Ground Vehicle Standards committees in the passenger-vehicle and commercial sectors are examining the cybersecurity discipline. The E/E Diagnostics Committee is examining OBD security and OBD "dongle" security. The On-Road Automated Vehicle Committee is beginning to research J3061 and do a gap analysis. The Truck and Bus Controls and Comms Committee has a cybersecurity task force. In addition, the Dedicated Short Range Communications committee has long been tackling security issues in DSRC communications.

Joint SAE-ISO collaboration: "SAE is being targeted by many other standards-development organizations and those such as **IEEE**, **TIA** and **ITU**, for joint work," Weisenberger said. And the growing list of active collaborations is expected to continue, he added.

It includes SAE and ISO approving a Partner Standards Development Organization (PSDO) Agreement that kicked off late last year. With approximately 44 experts from 11 nations, SAE and ISO created the Joint Working Group to house experts from both organizations to co-develop an international, joint SAE-ISO standard.

"The importance of the Joint Working Group is that it is the first test case for the PSDO between SAE and ISO," Weisenberger explained. The agreement is a test only. It aims to drive cooperation between correlated SAE and ISO standards.

The group has developed processes, procedures and rules that can serve as the template for all future joint work items. "Now we are poised to begin the technical work and both SAE and ISO will be examining the success of work-item development to inform them on future collaborations," Weisenberger said.

SAE-NIST team up: In a related development, SAE is currently engaged with the **National Institute of Standards and Technology** on a limited pilot project to test the effectiveness of security methods and tools applied at an automotive supplier or OEM using NIST's "federated testbed," a portable software set. ■

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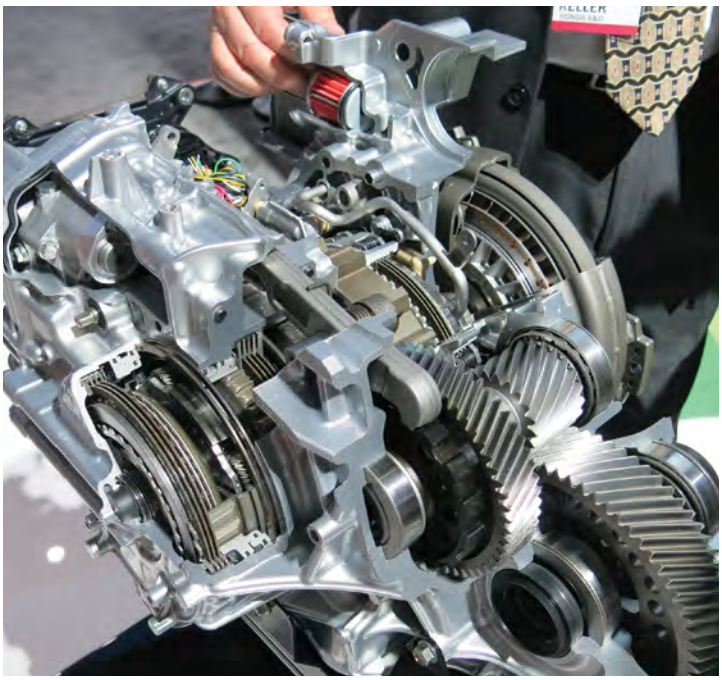
PROPULSION

Honda's new 10-speed is a slick shifter



Less than 15 in long, Honda's new 10-speed transaxle for FWD applications is a packaging triumph. (Lindsay Brooke photo)

Honda R&D transmission engineer Tom Sladek as viewed from the differential end of the new 10-speed. He promises "beautifully smooth" and rapid gear changes. (Lindsay Brooke photo)

Honda's 2018 Odyssey offers room for eight passengers and its all-new transaxle packs 10 forward gears. Developed in-house over a three-year period, the new automatic is the industry's first production 10-speed for front-drive vehicles. It is being produced at the company's Tallapoosa, GA, transmission plant.

Automotive Engineering spoke with Tom Sladek, principal engineer at Honda R&D in Raymond, OH, about the new gearbox during the Odyssey's media unveiling at the 2017 Detroit auto show. He said the transaxle's input torque rating is 370 N·m (275 lb·ft) "with some degree of headroom designed in." While Honda has yet to announce the **SAE**-rated torque of the Odyssey's 3.5-L V6, it is expected to be greater than the 2017 engine's 250 lb·ft (338 N·m). SAE peak power for the 2018 engine is 280 hp—a 32-hp increase over the current engine's output.

Interestingly, Honda is launching the new minivan with two available automatic transaxles—a **ZF**-sourced 9-speed and the new corporate 10-speed. The latter, equipped with standard stop-start capability, initially goes into the premium-trim Odyssey models; it is slated to proliferate steadily throughout the Honda and **Acura** ranges, replacing Honda's 6-speed automatic currently coupled with the 3.5-L V6. The new Odyssey is front-drive only.

The 10-speed transaxle's overall ratio spread of 10.1 compares with 9.81 for the ZF 9-speed used for the Honda Pilot/Acura MDX and TLX and marks a 66% upgrade compared with the 6.03 spread for Honda's 6-speed. The 10-speed is overdriven in gears 7 through 10. Sladek promised "beautifully smooth" kickdowns for rapid acceleration because the transmission is designed for non-sequential skip-shifting—it is capable of instantaneously downshifting from 10th to 6th gear or from 7th to 3rd.

Optimized internal ratios in combination with "a continuing focus on reducing internal friction" help boost the Odyssey's fuel economy by at least 6% over the 6-speed, he said. The wide ratio spread allows engine rpm to be reduced to 1500 rpm at 62 mph (100 km/h), compared with 1920 rpm on 6-speed vehicles. The spread of ratios (Sladek did not have gear-by-gear specifics at the show) enables a 14% improvement in highway passing acceleration, while a lower first-gear ratio boosts off-

The 10-speed's torque converter is an entirely new design aimed at optimally collaborating with the engine's cylinder deactivation and stop-start systems. (Lindsay Brooke photo)

the-line grunt. Redesigned electro-hydraulic controls and a revised solenoid design provide a 30% faster gear-change response time, he claimed.

"Optimizing the overall package was one of our primary design goals," Sladek noted. "Overall length is just under 15 in (375 mm)—about 1.7-in (45-mm) shorter than our existing 6-speed." There are four planetary gearsets aligned with the crankshaft axis, along with the three clutches and three brakes. Sladek pointed to key design elements that contribute to the ultra-compact package: a new two-way clutch that replaces the forward/reverse mechanism's one-way clutch and multi-disc brake; a smaller diameter and slim-line torque converter; and a clever ring gear incorporating a row of teeth on its inner diameter that transfers torque to the differential.

The high-attenuation/low-inertia torque converter incorporates a three-stage vibration damper that was engineered and calibrated for the V6's cylinder deactivation and stop-start systems, Sladek noted. An accumulator activates the 1st-gear clutch either rapidly or slowly, depending on operational inputs, to optimize the engine stop/restart sequence.

Lindsay Brooke

AUTONOMOUS DEVELOPMENT

SAE Level 3 'hand off' challenging AI researchers

When Gill Pratt, the CEO of **Toyota Research Institute**, the carmaker's artificial intelligence (AI) lab in Menlo Park, CA, mounted the CES 2017 stage in January, he delivered a reality check about automated driving.

"We're not even close to Level 5 autonomy, which the **SAE** defined as full robotic control everywhere, at any time, in any conditions," Pratt told the audience. "We have many years of machine-learning research to do to achieve Level 5."

Later, in an interview with *Automotive Engineering*, Pratt credited recent steady progress to most driving being relatively easy—"we do most of it without half thinking," he said. But true self-driving vehicles will need "trillion-mile reliability" and the elusive ability to handle "corner cases" in their automated search for the best solutions. These are the difficult and rare problems or situations that can occur outside of normal operating parameters.

He likened the required robo-driving skills of the future to those of trained professional airline pilots. Current driving capabilities are more like the skills of general-aviation pilots.

On the other hand, SAE Level 4 autonomy, where the car operates fully automatically only at limited speeds in certain operational areas, weather conditions or time of day, "is coming much

A future version of Toyota's Yui driving assistant might help keep humans focused during autonomous driving, helping ease Level 3 "transition" concerns.

A future Yui could help improve safety by providing 'mild, secondary tasks' to human drivers that boost their long-term attention.

faster," the former **MIT** professor and **DARPA** director told the CES audience. "In fact, it's very likely we'll get to Level 4 within the decade."

Warning is 'hard to guarantee'

Pratt then highlighted a key challenge to Level 3 and 2 operations that his all-star team of AI scientists in now studying. "If the autonomous car needs to hand-off control to a human driver in Level 3 driving, it must ensure that it gives sufficient warning, a "request to intervene" to the driver, who may not be paying attention at the time," he explained.

Perhaps even more challenging, he believes, is the requirement for the Level 2 human driver to always supervise the operation of the autonomy, "taking over control when the autonomy fails to see danger ahead." To give a disengaged driver 15 s of warning at 65 mph (105 kmh), the system must spot trouble ahead at a distance equivalent to five football fields. Such a feat requires prediction before the hazard has yet appeared.

That's extremely hard to guarantee," Pratt asserted, "and unlikely to be achieved soon. In fact, it is possible that Level 3 may be as difficult to accomplish as Level 4."

Further, tests demonstrate that "the longer drivers disregard control of the vehicle, the longer it takes to regain control," he noted. Psychologists who studied this "breakdown of vigilance" in WWII radar operators, call this issue the "vigilance decrement."

Pratt asked the CES audience if, over a two-hour road trip, they would be likely to remain vigilant for a possible handoff of the Level 2 vehicle's autonomy. "Does this mean that Level 2 is a bad idea? Some companies have already decided to skip Levels 2 and 3," he noted.

To help investigate this and other such technical challenges, the TRI leader said that Toyota Motor Corp. is doubling the size of the 100-member team that he assembled a year ago to conduct the $1-billion collaborative program, which includes researchers from **Stanford University**, MIT and the **University of Michigan**.

Steven Ashley

BODY | CHASSIS

Lightweight door module aims to trim vehicle weight

Magna's ultralight door module, developed in collaboration with FCA, Grupo Antolin and the U.S. DoE, achieves 40%-plus mass savings versus current production counterparts.

A new ultralight door architecture nets a 42.5% weight savings compared to a current production door—and that's enough to put this lightweight concept in an enviable position.

"This lightweight door module has a great opportunity to be commercialized. It's not just high-tech. It's also at the right cost," said Reuben Sarkar, Deputy Assistant Secretary for Transportation, Energy Efficiency and Renewable Energy at the **U.S. Department of Energy**.

Sarkar and Ian Simmons, Vice President Business Development, Corporate Engineering and R&D at **Magna**, spoke with *Automotive Engineering* following a press conference detailing the lightweight door project at the recent 2017 Detroit auto show.

Magna, in cooperation with the DoE and partners **FCA** US and **Grupo Antolin**, developed the driver's-side door in less than 10 months.

Aluminum accounts for approximately half of the total mass reduction of the door-in-white assembly. The door module also includes Magna's SmartLatch electronic latch system, which eliminates the need for mechanical hardware.

Grupo Antolin's contributions in the area of molding techniques and polymers represented approximately 7% of the total mass reduction.

"This lightweight door was done with today's production materials and today's production processes and methodologies in mind. It's a holistic approach that includes the module, door inner, mirror and trim," said Simmons.

The concept door also was developed at significantly less than the venture's cost bogie. "The target in terms of cost was approximately $5 per pound and we came in at $2.59 per pound," Simmons said.

Simulation showed the door module passing all safety and durability requirements. "FCA US is supporting us with all the prototype builds and all the testing. And it's their functional requirements that we simulated," said Simmons, "All the simulation work and all the initial testing has come back positive."

Next steps include the manufacture of full-scale prototype door assemblies, performance tests and safety tests to validate the design. The goal is to have the lightweight door available for production vehicles by the fall of 2020.

Kami Buchholz

PROPULSION

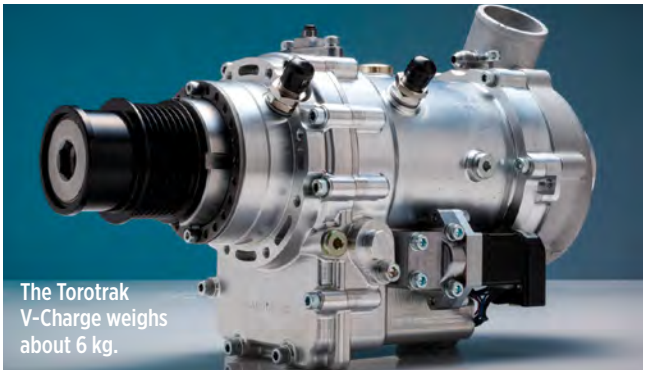
Exclusive first drive: Torotrak's V-Charge technology

Being the first journalist to test drive the only example of a new piece of technology still in development always concentrates the mind. Doing so in wet and windy weather battering rural roads close to England's North Sea coast brings an added dimension to the experience.

But that was how **Torotrak** demonstrated to *Automotive Engineering* the potential of its new, CVT-controlled V-Charge pressure charger—a mechanical, gearless, fully variable pressure charger driven by a conventional pulley. It allows compressor speed to vary independent of engine speed. It's designed to provide low-end torque and tackle the effects of turbo-lag on downsized gasoline engines. (See http://articles.sae.org/12401/; also SAE Technical Paper http://papers.sae.org/2015-01-1971/).

