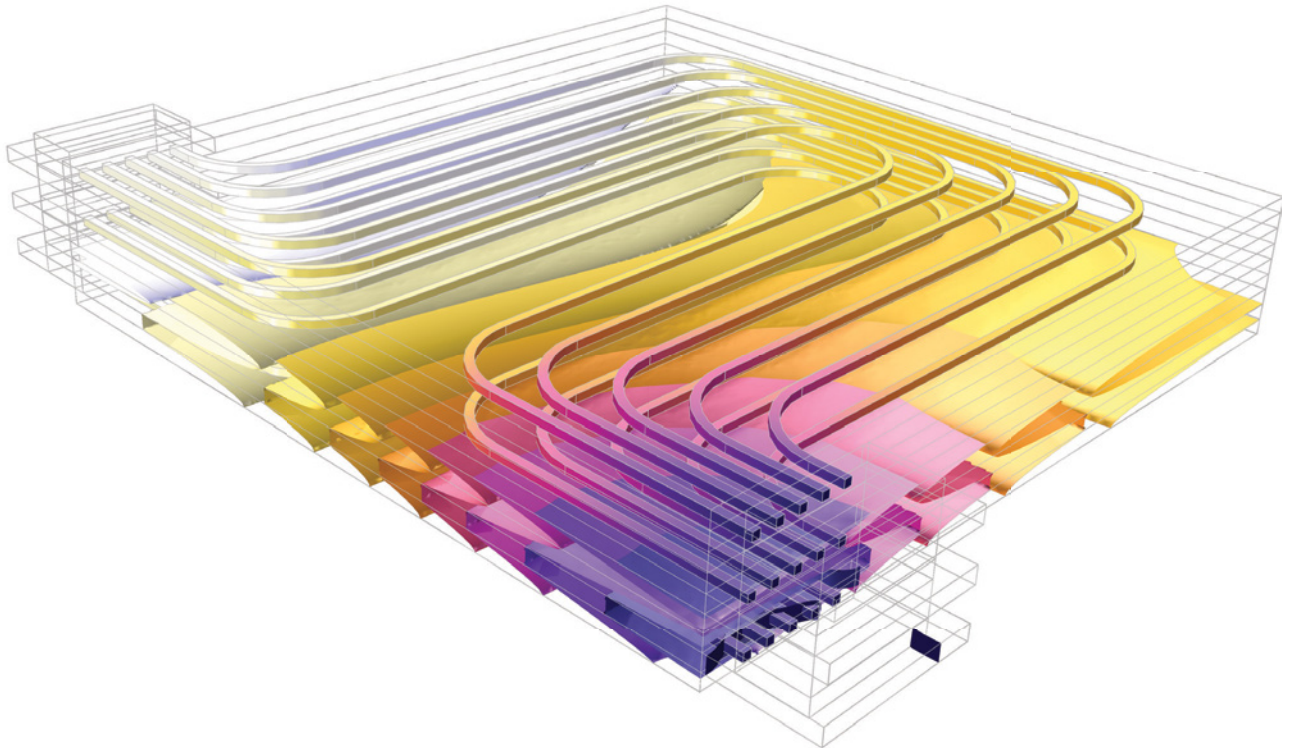


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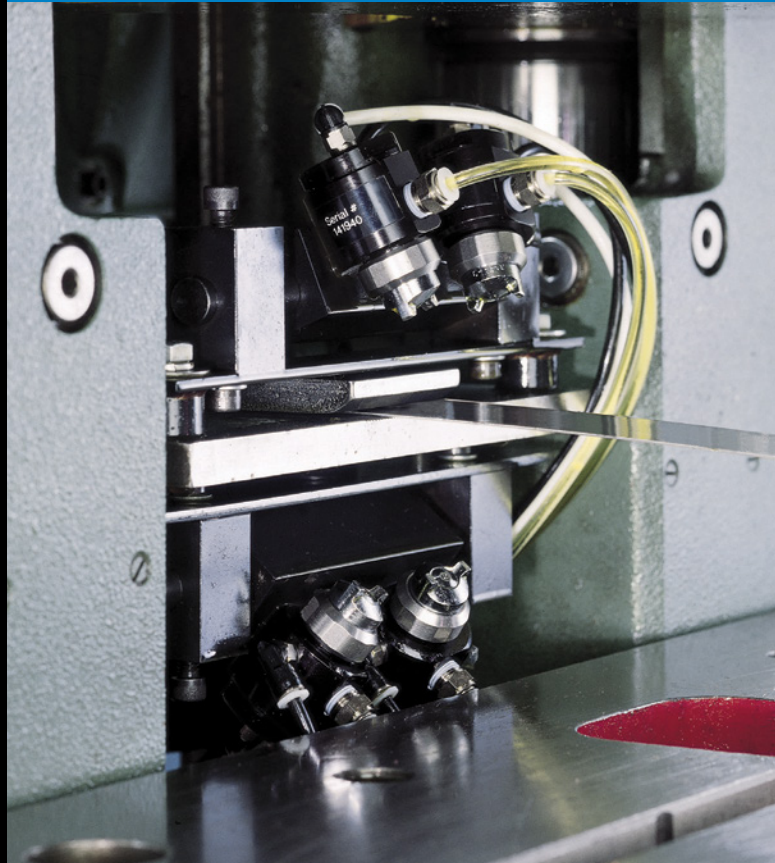
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## Rethinking the **HUD** Toward augmented reality for head-up displays



**CAE simulation progress**

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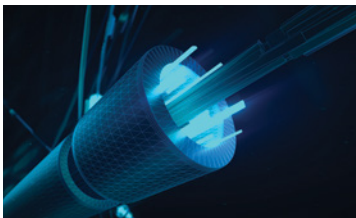
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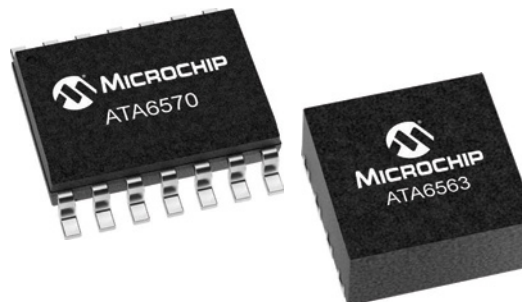
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*Automotive Engineering*, March 2019, Volume 6, Number 3. *Automotive Engineering* (ISSN 2331-7639) is published in January, February, March, April, May, June, September, October, and with combined issues July/August and November/December by Tech Briefs Media Group, an SAE International Company, 261 Fifth Avenue, Suite 1901, New York, NY 10016 and printed in Mechanicsburg, PA. Copyright © 2019 SAE International. 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](mailto:copyright@sae.org). To purchase reprints, contact [advertising@sae.org](mailto: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.saedigitalibrary.org](http://www.saedigitalibrary.org). (ISSN 2331-7639 print) (ISSN 2331-7647 digital)







# EDITORIAL

## Kill the EV tax credit by 2025

What role should government play in shifting consumer demand to cleaner forms of mobility?

For the past decade, federal tax credits of up to \$7,500 have helped woo a minuscule percentage of U.S. buyers into the plug-in electric-vehicle (EV) fold. The tax credits were key to the Obama administration's plan to have 1 million EVs on the road by 2015. That goal wasn't achieved until 2018, when U.S. market share of EVs reached a heady 2.1%—up from 0.62% in 2013.

That 239% growth rate over five years was driven mainly by Tesla's ascendancy in the segment. Sure, total EV sales remain paltry within a 17-million-vehicle U.S. market that's awash in cheap hydrocarbon fuel. But it is growth, nonetheless.

The tax credits also accelerated EV buyers' decisions to "go electric" by one year or more. They sparked more than 30% of early plug-in sales (including about half of Nissan Leaf EV sales), according to a 2016 study by the University of California-Davis. Meantime, 37 U.S. states and the District of Columbia dangled to the public their own tax breaks, utility-rate discounts, free parking, HOV lane privileges and other incentives.

These "buy a car, get a check" schemes are right out of the old Lee Iacocca playbook. Except the American taxpayer, not Chrysler Corp., is footing the bill. Opponents of the tax credits in the U.S. Congress, led by both senators from Wyoming (a state with more than two cattle per human) are again working to eliminate them. They say the credits subsidize wealthier households—currently the core of the EV

customer base. The opponents also argue that EVs are a double burden because they diminish gasoline-tax revenues typically used to fund road and infrastructure repair.

According to the Manhattan Institute, a free-market think tank, ending the federal EV purchase subsidy will save taxpayers about \$20 billion over the next decade. For Tesla and GM, the subsidies are already ending. Each has exceeded the 200,000-unit delivery cap, which by law triggers the credit phase-out. By 2020 their credits will be gone. Latecomers to

the EV market who haven't yet reached the cap will continue to reap the full credits.

When will the EV market finally take off? It hasn't yet happened in Europe, where a gallon of Super 95 costs about \$5.50. With petrol there priced so high, you'd wonder who would want to buy a new combustion-engine vehicle. Yet EV market share in Europe is, at about 2.35% in 2018, on par with cheap-gas America.

While the industry pours billions into EV development with little near-term payback, a potential solution is being debated in Congress: End the vehicles-delivered cap for EV tax credits and replace it with a time limit. An industry coalition supports this alternative; I'm propulsion-agnostic and I do, too. But for how long should the clock tick?

Let's give the credits five more years—stop subsidizing EV purchases by December 31, 2025. By then, a flood of new EV models will be on sale, with a greatly-expanded charging network. By then, the value proposition of EVs should be able to stand on its own.

**Lindsay Brooke**, Editor-in-Chief

**Within five years, the value proposition of electric vehicles should be able to stand on its own.**

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# The Inside Story on Glass Lamination Film Technology for Tomorrow's Vehicles

**S**WM International has more than 30 years of experience developing and manufacturing high-performance extruded polyurethane films for a variety of markets. The company's leading glass lamination films, sold under the name Argotec™ Interlayer Films, were created for demanding applications in aerospace, automotive and building/construction markets.

In an interview with SAE's *Automotive Engineering*, Tom Niziolek, Commercial Director, Optical, explains the new, unique characteristics and benefits of Argotec™ Interlayer Films in automotive glazing.

**AE: Glass lamination-film technology has been around since the 1930s as a safety enhancement for automotive windshields, but talk about some of the recent innovations and applications for SWM's thermo-plastic polyurethane (TPU) lamination film that go beyond windshield glazing.**

**Niziolek:** Glass lamination technology has expanded far beyond windshields. Automotive designers and manufacturers now are looking for solutions to reduce cost, mitigate outside noise and improve aesthetics in all car glazing. SWM's TPU films are preferred in automotive glazing laminate applications particularly for panoramic roof systems and side windows because they are high-strength, lightweight and extremely transparent.

When it comes to strength, TPU interlayer film has a long history of being used in bullet resistant "armored" windows for vehicles because it is an excellent bonding agent for dissimilar materials such as glass and plastic. It also absorbs and diffuses energy from an impact, making vehicle glazing safer.

**AE: What are some of the advantages of TPU for glass lamination film compared with "more-traditional" polyvinyl butyral (PVB)?**

**Niziolek:** A key advantage of TPU compared to traditional lamination films is TPU's ability to bond to both glass and plastic surfaces; TPU is well-suited for bonding of dissimilar glazing layers like glass to polycarbonate, or acrylic or polyester. Also, TPU is a very stable and durable film across a wide range of temperatures—in a laminate, it will last through many years of UV exposure without any color change.

**AE: What are the changing requirements and potential future applications that you see for advanced glass-lamination technology? What else can these materials do?**



SWM International's Tom Niziolek, Commercial Director, Optical.

**Niziolek:** Manufacturers are using advanced glass-lamination technology to improve passenger comfort while simultaneously ensuring their safety. We are seeing a growing demand for efficient light filtration: TPU technology filters the UV spectrum while allowing natural light to pass through, in turn providing glare and heat reduction to passengers. Reducing outside noise also is a concern and TPU has exceptional sound-deadening properties that assist with decreasing road noise.

**AE: "Panoramic" sunroofs have become a common feature in passenger vehicles. Is TPU a good solution for these very large glass applications?**

**Niziolek:** TPU is a very good material choice to build highly impact-resistant, transparent and lightweight glazing composites for panoramic sunroofs. With the growth of transparent materials for head-up displays (HUDs), TPU is an enabler for HUDs and other high-tech vehicle features.

**AE: What should designers and engineers know about TPU lamination film when considering their options for glass applications? Can SWM be a design resource for them?**

**Niziolek:** TPU film is not only for armored windows; it is a premier option for making lightweight, impact-resistant glazing materials—and often where a layer of glass is being replaced by a clear plastic.

There is growth in designing "operator"-controlled vehicle switchable shading—not just dark-tinted glass, where TPU is very compatible with the liquid-crystal technology being used for these applications. SWM is a resource and material consultant and partner to aid in forward-thinking designs for vehicles. When it comes to custom engineering, we work directly with glazing designers and manufacturers to understand their requirements and create custom solutions using our advanced film technology. ■

# WHO IS SWM?

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## SAE and Synopsys collaborate on cyber study

It's called *Securing the Modern Vehicle: A Study of Automotive Industry Cybersecurity Practices*—a must-read report released last month by **SAE International** and **Synopsys**, Inc. Based on an independent survey of global OEMs and suppliers conducted by the IT security research organization **Ponemon Institute**, the report highlights critical cybersecurity challenges and deficiencies affecting many organizations in the automotive industry.

According to the study, 84% of automotive professionals have concerns that their organizations' cybersecurity practices are not keeping pace with evolving technologies. And 30% of organizations do not have an established cybersecurity program or team, while 63% test less than half of the automotive technology they develop for security vulnerabilities.

SAE's Tim Weisenberger, Project Manager, Technical Programs Global Ground Vehicle Standards, believes industry really is aware of the cybersecurity threats it faces across the interconnected-vehicle ecosystem.

"I think they're pointed in the right direction by developing cybersecurity processes that are risk-based and process-driven that they implement into their product development lifecycle," he told *Automotive Engineering*. "Their resources may be applied a bit more thinly than they'd like, but they're very aware of their strengths and shortcomings."

