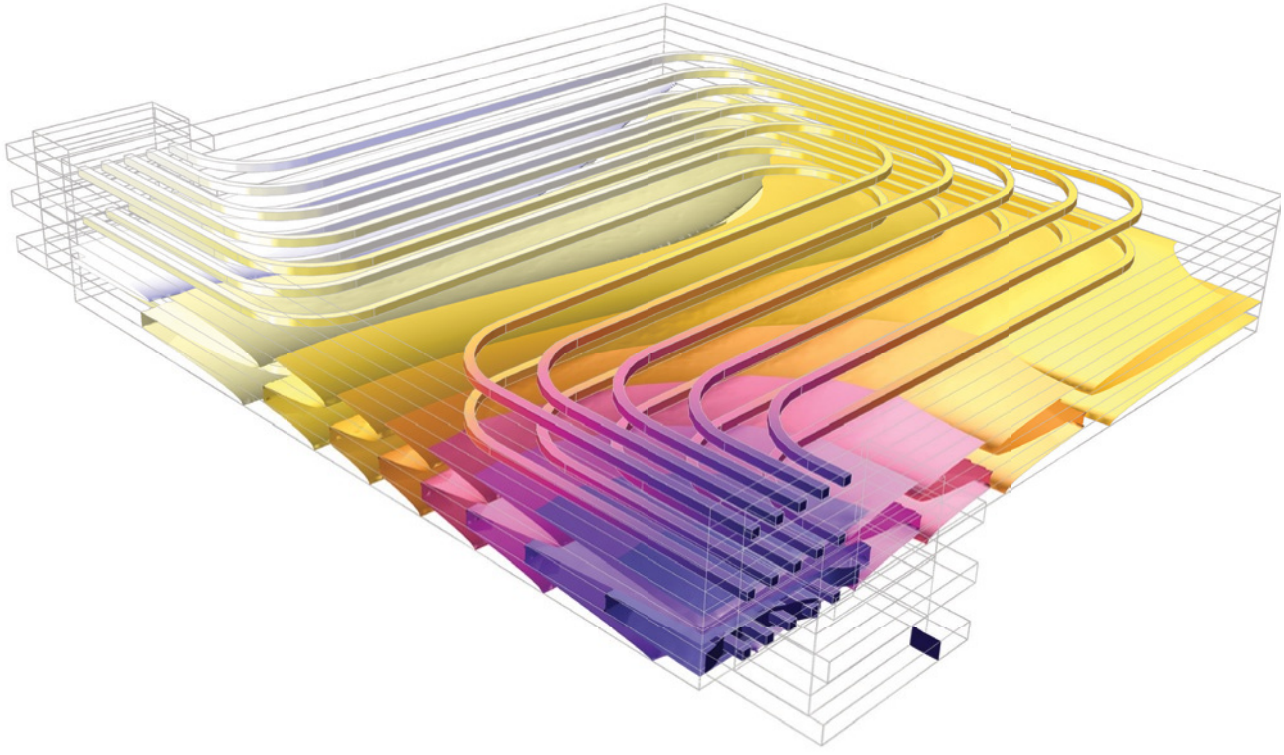
Autonomous vehicles require batteries with lasting power.