Fitted to a 1.0-L **Ford** Focus as a technology demonstrator (Torotrak is partnering with Ford on the project), it is currently being shown to industry engineers and senior executives across Europe.

As well as general downsizing, V-Charge is proving of particular interest to those companies working on Miller-cycle engine applications to meet Euro 7 emissions legislation, said Richard Dunne, Torotrak's Group Business Development Manager. Independent testing has been conducted by the U.K.'s **University of Bath**.



The Torotrak V-Charge weighs about 6 kg.

Getting something for nothing has always been a problem for engineers. So V-Charge does not reduce fuel consumption of the regular 1.0-L— that isn't "Plan A," Dunne explained. But compared to the equally regular Ford Sigma 1.5-L (a 4-cylinder powerplant) it is claimed to cut fuel consumption by up to 12%,

with a comparable cut of CO_2 emissions.

The V-Charge setup does this without recourse to 48-volt mild-hybrid technology and uses a standard, off-the-shelf (OTS) compressor. Unlike an e-boost system, V-Charge provides continuous boosting, asserted Dunne: "It is not complex; the variable-ratio traction drive is a scaled-down version of our established and proven toroidal CVT technology,." he noted. System weight is 6 kg (13.2 lb).

The test drive

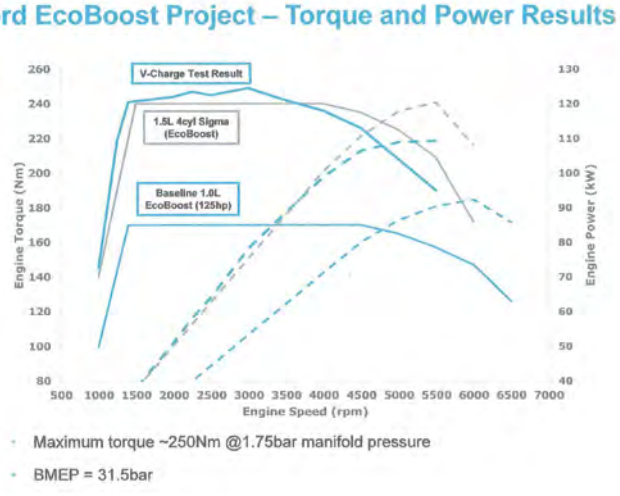
In a manual-gearbox Focus demonstrator, Dunne used laptop control to switch the system in or out to give direct engine-behavior comparisons. The development car uses a turbocharger slightly larger than that of the standard Ecoboost unit to give 110 kW (147 hp), an 18-kW/24-hp increase.

The efficacy of the V-Charge was apparent on the first steep hill encountered; the initial step-off from an intersection and in a 90° corner tackled with engine speed dropping towards 1000 rpm in 3rd gear. Low engine speed and (relatively) high torque were smooth partners—typically (and critically) without the need for downshifting.

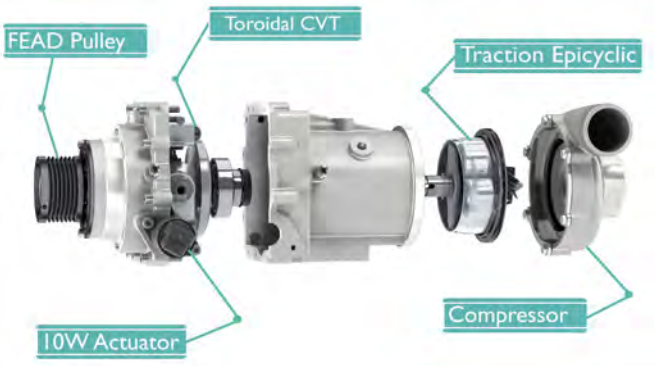
Baseline rated torque for a regular Ford 92-kW (123-hp) triple is 100 Nm (74 lb·ft) from 1000 rpm and 170 N·m (125 lb·ft) from 1400 rpm. With V-Charge the figures rise to 145 N·m (106 lb·ft) and 240 N·m (177 lb·ft) respectively, very similar to those for the 1.5-L 4-cylinder. It seems perfectly amenable for C-segment or smaller cars with a curb weight of 1289 kg (2841 lb).

With a CVT ratio spread of 10, an 1100-rpm engine speed can be converted to anywhere between 10,000 and 100,000 rpm at the impeller without any traditional gearing, explained Dunne. The system is designed to provide greatest efficiency from idle to 2500 rpm, tapering off to avoid over-boosting. It provides a ratio change in a maximum of 400 ms.

All this happens quite quietly; Dunne said the system is 97% quieter than a comparable Roots-type supercharger. It is easily packaged at the rear of the engine and no noise attenuation is required, he claims.



The V-Charge 1.0-L triple's performance against the 4-cylinder 1.5-L engine demonstrates its potential. (courtesy of Torotrak)



Exploded view of the V-Charge showing the rotors of its toroidal CVT. The compressor is an off-the-shelf component.

An electric actuator is used to change ratios (there are no control hydraulics), so parasitic losses are minimized. There is no metal-to-metal contact in the CVT, which uses traction fluid of proven performance. The ratio spread provides 0.28 to 2.82:1 gearing. When the charger is not needed, the ratio moves to its minimum and there is no need for a disconnect clutch.

The system is designed to provide a power capacity of up to 17 kW (23 hp) and can run at that level continuously.

Claimed fuel consumption and emissions for the 1.0-L with V-Charge are 2-5% higher than the standard engine due to the added load (about 100 W) caused by the system. However, the figures are estimated to be 12% lower than the 1.5-L 4-cylinder's at similar or improved performance.

Cost similar to a VGT

Torotrak is not a manufacturer; it would sell or license V-Charge technology to a Tier 1 supplier. Doug Cross, Torotrak's Chief Technical Officer, says the V-Charge would represent cost comparable to a variable-geometry turbocharger.

"The complete on-cost needs to be considered to determine a cost/benefit ratio," Cross told *AE*. "When you sell technology to an OEM, your transfer price is effectively doubled by the time it reaches the customer." But offsets include cost saved by using a triple instead of a 4-cylinder engine without loss of performance.

It is possible, therefore, that by adding V-Charge only a modest cost penalty might be involved — and even a cost saving, Cross believes.

Miller-cycle compatible

One concern regarding use of any CVT was once the behavior of its traction fluid in extremely low temperatures, explains Cross: "We have done a huge amount of development and we now have a traction fluid that is liquid-pumpable down to -30°C."

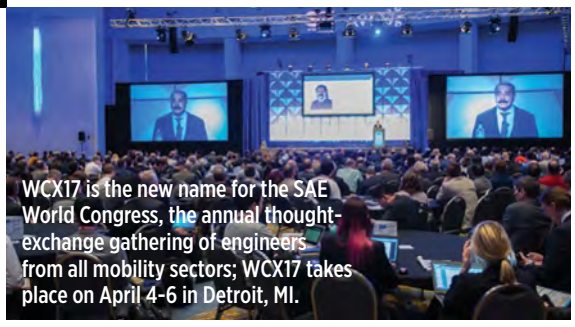
With many OEMs involved in Miller-cycle engine development (or variations of it), Cross is confident that V-Charge would be compatible with the technology.

Although Torotrak has concentrated on gasoline engine applications for V-Charge, it would also be applicable to turbodiesels, overcoming the negative aspects of transient load steps when the accelerator is floored.

Stuart Birch

Preview: SAE WCX17

SAE again evolves mobility thought exchange with the new-look WCX17.



WCX17 is the new name for the SAE World Congress, the annual thought-exchange gathering of engineers from all mobility sectors; WCX17 takes place on April 4-6 in Detroit, MI.

On the centennial of the Society of Automotive Engineers' first "Annual Meeting" in 1917, the organization is evolving the mobility sector's all-encompassing collaborative gathering—long known as World Congress—into the SAE World Congress Experience (WCX) for 2017.

The inaugural WCX17, April 4-6 in Detroit, MI, continues the spirit and intent of the original Annual Meeting by retaining an exhaustive list of technical sessions and newly published technical papers as the event's foundation—in 2016, there were more than 1500 technical presentations and an equal number of published technical papers. But WCX17 adds an even wider variety of thought-exchange forums and events, professional-development and networking opportunities and even business-relationship incubators.

"SAE International is excited to unveil this completely redesigned event," says Jim Forlenza, Group Director, Event Sales, SAE International. "WCX will emphasize active learning and increased collaboration through the dynamic new elements our team has worked tirelessly to develop; beyond that, we're incredibly proud about the unsurpassed education sessions, top-notch speakers and myriad opportunities to connect."

Blending new experiences with established favorites

Addressing the mobility community's request for more-focused—and sometimes less formal—opportunities to explore emerging-technology development, WCX 17 offers several unique new venues as well as recognized attendee favorites.

- The **Launch Pad** is a new, dedicated presentation area where startup companies can showcase products and services to potential investors.
- The **Innovation Market** highlights emerging technologies and concepts and new-to-market products and developments.
- The **Learning Lab** is where OEMs and top-tier suppliers will deliver technical presentations, host Q&A sessions and even perform full product launches.
- In the **Experience Lounge**, exhibitors and buyers can meet to network and exchange ideas in a comfortable, low-pressure "neutral" environment.
- **Technology Pavilions** address future mobility innovations in specific areas such as additive manufacturing, augmented reality and lightweighting.
- In the always-entertaining **Tech Hub**, no holds are barred as groundbreaking and sometimes unconventional thinkers cover a wide bandwidth of mobility ideas, concepts and developments.
- Meanwhile, the WCX17 **Leadership Summit** gathers engineering and business leaders from OEMs, large suppliers and government and regulatory interests to further the mobility conversation from both traditional and non-traditional perspectives.

A "speed-mentoring" session is one of WCX's recent Young Professionals Program innovations.

Test rides in the latest personal-mobility prototypes are always popular at WCX.

Thought-provoking panels, sessions

Aside from technical sessions and paper presentations, the public forums and conferences conducted at WCX attract the event's largest crowds and engaging discussions. As visitors have come to expect, WCX17 presents a spectrum of thought from top-level sources in all areas of the mobility universe.

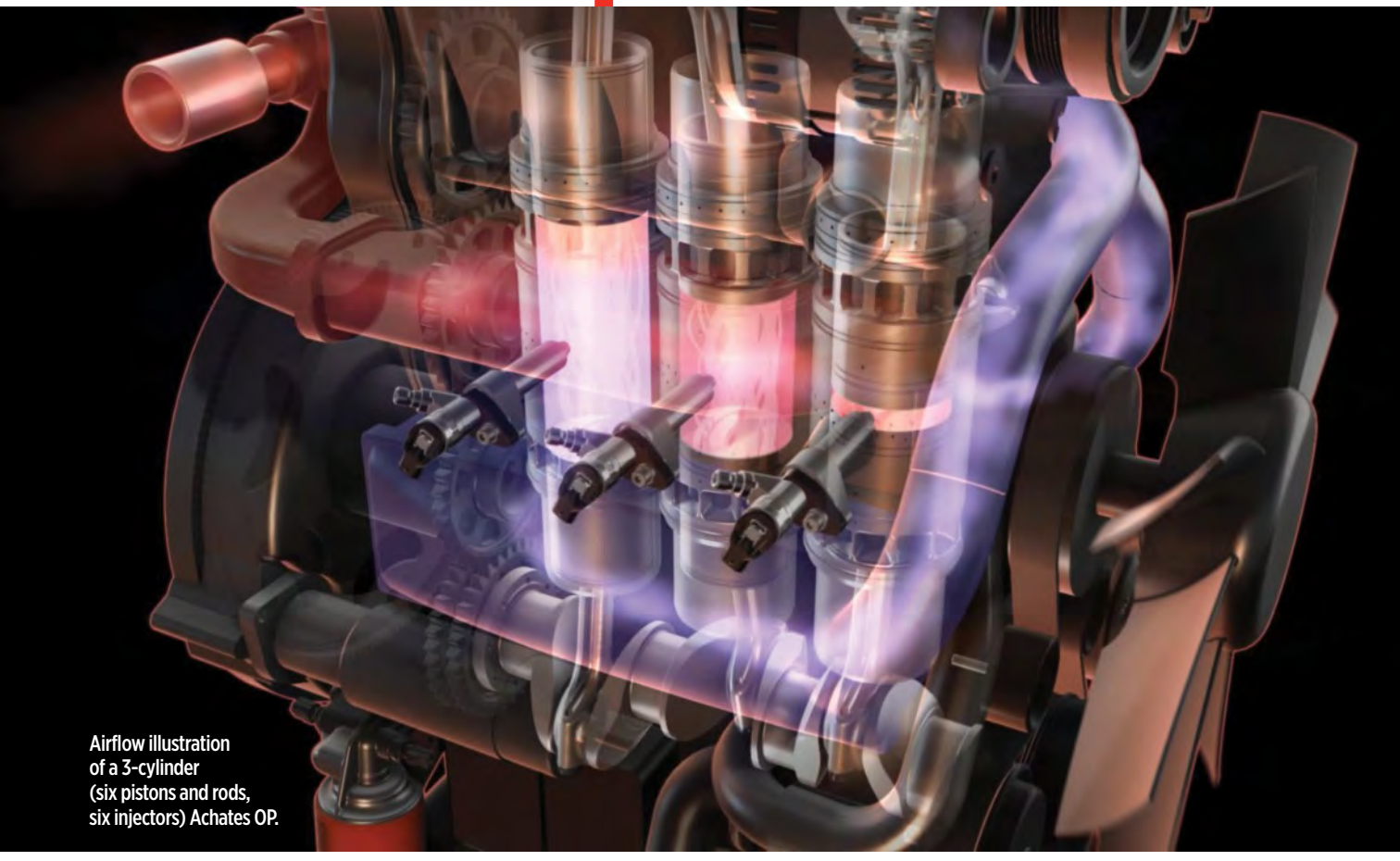
In the Tech Hub, for example, speakers range from **Baidu**'s Jun Liu ("A Race to Automated Driving") to speakers representing electric-vehicle startups **Nikola Motors** (Trevor Milton) and **Faraday Future** (Peter Savagian). On Day 2, the Tech Hub features speakers such as **BMW** Group's Roberto Rossetti ("BMW—The Next 100 Years") and Prasanna Balaprakash from **Argonne National Laboratory** to assess the current state of artificial-intelligence development.