SAE and Synopsys brought their strengths together to collaborate on the independent study—the first of its kind in this space, Weisenberger said. SAE gathered approximately 10 subject-matter experts from its cybersecurity technical standards discipline who work throughout industry to collaborate with Synopsys SMEs to develop the survey questions. The SAE experts represent OEMs,



**Jennifer Shuttleworth**  
Associate Editor  
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**We now have real empirical data to validate our hunches. From here, the next steps... are to look for solutions...**

suppliers, consultants and security professionals.

SAE and Synopsys commissioned the Ponemon Institute to develop and conduct the survey to examine current cybersecurity practices in the automotive industry and its capability to address software security risks inherent in connected, software-enabled vehicles. Ponemon surveyed 15,900 professionals from global automotive OEMs, suppliers and service providers, of which 593 replied—a healthy 3.7% return rate. To ensure knowledgeable responses, all respondents are involved in assessing or contributing to the security of automotive technologies, including infotainment systems, telematics, steering systems, cameras, SoC-based components, automated vehicles and RF technologies such as Wi-Fi and Bluetooth, among others.

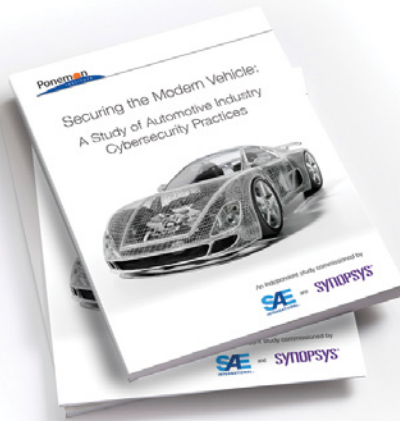
When the survey came back, the two organizations analyzed the raw answers. "Then we tried to dig in and ask 'what does this tell us?'" Weisenberger explained. In a blog post on the Synopsys website in early February, he and Chris Clark from Synopsys discussed the survey and its findings. Clark said one of the most important conclusions is that security is an evolving process.

"Organizations shouldn't look at the survey and be concerned or upset," he offered. "They should realize that people in the industry really are interested, want to make changes and look for the right partners to address those changes. They should look at this as a growth opportunity versus a threat to their industry."

Weisenberger noted that SAE, as, "the best convener of the industry in the mobility space" was eager to work with Synopsys to commission the survey. "We now have real empirical data to validate our hunches," he said. "From here, the next steps, once the industry absorbs this a bit, are to look for solutions we can drive throughout industry. We want to address the question: 'How do we make ourselves more secure, which equates to more safe?'"

The Synopsys/SAE team has a robust schedule of activities aimed at sharing results with industry. Synopsys and SAE hosted a webinar on February 27. Weisenberger, Clark and Larry Ponemon from Ponemon Institute discussed the survey methodology and finding. Future efforts include webinars hosted by SAE and by **Auto-ISAC** in March. The study's findings will also be presented April 2 at the **NHTSA-SAE Cyber Workshop** in Washington, D.C. held in conjunction with the SAE Government/Industry Meeting April 3-5. For information and registration, visit [www.sae.org/attend/government-industry/attend/special-events/cybersecurity-workshop](http://www.sae.org/attend/government-industry/attend/special-events/cybersecurity-workshop).

Download a free copy of the 29-page report at [www.synopsys.com/auto-security](http://www.synopsys.com/auto-security). ■



Released last month, SAE and Synopsys partnered on an independent cybersecurity survey of the global automotive industry conducted by Ponemon Institute.

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## New Co. vs. Old Co.

**W**e can debate how quickly the electrified, connected and autonomous future will arrive. But there is no questioning how profoundly its changes will impact the entire mobility ecosystem—OEMs, suppliers, dealers, finance, energy and road infrastructures, and customers.

Few chapters of past automotive history—including the growing regulatory landscape, the rise of the postwar Japanese industry and its manufacturing investment in North America, the 2009 **GM** and **Chrysler** bankruptcies, and the emergence of **Tesla**—can compare with the disruption that's beginning to unfold. OEMs must establish new business models to fund, nurture, and profit from the technological and ideological changes. Suppliers up and down the tiers must decide how, where, when—and whether or not—they aim to participate.

Industry observers find the current period almost irrational. Billions in capital are being devoted to autonomous driving technology companies, artificial intelligence, advanced connectivity and shared-mobility concepts, with essentially no return on investment in the near term. Ditto the enormous outlays for vehicle electrification and charging. Fortunately, some of the giant Tier 1s can fund their future-tech development through their traditional enterprise: making and selling tires, gearboxes and axles, engine hardware and other essential “old tech” products. For the Detroit 3, continued strong sales of pickups and other light trucks are bankrolling the shift.

It's a manifestation of what I call ‘New Co. vs. Old Co.’

Virtually every OEM has established new entities from acquired start-up companies, or from new strategic partnerships with suppliers and other OEMs. GM has **Cruise**. Ford has **Argo AI**. Hundreds of other relationships form a complex and dynamic web. The automakers' focus is to obtain key IP and new capabilities, while continuing to “own” the driving experience and control what the future value differentiators will be.



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**Suppliers of legacy systems will command a smaller proportion of the vehicle's overall value.**

In doing so, they are adamant not to allow competitors to gain a technological advantage.

Less than two decades ago, such added capability would be built organically from within—start a new division, pulling resources from existing operations. But the scale and sheer technological depth and breadth of the electrified/connected/autonomous challenge demands a new model. Going forward, it's all about shared risk and speed to market.

The capital structure of these new entities is deeply rooted in electronics and software know-how rather than, for example, a 3,000-ton stamping press. The ability to obtain the right talent (which is being hired outside our industry), to move fast, and to deftly apply capital are key here. And it's not necessarily about operational efficiency out of the gate.

There are other factors in the Old Co. vs. New Co. reboot. Work environments and cultures are significantly different in southeastern Michigan, Silicon Valley, Stuttgart and Shanghai. So are product cycles which are faster everywhere. And the arm's-length separation of these entities allows for partnerships with their peers (GM and **Honda** with **Cruise**) and the ability to eventually spin these as part of a future IPO.

All of this should be important to the average component supplier. First, OEMs now have a new destination for their capital, time and resources. While traditional systems have evolved, an increasing percentage of the value will emanate from new areas. Second, OEMs increasingly will be under pressure from consumers and regulatory agencies to incorporate costly autonomous capabilities and hybrid propulsion.

As this occurs, suppliers of legacy systems will command a smaller proportion of the vehicle's overall value. Without careful strategic planning, leverage and the ability to attain above-industry returns will decline.

For suppliers, the next few years will be all about navigating a mobility ecosystem that is becoming more complicated and complex—for Old Co., New Co., and their alliances. ■

## 2019 Subaru Ascent Premium

When the Tribeca, **Subaru's** first shot (2009) at a three-row SUV, didn't quite deliver the goods in this brutally competitive segment and went away in 2014, Fuji Heavy planners went right to work on the replacement—the all-new Ascent. It's more aesthetically pleasing, boasts a lighter and stiffer global architecture (long-wheelbase version of the latest Impreza sedan) and is better-designed and -equipped inside.



The Ascent Premium is the first price-walk up from the base car. The one I tested stickered at \$39,430, outfitted with a moonroof and comprehensive 'Starlink' navi-tainment suite worth \$4,200. Standard Ascent propulsion comes from Subaru's 2.4-L flat-four gasoline engine, turbocharged to deliver 260 hp (194 kW). It's coupled with Fuji's own TR690 CVT and torque-vectoring AWD, all capable of pulling a 5,000-lb (2268-kg) trailer. While I did not tow during my time with the Ascent, under normal loads and hard acceleration the 'boxer' engine and CVT can be comparatively noisy and transmit excessive harshness through the pedals and wheel.

The Ascent's cabin proved roomy and practical. Second-row seats are reconfigurable, but the third-row bench is useless for carrying adults. And greater NVH attenuation is needed—attenuation of wind noise at highway velocities is, to my ears, sub-par.

Loyal owners of smaller Subaru SUVs will telepathically step up to Ascent, I reckon. Those cross-shopping other brands may be a harder sell.

Lindsay Brooke

## 2018 Jeep Wrangler Unlimited Rubicon

A testimony to how good the new-generation JL-series **Jeep** Wrangler is on the tarmac: it was quite civil in an 800-mile, nearly all-highway week of travel to the Detroit auto show in January.



Doesn't mean I'll ever view the Wrangler—regardless of the new JL's comparative refinement—as a reasonable thing for driving on pavement virtually all the time. You know, the way almost all Wranglers are used.

For around-town driving and errand-running, the 4-door Wrangler Unlimited, even in rough-and-ready Rubicon trim, is hardly an ox cart, but once you get past the image thing, driving to and fro on solid and front and rear axles and nearly 11 in. (279 mm) of ground clearance doesn't seem the most rational of commuter-vehicle choices. And although the JL's wheelbase is stretched by 2.4 in. (61 mm) to a reasonable 118.4 in. (3007 mm)—the same as a **Honda** CR-V—the high center of gravity and hefty curb weight of the Wrangler Unlimited make abrupt steering and cornering feel dicey.

The Wrangler Unlimited we drove was fitted with the 3.6-L V6 and its 285 hp and 260 lb-ft (365 N-m) didn't have too much trouble achieving and maintaining parity with other traffic, but the Wrangler's still-bruising aerodynamic profile makes maintaining a 75-mph Interstate cruise a bit of a chore. At cruising speeds, the Wrangler didn't have a prayer of achieving its 23-mpg highway rating; on flat highway, the Jeep rarely produced mid-teens efficiency readouts. The new 8-speed automatic transmission keeps the powertrain howl calmer than in any prior Wrangler, but at a scandalous \$2,000 option price.

Bill Visnic

## 2019 Genesis G70 RWD

The G70 is the fledgling **Genesis** brand's entry into the age-old "BMW 3-Series-fighter" category.

Over decades, others invariably have fallen short. Genesis pulled it off.

Athletic, almost edgy rear-drive chassis with near-zero extraneous body motion? Check. Chesty six-cylinder power and torque? Yep. Steering that gives a little back for what you put in? As good as just about anything you can buy for reasonable money.



The rear-drive G70's chassis is astoundingly balanced and even biased towards naughtiness. The 365 horses channeling from the big—though somehow slightly hoary-feeling—3.3-L turbo-charged V6 provokes the rear axle in a most satisfying fashion.

Switch up the drive mode to "sport" and the stability control takes a healthy coffee break before intervening in the torque flow, permitting rather wanton wheelspin and surprising amounts of yaw (neighbors: "Did he just slide that car around the cul-de-sac?") before the electronics almost grudgingly arbitrate. It's a totally unexpected departure from the normally soft and staid Korean approach to chassis tune.

Some may grouse the G70's sheet-metal is unspectacular and I'll admit that the course grain of some of the minor cabin trim pieces caught my generally ambivalent attention for such things, but otherwise, the G70 is the goods in just about every metric.

If there's any justice in the world, its wholly impressive driving dynamics and impressive 5-year warranty and three years of free maintenance really should cement the G70 as a brand-switching temptation for those shopping the tried-and-true choices in the segment.

Bill Visnic



## PRODUCT DEVELOPMENT

### Supra's revival is Toyota's spin on German engineering



The all-new 2020 Supra is based on BMW's new-generation Z4—whether enthusiasts like it or not.

In today's world of rationalized product lines with optimized bills-of-material sharing for maximum scale, the corporate case for low-volume sports cars is tricky. A desire to return its Supra (last produced in 2002) to production led **Toyota** to partner with **BMW**, sharing the CLAR architecture, underpinnings and drivetrain from that company's latest (G29) Z4 roadster and contracting assembly to **Magna Sty**'s Graz, Austria plant.

It makes for a strong example of the benefits of global markets, as this arrangement lets Toyota return a flagship sports car to showrooms. It even features an inline 6-cylinder engine, which was a hallmark of earlier Supras. But all this sharing of parts leaves fans wondering whether the 2020 Supra is a real Toyota, or just a BMW in disguise.

In this case, the engine is an undersquare BMW 3.0-L inline 6-cylinder, code-named B58M30 01, rather than the Toyota-designed 2JZ of the previous Supra. In Supra specification, the turbocharged I-6 is claimed to deliver 335 hp (249 kW) and 365 lb-ft (495 N-m), which compares to 382 hp and 369 lb-ft (285 kW and 500 N-m, respectively) in the Z4.

Toyota doesn't want to discuss whether there are any hardware differences between the engines, leaving the possibility that the Supra is a simple software upgrade away from BMW-level power. Both cars use a **ZF**-supplied 8-speed planetary automatic transmission driving the rear wheels.

Apart from a different state of engine tuning, differences seem to be mostly cosmetic. The styling clearly includes cues to historical Toyota sports models, but still manages to look like a

Z4 because of the underlying proportions. "It combines the heritage of the 2000 GT, the 86 and the Supra," insisted Tetsuda Tada, chief engineer. "We made sure there were remnants of that in the side view."

But other than visually, Toyota didn't seek to push the Supra away from the Z4. "It wasn't a specific intent to differentiate," explained Tada, who maintains Toyota doesn't know anything about the Z4. "Toyota had a vision of what a Supra should be and created it. Our car is a coupe and theirs is open, so the advantages of each are different."

Manual-shifting enthusiasts also might wish Toyota had opted to deviate from BMW in choosing to spec only the 8-speed automatic. "The automatic transmission is highly refined," said Tada. "It is geared so you can concentrate on driving." He doesn't rule out a manual transmission at some point, however. "If the market demands one, we'd consider it." And maybe there could be engine upgrades too. "BMW has variations of the engine, 500-horsepower ones," Tada noted. "The beauty of sports cars is always looking for improvement."

If Toyota had input in BMW's development of the chassis, it may have been the requirement to design the production car with racing modifications in mind from the outset. "It is the first volume Toyota built with the premise of being a race car," Tada said. "The hardest part of building a race car is being able to cool it. If you can't cool it, you can extract maximum performance. There is space for an enlarged radiator and passages for air flow."