Over at WCX17's Leadership Summit, Day 1 attendees will hear from a roundtable of sources that include **Magna International**, **Ford** and **Deere & Co.**, all discussing "Establishing a Culture of Innovation." Also on Day 1 is a panel discussing the Internet of Things (IoT) that includes executives from **Cisco**, **Intel** Corp. and **IBM** Corp.

The Leadership Summit finishes Day 3 with a panel talk: "How, What and if You Will Drive in the Next Decade," that includes speakers from Ford, **FCA US**, **General Motors** and **Roland Berger Strategy Consultants** and the Summit finishes with a panel providing executive conclusions that includes Doug Patton of **Denso**, who also serves as 2017 SAE International President.

Bill Visnic

ACHATES POWERS toward production



Airflow illustration of a 3-cylinder (six pistons and rods, six injectors) Achates OP.

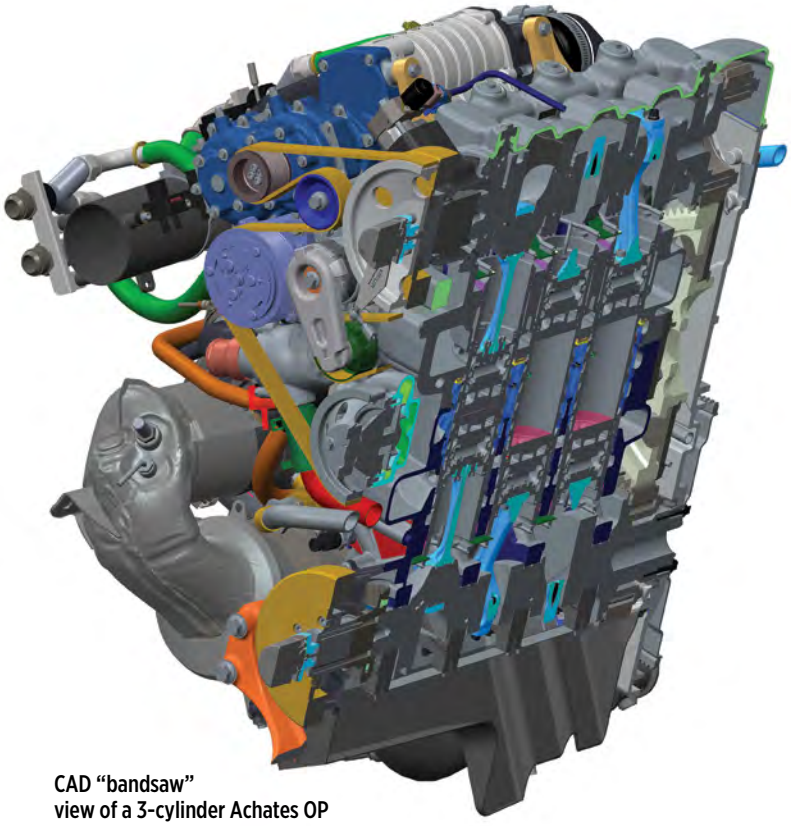
A potential ICE game-changer, the Achates OP engine is being tooled up for production at one OEM while a new 2.7-L triple for light-truck demonstrations enters the build phase.

by Lindsay Brooke

Nothing short of a game-changing technology has any chance of disrupting the world's combustion-engine mainstream, it is generally believed. Felix Wankel's rotary came the closest, carving out a successful niche at **Mazda** after **GM** spent millions tooling up for, then killing, its own high-volume rotary program in the 1970s. Now comes **Achates Power**, the San Diego technology company that has brought its opposed-piston, 2-stroke, compression-ignition engine to the brink of production after 13 years of careful and relentless development.

At January's 2017 Detroit auto show, Achates' top engineers made two promising announcements. First, one of the company's nine global OEM customers has begun tooling an engine plant for serial production of an Achates 'OP' engine. While no details or timing were provided, Achates' current customer base includes applications for passenger-vehicle, light and heavy commercial vehicle, military and marine/stationary power. The engine programs span a broad range of fuel strategies and configurations—from 50-hp (37 kW) single-cylinder units to 5000-hp (3768-kW) twelve-cylinder monsters aimed at stationary and marine use. Development also includes a gasoline compression-ignition program (see sidebar).

Achates CEO David Johnson also reported that a new 2.7-L 3-cylinder diesel unit—each OP engine has two pistons and con rods per cylinder, driving two geared crankshafts—is entering the build phase. A batch of engines will then start clocking dyno time in preparation for light-truck



CAD "bandsaw" view of a 3-cylinder Achates OP shows cylinder porting. These engines have wet-sump crankcase lubrication and plain bearings similar to a 4-stroke.

One of Achates Power's dyno cells at the San Diego headquarters, which continues to expand to meet customer demand.

on-road demonstrations and customer evaluations in 2018. Turbocharged and supercharged, the 2.7-L will be capable of delivering 270 hp (201 kW) and 479 lb·ft (650 N·m) at crankshaft speeds comparable to current-production light-duty diesel engines, he said.

The demo units, their fully-dressed package volume and mass equivalent to that of **Ford**'s 2.7-L Ecoboost V6, will be installed in full-size pickups and/or SUVs—the market segment Achates is promoting for its volume, profit and CAFE-impacting potential, Johnson explained. The 2.7-L "will be fully measured and characterized and will achieve 50% improvement in fuel economy versus downsized, turbocharged, spark-ignited gasoline engines today." It will also be 30% more efficient than the best incumbent passenger-vehicle diesels, he said.

Johnson quoted a 37-mpg (unadjusted) CAFE number for the engine; 2025 U.S. regulations call for vehicles with a 65-70-ft2 'footprint' to deliver 33 mpg. City/highway/combined EPA fuel economy for an Achates-powered base truck calculates at 25/32/28 mpg.

"We'll have a 'CAFE-positive' vehicle," he asserted. Johnson, a veteran of GM's global diesel engineering and Ford truck product planning before joining Achates Power in 2008, also is confident the 2.7-L six-piston OP diesel will meet the federal Tier3 GHG fleet average of 0.03 g/mile NMOG + NOx with minimal tradeoffs in BSFC. Upcoming Euro6 standards also are achievable he said.

Development work conducted with **Johnson Mathey**, **Emitec** and other aftertreatment-system suppliers project the OP engine's aftertreatment-cost burden to be 30% less than current-production light-duty diesels, according to Johnson. Smaller catalysts (with less precious-metal content) are required due to the OP's comparatively low engine-out NOx emissions.

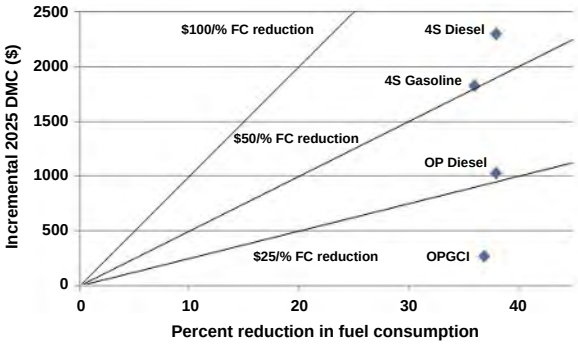
Particulate formation is inherently reduced due to the OP's injection environment, the engineers claim. Two injectors per cylinder, fed by a 2000-bar common rail, spray fuel across the cylinder bore perpendicular to piston travel towards top-dead center. Fuel droplets therefore "do not impinge on the combustion chamber wall, dramatically reducing soot formation. As we run, test and measure our engine, we find its soot production to be low. We have tremendous datasets [regarding PM] with our diesel," Johnson explained. He expects, though, that Achates' gas and diesel engines will at some point require PM filters.

Traditional 4-stroke gasoline ICEs are least efficient during low-speed/low-load operation—the region where most drivers spend most of their time. Rondon noted that Achates' OP engine has demonstrated its ability to minimize the efficiency drop at low loads; where traditional 4-strokes' pumping comes from their systematic "suck-spark-bang-wheeze" cycling, the OP's supercharger, currently an **Eaton** unit, provides independent cylinder charging. It can be adjusted to supply precisely the amount of air needed per quantity of fuel injected, providing what Rondon calls an advantage over the incumbents in low-load/low-speed running.

The operating characteristics, inherently good primary balance and steady-state emissions profile also lend themselves to hybrid applications; Johnson noted that Achates has a study underway for a small-displacement (600cc-700cc per cylinder) range extender.

"Our opposed-piston engines are the most cost-effective, fuel-flexible, power-and-torque-dense solution for OEMs to meet the CO2 and fuel economy regulations of the next decade, without having to change the world's fuel infrastructure," Johnson told *Automotive Engineering* in December 2016 during a visit to his company's headquarters.

ACHATES POWERS toward production



Achates 2017 plot showing how the OP engine compares on value-for-fuel economy.

$1000/unit cost savings

The industry's expanding interest in Achates Power OP developments includes work with **Cummins** on the **U.S. Army TARDEC** Advanced Combat Engine, a single-cylinder demonstator, plus programs with **Fairbanks-Morse** and the ARPA-e OPGCI project with **Delphi** and **Argonne** noted in the sidebar.

The engineering team's enthusiasm continues to grow with each week of testing and development. "There was a time when I joined Achates Power that I didn't know if the technology would work or not," Johnson admitted. "Now, I have absolutely no doubt we'll get into volume production. When we started, top powertrain engineers from major engine companies said to me, 'You'll never be able to achieve good combustion with this engine.' So we went to work on that. We solved that problem and patented the solutions and demonstrated them. We did the same with NVH." Achates currently owns 120 patents on the OP engine with another 200 pending.

Company founder Dr. James Lemke saw significant advantages in the basic OP 2-stroke design that has powered aircraft, ships and military vehicles since the 1930s. He believed that clean-sheet re-engineering and application of the latest technologies could boost the OP's historic attributes—low heat rejection, high expansion ratio, lean combustion and reduced pumping losses—and reinvigorate the engine for 21st century propulsion duty.

For background, see our June 3, 2014 feature article, available for download at http://magazine.sae.org/14autp06/. Also see SAE Technical Paper, "An Analytical Assessment of the CO 2 Emissions Benefit of Two-Stroke Diesel Engines," Alok Warey GM R&D, et al, http://papers.sae.org/2016-01-0659.

Many factors contribute to Achates' claimed $1000 to $1500 per-unit cost savings for its OP engines versus comparable current LD gas and diesel engines, explained Fabien Redon, Vice President, Technology

CEO Dave Johnson (left) and development chief Fabien Redon with an OP cylinder. (Lindsay Brooke photo)

Development. Bill-of-material advantages are significant because there are no cylinder heads, gaskets, camshafts or valvetrain. Along with head machining, the head(s) and valvetrain typically account for 15-20% of the cost of a 4-stroke base engine. This more than offsets cost of the OP's second crankshaft and supercharger, Redon said.

Compared with a state-of-the-art V6 with supercharger, the 2.7-L Achates OP's BoM is more than 60% smaller, enabling an approximate 10% cost reduction, he noted.

Engine assembly is simplified and there is minimal "all new" in the manufacturing process, the majority of which is shared with incumbent ICE production. The Achates' long stroke-to-bore ratio (typically 2.2:1) helps deliver strong output-torque characteristics that may lessen the need for 10-speed transmissions now emerging in the industry.

"Our fuel maps for both the gas and diesel engines are similar—and they're much flatter than those of other light-duty diesels, so we don't need all those [transmission] speeds," Johnson surmises.

And without a cylinder head, the OP rejects less heat to the coolant. The resulting lower radiator and fan loads mean those components can be reduced in size. A powertrain-engineering expert contacted by the author for comment, who is familiar with Achates' technology called the 2.7-L project "quite viable in virtually every metric to this stage."

Oil consumption no issue

Like countless classic piston-port 2-stroke motorcycle engines, the Achates OP has its intake and exhaust ports in the cylinder walls—but with the intakes at one end of the cylinder and exhausts at the other. The ports are opened and closed by the piston motion, enabling "uniflow" air scavenging. But the piston-port design also was the Achilles' heel of those historic engines, contributing to excessive oil consumption as the piston/ring assembly drags the oil film past a port with every piston reciprocation. The term "oily mess" was probably coined by the black-coated **Detroit Diesel** 6-71 engines that powered every GM city bus.

OPGCI project pushes toward 50% BTE gains

In late 2015, ARPA-e, the **U.S. Dept. of Energy**'s Advanced Research Projects Agency, awarded a $13 million grant to Achates Power, **Delphi Automotive** and the **Argonne National Laboratory** (ANL) to develop, in a three-year program, a gasoline compression-ignition (GCI) version of the Achates Power OP engine. An OPGCI?