**Dan Carney**

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## NVH ATTENUATION

### 2020 Explorer is the first product to emerge—more quietly—from Ford’s newest NVH lab

The 2020 Explorer is the first Ford product to be engineered via the automaker’s new driving dynamics laboratory, which provides multiple tools to create quieter vehicles, including a new semi-anechoic, rolling-platform test chamber. The Explorer also features a first-for-Ford “dual-walled” bulkhead; in essence this is a sealed composite engine shroud to further isolate the cabin from powertrain noise.

Parker Lewis, Ford’s noise, vibration and harshness engineering manager, said the new facility makes it easier to “confirm our analytical predictions with physical testing on a component system level, as well as at the full-vehicle level in the semi-anechoic room.” Lewis also noted that the new facility complements the host of front-end CAE, dovetailing virtualization software with actual production-ready components.

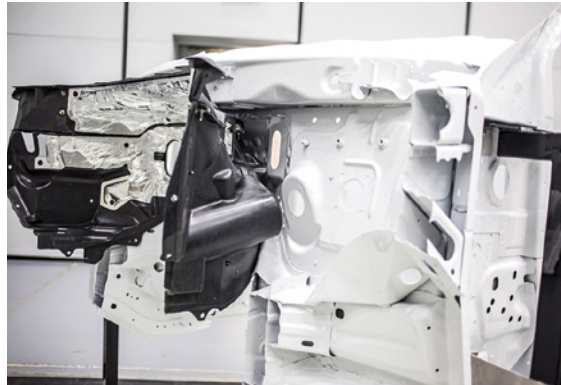
“This validation allows us to confirm that the customer isn’t going to experience issues in places that we might have disconnects in our CAE. Places we might have to optimize materials selection or space considerations, to make sure we have no hot spots that the customer would hear or feel.”

#### New NVH lab

The new driving dynamics lab in Dearborn, Michigan, is the latest Ford noise, vibration and harshness (NVH) testing facility. The lab allows engineers to test vehicle NVH in different settings, including a semi-anechoic chamber with 4-wheel rollers to simulate a variety of road surfaces, in temperatures from -40°F (-40°C) to 140°F (60°C). The controlled climate is crucial to the engineering validation process, as it permits engineers to thermally shrink and expand materials that could introduce squeaks or rattles.

“How all those pieces and elements coming together fit, and what they are made from are critical questions for us to ensure proper assembly to reduce gaps that can allow wind noise in in the

Ford’s new driving dynamics NVH lab includes a semi-anechoic chamber for full-vehicle validation testing.



Developed in Ford’s new driving dynamics NVH lab, the new engine shroud on the 2020 Explorer is formed from a composite sheet-molded compound.

first place,” Lewis said.

Individual vehicle parts can also be tested in the lab’s fully anechoic chamber and reverberation suite. The anechoic room provides an area free of echo and reverberation to create a pure working environment for sound measurements, while the second is used to determine how noise permeates full components or materials, such as sheet metal. A shared, configurable wall between these two spaces lets engineers test sound permeability of individual or layered components.

#### New “dual-wall” bulkhead design

Developed using the tools in the new lab, the 2020 Explorer features a new “dual-wall” bulkhead designed to significantly reduce powertrain NVH. This new engine shroud—formed with a composite sheet-molded compound (SMC)—creates an air gap between the

engine compartment and the steel front bulkhead by wrapping around the back of the engine and meeting the strut towers on each side of the engine bay.

The Explorer uses the new composite engine shroud in combination with a laminated windshield and front-window glass (plus active noise cancellation on hybrid models), to attenuate road and powertrain noise. Beyond general comfort and ease of conversing, quieter cabins are also expected to enable greater implementation of voice-activated features—such as Amazon’s Alexa—which engineers said will become more prevalent in upcoming platforms.

Introduced during the 2019 North American International Auto Show in Detroit, the all-new 2020 Explorer will be manufactured at Ford’s Chicago Assembly Plant. It is expected in dealerships this summer.

Paul Seredynski

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## ELECTRIFICATION

### Nissan concept sport sedan is all-electric, driver-optional



Nissan IMs concept is battery electric and automated-ready.



Although billed as a sport sedan, the IMs steering wheel retracts for SAE Level 5 autonomy if desired.

Nissan looks to pump up the fun factor with the IMs, an all-electric sports sedan concept with autonomous driving capability. The car made its global debut at the 2019 North American International Auto Show. “While still being a driver’s car, this concept lives within our very graspable future of creating/engineering a thrilling autonomous ride, bringing the car into the realm of ‘entertainment’, Giovanni Arroba, Nissan’s program design director, told *Automotive Engineering*.

IMs features dual electric motors in the front and the rear with an estimated 483 hp (360 kW) and 590 lb-ft (800 N-m) for all wheel drive capability. The 115 kWh battery pack, packaged under the floor, provides an estimated 380-mi (611.5-km) driving range. The sedan’s dedicated EV platform essentially mirrors that of Nissan’s IMx KURO electric crossover concept that debuted at the Tokyo Motor Show in 2017.

As a new member of Nissan’s advanced electric-vehicle concepts, the IMs is a showpiece of future possibilities. The IMs doesn’t have a traditional front grille, nor does it have B-pillars. IMs’ aerodynamic design cues include flush exterior lighting, streamlined side glass, unseen door handles, hidden

windshield wipers, an integrated rear spoiler, and wing cameras that become body-flush when the vehicle is in autonomous driving mode. Light blades, which run just below the hood on the front end, and along the upper portion of the rear end, glow blue when the vehicle is in autonomous mode.

The IMs has a 114-in (2900-mm) wheelbase, and rides on custom Michelin 255/40R22 performance tires fitted to 22-in x 10-in aluminum alloy wheels. The car’s air suspension adapts to the roadway and the driving mode.

Inside the cabin, the IMs provides functionality for either hands-on or autonomous driving. The driver-centric cockpit conveys vital vehicle information on a ‘floating’ clear screen with dual layers.

“This was really inspired by a jet fighter’s information displays, so you always have a commanding view of information and the road,” Arroba said.

The three-across rear seat converts to an oversized center seat when the outboard seat positions are folded. “This car captures the benefits of a crossover, but also retains the beauty of the sedan,” Arroba said.

**Kami Buchholz**

## ELECTRIFICATION

### MEET a new propulsion proposition for Mahle

A 2-seat electric car concept recently unveiled by a major automotive supplier—best known for pistons and other power-cylinder components—is capable of making inner-city jaunts for up to seven days on a single battery charge.

**Mahle** showed its MEET (Mahle Efficient Electric Transport) technology demonstrator during AutoMobili-D activities at the 2019 North American International Auto Show in Detroit.

“This concept is really a proof-point for Mahle’s commitment to meet the demands of future urban mobility,” said Dr. Jorg Stratmann, CEO of Germany-headquartered Mahle. The supplier’s wide portfolio includes powertrain and HVAC technologies for electrified and internal combustion engine (IC)-powered vehicles.

MEET’s propulsion power is derived from two Mahle Interior Permanent Magnet (IPM) synchronous motors. Although engineered for inner-city use, the IPM can achieve velocities up to 100 km/h (62 mph).

The car’s traction drive system comprises a 48-volt twin-power drive unit with torque vectoring capability. Because separate motors drive each rear wheel, a differential isn’t needed. Peak power output for each motor is 30 kW (40 hp) and 110 N-m (81 lb-ft). MEET’s central axle transmission has an 11:1 ratio.

When the 48-volt twin-power drive is paired with a 15.4 kWh lithium-ion battery pack, the concept demonstrator provides an estimated 120-mile (194-km) driving range. That translates to more than 13 miles (20 km) a day for a week of urban-only driving on a single charge, Mahle offered.

The city car is designed as an all-weather commuter. “As in all vehicles with a purely electric powertrain, one of the biggest challenges with respect to energy storage is heating the interior, particularly in the winter,” Dr. Stratmann said, noting the importance of thermal management.



Mahle's Dr. Jorg Stratmann is seated inside the supplier's MEET, an electric concept demonstrator.

vide surface heating and cooling in direct proximity of the occupants.

In comparison to a positive temperature coefficient heater, the thermoelectric heat pump can extend the car's driving range by 30% with an ambient temperature of 0 degrees C in Europe's recently-adopted Worldwide Harmonized Light-Vehicle Test Procedure (WLTP) and an estimated 50% based on Mahle's simulated and actual urban test drives.

The MEET and its modular drive unit, which also can be used as an e-axle for a 48-volt hybrid system, serves as a precursor to other Mahle demonstrator concepts. "There is more to come," Dr. Stratmann said.

**Kami Buchholz**

A thermoelectric coolant-to-coolant heat pump extracts waste heat from the electric motor, the power electronics and the battery for use by the vehicle's HVAC

system. Inside the car, thermoelectric heating and cooling elements—located within the instrument panel, door trim, and armrests—can be activated to pro-

JEFF KOWALSKY

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## PROPULSION

### Continental's new CTO to lead retooled R&D pillar

At a recent media roundtable with its executives, **Continental** introduced its new CTO, Dirk Abendroth, who took on that role on January 1, 2019. Abendroth, 43,

will serve as chief technology officer of Continental's upcoming Automotive Group and report to Continental CEO Elmar Degenhart. Abendroth joins the

global supplier from EV start-up **Byton**, where he led Powertrain and Autonomous Driving development since July 2016. The Hamburg native was previously at **BMW** in Munich in EV development, including work on the BMW i3 and i8.

Note the term "upcoming," as perhaps equally significant with its new CTO is a foundational change in Continental's corporate structure, along with a large shift in engineering expertise. The change in corporate structure is adapting to overall growth, and the company also plans to shift thousands of engineers to help it adapt to the rapidly evolving automotive landscape. Under its new Automotive Group, Continental will pool its R&D resources to instill faster creation of next-gen autonomous and connected mobility tech.

"The intention is to move responsibility for the business down in the organization. We are too centralized for the complexity and size of the company," said CEO Degenhart. "We will realign our R&D capacities on the automotive side. The target is to do this by the end of 2019. The focus will be on autonomous driving on one side, vehicle networking on the other."

### New structure and potential powertrain IPO

Abendroth's appointment to CTO caps a shift Continental has been discussing since late 2018, in what it describes as "one of the largest organizational changes in the technology company's history." The global supplier is realigning its business units under a new Continental Group umbrella, overseeing three sectors: Continental Rubber (tires); Continental Automotive (which encompasses the new R&D group) and Powertrain.

As of January 1, Continental had already completed the spinoff of its Powertrain division into an independent entity (with a new name forthcoming) and it's preparing for an IPO. "Our realignment is a response to the profound changes in the automotive industry and the associated challenges," said Degenhart. "After this initial key milestone

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Continental's new CTO said "the train has left the station" in terms of the transformation to electrified propulsion—and the company is restructuring accordingly.

in our realignment, we are now working at full steam to prepare for the partial IPO of our successful powertrain business, which could be possible from mid-2019."

"If you're looking at what will happen in the powertrain arena in the next fifteen years, then the train is out of the station in regards to transformation from combustion technology to electrification technology," Degenhart explained. "And the train is picking up speed. This is one of the major reasons why we decided that powertrain has to stand on its own feet, has to be run by its own management team who has the freedom to make decisions, and be fast and flexible."

## Automotive group combining functions

The new Automotive R&D group led by Abendroth will draw expertise and mission from both the Interior (which includes communication tech) and Chassis divisions. "What we are intending to do within the two divisions, interior and chassis, today are about 27,000 engineers. The target is to take about 12,000 of these engineers and centralize them under the responsibility of Dirk," Degenhart explained. "This will be an engineering powerhouse. If you are talking about complex developments for autonomous driving, for connectivity, this makes a lot of sense and will be to the benefit of our core customers especially."

## Software is now central

The autonomous future will be heavily code-driven, and Continental claims more than half of the investment in new advanced-driving functions is centered on programming. "The future of mobility requires more and more software," Degenhart said. "We're in the acquisition phase of projects where 100% of the development effort will be spent for software development. We have to re-use software to a much higher content in the future than in the past."

Paul Seredynski

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## New V8, big towing, trick features and tech for 2020 Chevy Silverado HD



Chief Engineer Jaclyn McQuaid details the chassis and technical features of the 2020 Chevrolet Silverado HD.

With pickup trucks seemingly taking over the personal-vehicle market, it's no surprise the Detroit Three automakers are devoting more attention than ever to the pickups-for-real-work side of the equation, too. In launching the 2020 **Chevrolet** Silverado HD line at a high-profile event at the trucks' newly-expanded assembly plant in Flint, Michigan, **General Motors** president Mark Reuss said, "At GM, we've been preparing for this changing market for years."

So have **Ford** and **FiatChrysler**, too, though, and with all three powering into 2019 with all-new (FCA's 2019 **Ram** HD) or significantly updated (Ford 2020 Super Duty) 2500/3500 heavy-duty pickups, expect competitive fireworks.

One particular challenge for the new Silverado: well before the Silverado's technical specifications were announced, FCA revealed the 2019 Ram's new, **Cummins**-made optional 6.7-L I-6 turbodiesel comes to market with a crushing 1000-lb-ft (1356-N·m) torque rating. Although it's churning out a hardly-inconsequential 910 lb-ft (1234 N·m) from its 6.6-L V8 turbodiesel, the Silverado immediately is saddled with

an on-paper disadvantage in this speculative segment.

### New small block-derived V8, more gears

To her credit, Silverado chief engineer Jaclyn McQuaid was ready with an answer for the inevitable torque-deficit question, saying, "We can put all 910 pound-feet through the wheels in first gear." Previous Duramax diesels' torque was electronically governed in lower gears and her statement may insinuate there could be low-gear torque-management involved with the new Ram HD (although to this editor's knowledge, that has yet to be independently verified).

The new Silverado HD's Duramax diesel develops an unchanged **SAE**-rated 445 hp but is backed by an industry-exclusive 10-speed automatic transmission supplied by Allison. "This is the transmission everybody wants," McQuaid boasted, and the upgrade of four additional speeds over the previous transmission and other upgrades to the Duramax are what enable, she added, a massive 50%-plus hike in maximum towing rating of 35,500 lb (16,103 kg)—

400 lb (181 kg) better than the new Ram's claimed maximum towing ability. At the time of this writing, Ford had yet to release performance ratings for its updated 2020 Super Duty pickups.