Delphi and Argonne had previously demonstrated that by combining high compression ratio and throttleless lean operating conditions, gasoline can be ignited and combusted without a spark plug. Cylinder temperature, pressure and fuel distribution must be precisely controlled, but the result is diesel-like torque and performance and claimed 50% greater brake thermal efficiency than current gasoline ICEs. Lower peak temperatures result in reduced NOx and there's less particulate formed due to mostly lean local mixture conditions in the cylinder. The higher hydrocarbon and CO emissions that result can be managed using an oxidation catalyst.

According to a report by Fabien Redon, VP Technology Development at Achates Power and Steve Ciatti, Principle Mechanical Engineer with ANL, the opposed-piston 2-stroke engine helps minimize the following technical challenges of GCI:

Mixture preparation and GCI Injection: Clean, robust GCI combustion requires a stratified charge, with locally lean and rich areas and multiple injection events. The Achates OP, with its diametrically opposed dual injectors spraying across the cylinder bore's combustion space, has advantages for charge stratification, the engineers explain. Each injector can be independently controlled and its events staggered for optimum mixture distribution.

Charge-temperature management: GCI requires higher temperatures for combustion at low loads, such as at idle or coasting. Engines operating in such conditions generate relatively little heat—a problem that worsens in small cylinders with high ratios of surface area to combustion volume. The Achates OP engine can retain exhaust gas in-cylinder, especially at low loads when relatively little new oxygen is required. Its in-cylinder scavenging is determined by the pressure ratio between the intake and exhaust manifolds.

At low loads, the Achates OP engine can reduce the supercharger work used to boost the intake manifold pressure. This reduces the amount of work by the supercharger, thus improving efficiency. In-cylinder temperatures remain high for good combustion stability. An internal EGR effect is provided for low-NOx combustion and high exhaust gas temperatures are created for rapid catalyst light-off.

High-load operation and pumping: GCI engines bring challenges under high loads that create tradeoffs. They require high air and EGR levels to control combustion—adding significant pumping work that erodes fuel efficiency. This also creates high cylinder pressures that can limit the engine's maximum-load capability and create combustion noise. The OP engine's 2-stroke combustion cycle, by comparison, reduces the maximum BMEP requirement (and displacement) while maintaining performance requirements. Reduced pumping work is due to the relatively large flow area of the OP engine's ports, more optimum turbocharger performance and efficient EGR pumping. Also, the OP's larger cylinder volume available for combustion enables faster heat release rates without increasing combustion noise.

Among the benefits of combining the Achates OP engine with GCI, the engineers noted the lower cost of the entire powertrain package versus diesel, due to a reduced aftertreatment (smaller catalysts) burden. Watch this magazine for an update on the ARPA-e project. **–LB**

The new 2.7-L three-cylinder OP is engineered for both gasoline and diesel fuels. Note cylinder axis slanted slightly for packaging, supercharger at top of image, and close-coupled catalyst at left center.

That won't be the case with the Achates OP. Oil consumption is comparable with that of 4-stroke diesels, perhaps "a little bit above," Johnson claimed. "No exotic coatings or materials required. It's really about the details of the bore hone, port shape, ring tension and ring profile. All are critical and we've done a lot of work on them," he explained.

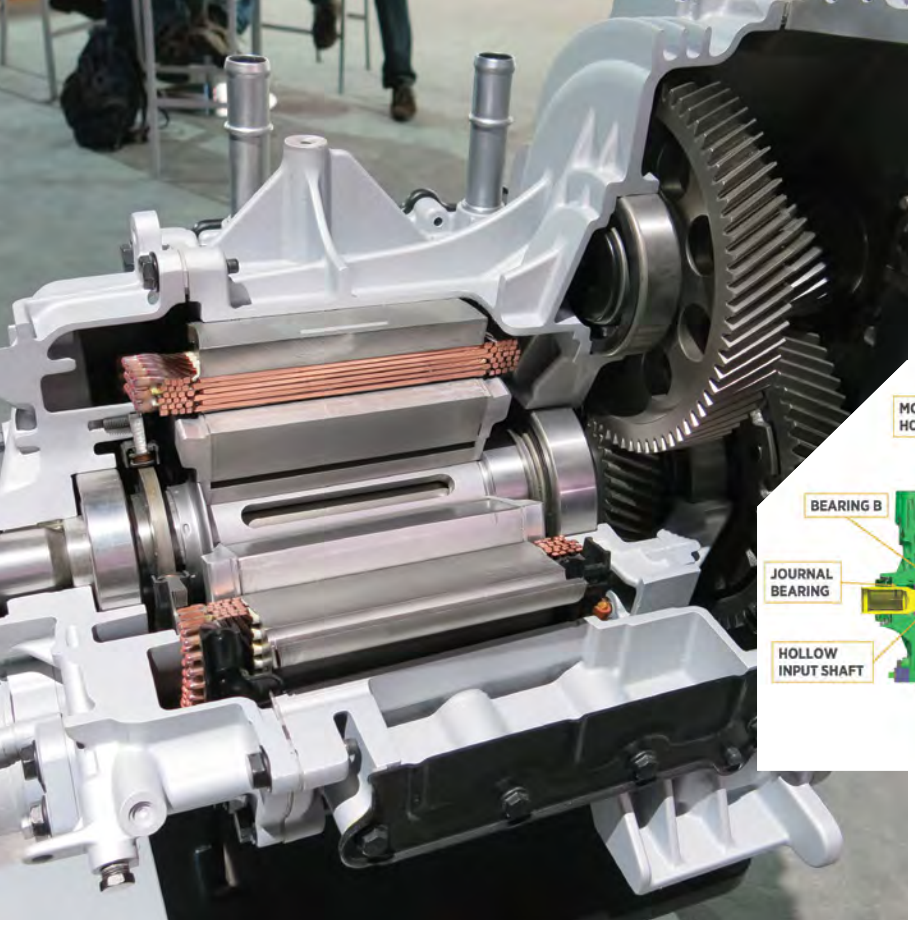
In 2010, Achates took delivery of a refinery gas analyzer from **Da Vinci Laboratory Systems** for measuring exhaust sulfur content. "It allows us to measure the real-time oil consumption while the engine's running," Johnson noted. "We create an oil-consumption map for any running engine within two hours. Change parts, new map. We've published papers on this."

Achates' next step is getting the batch of 2.7-L triples built and into customer dyno cells and demo vehicles.

"The big challenge for us is the protracted timelines of the engine business," Johnson said. "It takes a long time to start a new engine program and get to SOP (start of production). The good news is we have customers and more than 50% of the world's major engine companies have started a project with us. So we can begin to forecast when production is going to be."

Technically, the Achates Power engineering team doesn't see any major barriers. "We are bringing this engine forward toward production with our customers," said Johnson. "When you have all the customers that we do, it's now kind of a race." ■

Inside the Bolt EV



Electric transaxles are simplicity itself: the Bolt EV drive unit cutaway reveals GM's trademark bar-wound stator, hollow shaft, robust bearings and helical gearset. (Lindsay Brooke photo)

While the new battery deserves credit for the car's +200-mile range, systems optimization, careful motor design and proprietary CAE tools were equally important.

by Lindsay Brooke

Cutaway propulsion systems displayed at motor shows attract engineers faster than free beer and pizza. So perhaps it wasn't surprising when Matthias Mueller, the newly-promoted chairman of **Volkswagen Group**, and his five-man entourage charged into the **Chevrolet** stand during the 2016 Detroit auto show.

"Hier ist es," (here it is) said Mueller's assistant, pointing to the 2017 Bolt EV propulsion module unveiled earlier that day. The dark-suited VW execs huddled closely around the cutaway property, its traction motor and large helical gearset in full view through the artfully milled aluminum case. One of Mueller's lieutenants—who may have studied the Chevy module already—listed some design highlights while Mueller listened attentively. A fellow carrying a notepad made a technical sketch while another snapped close-up photos.

Within ten minutes they departed. The author and Steve Poulos, GM's veteran chief engineer of electric-propulsion systems, stepped back to the cutaway. We picked up our own discussion from before the interlopers arrived.

"That's not the first competitor to visit us today," Poulos noted. "We knew we'd get some interest." Such understatements from the engineering team a year ago foreshadowed numerous awards to come for the newly-minted Bolt EV, including 2017 North American Car of the Year. As the first production battery-electric vehicle to deliver more than 200 mi (322 km) range at a price less than $40,000, the Bolt EV proves the strategic collaboration between GM Global Propulsion and LG Electronics Vehicle Components is an EV development force. The **LG Corp.** group was established in 2014 to co-develop the Bolt powertrain and other subsystems.

Much of their triumph has been credited to the Bolt's battery pack, featuring a new nickel-rich Li-ion NMC chemistry which gives greater heat tolerance without impacting battery life, according to Bill Wallace, GM's director of global battery systems. Larger cells with more surface area deliver a 40-kW gain over the previous Spark EV pack. Nominal energy is increased more than 3X, from 18.4 kW·h on Spark EV to more than 60 kW·h for Bolt, with only a doubling of battery mass.

It's a significant increase in both gravimetric (Watt-hours/kg) and volumetric (kilowatts/L) energy (see table). Its high thermal mass—the pack weighs 959 lb/435 kg—means temperature swing during operation is single-digit minimal. There isn't much wasted heat, which helps improve the amount of energy recuperated during the Bolt EV's "single-pedal" lift-off deceleration and regen braking. *Automotive Engineering* editors call it "the small-block V8 of battery packs."

Motor design details

But systems optimization of the battery, e-motor, gearing power control and thermal management is the bigger story behind Bolt EV, Poulos noted.

"We looked at numerous ways to optimize the motor to

GM's EV PROGRESS: COMPARING ELECTRIC CHEVIES		
	2014 Spark EV	*2017 Bolt EV*
Vehicle Class	A	B
Curb wt (kg)	1342	1625
0-60 mph, s	7.5	<7
0-30 mpg, s	3.1	2.9
Max. launch grade, %	28	30
EPA label range, mi	82	200
Battery chemistry	Li-ion	Li-ion, nickel-rich
Battery nominal energy	20 kW·h	60 kW·h
Battery mass	260 kg	436 kg
Max. battery power	120 kW	150 kW
Battery nominal voltage	360V	350V
Battery cooling control	Liquid active	Liquid active
Peak axle torque, N·m	1710	2500
Gear ratio	3.87	7.05
Drive unit mass, kg	68	76
Lubricant type	Dexron VI	Dexron VI
Total ATF volume, L	4.2	2.9
Motor peak power density, W/cm3	18.5	28.8
Peak torque density, N·m/cm3	0.09	0.07
Peak torque, N·m	540	360
Max speed, rpm	4500	8810
Rated current, Arms	450	400
Nominal DC bus voltage, V	350	350
Motor stack length, mm	125	125
Motor outer diameter, mm	213	204
Number of poles	8	8

achieve peak [97%] efficiency," he said, "because the more efficient we make the motor, the less battery we need to carry to achieve our 200-miles range." Designed in-house at GM, the motor program found the ideal magnet location in the rotor to break up frequencies and squeeze out as much torque density as possible.

The neodymium iron boron (NdFeB, or NIB) magnets are placed deep within the rotor in a two layer 'V' arrangement, assymetrically between adjacent poles to minimize torque ripple and radial force. A double-layer arrangement of magnets and barriers offers design flexibility and boosts motor performance at higher speed. The bar-wound stator construction is a GM e-motor trademark that provides high slot-fill, improved thermal performance and higher efficiency, the engineers said.

Poulos's team also realized the permanent-magnet motor needed to spin significantly faster than that of the Spark EV to produce the power needed for the larger, heavier Bolt and its much-higher performance targets. The new motor's 8,810 rpm peak is nearly twice as high as that of the Spark motor. It runs on slightly lower current for more efficiency. Peak torque is less than the Spark motor but axle torque is higher due to a higher (7.05:1 vs. 3.87) final drive ratio.

That helped reduce the propulsion unit's weight (167 lb/76 kg, most of which is the 150-kW motor) and package volume. The drive unit's compact design allowed it to be located precisely in the vehicle centerline, which enabled identical-length axle shafts. The result was minimized torque steer, reduced integration cost and greater manufacturing efficiency.

Additionally, the single-speed gearset architecture created advantages in the park system loading. Also, the split lines between the end cover and motor housing and between the motor and gearbox housings increase structural rigidity. This in turn enables the motor assembly to be manufactured as a separate stand-alone unit and allows motor-compartment maintenance without disassembling the entire drive unit.

Veteran GM electrification engineer Steve Poulos served as chief on both the Bolt and Spark EV programs as well as the E-Assist mild hybrid. He's currently chief engineer of GM's fuel cell activity. (Lindsay Brooke photo)

GM's unique analysis tool

The lubrication system in this electronic-automatic propulsion device is a combination of pressurized and gravity feed/flow. It uses a 12-V variable speed pump mounted outside of the transmission housing. The low-pressure pump will only run when out of Park or Neutral and vehicle speed is detected. The 12-V pump also helped optimize filter position and minimized ATF volume inside the drive unit, which helped reduce cost, mass and drag/spin losses, Poulos noted.