The new Silverado HD's gasoline engine choice is an all-new, 6.6-L V8 derived from its longstanding small-block engine architecture. Fitted with direct fuel injection, the V8 produces an SAE-rated 401 hp and 464 lb-ft (629 N·m), respective increases of 11% and 22% compared with the outgoing 6.0-L V8. The engine has an iron block and aluminum heads, as well as a forged-steel crankshaft. Compression ratio is 10.8:1.

Backing the new gasoline V8 is the GM-made 6L90 6-speed automatic transmission. Maximum tow rating for gasoline-engine models is 17,500 lb (7938 kg).

The driveline now features larger and stronger axles, McQuaid said, while 2500 variants get a larger, 11.5-in (292-mm) ring gear and 3500 models get a 12-in (304-mm) ring gear and all get 30% larger prop shafts. The decision when to use 4-wheel-drive really isn't a decision, as all 4X4 drivelines now use the Autotrac 2-speed transfer case that



The 2020 Silverado HD pickup truck is all-new and larger in nearly every dimension. Front-end styling for some trims is sure to be controversial.

automatically selects 4-wheel-drive when slippage is detected.

**Bolstered chassis, new electro-features**

The 2020 Silverado HD's ladder-frame chassis features fully-boxed rails and in light of its increased tow and payload ratings; gross combined vehicle weight rating (GCWR) now is up to 43,500 lb. (19,731 kg). The HD pickups continue with short/long-arm front suspension, a setup unique to the class.

And here's where the electronic enhancements come in, as all OEMs begin to leverage the wonders of camera vision, in particular, to make these big pickups' jobs easier than ever (Reuss said 30% of HD pickup owners "use their trucks to make a living" and company figures indicate 90% of buyers use their HD pickup to tow).

Standard and or optional electronic assists include a driver-selectable engine brake, automatic grade braking, trailer-sway control and an integrated trailer-brake controller, while powered towing mirrors as standard.

Meanwhile, the Silverado HD can be fitted with up to eight cameras to deliver as many as 15 exterior camera views, including a surround-view monitor, a

view that peers directly into the bed and a brilliant "transparent trailer" feature that mingles images from several exterior cameras to simulate a view of what's behind and to the sides of a trailer.

**More configurations**

The only sheetmetal the 2020 Silverado shares with its 1500-series cousins now is the roof and the HDs are larger in just about every dimension. A crew cab, standard-bed model has a 158.9-in (4037-mm) wheelbase, which is 5.2 in (132 mm) longer. Overall length, at 250 in (6349 mm) is extended a significant 10.4 in. (264 mm). Width is 1.4 in (35 mm) greater. Much of this translates to more room in the cabin.

The standard box itself now is 82.2 in (2089 mm) long, a full 3.4 in (86 mm) longer and total volume is up by 8.6 cubic feet. The long box now is truly that, lengthening by a half-inch to a total length of 98.3 in (2496 mm).

When the 2020 Silverado HDs go on sale this summer, it will be available in regular cab, double cab and crew cab body styles, standard and long boxes and two chassis-cab lengths. There will be five trim levels: Work Truck, Custom, LT, LTZ and High Country.

Bill Visnic

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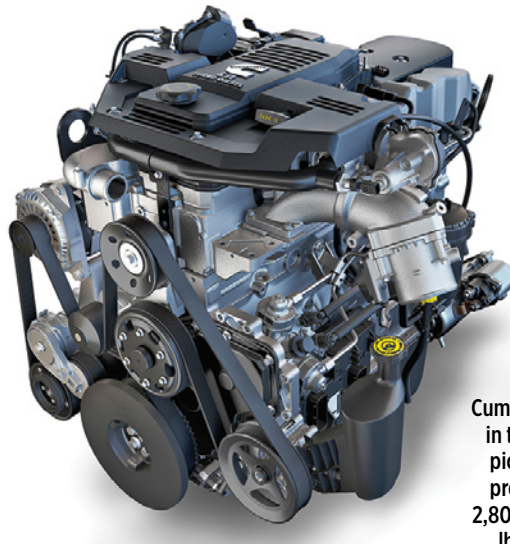
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## FCA debuts new Ram Heavy Duty pickups



The 2019 Ram HD pickup truck lineup features an all-new front-end design that continues to get bolder and helps improve cooling efficiency.



The new 6.7-L Cummins turbodiesel in the 2019 Ram HD pickup truck lineup provides 400 hp @ 2,800 rpm and 1,000 lb-ft @ 1,800 rpm.

FCA's Ram truck division unveiled its new 2019 Heavy Duty (HD) pickup truck lineup at the 2019 North American International Auto Show (NAIAS). The new HD pickups feature the slick interiors and tech from Ram's new 1500 line, significant powertrain and chassis upgrades and all-new front and rear sheetmetal. The Ram HD lineup will face off against Chevy's new HD pickup offerings and Ford's established F-Series and includes 2500/3500 capacities in regular, crew and mega-cab configurations.

Since it's a heavy-duty truck launch, Ram is of course tout-ing new capability figures for its HD lineup, which retains its basic cab architecture, but sees nearly every other part of its chassis upgraded. A new 6.7-liter turbo-diesel producing 1,000 lb-ft of torque—the first HD pickup to break the four-figure torque-output barrier—combines with a redone frame that's now 98.5% high-strength steel to provide what Ram claims are class-leading figures of 35,100-lb (15,921-kg) towing and 7,680-lb (3,565-kg) of payload.

### New diesel, 8-speed for the Hemi

The standard engine for the 2019 Ram 2500 and 3500 HD is the "Hemi" 6.4-L gasoline V8 producing 410 hp @ 5,600 rpm and 429 lb-ft (582 N-m) @ 4,000 rpm. An optional new 6.7-L Cummins High Output turbodiesel I-6 produces 400 hp @ 2,800 rpm and 1,000 lb-ft (1,356 N-m) @ 1,800 rpm.

Changes to the new diesel include an all-new compacted-graphite-iron cylinder block, new cast-iron cylinder head, lighter and stronger pistons, new forged connecting rods and new bearings. An all-new exhaust manifold anchors an updated variable-geometry turbo that provides up to 33 psi of boost to the 60-lb (27-kg) lighter engine. The 6.4-L gasoline V8 is now mated to the standard TorqueFlite 8HP75 8-speed automatic, which is now shift-by-wire and uses the rotary

shift dial from the Ram 1500.

Ram 3500 HD models equipped with the 1,000 lb-ft high-output diesel will be paired to the Aisin AS69RC electronically controlled 6-speed automatic, which gains a transmission controller with a new dual-core processor and double the memory to improve shift precision. Standard 6.7-L diesels (370 hp; 850 lb-ft/1,152 N-m) will be paired to an upgraded 68RFE 6-speed automatic transmission that nets new variable-force solenoids and refined accumulator and hydraulic controls to smooth shifts into reverse and Park.

### Fully optimized frame structure

The 2019 Ram HD pickups feature new optimized frames constructed of 98.5% high-strength steel, six crossmembers, hydroformed main rails and fully-boxed rear rails. A new two-piece front-suspension crossmember adds a longer frame-weld interface and the rear-axle structural crossmember (load point for fifth-wheel and gooseneck hitches), has been upgraded for 2019 to accommodate the increased towing capacity.

The 2019 Ram HD suspension includes the FRD shocks, new progressive springs with updated bushings and continues to provide the class-exclusive rear five-link coil design on Ram 2500. A class-exclusive Active-Level rear air-spring rear suspension is also available on both the Ram 2500 and 3500, which on the 3500's Hotchkiss rear setup permits softer heavy-load leaf springs for improved unladen suspension articulation.

No pricing information for the 2019 Ram HD pickups was revealed at NAIAS, and the Chassis Cab versions of the HD trucks were expected to debut at February's Chicago Auto Show. The new versions of the Ram HD trucks will continue to be built at FCA's Saltillo Truck Assembly Plant in Coahuila, Mexico, and the new trucks are expected to go on sale in April, 2019.

Paul Seredynski

## 2020 Ford Super Duty debuts all-new OHV V8



Ford promises best-ever tow ratings from the upgraded 2020 Super Duty powertrains.

The 2020 **Ford** F-Series Super Duty will arrive with the heavy-duty pickup truck's best-ever conventional, gooseneck, and fifth-wheel trailer towing and payload ratings. "What makes these highest-ever ratings possible is our strongest-yet Super Duty powertrain offerings," said Dave Filipe, Ford VP of global powertrain during the 2020 F-Series Super Duty's January 30 debut in Detroit.

*Automotive Engineering* spoke with Ford powertrain engineers about the all-new pushrod V8, the third-generation 6.7-L Power Stroke diesel V8, and the all-new 10-speed TorqShift automatic transmission offered on the 2020 F-250, F-350, and F-450 trucks, which are expected to begin shipping to dealers in the fall of 2019.

### All-new 7.3-L OHV V8

The all-new Ford engineered and built 7.3-L powerplant uses a pushrod-actuated overhead-valve architecture and is the largest V8 gas engine for Class 3-5 trucks. It joins the standard 6.2-L V8 in the Ford heavy-duty lineup, and includes a cast iron block, aluminum cylinder heads, forged steel crankshaft and cast stainless-steel manifolds.

The new V-8 features port fuel injection, variable valve timing and a variable-displacement oil pump to reduce

parasitic losses. Like the 6.7-L diesel engine, the gasoline V8 has oil jets to cool the pistons during heavy load operation. "All of the knowledge that we learned from building turbo-diesel engines and EcoBoost turbocharged engines has been applied to this V8," said Joel Beltramo, the 7.3-L V8's engineering manager.

For instance, the piston rings' coating is usually reserved for turbocharged engine applications as are the materials for the valves and valve seats. "This is not a boosted engine, but we're doing things to extend the durability," Beltramo said. "We have customers that will drive 400,000 to 500,000 miles, so our powertrain goal is to outlast the vehicle."

The compact and narrow V8 was designed and optimized to power a range of vehicles. "So if you're running a fleet, you can have standard service as all the maintenance parts are common," Beltramo said. Ford's new V8 is a companion to the standard 6.2-L V8 that produces an SAE-rated 385 hp (287 kW) at 5750 rpm and 430 lb-ft (583 N-m) at 3800 rpm. Power output numbers for the 7.3-L V8 have not yet been released, but it will also be available with a compressed natural gas (CNG) option.

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The all-new 7.3-L gasoline OHV V8 with two valves per cylinder is offered on the 2020 Ford F-Series Super Duty line-up.

### Third-gen 6.7-L diesel V8

In its latest incarnation, the 6.7-L Power Stroke will produce more horsepower and torque than the second-gen (450 hp/336 kW); 935 lb-ft/1,268 N·m) with new ratings planned for release at a later date. The prior-generation fuel injection system produced 30,000 psi (2,068 bar) versus the new system's 36,000 psi (2,482 bar). "We've increased the operating pressure for better emissions and fuel economy," said David Ives, Ford's diesel technical leader.

Major changes to the Honeywell turbocharger involve the vane control mechanism and replacing the former unit's electro-hydraulic actuator with an all-electric actuator. "This new version is more responsive in colder weather," said Ives.

Vanes on the turbocharger are now located on both sides of the plates/walls. The prior version had the vanes pinned on one side with a guide-slot on the other side. "The closer that the vanes ride the wall means less internal air leakage and more efficiency," Ives explained.

The block, cylinder heads, main bearings, connecting rod, and pistons were upgraded to handle the higher operating pressures. "We have nearly nine years of

field experience with the engine, so we've been able to apply that knowledge toward optimizing the engine for higher performance output," said Ives, noting the first-generation powerplant debuted in April 2010.

### New 10-speed and trailer tech

A new 10R140 TorqShift 10-speed automatic replaces the Super Duty's 6-speed automatic transmission, and can be paired with all three engine offerings. Packaged in the same space as the 6-speed, the 10-speed weighs only 3.5 lb (1.6 kg) more. Next-generation software and controls are similar to those in light-duty F-150's 10R80 transmission.

"With the new controls, the shifting is faster, more accurate, and smoother," said Greg Stout, the automaker's 10-speed transmission systems manager.

The electronically controlled transmission provides various selectable drive modes: normal, tow/haul, eco, slippery, and deep sand/snow. Like the prior 6-speed, the 10-speed transmission will offer a class-exclusive live-drive power takeoff, enabling operators to engage snowplows and other industrial accessories when the truck is in-motion.

Kami Buchholz

## 2019 Chevrolet Blazer just right for the voracious SUV market

Leaving its dirt roots in the past, the all-new 2019 Chevrolet Blazer is a stylish, on-road-focused 2-row SUV that slots between Chevy's Equinox and Traverse, deftly closing a gap in its SUV lineup. Based on the GM global-C1 architecture underpinning the Cadillac XT5, the new Chevy Blazer is quite conventional but contains a host of keen features including a versatile AWD setup.

The all-new 5-door, 5-passenger FWD/AWD Blazer will compete with other 2-row SUVs—including the Ford Edge and Nissan Murano—in a segment which relies heavily on styling for purchase consideration. "The first time we saw the concept sketches we were excited about it," said Jeff Boike, the Chevrolet Blazer program engineering manager. "I think the big challenge for engineering is to deliver. A lot of times you'll see a theme, and by the time you incorporate all the engineering criteria, you kind of lose the very thing you were after."

### Unique dimensions, multi-link suspension

Blazer's global C1 SUV platform is engineered with dedicated mods to enable the vehicle's rakish exterior design.



The 2019 Chevrolet Blazer has one of the cleanest and most understated IPs of recent memory. The signature round vents from the Camaro remain on call here, but still cleverly use their outer rings as climate controls.

FROM TOP: FORD; CHEVROLET



Hitting what Chevy (and others) believes is open white space in the market, the 2019 Blazer is offered in six trim levels.

“There were some challenges,” Boike noted, including extending the track 44 mm when compared to a XT5, “but this enables the 21-in wheels and much improved vehicle dynamics.

The Blazer uses a MacPherson strut front suspension and 5-link rear suspension. The rear arrangement employs aluminum knuckles, hollow stabilizer bar, an isolated fluid-filled crossmember and cross-axis ball joints for the lateral links. A rack-mounted, belt driven EPS setup grants linear and accurate steering, a trait likely aided by the 5-link rear suspension’s ability to isolate lateral loads from suspension articulation.