Key to the propulsion system meeting and in some ways exceeding its design targets was a proprietary CAE program, said Poulos. "We input all the different maneuvers we want to design this motor to do—various drive cycles, climbing a grade, 0-60-mph acceleration, passing maneuvers, etc.—to generate thousands of points on the torque-speed map."

Without the unique analysis tool, the thousands of combinations would require far more time to sort out. The program then breaks the map into zones and prioritizes them according to their importance to the car's performance. It then generates a 'center of gravity' for each representative point.

"Then we do a Design of Experiments and a whole series of design variables and it gives us the optimum," explained Poulos, who is now chief engineer of GM's fuel cell activity. "We keep adding these points until the data converges into an answer that doesn't change."

Added Tim Grewe, GM director of general electrification, "It's a very powerful technique we developed internally to ensure we have no more iron, copper, size and mass than we need to meet our performance requirements.

"From a customer-pleasing point of view, this program goes way beyond the cycle, which we also weighed into the calculation to determine what to optimize," Grewe said. "It tells us quite precisely that we've optimized the motor for every drive cycle without compromising something that disappoints the customer."

Further details can be found in SAE Technical Paper: Design of the Chevrolet Bolt EV Propulsion System, http://papers.sae.org/2016-01-1153/. ■

CES 2017:

Lush luxury EVs, sophisticated connectivity

Suppliers challenge OEMs in advanced tech

By Steven Ashley, Lindsay Brooke, Terry Costlow and Kevin Jost

The view from Las Vegas as the 2017 CES (formerly the Consumer Electronics Show) opened in early January to over 160,000 attendees including engineers, product planners and policymakers: Development of advanced mobility technologies is increasingly being driven by suppliers rather than OEMs. And expect numerous acquisition or collaboration megadeals worth at least $500 million as the auto sector rushes to address technology weak points.

The annual CES trade show, presented by the **Consumer Technology Assoc.** and not open to the public, continues to challenge global auto shows as the "first look" showcase for future mobility solutions—everything from more powerful chipsets for faster data processing, to new sensors, software, user experience and complete vehicle systems.

The 2017 show, spread out over 212,000 ft^2 of floor space, is even a stage for full-blown vehicle debuts: This year Chinese start-up EV maker **Faraday Future** once again revealed an all-new vehicle. Another newcomer, **Lucid Motors**, had top engineers demonstrating its Air luxury electric sedan concept. The CEOs of **Ford** and **Nissan** delivered keynote addresses and **FCA** participated at CES for the first time.

Major electronics-focused Tier 1s including **Bosch**, **Continental**, **Delphi**, **Valeo** and **ZF TRW** used CES to both demonstrate their latest products to customers on the show floor and on public roads. They also used the event to meet privately with start-up innovators bringing their latest developments to the global market. **SAE International** held a day-long Connect2Car technology conference, as well, amid many other panel discussions and expert presentations.

Autoliv, **Clarion**, **Delphi**, **IAV**, **Gentex**, **Mitsubishi Electric**, **Navya**, **NVIDIA**, **NXP** and **Renesas** also brought engineers and other experts to conduct product demos.

CES is having an undeniable influence on planning at the world's traditional auto shows, which have scrambled to add their own advanced electronics and connected-vehicle adjuncts, such as the Connected Car Expo at the L.A. Auto Show and the new Automobili-D component of the 2017 North American International Auto Show in Detroit.

Most major automakers participated in CES this year—**Audi** and **General Motors** are the notable absentees, observed industry analyst Gerald Conover. "The supply community really has center stage for the automotive portion of CES. Everyone who is anyone is taking part," he noted.

Conover, who publishes the insider weekly *Car Smart Industry News* focusing on intelligent vehicle systems, V2X and vehicle electrification, identified key emerging trends at CES: User Experience (UX) including the human-machine interface and vehicle cabin configurations and solid-state LiDAR, which he believes is a "key to acceptable design and packaging of autonomous-vehicle (AV) sensors."

Holographics and the practical use of **Microsoft**'s HoloLens, cockpit displays aimed at minimizing driver distraction, advances in virtual reality and Biometrics for both security and drowsy driver detection are other areas of attention at CES '17.

A growing number of analysts believe the industry's technology center-of-gravity has, for the most part, already shifted in favor of the global Tier 1s as vehicle electrification, autonomous driving and advanced chassis and safety technologies continue to make up a greater percentage of new-vehicle value. Their OEM customers, by comparison, are responsible for body structure engineering and development, conventional combustion-type propulsion systems, and systems integration.

"The convergence of consumer and automotive tech is a risk worth monitoring," Conover noted. "Some high-margin niches could become more crowded and therefore less lucrative."

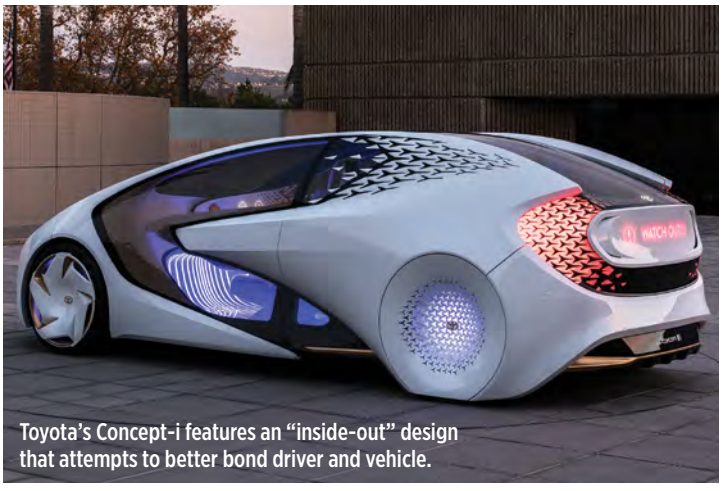
He said the major Tier 1s "seem less vulnerable to disruption than their clients," as most have intellectual property that will end up in electric vehicles, whoever makes them.

"The real winners from tech changes in the auto industry will most likely be the tech-savvy suppliers," Conover opined.

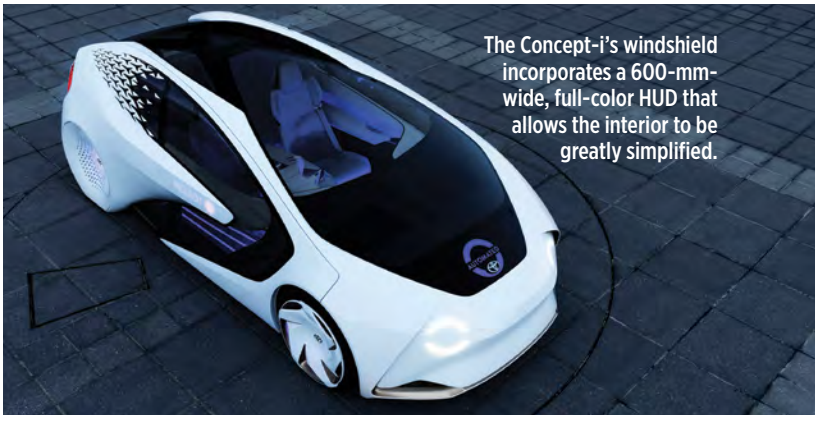
Car as close companion

Yui (pronounced 'you-ee'), is **Toyota**'s new vehicular personal assistant in the automaker's Concept-i

Connected-vehicle applications and implications were part of expert-panel discussions at CES2017. Shown is the "Beyond Smart Cities" panel at CES '16 (left photo, Bill Visnic).



Toyota's Concept-i features an "inside-out" design that attempts to better bond driver and vehicle.



The Concept-i's windshield incorporates a 600-mm-wide, full-color HUD that allows the interior to be greatly simplified.

vehicle unveiled at CES 2017. Yui is a dashboard-dwelling, AI-based drivers' aide with the aim of creating a closer relationship between you and your car. Yui, your devoted virtual-twin buddy and clever little helper, watches your every move like a devoted dog to better know you and predict your preferences. And maybe even extend you emotionally into the vehicle you control—even if you usually let Yui and Concept-i do the driving.

Yui is Toyota's first smart ambassador to a new kind of personalized, "relationship-based" driving environment that Toyota hopes can augment the user experience in its future cars. The Concept-I designers at **Calty Design Research** in California exploited everything from floor lighting cues to haptic feedback to exterior text displays and a giant windshield head-up display to help cultivate this link.

"We've designed a lot of concept cars," observed chief designer Ian Cartabiano, "but this is our first 'philosophical' design in a while." The Concept-i is designed, he continued, "from inside out to foster a warm and friendly user experience while presenting a futuristic vision of 2030. The idea is to explore how we might most harmoniously connect the driver and car to society, and create a bond strong enough to help reignite a love for cars in the future."

The vehicle's "inside-out" design attempts to wrap the occupants in an ubiquitous intuitive interface that helps make communications easy—because almost every surface can double as an information display.

Steadily learning your likes, dislikes, and interests as it monitors your actions and digital correspondence, Yui can offer informed suggestions regarding routes or destinations and strives to keep you safe and healthy. For example, like any loyal wingman, it might suggest that you relinquish the wheel to autodrive after it observes you exhibiting bio-signs of agitation, fatigue, or even over-consumption of alcohol.

Schaeffler surprises CES with 'bio-hybrid' minicar for urban use

By 2050, urban populations worldwide will have grown by 2.5 billion, according to the United Nations. But "infrastructure expansion is not keeping pace with population growth, resulting in enormous traffic problems," said Peter Gutzmer, Deputy CEO and CTO at the **Schaeffler Group**, at the 2017 CES.

"Intermodal traffic in areas where space is at a premium and the ability to change smoothly from one means of transport to another will be highly significant," he noted, adding that these areas "will require the smallest possible traffic footprint with the maximum mobility."

This disquieting prospect has Schaeffler engineers—best known for their clutch, stop-start, 48-V, roller bearing and other technologies—pondering new vehicle designs that could help meet the challenge, particularly for vehicles that occupy "the space between pedestrians and small cars," Gutzmer said.

The first result of the supplier's contemplation of the mega-city future: Bio-Hybrid, a compact urban-vehicle prototype that is intended to operate on bicycle paths and downsized roadways that are expected to proliferate in newly-built cities in China, Korea and Arabia—and in renovated existing cities in Europe and America.

The four-wheel, pedal-electric-powered mini-vehicle is intended to be

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Bio-Hybrid is the Schaeffler Group prototype pedal-electric minicar for crowded megacities.

a capable single-passenger runabout for congested urban areas. Bio-Hybrid, which has a retractable roof to provide some protection from the elements, occupies minimal space with a length just over 2 m (6.6 ft) and a width of 85 cm (33 in)—sufficiently narrow for use on most cycle paths.

The vehicle's electric drivetrain is adapted from an e-bike, Gutzmer explained, so the driver does not have to rely entirely on pedal power. The e-motor recaptures braking energy and stores the power in the battery, which provides a range of 50 to 100 km (31 to 62 mi). When the battery runs low, it can be removed and recharged from any socket, he noted. The prototype also features integrated mobile phone capability.

The car's lightweight metal spaceframe and plastic panel structure can take various forms, including a three-wheel variant that resembles an auto rickshaw. It also can also be retrofitted with a child seat or a compartment for carrying luggage or packages. Future versions also may incorporate an electric kickboard scooter that is designed for the so-called 'last mile' to make it easier for people to make use of public transport and vehicle sharing, Gutzmer noted.

The Bio-Hybrid is intended as a directional program and an inspiration for Schaeffler engineers when considering new forms of mobility," Gutzmer said. However, he expects to see its use in pilot projects within five years.

Faraday Future shows its first vehicle—the FF 91

After teasing the media and consumers with a racecar concept at the 2016 edition of CES in Las Vegas—and then with a series of detailed close-up images and disguised prototypes of its first production vehicle shown in company videos drag racing primary competitors—**Faraday Future** (FF) launched the real thing at CES 2017. At an exclusive off-site event, the company revealed its first production vehicle, the technology-laden, all-wheel-drive FF 91 electric vehicle.

Just as the launch sequence followed a unique formula, so does the FF 91 itself, mixing configuration elements of car, minivan, and crossover. The company claims it's the first vehicle to combine supercar performance, precise handling, the comfort of an ultra-luxury passenger vehicle, and a unique collection of intelligent internet features. It measures 206.7 in (5250 mm) long, 89.9 in (2283 mm) wide, and 62.9 in (1598 mm) tall, on a long 126-in (3200-mm) wheelbase.

To lend importance to the launch and allay some concerns on the

Faraday Future's first production vehicle, the FF 91, features a segment-bending combination of car, minivan, and crossover proportions with an electrified powertrain and a high level of technology content.

ongoing legitimacy and financial robustness of the company, FF trotted out its top executives for the launch, with Nick Sampson, Senior VP of R&D and Engineering, being the master of ceremonies for Hong Bae, Director of ADAS and Self Driving; Peter Savagian, VP of Propulsion Engineering; Richard Kim, VP of Design; and Jia Yeuting, Founder & CEO of China-based **LeEco**, the primary financial and technology backer of FF.

The FF 91 is built on the company's Variable Platform Architecture (VPA), a flexible powertrain and monocoque structure. The VPA shown had all-wheel drive, claimed class-leading battery technology, multiple motor and battery configurations and the company's first patent—for the FF Echelon Inverter. The FF 91's multimotor setup enables rear-wheel torque vectoring.