The standard engine on the new Blazer is GM’s 2.5-L inline-4, SAE-certified at 193 hp (143 kW) and 188 lb-ft (255 N·m). An available 3.6-L V6 is SAE-certified at 308 hp (230 kW) and 270 lb-ft (366 N·m). The all-aluminum V6 was redone in 2016, and features an 11.5:1 compression ratio, digital cylinder deactivation (active fuel management) and variable intake/exhaust valve phasing.

Both direct-injected gasoline engines will feature stop-start functionality and will be paired with GM’s 9-speed automatic transmission.

The optional AWD system comes in two flavors: a single clutch system, and a new twin-clutch system on upper trims. Both use an active disconnect setup that in FWD mode stops the rear drive hardware from spinning (a feature alone worth 0.5 mpg according to engineers). Lower trims net a single-clutch rear drive unit (RDU), while RS and Premier trims get the twin-clutch RDU with active

torque vectoring/yaw control.

Tied into the driving modes (Normal (FWD); 4x4 (AWD); Sport; Off-Road; plus Tow/Haul if equipped with the towing package) and also leveraging the brake-based traction-control system, the AWD setup provides mode-tailored characteristics. These include Sport mode increasing rear torque bias and yaw assist, and Off-Road mode permitting additional yaw error and rear-power bias at lower speeds. The distinctive modes combined with a true FWD setting adds real versatility to the Blazer while reducing the efficiency hit.

### Driving the new normal

Though not ground-breaking in terms of propulsion performance, the Blazer is rife with small engineering touches. These include six illuminated USB ports, a second row that actually folds flat, an electric glovebox with a PIN setting for valet mode, a logo beamed onto the ground to indicate where to swipe your leg for the hands-free tailgate and a floor-track-based cargo-management system that would be right at home on a premium European offering.

The 2019 Chevrolet Blazer will be offered in six trims from the base Blazer L to Premier with MSRP’s starting at \$29,995, and the top Premier trim starting at \$43,895.

The Blazer will be assembled at GM’s Ramos Arizpe, Mexico facility. U.S. dealer pipelines are expected to be fully stocked by April 1, 2019.

Paul Seredynski

# HOW IT FEELS



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Simulation of Continental Holographic HUD technology under development, showing highlighting of a motorcyclist that's partially shielded by the SUV at left, and two pedestrians near the road at right.

# Rethinking the HUD

New tech solutions move toward augmented reality to bring greater capability to head-up displays.

By Dan Carney

**H**ead-up displays (HUD) debuted in the late 1950s as a means of providing jet fighter pilots critical information while maintaining situational awareness outside the cockpit.

Today these systems for projecting data onto the windshields of cars and trucks are becoming a vital conduit of information to drivers.

The first production automotive HUD appeared in the 1988 Oldsmobile Cutlass Supreme Indianapolis 500 Pace Car Convertible. That early **GM** system employed a vacuum fluorescent display tube and mirror to project a virtual speedometer in the pale green hue that would become familiar to drivers of cars so equipped.

Today, HUDs are obviously more sophisticated, and common, as technology advances have made them better and cheaper. Their appeal lies in their ability to convey information "in a simple way that is easy to understand," explained Stephan Peters, project manager for human-machine interfaces at **BMW**.

While in-dash display screens might be used for various purposes, such as showing lavish satellite photo image maps and song information complete with cover art, HUD data is more specific. "The focus is on

driving-relevant information," Peters said.

According to research firm **Future Market Insights**, the global market for HUD devices was \$2.9 billion in 2017 and is forecast to grow to \$18 billion by 2027. Automotive HUDs accounted for 77.5% of the market in 2017; by 2027 their share is expected to reach 88.4%, or \$15.9 billion globally.

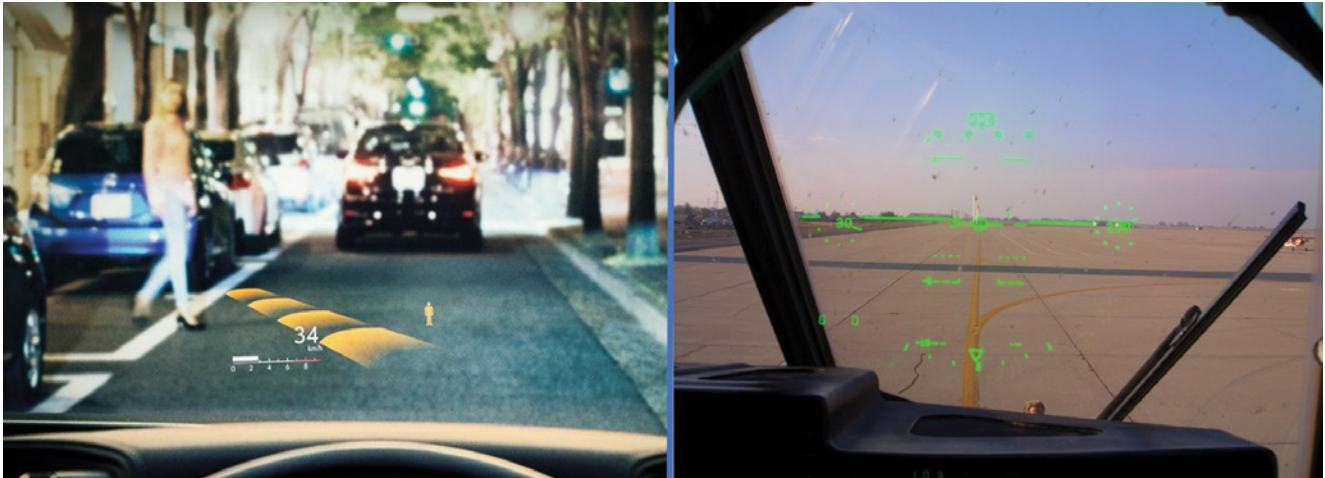
"The market is growing faster than we initially thought," stated Sue Drescher, head of innovation for supplier **Continental's** advanced technology product group in North America. "The market is going to grow substantially over the next few years," she observed.

## More info in the driver's FOV

Today's typical HUDs employ Thin Film Transistor (TFT) devices, which are becoming increasingly affordable but suffer from limited brightness and field of view, according to John Davis, **Ford's** chief engineer for the 2020 **Lincoln Aviator**.

To overcome those constraints in developing the Aviator's HUD, Davis' team turned to Continental for its HUD featuring Digital Micromirror Device (DMD) Digital Light Processing (DLP) technology. It delivers the brightness necessary to overcome the typical HUD incompatibility with drivers' polarized sunglasses. Lincoln engineers claim the system, which is also used on the brand's Continental and

CONTINENTAL



Comparison of production Denso HUD display in current Lexus LS (left) and the co-pilot's HUD in a U.S. Air Force C-130J Super Hercules transport aircraft at right. The 24-in. Denso unit alerts drivers with pedestrian cross-traffic warning.

## “Anything on the CAN network can be brought into the HUD.”

Navigator models, has the largest field of view (FOV)—10 degrees wide and 2.5 degrees high.

It's also claimed to be the brightest display, providing “great image clarity and brightness simultaneously,” enthused Davis.

Larger and brighter full-color displays provide the opportunity to move more driver information off the instrument panel and onto the windscreen, where it can be seen more effortlessly by the driver. In addition to the typical digital speed reading, the HUD can convey data about the current speed limit, adaptive cruise control system's status, indicate turn signal use, and flash collision-avoidance warnings. In manual-transmission-equipped sports cars, HUDs provide upshift lights like those in Formula 1 race cars.

Indeed, “anything on the CAN network, you can bring in to the HUD,” noted Drescher. Improving the image quality boosts the effectiveness of bringing that data to drivers, she said, adding: “The colors are definitely much more saturated so you can get nice contrast against the background so you can provide better alerts.”

This is particularly relevant when driving in snowy environments, she explained, when the bright ambient light tends to wash out conventional HUD images.

The 24-inch Denso-supplied system in the Lexus LS includes pedestrian alerts and front cross-traffic alerts right in the HUD where they can't be missed.

“By integrating the Front Cross Traffic Alert System into the Head Up Display on LS, you are alerted very easily with the direction of the upcoming vehicle, before you can even see the vehicle in some situations,” noted Chad Deschenes, Technical Training Senior Analyst for Lexus College. This alone helps decrease the reaction



The HUD market “is growing faster than we thought,” noted Sue Drescher at Continental North America.

time for drivers, saving valuable seconds when every second matters.

As more information moves into the driver's field of view, there is less need for the proliferation of displays on the dashboard. “Today, when we use our HUD, we reduce the amount of information on the instrument panel, because it is redundant,” Lincoln's Davis said.

### Holographic waveguide tech

And as HUDs grow in display area, they have started pointing the way to the ‘holy grail’ of driver-information conveyance—augmented reality (AR). Next generation HUDs will combine AR information in the HUD image, such as road signs and objects. The aim is to make understanding of driver information more intuitive.



In-situ package-volume comparison between typical incumbent HUD unit (left) and Continental's waveguide-type system that offers greater FOV at one-sixth the volume.



Lincoln's latest HUD (far left) uses Digital Micromirror Device technology to enable display brightness that overcomes the filtering effect of polarized sunglasses. Chief engineer John Davis wants HUDs that are more energy- and package-efficient.

Continental touts the DMD HUD technology it supplies to Lincoln as “a bridge” between head-up displays and augmented-reality solutions. “That is an area of opportunity,” agreed Davis. “But the viewing angles and light paths are difficulties.”

That’s because the challenge of expanding the HUD to cover the driver’s entire forward FOV is packaging—fitting a display into the upper surface of the IP that’s large enough to cover much of the windshield. Future-gen HUDs with significantly larger image sizes will require new relay optic system technologies to maintain reasonably small HUD package requirements. Indeed, Davis would like to have “something energy-efficient, in a smaller package.”

Continental has developed what its engineers believe is a solution. It’s a holographic waveguide projector technology pioneered by **DigiLens Inc.**, a specialist company in which Continental has invested. And it could be in production vehicles by 2023, advanced-tech leader Drescher said.

Instead of using mirrors to direct and magnify images, waveguide technology diffracts the light, enabling a much flatter physical package. It produces a FOV that is twice as large as that offered by a conventional mirror-based HUD projector, but from a device that consumes one-sixth the volume.

Holographic film embedded in the windshield is another potential solution. **Yazaki** is currently working with several suppliers to explore this emerging technology, as well as HUDs in general.

By covering much more of the windshield, AR-based systems will

be able to do things like draw a box around pedestrians or deer ahead, highlight road signs, and circle objects in the road. They can even project night vision images of threats that are invisible to the eye, finally fulfilling the potential of infrared night vision that has so far gone unrealized in the automotive space.

The AR systems will also focus the data at the distance of the objects being highlighted, so drivers won’t have to change focus between distant objects and the HUD data which is focused at the distance of the front of the car. This is especially relevant to older drivers whose eyes require more time to refocus, Drescher pointed out.

But all drivers will benefit from being able to keep their eyes on the road rather than looking down at the instrument panel periodically, she added. “It does have a potential for great improvement because your off-road glance times are practically eliminated.”

Ideally, moving toward greater degrees of augmentation will help keep drivers safer. And if nothing else, including vehicle speed on the HUD should help us avoid inadvertently speeding and getting ticketed.

“I definitely go the speed limit more when I have a HUD,” Drescher claimed. ■



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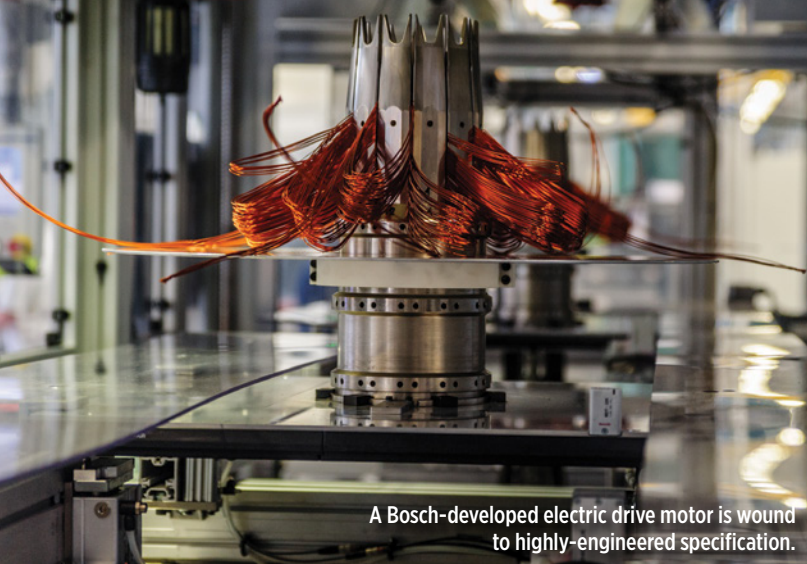
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A Bosch-developed electric drive motor is wound to highly-engineered specification.

# Motor matters

New designs and materials are key to the next generation of electric machines for EV propulsion.

By Bill Visnic and Lindsay Brooke

**W**ith the momentum to expand vehicle electrification increasing steadily, the industry is beginning to arrange the pieces for its multi-billion-dollar transformation of powertrain development.

**Ford** said it intends to have some 40 electrified models in showrooms by 2022, including 16 all-new battery-electric vehicles. **Honda** projects electrified vehicles will account for two-thirds of the company's global sales by 2030. **General Motors** plans 20 electrified models globally by 2023. Even **Ferrari** is joining the march. As the list grows, it's clear that in a few years, propulsion-system electrification no longer will be news per se. The dialogue will then shift to key differentiators in design, engineering and manufacturing that impact efficiency.

**Bosch**, for instance, in early 2019 assumed full ownership and control of its **EM-motiv** electric-motor development joint venture with **Daimler**, as the supplier seeks to manage the full value chain of electric propulsion—from battery pack to power electronics to motors. Optimization of system thermal management alone, the company believes, can increase an electric vehicle's (EV's) range by as much as 20%.

"In the end," said Bosch in a recent release, "affordable [driving] range is the key to helping electromobility achieve a breakthrough."

## Tailored designs

For EVs, the discussion often focuses on battery capacity, but the drive motor is as much a factor as the engine is in a conventional powertrain. Electric-machine power and efficiency are mutually related—and how those characteristics are tailored for automotive propulsion is a matter of widening engineering investment.

The two primary types of alternating-current (AC) traction motors, permanent-magnet and induction, have advantages and limitations for automotive applications. Many automakers and suppliers have favored permanent-magnet motors because they typically are inherently more efficient. **Honda**, **Toyota**, **GM** and **BMW**, as well as many major suppliers, currently use permanent-magnet motors in production vehicles.

AC induction motors may be preferable if high power output is a factor, but they are less efficient. **Tesla**, which many consider a bellwether of EV technology and development, uses AC induction motors for its larger and more performance-oriented Model S and Model X vehicles, but elected permanent-magnet drive motors for its most recent (and smaller) Model 3.

Many in the past have viewed induction motors as more aligned with EVs that are either larger and heavier or are focused on high performance, but permanent-magnet motors are not limited to

smaller, efficiency-focused vehicles. Although EV startup **Rivian** has disclosed scant specifics regarding its intriguing new platform for its R1T electric pickup truck and R1S sport-utility, a company spokesperson did confirm to *Automotive Engineering* that its drive motors—one for each wheel, combined in a unique integrated twin-motor/transmission housing for the front and rear—are permanent-magnet design.

## Materials quest

High-volume manufacturers have been wary of permanent-magnet motors because of their traditional reliance on heavy rare-earth elements. The preponderance of these materials currently comes from China, which is estimated to hold 35-40% of the world reserves of rare earths such as neodymium and dysprosium. Both are critical to all manner of magnetic products.

Magnets used in automotive traction motors typically aim for high coercivity, or the ability to maintain magnetization, at the high temperatures that can be common in automotive applications. The rare-earth materials impart added coercivity; often around 30% of the elements used in magnets are rare earths.

In mid-2016, **Honda Motor Co.** and **Daido Steel Ltd.** announced the first production application of a new magnet material for EVs. That material was hot-deformed neodymium and it was first used for a new-design permanent-magnet traction motor for the 2017 **Freed Sport Hybrid** compact minivan.

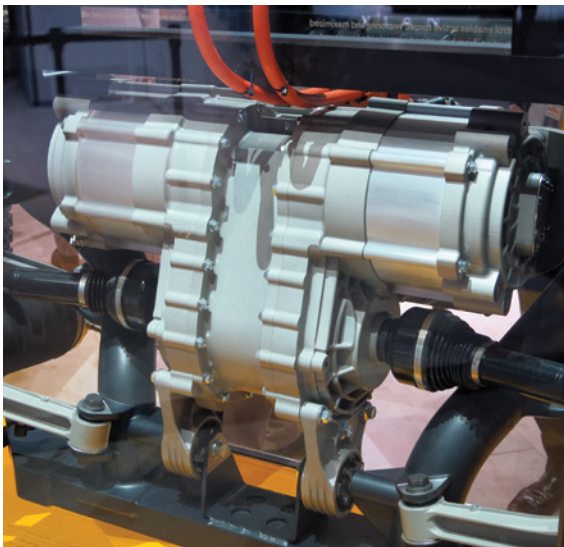
The hot-deformed neodymium doesn't require infusion with dysprosium or terbium "heavy" rare earths to achieve the high heat-resistance characteristic vital to traction motors.

**Honda's** latest **Insight** and **Accord Hybrid** models employ the third generation of the company's dual-motor (traction motor and generator) hybrid design; the magnets for both motors, the company said, use no heavy rare-earth metals. For the **Insight Hybrid**, the traction motor develops a claimed 129 hp and 197 lb-ft (267 N·m).

In a similar vein, **Toyota** said last year it had developed a new neodymium-reduced, heat-resistant



Honda's twin-motor drive/generator design for the 2019 Insight Hybrid eliminates rare earth materials for motor magnets.

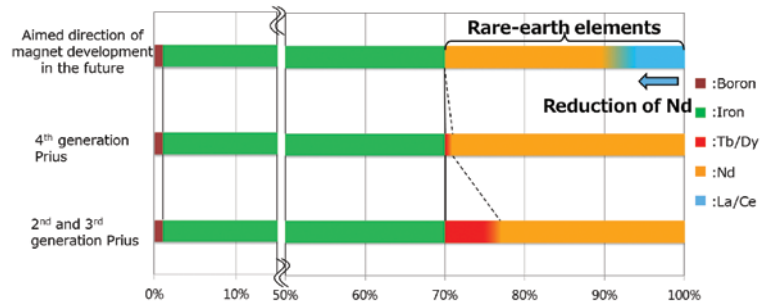


EV startup Rivian employs a traction motor for each wheel, uniquely packaged in an integral twin-motor case that also houses a transmission for each motor.

magnet for electric motors. "The new magnet uses significantly less neodymium, a rare-earth element, and can be used in high-temperature conditions," the company said in a release.

The new magnets use no terbium or dysprosium "necessary for highly heat-resistant neodymium magnets," Toyota said, adding, "A portion of the neodymium has been replaced with lanthanum and cerium, which are low-cost rare earths, reducing the amount of neodymium used in the magnet."

Use of lanthanum and cerium—both abundant and low-cost rare earths—enables high heat resistance to be



Toyota is progressively reducing rare-earth loading for its permanent-magnet motors.

maintained and loss of coercivity minimized, Toyota engineers believe.

In the U.S., the **Advanced Research Project Agency – Energy** (ARPA-e, a part of the **U.S. Dept. of Energy**) started its REACT (Rare Earth Alternatives in Critical Technologies) program to develop low-cost, reliable alternatives for rare earths. The REACT program in the last decade has helped fund several development efforts for EV motors using non-rare-earth magnets.

Deeper engineering of every aspect of motor design is certain to improve efficiency, power and reliability. Honda, GM (in its Bolt EV) and others have gleaned solid results from using square-cross-section wire for stator windings because it was determined the square wire "nests" more effectively, providing increased density for the given area. And winding technique, some sources say, also can have a significant impact on motor output and efficiency.

## Placement options

For pure EVs, traction motors typically drive an axle, or in some cases such as Rivian's, individual wheels. But for hybridization, there are numerous choices for where in the drivetrain the electric motor can do its work.

Early efforts for "mild" electrification have placed motor/generator units to act on the front of the engine crankshaft, typically linked by a drive belt, for a so-called "P0" location. The electric machine can be progressively moved back in the drivetrain, generally to impart increasing degrees of influence on the engine crankshaft or the drive wheels. A P3 location integrates the electric machine into the transmission, while a P4 location insinuates an electric motor driving an axle not mechanically connected to the combustion engine.

The case for in-wheel traction motors is made by **Protean Electric**, whose Pd16 and Pd18 wheel-motor systems are packaged with the road wheel rim—the permanent-magnet synchronous machine is contained in the outer rotor. Power and control electronics are also integrated into the units. Protean is aiming its wheel motors at autonomous shuttle applications, and the Pd18 is used in 'Olli,' **Local Motors'** self-driving shuttle.

As a bridge to EVs, industry sources project increasingly sophisticated designs for incorporating electrification into conventional drivelines. As electric motors progress through the various "P" stages, the corresponding benefits are efficiency- and performance-enhancing features such as drive-decoupling "sailing," torque "fill" to mask lag in engine boost and smooth gearchanges, as well as all-wheel-drive via fully-contained "e-axles." ■



# Harnessing the power of Sim



According to experts, every ten years simulation will enjoy a 1,000X increase in comparative advantage over physical testing. But challenges remain.

**Real cost savings could come from eliminating vehicle- and systems-level tests. Powerful simulation tools may be the only way to tackle the increasing complexity in mobility development.**

By Bruce Morey

**R**eliance on building and testing physical prototypes of systems and vehicles is giving way to more virtual testing using CAE simulations. It's one of the most significant trends in the mobility industry, and details of how it is evolving was the focus of a conference, "Engineering Analysis & Simulation in the Automotive Industry," held earlier this winter and attended by *Automotive Engineering*. The conference was sponsored by **NAFEMS**, the International Association for the Engineering Modeling, Analysis, and Simulation Community.

Engineers realize that while physical testing will always be needed, especially for materials properties and validating models, real cost savings could come from eliminating vehicle- and systems-level tests.

To traditionalists, this notion may seem heretical. However, according to Keith Meintjes, Executive Consultant, Simulation for **CIMdata**, simple economics is giving the industry no choice. Following Moore's Law, computers continue to grow more powerful and cheap.

"Every five years, computing has become ten times faster; in ten years 100 times faster," he noted. "We can compute in one second today what it would have taken the Apollo program computers 1,700 years to do."

At the same time, Meintjes cited the fact that the cost of physical testing is increasing about 7% a year. To compare it to simulation, testing's cost will increase ten times in the same ten years that computing will decrease its cost 100 times. He asserted that this is an opportunity to be embraced – every ten years simulation will enjoy a 1,000X increase in comparative advantage over physical test.

In this analysis, like it or not, simulation will come to dominate the engineering development process. "With computing getting so cheap it is possible to brute force solutions to some of these difficult problems," he said.

Challenges remain, however. Various participants in the conference detailed what they were doing to improve simulation, ranging from better physics models to how organizations will need to adapt to get best results.

## Understanding models

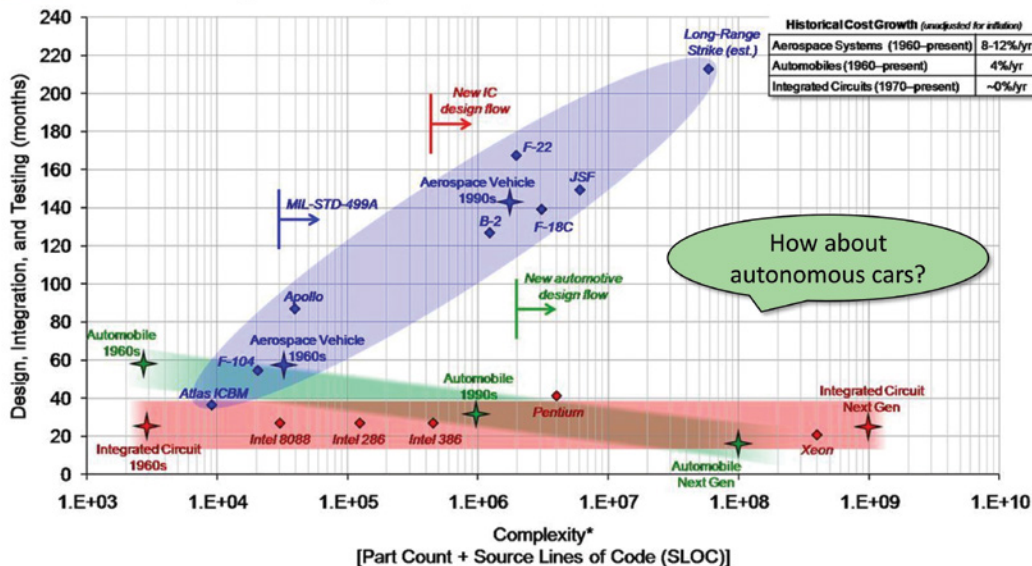
System models of vehicles that use simplified parametric components exist that are useful early in the development process. Often, test data is converted into a statistical model and used in system models. Multibody products, such as **MSC's** ADAMS or CarSim, provide vehicle dynamics simulations. Engines are modeled using system models and full 3D combustion models. But putting a highly detailed, 3D vehicle together is still a work in progress.

A panel discussion at the conference titled "Technology Gaps in Delivering Full Automotive Virtual Validation" attempted to identify critical shortfalls in developing a full 3D, virtual replacement for a physical prototype. While the list of gaps the panel of experts created was comprehensive and detailed, the following is a summary of the discussion:

**The more difficult physics models still need to be understood or improved.** These include high fidelity combustion models, tire models, battery chemistries, damping of running powertrains, accurate high-fidelity sensor models for ADAS, and vehicle-level durability analysis.

**Material properties are fundamental to accurate mechanical simulations.** Fortunately, CAE engineers have access to materials databases built up over decades of testing. Unfortunately, every year the industry continues to adopt new materials in the ever-lasting search for lighter, tougher and more durable materials. As one panelist commented: "We have not run out of materials to test. It is difficult to keep up."

## The Complexity Issue



The complexity and compressed development time of next-gen mobility systems versus some iconic 20th century aerospace systems—F-104 Starfighter, Atlas missile, Apollo program—is staggering.

Another key point is that materials need to be tested “as manufactured,” the panelist noted. “It is difficult to couple manufacturing simulations with performance simulations,” he said—the material properties of a tested material may change after forming or stamping. Getting those properties right is still one of the bigger challenges, according to the panelist.

### Modeling interactions between systems at their interfaces.

Simulation experts have, quite rightly, developed accurate individual system models such as chassis, engines and transmissions. Each may have the right physics and numerical models to get answers within each domain. Putting those component models together and have them interact with each other in a simulation gets quite involved. Modeling the interfaces is important. Further development is needed to ensure accuracy and to understand how variations propagate.



**Frank Popielas of SMS ThinkTank:** Simulation needs to be used by engineers even if they don't fully understand the theory.

### A culture for implementation

It may be more than technology. “I recommend looking at organization, culture and processes first before you start to talk about technology,” recommended panelist Frank Popielas, Managing Partner for **SMS ThinkTank**. Adding to that are business challenges that include a global, interconnected supply chain and new competitors. Potential technology solutions such as IoT, Big Data and Cognitive Engineering techniques are advancing rapidly. These factors will challenge a comprehensive simulation model, requiring

inputs from diverse sources and keeping track of simulated results.

It's a tougher problem than with experimental data, the experts noted, since simulations can crank out much more data.

Popielas pointed to new concepts that can help this, such as Digital Twin and Digital Thread. “But the key question,” he asked rhetorically, “is do you know what you need out of those [technologies] and do you have the culture to implement it?”

Another key element in making simulation more broadly useful is getting it into the hands of more users. “It needs to be used by engineers who are not simulation experts, even if they don't fully understand the theory,” Popielas explained. Such simulation tools need to be as simple, perhaps, as an app on a smart phone.