Peak motor power is 783 kW (1050 hp) and motor-shaft torque is more than 1800 N·m (1328 lb·ft), which help to deliver a claimed production-record-breaking 0-60 mph (0-97 km/h) acceleration time of 2.39 s. The company demonstrated the vehicle's acceleration during the launch event in Las Vegas against major competitors: the **Bentley** Bentayga W12, **Ferrari** 488 GTB, and **Tesla**'s Model X and Model S (both Teslas using the revered, performance-enhancing Ludicrous Mode).

The FF 91 configuration revealed at CES is fitted with a 130-kW·h battery pack for a 378 mi (U.S. EPA est.) and over 700 km (European NEDC est.) range. The car is designed for 200-kW DC fast charging, with wireless charging to come. Range at a constant 55 mph (89 km/h) is 482 mi (775 km).

Samson claimed the vehicle has the highest energy density battery in the world. Engineered in partnership with **LG Chem**, it is positioned, like most recent pure EVs now, in the bottom of the chassis for more cabin space and a low center of gravity. The company also claims that the FF 91 has the fastest charge speed currently available, with the ability to charge at more than 500 mi (805 km) per hour. The included home charger achieves 50% of full charge in under 4.5 h at 240 V.

Smart dimming technology is used in the roof, rear, and side windows enabled by PDLC (polymer dispersed liquid crystal) glass, which is activated by

The FF 91 is built on the company's Variable Platform Architecture (VPA), a flexible powertrain and monocoque structure with the batteries under floor. (Kevin Jost image)

Control concepts for Bosch HMIs include OLEDs, haptics and ultrasound.

tapping for instant privacy and shade.

Also on the electronics front, the FF 91 features a hood-mounted-and-lit retractable 3D LiDAR for autonomous driving. It is combined with an overall ADAS/automated driving sensor system including 10 high-definition cameras, 13 long- and short-range radars, and 12 ultrasonic sensors. Their data are crunched by industry-leading computing power. One automated feature enabled by the sensor suite is a Driverless Valet parking feature.

The company is accepting FF 91 reservations for $5000 at its new website at FF.com. The first 300 orders will have the

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opportunity to upgrade to an exclusive launch series, the Alliance Edition, in March 2017. No pricing was announced, but production is planned to start in 2018—despite the company halting construction of its $1B assembly plant north of Las Vegas and reports that FF is overextended financially.

As of last November **LeEco** had spent 10B yuan ($1.475B), according to a letter to employees from Yueting that was made public. The company has stated that the Nevada plant construction will resume "in early 2017."

Your car is gabbing with the refrigerator

Vehicles are becoming more closely linked to consumer electronics as infotainment systems offer more options and automated driving technologies bring the promise of more free time during travels. **Robert Bosch** is hoping to leverage its position in vehicle and home electronics as mobility merges and integrates with the Internet of Things.

At CES 2017**,** Bosch demonstrated a range of technologies for cars and motorcycles while addressing consumer demands for a single connected lifestyle.

"The vehicle will play a central role in cross-domain communication," said Werner Struth, member of the Bosch board of management. "Once highly automated driving becomes reality, the car will be a third living space next to the home and the office."

Vehicle human machine interfaces (HMIs) are a major element in this evolution. Bosch's latest ultrasonic system enables gesture recognition when a user's hand approaches the right spot to control functions. Developed in conjunction with startup **Ultrahaptics**, it augments NeoSense, a touch-input system with feedback that helps drivers keep their eyes on the road while they're manipulating controls. And 12.3-in. organic LED displays were also on display, giving developers a thin screen that saves space for electronic controls.

Smartphones are playing a greater role in automotive HMIs, serving as keys and actuators for other functions. Codes stored in the phone communicate with the vehicle, unlocking doors and adjusting seats, mirrors and radio settings before the driver climbs in.

Similar capabilities can be provided in cars with a Driver Monitor Camera that uses facial recognition to identify drivers and personalize settings. Driver monitoring is expected to become commonplace as autonomous driving advances.

Connected vehicles can also communicate with home automation systems, adjusting lighting temperature and other parameters when drivers leave or return home. Bosch was among many companies that demonstrated home networking technologies at CES. ■

New 10-speed auto delights in 2017 Ford F-150

Less than 200 feet after leaving my driveway, the F-150's transmission is already in 3rd gear. A half-block later it has upshifted into 5th. Merging into the main drag on light throttle, the transmission upshifts two gears at a time. The gear changes up and down are so seamless and hushed, I have to watch the indicator lights on the cluster to know what gear is engaged.

It took perhaps five minutes of driving this 2017 **Ford** pickup, a King Ranch-spec crew cab with the new 3.5-L twin-turbocharged V6 and equally new 10-speed automatic, to realize this is the future for full-size truck transmissions. More ratios are better, as long as they're calibrated as exquisitely as in this early production test truck. And 10 of them feel ideal in a 5000-lb (2268-kg) vehicle propelled by 375 **SAE**-rated horsepower (280 kW) and 470 lb·ft (637 N·m).

Co-developed by Ford and **GM** (download the July 2016 AE feature, http://magazine.sae.org/auto/), the 10R80 carries four planetary gearsets and six clutches in an overall package that's virtually the same size and mass as the 6-speed unit it replaces. Ten gear ratios appear to be an increasingly popular solution at other OEMS, too, as **Toyota** debuts its new **Aisin**-sourced AWR10L65 in the 2018 **Lexus** LC coupe and LS sedan and **Honda** springs its new 10-speed transaxle, developed in-house, for front-drive applications (see p. 10).

With a 7.4 ratio spread and three overdrive ratios in gears 8, 9 and 10, the Ford 10R80 I tested was typically in 7th or 8th gear when driving on 40 mph (64 km/h) suburban Detroit roads on light throttle. First gear is numerically lower than its 6-speed equivalent, and 10th is slightly higher than the 6-speed's 6th, with a super-close-ratio feel from the ratios in between. It's a set-up that provides more standing-start-acceleration punch and slightly reduced rpm in open-road cruising.

Tipping into the F-150's gas pedal for highway roll-on acceleration—65 mph (104 km/h) at 1,500 rpm—the gearbox zips imperceptibly from 10th gear to 7th. Later while northbound on Interstate 75, the truck's running at steady-state 80 mph (128 km/h) on light throttle in the indicated 10th gear, but a long hill looms ahead. Under load on three-quarter throttle, the 10R80 drops four ratios rapidly, then briefly drops two more—to 4th gear at 4000 rpm—before promptly upshifting four gears as the road flattens again. Slick and impressive!

The truck's stop-start function was smooth and unobtrusive in most circumstances. But few drivers will enjoy the loss of power steering boost when the engine shuts down—the wheel gets heavy immediately. Although the V6 starts instantaneously, the feeling of being stopped with a dead engine in the middle of a four-way intersection is unnerving.

A few WOT drag-style starts on my favorite backroad showcased the 10R80's ease in rocketing sequentially up through the 'box with almost CVT-like smoothness. In such situations the transmission doesn't skip-shift. In the 3.5-L F-150, fuel shuts off at 5750 rpm but the cals are designed to keep the V6 in its power sweet-spot under such conditions. The calibration team responsible for the F-150/10R package deserves a bonus for their thorough work—how about it, Raj (Nair, Ford's global product-development boss)? Just my opinion.

Addition of the 10-speed gave F-150 a 1-mpg bump in EPA fuel efficiency for the gas V6. Will pairing it with the 3.0-L diesel V6 next year push a 2WD F-150 over the elusive 30-mpg highway threshold?

Lindsay Brooke

Besides the F-Series application, the new 10R is also available in the 2018 Ford Mustang. (F-150 photo by Lindsay Brooke, 10R courtesy Ford).

Power and more underscore 2018 Toyota Camry

2018 Camry revealed by Toyota president Akio Toyoda at 2017 Detroit auto show.

The best-selling car in America for the past 15 years breaks its mold with a new platform and powertrains. Things have changed with **Toyota**'s 8th-generation flagship sedan and the legacy of being simply a "standard sedan" has been blown up.

"We don't want to just stay in that [standard sedan] position, so that was our driver to make an unprecedented change," Masato Katsumata, global chief engineer of the 2018 Camry, said in an interview with *Automotive Engineering* following the car's world debut at January's Detroit auto show.

Creating a car that would elicit fun and excitement for the driver was a key goal.

"This was not just another typical, conventional full model change," Katsumata said about the approach of the engineers who had a hand in developing a midsize car with more advanced technology—and unexpectedly performance—than the current Camry.

The Toyota New Global Architecture (TNGA) set the stage for a highly revamped Camry. With TNGA, said Toyota Motor Corp. President Akio Toyoda, "Our engineers were able to accommodate the new design's low center of gravity and the extreme sculpting of the sheetmetal."

Primary vehicle dimensions are a 111.2-in (2824-mm) wheelbase, 191.3-in (4859-mm) overall length, 56.7-in (1440-mm) overall height and 72.4-in (1839-mm) overall width. All but the height dimension have increased in comparison to the current Camry.

Camry will be offered with an all-new 2.5-L "Dynamic Force" 4-cylinder gasoline engine paired with an equally new Direct Shift 8-speed automatic transmission. This next-generation 4-cylinder spotlights higher torque, higher power and lower fuel consumption in the "total-use" range. And this high-output powerplant is reported to have 40% thermal efficiency, a claim Toyota also recently made about the 4-cylinder engine powering the Prius hybrid.

The 2018 car also will be available with a 3.5-L V6 with D-4S fuel injection, as well as a next-generation Toyota Hybrid System variant. Unlike the current Camry Hybrid's trunk-located battery pack, the 2018 model's power pack is under the rear seat. The hybrid system's CVT offers a new Sport Mode setting that enables the driver to feel smooth, quick simulated "gearshifts" via the simulated 6-speed sequential shift transmission.

The 2018 Camry is slated to reach dealerships in late summer 2017.

Kami Buchholz

I.D. Buzz: VW's latest future-look Microbus

It's a **VW** Microbus for future generations, an electric van capable of fully autonomous driving. But at this point, it's only a concept.

"We want to re-ignite America's love for Volkswagen. And we are fully committed to the future of mobility—smart, sustainable, affordable—that is the new Volkswagen," proclaimed Dr. Herbert Diess, Chairman of the Board of Management for the Volkswagen Brand.

Sharing the stage with the Volkswagen I.D. Buzz electric van concept during the automaker's 2017 Detroit auto show press conference, Diess said the Volkswagen brand's North America EV parade begins in 2020 with the launch of a completely new vehicle architecture. The 2025 goal is to sell one million EVs annually.

"The I.D. Buzz here on stage is one of the concepts we are examining," Diess said.

VW's new Modular Electric Drive Kit, VW's modular vehicle architecture for EVs known as MEB, underpins the I.D. Buzz. The 129.9-in (3299-mm) wheelbase electric van's all-wheel-drive system has a claimed total output of 369 hp. There is

The VW concept I.D. Buzz made its world debut at the 2017 Detroit auto show. (Kami Buchholz photo)

I.D. Buzz cabin can be reconfigured in several ways, while exterior dimensions are: 194.5-in length, 77.9-in width, and 77.3-in height.

an electric motor on each axle. The vehicle has a 111 kW·h battery, delivering an EV range estimated at up to 270 mi (600 km) on the U.S. driving cycle.

Befitting its intent as a fully autonomous driving vehicle, the I.D. Buzz has an unconventional cabin that includes a touch-sensitive steering wheel and an augmented-reality head-up display. The HUD enables navigation directions or other important information to be projected as a virtual image 23 to 49 ft (7 to 15 m) ahead of the vehicle. The concept van's front seats can be electrically unlatched and rotated 180° to face the rear seats.

Tomasz Bachorski, Technical Development, Head of Interior Design, said the I.D. Buzz's seats are more than a place to sit. The second-row seatbacks can be folded to form a table, while the third-row seats can become a bed. "It's really easy, really friendly, because life outside is complicated enough—so the interior here is easy-to-use," he said.

Kami Buchholz

2018 Ford F-150 diesel aims to beat 30 mpg

With two key 30-mpg enablers for the F-150 already in production—an aluminum body structure and 10-speed transmission—**Ford** Truck Engineering now brings the final piece of the technology puzzle: a 3.0-L turbodiesel.

Combined with standard stop-start, the first-ever diesel-powered F-150 will be shooting for an **EPA** fuel economy rating that exceeds 30 mpg—the Holy Grail for full-size trucks—when it enters production later this year as a 2018 model.

Ford announced the long-rumored diesel F-150 on Jan. 8, ahead of its 2017 Detroit auto show press conference. The news comes just weeks after CEO Mark Fields said the company also will build a hybrid-electric F-150 in the 2020 timeframe—not to mention revive the midsize Ranger pickup and Bronco SUV.

The 3.0-L PowerStroke V6, based on Ford's proven 'Lion' family developed in-house for group use when Ford owned **Jaguar Land Rover,** currently is offered in several JLR models. The 84 x 90-mm bore/stroke engine features a compacted-graphite iron (CGI) cylinder block and aluminum DOHC heads. It is expected to enable the Dearborn automaker to claim best-in-class fuel efficiency for its highest-volume and most profitable model. The diesel also will be a significant step toward getting the F-150 into federal CAFE compliance for MY2025, which mandates a minimum 30-mpg highway/23 city rating for vehicles with a minimum footprint of 75 ft² (7 m²).

Besides its new 3.0-L diesel option, the 2018 F-150 gets a new 3.3-L gasoline V6 and various exterior front-end changes to better differentiate models within the series.