An ideal use of simulation in a flexible system, illustrating its power, is in developing a virtual world for testing of autonomous driving, according Dr. Ashley Micks, Technical Specialist at **Ford**. Ford created its aDRIVE Simulation Framework to validate vehicle features at higher levels of autonomy. It is a prototype simulation workflow that flexibly meets the needs of specific projects through the use of open source gaming engine technology.

In a clever piece of systems engineering, Ford's team exploited an existing gaming engine, Unreal Engine 4 from **Epic Games**, connecting to it various sensor and vehicle dynamics models to create a framework to test autonomous driving algorithms. [See SAE Technical Paper 2017-01-0107: “Creating 3D Virtual Driving Environments for Simulation Aided Development of Autonomous Driving and Active Safety.”] ■



# An **OBE** for the **SAE**



SAE International 2019 President Paul Mascarenas believes that new technology areas such as data analytics and controls are now integral to expanding SAE's business and its membership.

**Meet Paul Mascarenas—SAE International's 2019 president. He's a staunch advocate for professional development for engineers, amid the mobility industry's transformation.**

**By Patrick Ponticel**

**P**erhaps it's not surprising that someone who joined a professional engineering society at age 16 would eventually lead one. And so, Paul Mascarenas seems an ideal fit as SAE International's 2019 president.

It's been more than 30 years since he joined the **Institution of Mechanical Engineers** as a student in his native Britain. Since then, Mascarenas has distinguished himself in many industry-leadership roles, including chief technical officer at **Ford Motor Co.** from 2011 to 2014.

"I'm tremendously excited to serve as the SAE president," Mascarenas, an SAE and IMechE Fellow, told *Automotive Engineering* during a visit to SAE headquarters near Pittsburgh. "It's an excitement in the sense of having the opportunity to really contribute to the profession that has served me so well over the course of my career," which recently has included the emerging mobility-technology environment.

Mascarenas is a staunch advocate of professional development, which he continued through his SAE membership after relocating from the U.K. to the U.S. midcareer. Serving in a leadership position at SAE where he aims to contribute to the professional development of the next generation of engineers "is for me very natural," he offered.

Before rising to the CTO position at Ford, Mascarenas served in various engineering, planning, manufacturing-launch and even marketing roles—three- to four-year assignments with enormous responsibilities, he explained. His experience began in Europe on the \$6 billion Mondeo program and spanned many more, including development and launch of the Super Duty F-Series pickup, when he was VP of North American vehicle programs. He was also 2014-2016 President of **FISITA**.

Among his many career honors, Mascarenas in 2015 was awarded the Order of the British Empire (OBE) by Queen Elizabeth II for services to the automotive industry—the first SAE president to be so acclaimed.

## **SAE and the mobility transition**

Since leaving Ford four years ago, Mascarenas has expanded his perspective on the mobility industry through diverse new relationships. He serves on the corporate boards of **ON Semiconductor**, **BorgWarner**, **U.S. Steel**, and **Spartan Motors Michigan**, a maker of emergency-response equipment. He also joined **Fontinalis Partners**, a Detroit-

based venture capital firm which invests in "startups and early-stage companies that are into pretty much all aspects of next-generation mobility"—from enabling technologies such as mobile payments systems, data management platforms, telematics and cybersecurity, to direct-consumer services such as rideshare, bikeshare and freight and logistics.

He noted that such a broad and deep professional vantage point allows him "to see through a different lens this sort of ecosystem that is so quickly emerging around next-gen mobility and the way this space is continually being reinvented"—valuable assets to bring to the SAE presidency and the SAE board of directors, on which he also serves.

Mascarenas asserted that SAE International, as a member organization and as a group, must be prepared for "the huge transition that this industry is going through right now, from the traditionally defined automotive, aerospace, and commercial vehicle sectors to one which is much more defined around integrated mobility." This transition, he said, "requires a different approach with respect to, potentially, the products and services that SAE International is providing to its members."

While the transition dictates new skillsets for engineers working in the traditional vehicle-development and technology areas, it also potentially appeals to a different membership group for SAE—"not at the expense of existing members," Mascarenas noted, "but in a more expanded group.

"For example, connectivity would be one area I would immediately think of," he said. "But there are a number of other technologies—data analytics and controls come to mind—that traditionally have not played a major part in SAE International's business but now become a very integral part, when you start to think about this more expanded definition of mobility and integration between our traditional sectors."

## Adapting to change

As this transformation progresses, Mascarenas believes SAE's three classic industry sectors—automotive, commercial-vehicle, and aerospace—will converge more, driven by consumers' expectations of a seamless, connected experience in point-to-point mobility and related services. This convergence, itself enabled by data and analytics, is already impacting SAE's annual business plan and its objective of sustainable growth.

For SAE, it means “ensuring that we are investing in the future, ensuring we've got the right skills and experience on the SAE staff.

“Now, the industry itself has to navigate through this themselves because, from a corporate perspective, it impacts the revenue model, the business model,” Mascarenas opined. “Potentially, you go from selling discrete products and services to selling into a sharing economy. This is clearly not a flip-the-switch-type transition. It's going to happen over many years.”

SAE International historically has demonstrated great adaptability to keep pace with industry changes. Continuing to adapt “is one of our most important challenges and considerations for the Board now,” Mascarenas said. “It's certainly one of the things I'll be spending a lot of time on.”

Blending his career experiences into the SAE President role “gives me broad perspective about the business of SAE International,” he said. “I'm very excited to now be part of the SAE leadership team.” ■



**“This is clearly not a flip-the-switch-type transition. It's going to happen over many years.”**

With broad exposure to new technology, Mascarenas will help SAE explore new opportunities during his 2019 tenure. He's shown here in a university motion simulator.

PAUL MASCARENAS

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# Solving the Propulsion PUZZLE

Must-attend expert panels at SAE's WCX '19 will cover the propulsion-tech future like no other.

By Lindsay Brooke and Bill Visnic

Never has vehicle propulsion strategy been so dynamic—and hotly debated—as it is today. And nowhere will engineers working in this space find a better place to learn about future directions than at SAE's 2019 WCX, the annual World Congress Experience taking place April 9-11 at Detroit's Cobo Center.

On the morning of April 11, two back-to-back Leadership Summit panels will deliver top-level insights on engines, transmissions, electrification, fuels, enabling technologies, regulatory challenges and much more. From 10 to 11:10am, engage with OEM and supplier decision-makers as they discuss the theme, "Today, Tomorrow, and the Future of Propulsion Systems." And you'll want to keep your seat for "Still Not Dead: The ICE's Continued Evolution" confab that follows from 11:20am-12:30pm.

Moderating the festivities: **SAE** Mobility Media editorial director Bill Visnic (the 10am panel), and editor-in-chief Lindsay Brooke (11:20am). Both roundtables take place in The Exchange, a comfortable theater area on the WCX exhibit floor.

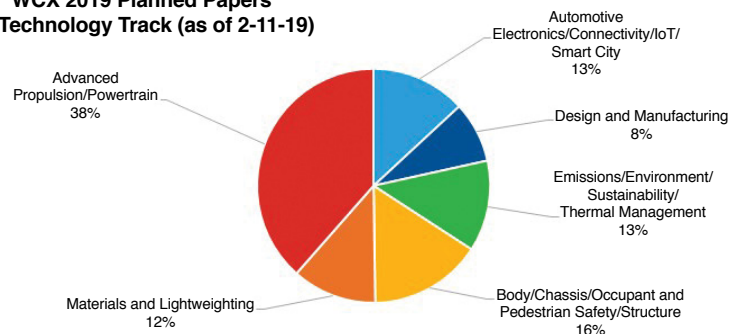
The SAE Leadership Summit discussions cover the "business of technology"—how new approaches are expected to impact the future of mobility. In addition to the popular Propulsion/Powertrain theme, primary topics and events for the WCX '19 conference include connectivity/HMI and autonomy; regulation; systems engineering and cybersecurity, as well as a CTO roundtable.

## Powertrains Today and Tomorrow

The macro-trends are clear: increasingly more-efficient and more-affordable electrification technology is available to augment internal combustion. But it can do more than augment, of course. As many world regions increasingly look askance at fossil-fuel emissions and urban air quality, electrification is gaining momentum to completely replace internal combustion—perhaps sooner than ever believed possible.

Within this global context, OEMs and key suppliers need decide how, when and where electrification makes sense, how it aligns with consumer demand

WCX 2019 Planned Papers by Technology Track (as of 2-11-19)



Subject-matter distribution for the hundreds of technical papers to be presented at WCX 2019.

and regulatory oversight and equally important, how to fit it all within a realistic cost- and technology-development framework.

Sharing their strategic views for this looking-over-the-horizon panel are: Dante Boutell, manager of the Powertrain Division of **Toyota** Motors North America; David Filipe, Vice President, Powertrain Engineering, **Ford**; Tim Frazier, Executive Director of Advanced Engineering, **Cummins**; John Heywood, professor of mechanical engineering and Director of the Sloan Automotive Lab at **MIT**; John Juriga, Director, Powertrain Systems – **Hyundai** America Technical Center and Jeff Lux, Head of Transmission Powertrain, **FCA** - North America.

## ICE's Not Dead Yet!

Next comes the disruptors—those armed with new technologies to extend the life, efficiency, and value of combustion engines. They're bringing a feast of innovations: Multi-fuel opposed-piston 2-strokes; variable compression-ratio solutions, Miller/Atkinson cycles; SPCCI and lean-burn methods, advanced digital cylinder deactivation, next-gen boosting solutions, new fuels—and the return of the **Mazda** Rotary, to name a few topics you'll hear.

"ICE's Not Dead Yet" drew a packed room at WCX '18 and this year's version promises to re-ignite the fire. Experts include Dave Crompton, the new president and CEO of **Achates Power**; Scott Bailey, CEO of **Tula Technologies**; Peter Davies C.Eng. FIMechE, senior director powertrain at **Garrett Motion** Inc.; Dr. Uwe Dieter Grebe of **AVL**; Masahiro Moro, president and CEO of Mazda North America; and Atsushi Teraji, Ph.D, Deputy General Manager, **Nissan** Motor Co. ■

## SPOTLIGHT: SENSORS/CONTROLLERS

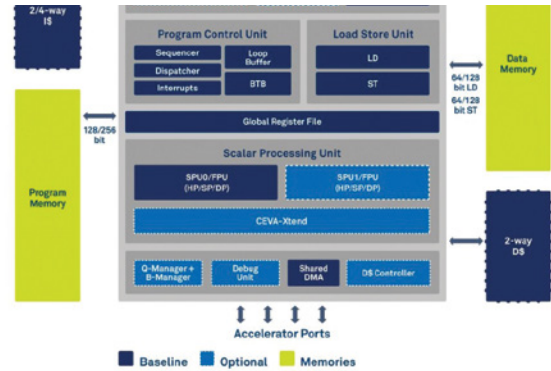
### Transmission speed sensor ICs



**Allegro MicroSystems'** (Manchester, N.H.) three new transmission speed sensor family members measure speed and direction information and integrate EMC (electromagnetic compatibility) protection capacitors. Complete with ASIL B certification, the A19520, A19530, and A19570 magnetic sensor ICs each bring a unique offering to the family. The A19520 allows compatibility with existing transmission designs, thanks to its performance and selectable output protocols. It uses Hall-effect technology and a two-wire interface. The A19530 provides advanced signal processing, open/short detection capability, and selectable speed or speed and direction output protocols. It uses Hall effect and a three-wire interface. Using GMR and a two-wire interface, the A19570 brings the same high algorithmic performance as its Hall-effect counterparts—but at what the company says are significantly larger air gaps and with flexible device orientations.

For more information, visit <http://info.hotims.com/73003-400>

### Hybrid DSP/controller architecture



**CEVA, Inc.'s** (Mountain View, Calif.) CEVA-BX all-purpose, hybrid DSP/controller architecture addresses new algorithms of digital signal processing in voice, video, communication, sensing and digital signal control applications. Offering general purpose DSP capabilities required for motor control and electrification, the CEVA-BX architecture extends CEVA's market reach into the automotive and industrial markets. CEVA-BX combines the inherent low power requirements of DSP kernels with the high-level programming and compact code size requirements of a large control code base. Using an 11-stage pipeline and five-way VLIW micro-architecture, it offers parallel processing with dual scalar compute engines, load/store and program control that reaches a speed of 2 GHz at TSMC 7nm process node using common standard cells and memory compilers.

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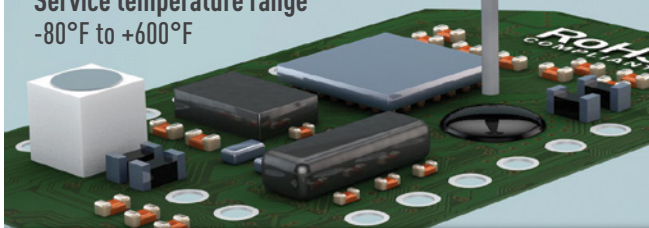
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## PRODUCT BRIEFS

### Ceramic capacitors

TDK Corp. (Iselin, N.J.) has extended its line-up of CeraLink capacitors to include modular flex-assembly (FA) technology with CeraLink FA types. This space-saving design connects two, three or 10 identical capacitors in parallel over the same terminals to increase the capacitance. The CeraLink FA types are available for rated voltages of 500, 700 and 900-V dc. Depending on the voltage and number of capacitors, this results in rated capacitance values of between 0.5  $\mu$ F and 10  $\mu$ F. These capacitors, which are based on PLZT (lead lanthanum zirconate titanate) ceramics, feature a high permissible operating temperature of 150°C (302°F). Despite their small size, they feature a ripple current capability of up to 47 ARMS. Applications for the capacitors include dc link or snubber capacitors in fast-switching converters.



For more information, visit <http://info.hotims.com/73003-402>

### Trusted platform module

Specifically for automotive applications, **Infineon Technologies** AG's (Munich, Germany) OPTIGA TPM (Trusted Platform Module) 2.0 protects communication between the car manufacturer and the car, which increasingly turns into a computer on wheels. The TPM is a hardware-based security solution. By using it, car manufacturers can incorporate sensitive security keys for assigning access rights, authentication and data encryption in the car in a protected way. These critical keys are particularly protected against logical and physical attacks in the OPTIGA TPM as if they were in a safe. A plug & play solution for automotive applications, the module is especially suited for use in a central gateway, the telematics unit or the infotainment system of the vehicle.



For more information, visit <http://info.hotims.com/73003-403>

### Multifunctional oil filter module

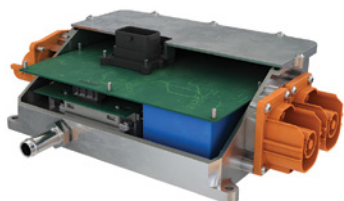
**Hengst's** (Münster) newly-developed multifunctional oil filter module meets all the requirements placed on fluid management of modern diesel engines. The lightweight design combines oil filtration and oil cooling in the tightest of spaces. The flow channel, which has been significantly optimized compared to the previous module, allows for reduced differential pressure, reducing the power requirements placed on the oil pump. The oil filter was designed for the new VW EA288 Evo 4-cylinder diesel engines from Volkswagen. The weight and flow of this module have been optimized to help increase the overall efficiency of the engine, which will first be installed in longitudinal-engine vehicles from **Audi**.



For more information, visit <http://info.hotims.com/73003-404>

SPOTLIGHT: EVs/HEVs MOTOR COMPONENTS

**Power-dense inverters**



Compact, power-dense automotive inverters from **Eaton's** eMobility business (Galesburg, Mich.) can increase the range of electric vehicles. The inverters draw electricity from the battery

and control how it is applied to the motor to manage power and torque. They will be tested by a global automaker in first quarter 2019. The vehicle inverters were developed with a power density of 35 kW per liter and 98% operating efficiency and can be tailored to a wide range of customer requirements and applications. The inverter's high-power density and compact, lightweight design help maximize range while taking up minimal space in the vehicle. Eaton's inverters can be used in all types of electric vehicles, as well as other alternative-fuel vehicles such as hydrogen fuel-cell cars.

For more information, visit <http://info.hotims.com/73003-405>

**Micro-v belts**



The **Gates** (Denver, Colo.) QMT EMD2 Micro-V Belt family is the company's next generation of micro-v belts designed specifically for belt-assisted (PO) mild-hybrid vehicle applications featuring start/stop, boost, recuperation and generation modes and deliver power transmission and noise performance across the various modes of hybrid vehicle systems. Designed with a patented cord construction, proprietary compounds and a specially-engineered production process, the QMT EMD2 Micro-V Belts are expected to provide 40% higher flex life and higher shear resistance than previous product design. The belt's composite design provides what the company says is "premium" noise resistance that enables compact packaging with captured-alternator accessory drives. The QMT EMD2 Micro-V Belt family 50% more cycles to failure on high-shear start test versus previous design.

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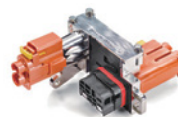
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For more information,

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## In-vehicle data logger

The in-vehicle EvoTRAC P201 high-performance data logger from Kontron



(Augsburg, Germany) is designed to reliably collect and store large video imaging and associated data to the Cloud. In addition, the EvoTRAC P201 can be used to monitor essential in-vehicle information to help operators reduce costs and maximize fleet productivity. It provides capabilities to perform a wide variety of demanding data logging functions, such as real time video playback and in-vehicle testing. The data logger also handles the tracking and storage of vehicle sensor and vehicle operational parameters including fuel consumption, driver behavior, driving hours and speeds, maintenance alerts and emissions data.

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## Analyzing Audi's new EV

Nice overview of VW Group's new electric starship in your February magazine. What strikes me in the current EV discussion is the technical achievements in the Audi e-tron are overshadowed by news of Tesla's woes—its ongoing production issues of Model 3, the scalebacks on Models X and S (where are their replacements?), and its prep employees getting the sack. Hopefully, that will change soon as more EV entrants arrive.

**Jim Radle**  
Seattle

Thanks to *Automotive Engineering* for your insightful look at "the German approach to EVs." Lots to admire in the Audi e-tron that's worth emulating for electric vehicles in general. I think the ability to use different form-factor batteries—pouch type and prismatic cells in this case—is important. Audi's battery pack development team should be commended for this innovation. Same with equipping the e-tron with 150-kW DC fast-charging capability. Using the CCS connector on a cooled cable appears to be a reasonable choice. Interesting, too, that the Electrify America and Ionity DC-fast-charge stations are equipped with cooled cables

**Pat Sapienza**

Hey, SAE! I love all the great cutaway and ghosted illustrations in the Audi e-tron feature. More, please! The car is super impressive—but until VW can create some serious production scale in its EV program, vehicles like e-tron are going to be revenue-negative and heavily subsidized. Still it's an engineer's dream car.

**Gene Guralnick, E/E**

## Silverado 4-banger

Ten years ago our program manager (and my boss) at the time predicted that the industry's ability to squeeze more and more power and torque out of 4-cylinder engines would enable them to replace larger engines with more cylinders in light trucks. Well, we first saw his prediction come true in SUVs, and now it's happening in full-size pickups. Turbocharger, check. Close-ratio multispeed transmission, check. Big enablers, these. GM's new 2.7-L delivers more HP and pound-feet than the Chevy small-block V8 delivered not long ago! My boss is retired but the rest of us are now waiting for the 4-banger shoe to drop at Ford, Ram, Nissan and Toyota, in their pickups.

**Rick Grieves**  
Tonawanda, NY

## Swapping batteries in China

I work in the EV battery industry and I hadn't heard that NIO had a battery swapping set-up in use until I read your article in the latest [Feb.'19] issue. NIO appears to be doing in China what the old Better Place company was trying to do in Israel. It's remarkable that they seem to have a workable business, but a lot of off-beat ideas in China seem to "work"—until the next government 5-Year Plan puts them under. Far too many variables that make the battery-swap concept impractical, even unsafe, for cars and trucks.

**Anodebro92**

## Doing biz with DATC

I can tell you some horror stories about trying to get systems supply business with the U.S. government. This was on various military ground vehicle programs my company was involved with in the 1980s. So I read your report on DATC [February] with fair amount of skepticism. Nonetheless, the article pointed to progress in cutting through the "red tape" that my team tried to get through before giving up. Maybe the DATC process is the first ray of hope?

**Ed Farleigh**  
York, PA

## More on SAE's new magazine

Where can I get the new SAE publication that covers automated and autonomous vehicles?

**Karyn D.**

Editor Lindsay Brooke replies: **SAE's Autonomous Vehicle Engineering (AVE)** turned out to be a hot item in 2018, following its launch as a quarterly supplement to *Automotive Engineering*. Starting this month (March '19), AVE becomes a stand-alone publication. Subscribe to it via the SAE website: <https://www.sae.org/publications/magazines/autonomous-vehicle-engineering>.

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



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**March 28:** Automotive Manufacturing  
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**April:** Automotive Engineering  
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- SAE WCX ISSUE
- Supplier Innovations
- Propulsion: ICE, Hybrids, EVs
- WCX Exhibitor Preview & Simulation/Analysis Tools spotlights

**April:** Truck & Off-Highway Engineering  
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- Automated & Connected Commercial Vehicles
- Bauma Preview
- Advanced Emissions Strategies for Off-Highway
- Electronic Components & Semiconductors/Engine Components/Fasteners & Adhesives spotlights

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- 3D Printing/Additive Mfg. Equipment & Test & Measurement Tools spotlights

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## Mazda pushes the propulsion frontier

It may be a small OEM, but **Mazda** has always punched far beyond its weight class in engineering and technology. That point is acknowledged by Masahiro Moro, president and CEO of North American Operations (MNAO) and an officer of the parent Mazda Motor Corp. A 34-year veteran of the company, Moro-san is responsible for all aspects of Mazda operations in the region. He clearly enjoys talking tech, as he'll do on April 11 as part of SAE's Leadership Summit at WCX '19 in Detroit. At the L.A. Auto Show he spoke with Editor-in-Chief Lindsay Brooke to discuss recent developments.

**Mazda's Skyactiv concept—the holistic combination of light weight, high efficiency, and driver-centric design—resonates with engineers across the industry. They get it.**

Yes, but it's very important that our customers and dealers get it, too! We have a process called 'co-creation' which is connecting the R&D engineering with the customer through sales and marketing. The story behind the technology is absolutely critical for the customer to understand and believe in Mazda as a company or brand.

**What is the status of Mazda's Rotary program?**

Thanks for asking about the Rotary; it's always been at the center of our hearts at Mazda and we've never given up on its development. A big opportunity has arisen for the Rotary engine to be used as a generator in a range-extender or PHEV. The Rotary is compact and smooth running—no vibration. And surprisingly, at constant rpm the fuel efficiency is very good. As you know we have a technical partnership with **Toyota**, in which Mazda will provide the Rotary engine to Toyota's new electric platform—the 'e-pallet' concept that Akio Toyoda announced at CES. It is scalable from small vehicle to big pickup. We have an electric vehicle concept underway. And I want to get that Rotary engine as a range extender to the U.S. market.

**Will this be a challenge?**

Well, it's a completely different value proposition compared to the usual electric vehicle. With a typical EV, when you make the vehicle bigger the battery also must be bigger. You need charging stations. With a rotary range extender, you just fill it with fuel and drive. No range worries. And still you can use the vehicle as an EV in town.

We also see opportunity to use the vehicle as a generator, for those who like to go camping.

We think the Rotary Range Extender has a larger purpose and makes sense for the customer who's looking for those usages. The concept puts Mazda in unique territory, and that's what we're always looking for.



Masahiro Moro

**Mazda is readying a Rotary engine range extender for potential deployment in North America, as part of its holistic Skyactiv strategy for increased vehicle efficiency.**

**And Skyactiv-X?**

Skyactiv-X is a step our engineers have made toward achieving the optimum internal combustion engine. We call it SPCCI [Spark-Controlled Compression Ignition]—very, very lean combustion, almost diesel-like. It's a huge leap compared with current engines in terms of combustion efficiency. It's a smart idea, using a spark plug to invite the high-pressure air/fuel mixture to self-ignite.

SPCCI has a wide operating range from low to high load. It has three layers of combustion, the third layer being greater than Lambda-1, which is super lean. Compression ratio is 15:1 or 16:1; by comparison our diesel is 14:1! So SPCCI is a breakthrough.

**What's the deployment plan?**

As one of Mazda's technology 'pillars,' Skyactiv-X is going to be mainstream in the future, as environmental requirements get more stringent and severe.

Our strategy is to introduce Skyactiv one-by-one, according to market. Europe's CO<sub>2</sub> emissions requirement is severe and the the CO<sub>2</sub> penalty there is enormously high. Skyactiv-X is in production for Europe and will immediately help CO<sub>2</sub> compliance there.

For the U.S., we'll be ready with robust plans to comply with CO<sub>2</sub> and greenhouse-gas requirements. ■

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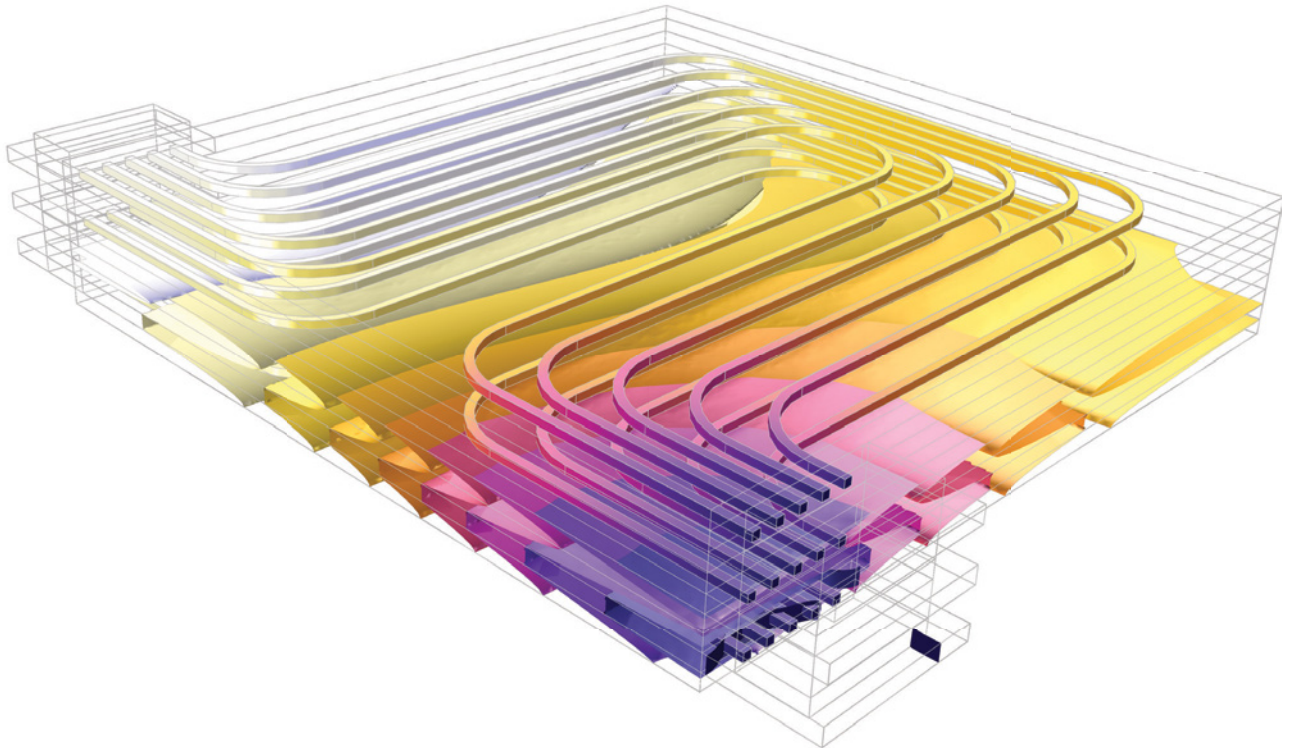


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# Autonomous vehicles require batteries with lasting power.



*Visualization of the temperature profile in a liquid-cooled Li-ion battery pack.*

The stage of the load cycle, potential, local concentration, temperature, and direction of the current all affect the aging and degradation of a battery cell. This is important to consider when developing autonomous vehicles (AVs), which rely on a large number of electronic components to function. When designing long-lasting batteries that are powerful enough to keep up with energy demands, engineers can turn to simulation.

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