Presently, **FCA**'s **Ram** 1500 with optional 3.0-L V6 turbodiesel and 8-speed **ZF** automatic is the class leader, rated at 27 mpg highway/20 city/23 mpg combined. No diesel or gasoline midsize pickup currently sold in North America achieves 30-mpg highway, either.

Ford's most fuel-efficient 2017-model F-Series is the standard-payload 2wd with 2.7-L twin-turbo EcoBoost gasoline V6 and 6-speed automatic, rated at 25 mpg highway/19 city. Trucks with the 3.5-L twin-turbo gasoline V6 and 10-speed 10R80 automatic co-developed with **GM** are rated at 25 mpg highway/18 city.

Complementing the diesel as the new standard engine in the 2018 F-150 lineup is a 3.3-L direct-injected, naturally-aspirated gasoline V6. Ford engineers expect it to achieve an **SAE** rating of 282 hp (210 kW) and 253 lb·ft (343 N·m), same as the incumbent 3.5-L V6. There's also a "second generation" 2.7-L EcoBoost V6 with reduced internal friction and improved robustness.

The 5.0-L V8 also benefits from "significant upgrades for power and torque" according to Ford. The V8 also will be paired with the new 10R80 transmission.

2018 F-150s receive new grilles, headlamps and bumpers aimed at differentiating the various models within the series, along with six all-new wheel designs from 17 in to 22 in.

Lindsay Brooke

PRODUCT BRIEFS

SPOTLIGHT: HYBRID/EV SYSTEMS & COMPONENTS

Electric drive module

GKN Driveline's (Auburn Hills, MI) complete electric-drive system for plug-in hybrid vehicles will help automakers more easily incorporate eDrive systems into their vehicle lines and eliminates the integration of individual components from multiple suppliers. Tighter integration of electric drivelines improves system efficiency and gives automakers more packaging and assembly options, GKN claims. The new module integrates a water-cooled electric motor and inverter with a single-speed eAxle reduction gearbox. Generating a maximum 65 kW of power, the system can deliver up to 2000 N·m (1475 lb·ft) of torque to the rear wheels. The complete eDrive module measures 300-mm (12-in) high and 325-mm (13-in) wide and with a mass of 54 kg (12 lb), making it around 20 mm (0.79 in) narrower and 2.5 kg (5.5 lb) lighter than comparable systems. According to GKN, production starts in 2019 on a global platform from a European vehicle manufacturer.

For more information, visit http://info.hotims.com/65848-400

1000-V SiC MOSFET

The 1000-V silicon carbide (SiC) MOSFET from **Wolfspeed** (Durham, NC), a **Cree** company, enables a reduction in overall system cost, while improving system efficiency and decreasing system size. The company claims the new MOSFET, specially optimized for EV fast-charging and industrial power supplies, enables a 30% reduction in component count while achieving more than 3x increase in power density and a 33% increase in output power. Designers can reduce component-count by moving from silicon-based, three-level topologies to simpler two-level topologies made possible by the 1000 V_{ds} rating of the SiC MOSFET. The increase in output power in a reduced footprint is realized by the ultra-low output capacitance—as low as 60 pF—which significantly lowers switching losses, according to Wolfspeed. The 65 mΩ MOSFET enables operations at higher switching frequencies, shrinking the size of the resonant tank elements and decreases overall losses, thus reducing heatsink requirements.

For more information, visit http://info.hotims.com/65848-401

Elastomers and thermoplastics portfolio

Qultimax proprietary elastomers and thermoplastics portfolio developed by **Minnesota Rubber and Plastics** (Minneapolis, MN) is suitable for application in custom-molded parts greater than 3 in (76 mm) in diameter that require durability, chemical resistance or low coefficient of friction properties while maintaining quality and high precision. Qultimax does not adversely impact any of the materials' bulk properties including compression set, which allows it to maintain its original form and sealing force, retaining integrity throughout a product's lifecycle. Qultimax also does not change the high-performance attributes of the product, including severe chemical exposure to acids, bases and solvents and thermal stability at temperatures as high as 500°F (262°C). Qultimax's low coefficient provides resistance to bonding and sticking to other materials.

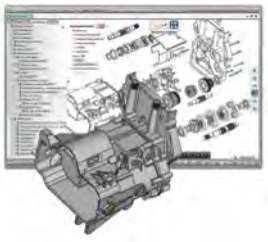
For more information, visit http://info.hotims.com/65848-405

Data acquisition and control system

DynPro2 from **Taylor Dynamometer** (Milwaukee, WI) is a data acquisition and control system that provides one common platform for engine, vehicle and industrial component testing. The system can automate the industrial controls for a room, test cell and even an entire test-cell facility, allowing the user to integrate room temperature, lights, safety interlocks and more into a user's overall testing process. According to the company, DynPro2 is simple to use, but flexible enough for the most rigorous applications. Frequently-run tests can be easily created and run repeatedly with the click of a button. The company claims operators are able to quickly create custom tests for those unique testing applications just by entering a few values. The system communicates with electronic engines through a multi-protocol interface device (MPID) using the supported protocols: J1708/J1587, J1939 and OBDII.

For more information, visit http://info.hotims.com/65848-408

CAD viewer module



CoreTechnologie (Moembris, Germany) offers a new module that enables easy creation of animated explosion views for assemblies of all major CAD formats for its conversion software and the CAD viewer 3D_Analyzer. Illustrated as explosion view, the model can be animated and visualized in 360-degree views like an interactive 3D video. This documentation software helps users make visible the structure, installation and disassembly of complex assemblies. According to the company, the user can view, zoom and move the animated 3D model from any point of view. The 3D animations are saved in a Core Technologie-native format. The video can be moved forward and backward, stopped and repeated at any position.

For more information, visit http://info.hotims.com/65848-402

Flat aluminum electrolytic capacitors

The new MLSG series of **Cornell Dubilier Electronics**' (New Bedford, MA) flatpack ruggedized flat aluminum electrolytic capacitors targets compact power supply applications in military and aerospace, as well as other critical systems. According to the company, design enhancements and a new electrolyte push the MLSG to nearly double the operating life of its predecessor and at no added cost. Two principal package profiles are offered: the MLSG Flatpack, which measures 0.5-in (12.7-mm) thick and 1.75-in (44.45-mm) wide, and the MLSG slimpack, which measures 0.5-in (12.7-mm) thick by 1.00-in (25.4-mm) wide. Both are offered in length increments of 1.5, 2.0, 2.5 or 3.0 in (38.1, 50.8, 63.5 or 76.2 mm).

For more information, visit http://info.hotims.com/65848-403

Hardware-in-the-loop simulator

With the new SCALEXIO LabBox, **dSPACE** (Wixom, MI) offers a compact high-performance system for hardware-in-the-loop tests. The LabBox fits on every desk and can be used for early function tests right at the developers' workplace, according to dSPACE. Consisting of LabBox and the SCALEXIO processing unit, the system can be adjusted to meet different project requirements. It provides slots for up to 18 I/O boards, which can be replaced at the front side of the box. If users need more I/O or computing power, they can extend the system themselves by adding more LabBoxes or processing units. The LabBox is connected to the processing unit via dSPACE's IOCNET network technology.

For more information, visit http://info.hotims.com/65848-404

UPCOMING WEBINAR

POLARIMETRIC RADAR FOR AUTONOMOUS DRIVE

Tuesday, March 7, 2017 at 9:00 a.m. U.S. EST

The automotive industry is moving from driver assistance applications to safety-critical perception systems that independently make decisions. This 30-minute Webinar examines a new polarimetric radar sensor for autonomous and highly automated drive applications. Experts discuss how this technology will dramatically improve the performance and reliability of automotive sensor suites in all environmental conditions.

Speakers:

Peter Schmitz
President,
Astyx, Inc.

Stefan Trummer
RF Engineer,
Astyx GmbH Communication and Sensors

For additional details and to register visit:
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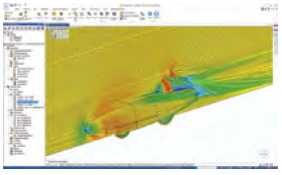

Mentor Graphics Corp. (Wilsonville, OR) offers the only fully embedded computational fluid dynamics (CFD) solution for Solid Edge software, a mainstream computer-aided design (CAD) solution developed by **Siemens**' product lifecycle management software business, according to the company. Solid Edge customers can now use Mentor Graphics' FloEFD front-loading CFD product to simulate fluid flow in their design process. Engineers can operate within their preferred and familiar mechanical CAD (MCAD) interface, thus reducing design cycle times by order of magnitude compared to traditional methods and tools, while increasing design quality. Key features include robust 3D fluid flow and heat transfer analysis software capable of solving complex real-life engineering problems.

For more information, visit http://info.hotims.com/65848-406

Through-shaft sensor

Piher Sensors & Controls' (Brighton, MI) hollow-shaft PST-360 contactless Hall-effect magnetic sensor was designed as a reliable solution for maintaining accurate pedal position (brake, accelerator or throttle) in x-by-wire applications, which is particularly important for on-road/car racing and off-road vehicles that demand accuracy even in the face of extremely harsh conditions. The sensor's through-shaft technology is achieved by means of the mechanical design that allows it to wrap anywhere around the shaft, enabling sensing directly at the source. The company claims this allows engineers to integrate a fully featured rotary sensor directly on existing shafts without the packaging issues (such as gears) that typically accompany encoders or other through-shaft sensing devices.

For more information, visit http://info.hotims.com/65848-407

150-V power MOSFETs

Targeting high efficiency designs and applications, **Infineon Technologies**' (Munich, Germany) OptiMOS 5 150-V portfolio product family further expands the OptiMOS 5 generation of power MOSFETs. The new product family is especially optimized for high performance applications that require low charges, high power density and yet high ruggedness, in applications such as forklifts as well as telecom and solar. It is an important contributor to Infineon's system solutions for low voltage drives, synchronous rectification in telecom rectifiers and brick converters as well as solar power optimizers. Infineon claims it offers a breakthrough reduction in on-state resistance R DS(on) of 25% in a SuperSO8 package and the FOM g is improved by up to 29% over the previous generation.

For more information, visit http://info.hotims.com/65848-409

High-pressure spiral hose

The EC600 X-FLEX high-pressure spiral hose from **Eaton** (Eden Prairie, MN) is designed for demanding applications that require very high-pressure performance in small areas. At 50% of the **SAE** 100R15 bend radius, the hose's flexibility makes installation in tight spaces much easier while reducing the total amount of hose needed on each machine. Eaton claims the hose features a highly abrasion-resistant cover material, supporting a longer hose assembly life while helping increase uptime and reducing overall operating costs. The hose offers both four and six spiral wire construction that is operable at temperatures from -40 to +121°C (-40 to +250°F).

For more information, visit http://info.hotims.com/65848-410

VIDEO

SEOE: New standards for self-driving cars

It's clear the global auto industry has entered a revolutionary era that is changing how we transport ourselves and our goods. In this episode of SAE Eye on Engineering, Editor-In-Chief Lindsay Brooke looks at the need for standards to develop, test, and validate self-driving vehicles. It can be viewed at **video.sae.org/12243**. SAE Eye on Engineering also airs in audio-only form Monday mornings on WJR 760 AM Detroit's Paul W. Smith Show. Access archived episodes of SAE Eye on Engineering at **http://video.sae.org**.

WHAT'S NEW

Detroit auto show: The 2018 Lexus LS gets twin-turbo V6, 10-speed—and yes, Shiatsu!

The flagship sedan that inaugurated the **Lexus** brand in 1990 ups the power and luxury quotient for its fifth-generation iteration with an all-new turbocharged V6, a 10-speed automatic transmission, and available Shiatsu massage for front and rear seats.

Power output for the 2018 Lexus LS climbs to a claimed 415 hp (305 kW) and 442 lb·ft (599 N·m) with a Lexus-first application of a twin-turbo 3.5-L V6 that handily outpaces the current LS model's 386 hp (288 kW) and 367 lb·ft (496 N·m) 4.6-L V8. A 10-speed **Aisin** AWR10L65 planetary-type automatic transmission, which debuted with Lexus' LC 500 coupe, replaces an Aisin 8-speed sequential-shift automatic.

"By utilizing the V6 twin-turbo engine mated with a 10-speed automatic transmission, we are able to achieve fuel efficiency that is beyond our competitors," Toshio Asahi, chief engineer of the new LS, told *Automotive Engineering* through an interpreter immediately following the car's world debut at the 2017 Detroit auto show.

Read the full story at **articles.sae.org/15198/**.

WHAT'S NEW

Ford prepares Transit PHEV fleet for London trials

Ford will launch a test program of its new Transit Custom plug-in hybrid (PHEV) vans in London aimed at helping to improve the city's air quality. The multi-million pound project will launch this fall. It comes as the automaker accelerates its electrification plans with 13 new global electrified vehicles scheduled for introduction in the next five years (see **articles.sae.org/15180/**).

Featuring a 12-month trial of 20 new PHEV Transit Custom vans, the **Transport for London**-supported project is said to reduce local emissions using vans that run solely on electric power for the majority of city trips such as deliveries or maintenance work.

According to the announcement, commercial vehicles in London make 280,000 journeys on a typical weekday, traveling a total distance of 8 million mi (13 million km). Vans are said to represent 75% of peak freight traffic, with more than 7000 vehicles per hour driving at peak times in Central London alone.

Read the full story at **articles.sae.org/15219/**.

READER FEEDBACK

Are new technologies too complex?

Concentrate on simple design, redundancy

I read with interest Michael Robinet's article about newer vehicle technologies [Supplier Eye, January]. I must comment that the newer technologies in the latest vehicles are causing catastrophic reliability problems. i.e. frequent circuit failures due to solder "bloom and fingers," increasing complexity leading to diagnostic failures and automation of systems that have no mechanical redundancy. This is a critical issue that is undermining safety. We MUST revert to more simplistic designs that have far fewer electronic components, or risk a world of vehicles sitting "failed" in junkyards and dealerships.

It goes without saying that as complexity increases, so do failure rates, due to the physical laws of nature that state that the more parts and complexity of the design, the higher failure rate. This is verified by the fact that vehicles manufactured from 1940-1970 have the lowest failure rate overall, easiest to repair, lowest cost of ownership. Of course, we don't want to give up on redesign, but we must concentrate on more reliability and LESS complicated designs using improved quality control and advanced materials. I have been working in the automotive and electronic industry since 1965 and I have seen many designs that should have been trashed. But instead they have found their way into modern products. This is the root cause of our failure to recognize "reliability issues" and consumer cost-effective values.

Mike Jobe
Jobe Electronix, Marion, IL

New EEAs need processing power

Excellent article on the new vehicle electrical architectures [cover story, January]. As it has been in the aerospace industry where I work, the need for more processing power continues to grow and the chipmakers are gaining dominance within systems engineering circles. And just like in aerospace, a handful of top tier suppliers appear to be driving the latest technology. The auto companies may end up assemblers in the not-too-distant future.

Ray Knight
San Diego, CA

The U.S. needs a single standard

To the SAE magazine: The next few months could get contentious as the new administration begins to tackle the complex regulatory web that government has spun around the auto industry. But it will be interesting to watch!

President Trump has pledged to roll back environmental rules, while the industry's lobbyists have asked for a review of the existing fuel economy standards out to 2025. Meanwhile, regulators at the California Air Resources Board and their Northeastern states allies are pushing higher quotas for "zero emission" vehicles. This is happening while market share of battery EVs continued its fall to 0.37% in 2016.

The best thing engineers could (and should) get out of all this from the new administration is a single, national set of rules for all mobile GHG emissions. Bring the EPA and NHTSA and CARB into the same room and lock the door. No one leaves until a single set of rules is established. A single set of rules will save the industry time and millions of dollars each year.

I enjoy the SAE magazines, thank you.

GHR
Saline, MI

I agree with you 100% about the need for a single set of national rules aross the mobile-emissions regulatory landscape. All good observations, thanks for writing.
– Lindsay Brooke

Hacking "the cloud"

Does anyone wonder, as I do, what will happen if "the cloud" (aka server farms) gets hacked? What will be the result when vehicles depend more and more on cloud-based data that must have zero latency between source and receiver, in order to ensure the nanosecond response times required of autonomous systems? I see this as one of the greatest challenges facing our industry.

Phantom84
via email

Designs beyond convention

Interesting article on the TankTwo battery technology [January]. It's definitely a disruptive approach in an industry segment (lithium batteries) that seems to have stabilized. There always "out of the box" thinkers out there, as AABC's Anderman commented. But this one is too far out of convention compared with the current architectures that are proving reliable. We have to lower cost significantly before such "out of the box" new designs have any chance to come forward.

Eddykurrent
via email

READERS: Let us know what you think about *Automotive Engineering* magazine. Email the Editor at Lindsay.Brooke@sae.org. We appreciate your comments and reserve the right to edit for brevity.

COMPANIES MENTIONED

UPCOMING FROM THE EDITORS

February 9:
Automotive Engineering
(Connected Car special edition)
Technology eNewsletter

February 15:
Truck & Off-Highway Engineering
Technology eNewsletter

February 16:
Aerospace Engineering
Technology eNewsletter

February 22:
Vehicle Engineering
Technology eNewsletter (all markets)

February 27:
Automotive Engineering
Technology eNewsletter

March:
Automotive Engineering
Print Magazine
- Vehicle electrification
- Additive manufacturing / 3D printing
- WCX17 Preview (SAE World Congress)
- Additive manufacturing / 3D printing product spotlight

March 1:
Aerospace Engineering
Technology eNewsletter

March 2:
Electronics & Connectivity
Technology eNewsletter

March 8:
Automotive Engineering
(Autonomous Vehicles special edition)
Technology eNewsletter

March 15:
Truck & Off-Highway Engineering
Technology eNewsletter

March 16:
Aerospace Engineering
Technology eNewsletter

March 20:
Vehicle Engineering
Technology eNewsletter (all markets)

March 24:
Heavy-Duty
Technology eNewsletter

AD INDEX

Q&A

IQM's Dan Lawrence sees considerable cross-industry interest in flexible hybrid electronics. (Lindsay Brooke photo)

Print your next wiring harness

Imagine your next-generation vehicle wiring harness printed in electrically-conductive ink on a thin, stretchable and flexible molded substrate with embedded sensors. Known as flexible hybrid electronics (FHE), this technology uses a combination of high-precision printing technology and advanced electronics. The result is lightweight, package-efficient and physically flexible circuitry, first used by **Ford** on a limited trial basis in the overhead console of the 2013 Fusion.

"FHE is basically printing the circuits on a large roll of film," explained Dan Lawrence, program manager at the **IQM Research Institute**, an advanced-technology incubator that is promoting FHE within multiple industry sectors. He noted that FHE can be "incorporated into any substrate—an injection-molded door inner panel or the physical structure of the vehicle." Headliners, the centerstack HMI, the roof panel incorporating photovoltaics and RFID antenna, to name a few applications.

Automotive Engineering spoke with Lawrence at IQM's Ann Arbor, MI, offices.

Was the impetus behind FHE vehicle electrification, connected-car and autonomy trends?
Yes, all of them. Because it allows you to do things that incumbent harness technology can't. And every kilogram you can shave off a car has tangible fuel economy benefits. The military land-vehicle systems folks at **U.S. Army TARDEC** and the commercial-appliances sectors are also interested. We're working with companies across the industry. It's up to them to take those learnings and apply them to their own projects for commercialization.

We're not looking at vehicle programs 15 years down the road—we're looking at the next 2 to 5 years. FHE is a platform that's basically ready now. We're also looking to add some laboratory and demonstration capability to this area as well, including prototyping and small-scale batches of actual products. We're (IQM) here to evangelize and collect the industry's wants and needs and show what's possible so that the designers, engineers, purchasing departments can say, 'Hey, this has value, let's bring this technology forward.'

The technology would be a disruptor to incumbent harness technologies supplied by the Yazakis and Delphis of the world, yes?
FHE can be a distruptive technology because the wire harness manufacturer, the headliner manufacturer and whomever else is in the supply chain up to the OEMs, in the sense that it has potential to add value. If you're only making headliners, FHE offers the chance to make them far more functional. We're not here to steal anyone's business; we're here to help them grow.

How does FHE incorporate electronics hardware such as circuit boards?
Circuit boards will remain with us for the forseeable future, but in terms of manufacturing they're rate-limited by pick-and-place machines. FHE is basically printing the circuits off a large roll of film. My background's in the printing industry—it's amazing how fast and in what large volumes the product comes off the press. Being physically flexible in and of itself is not really the selling point—it's where you can put that flexibility, including package and manufacturing flexibility. A key benefit is we can make hundreds of thousands and also do customized ones. We use high-speed production and a change of printing plates won't break the bank.

You can use an entire door panel as electronics, for example. You can't do that with a printed circuit board. Or for any user interface. On an appliance control panel, if you have a hard circuit board and have your switches populated and your lighting populated, it starts to get pretty expensive. We'll probably still need some microcontrollers depending on the design rules, but going forward we'll need less and less of them.

Does the ink contain a magnetic constituent?
You can have magnetized ink for a coil and dialectric ink for a capacitor and semi-conducting ink for a transistor. If you disassembled your laptop and looked at its board, a decent amount of the content can be replicated with the printing process.

For more information on FHE, contact Dan Lawrence: dan.lawrence@iqmri.org; 734-709-8550. Also see www.manufacturing.gov and download the January 2017 AE cover story (page 16-17): http://magazine.sae.org/17autp01/.

Lindsay Brooke

SAE INTERNATIONAL

TOGETHER WE MOVE MOBILITY FORWARD

Collaboration. Despite today's highly competitive world, it's still how problems are solved, challenges overcome, and advances are made.

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Yet, while today's mobility challenges are very different from those of yesterday's, automotive, aerospace, and commercial vehicle engineers continue to look to SAE International to connect with each other and the technical resources needed to advance themselves, their companies, and industry.

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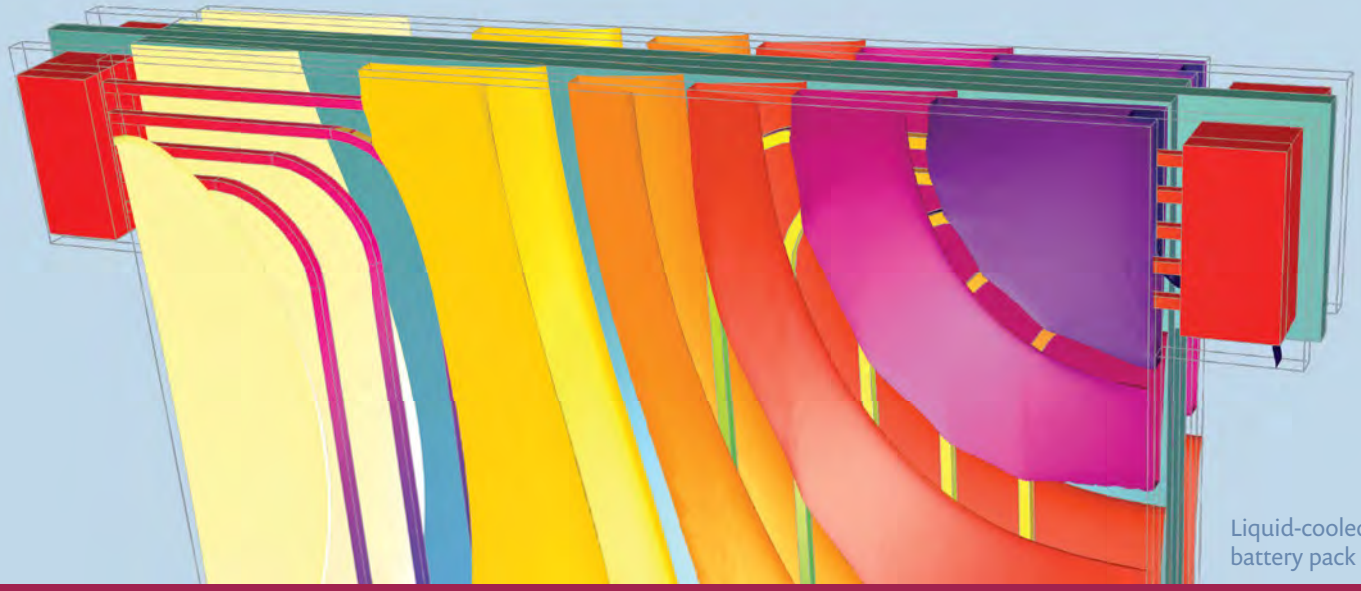

Liquid-cooled battery pack

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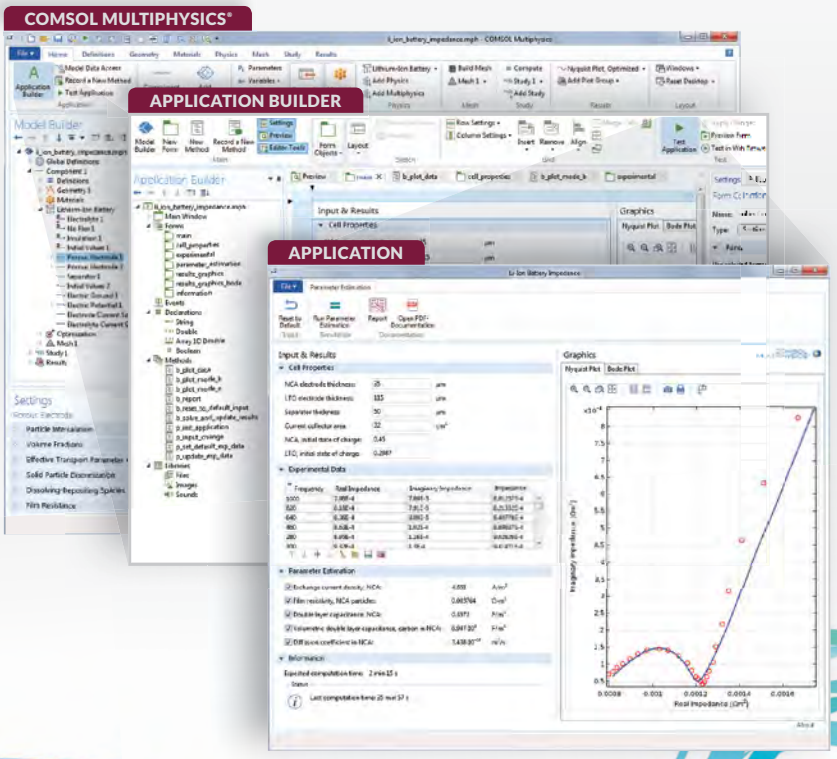

Li-ion battery

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