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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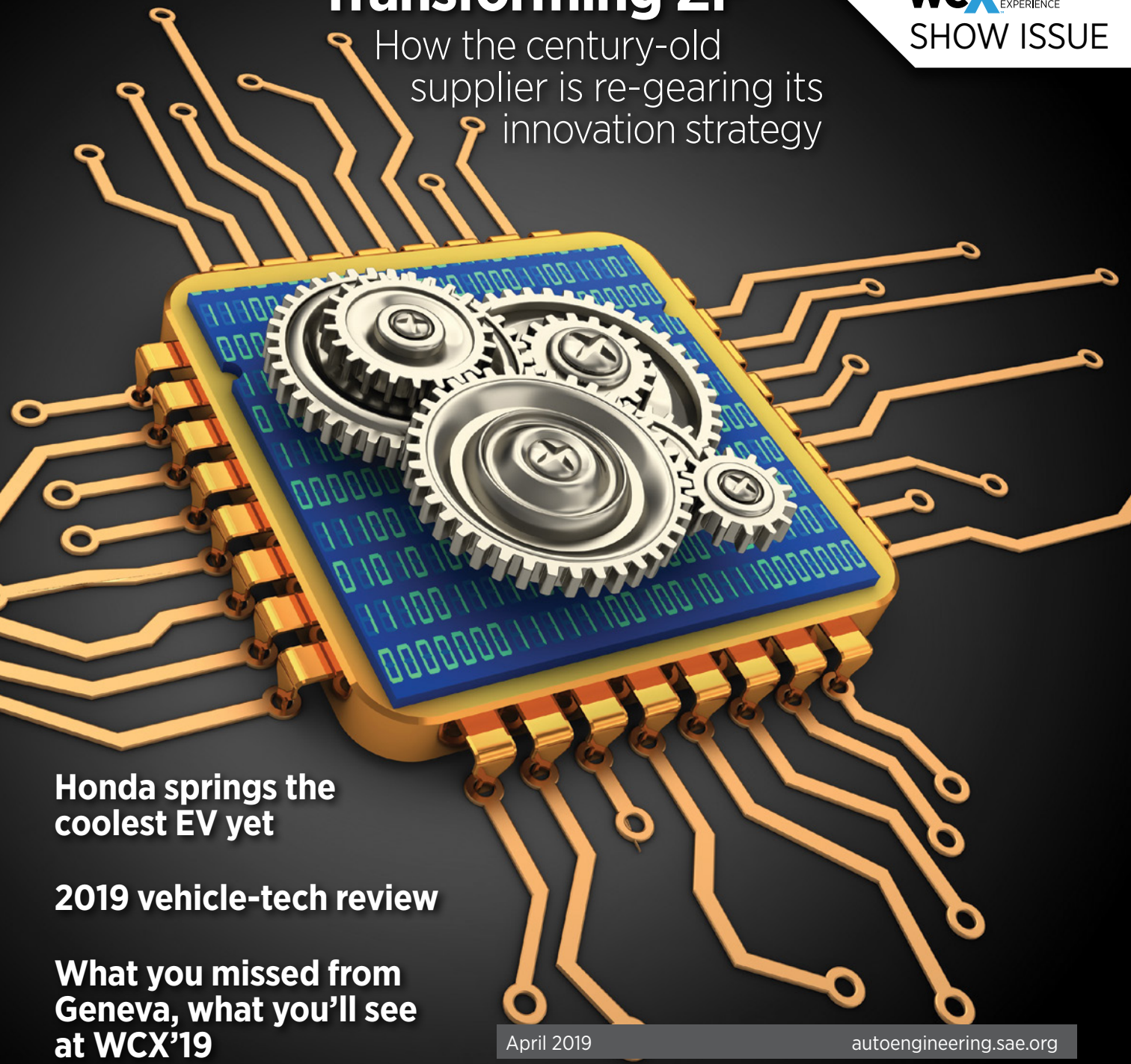
SAE 2019 WCX WORLD CONGRESS EXPERIENCE SHOW ISSUE

Transforming ZF

How the century-old supplier is re-gearing its innovation strategy



Honda springs the coolest EV yet

2019 vehicle-tech review

What you missed from Geneva, what you'll see at WCX'19

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ON THE COVER

Transmissions and other legacy technologies remain core for ZF Friedreichshafen GmbH, but the century-old Tier 1 is moving into mobility innovations based on electronics, Big Data and AI; its new Zukunft Ventures is driving the company's 're-gearing' strategy. (image: Mmaxer/Shutterstock)

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SAE INTERNATIONAL

EDITORIAL

Why would you want to be a mobility engineer?

Reporting on product development, technology, and process in the auto industry has always been compelling for me—I've been at it for over 30 years. And experience proves that whenever events start to seem smooth and predictable, change and disruption are on the way.

As I write this in late March, the industry is unsettled. Companies are restructuring. Consolidations loom. Product lines that launched with great promise are getting the axe. They're victims of falling sales, shifting priorities, rising costs, trade friction and waning consumer interest.

And jobs are disappearing in mass. They're getting swept up in the wake of the gradual transition to the electrified, connected, robo-shuttled and, in a growing number of places, car-averse future.

The numbers, tied directly to cost reduction strategies, are alarming. **GM** cuts about 8,000 salaried jobs, 15% of its white-collar workforce, and halts production in five plants in North America. **Ford**'s global reorganization will involve thousands of job cuts—5,000 in Germany and more in the U.K. **Volkswagen Group** said it will eliminate up to 7,000 staff as it aims to boost productivity and deliver €5.9 billion in annual savings by 2023.

In such an ostensibly gloomy environment, why would anyone want to be an engineer in this business? Someone asked me that recently while standing in line for a movie. When I mentioned that I write for an automotive-engineering audience, the reply was blunt: "Well, that's a dying breed."

"Just the opposite," I offered. "Even if you rode a scooter to the theatre, engineers got you here. If it moves, engineers design it, develop it, test it, validate it, and manufacture it. In some places, there aren't enough engineers to cover the growth areas," I said. "And, there's an upside to the downturn that's already in progress."

It's important to remember that engineering competencies in the core vehicle structure and systems areas will always be needed. But transportation's upheaval is laying a new foundation built of electrons and code. While VW, for example, expects to reduce staff as it prepares to roll out EVs which are less complex to build and require fewer workers, the company will create 2,000 new software jobs, as well as electronics positions in technical development. **Cruise**, GM's self-driving car subsidiary, plans to hire 1,000 more staff this year as it readies a new robotaxi service. The majority of hires will be engineers.

The upheaval is laying a new foundation for engineering jobs that's built of electrons and code.

Similar scenarios are playing out with small and large companies across the industry. At **Volvo Cars**, VP of Research & Development Henrik Green (see Q&A p. 64) says attracting young engineers to his company "is an interesting challenge that we face every day."

Volvo and its parent **Geely**, whose Sweden engineering facility is located near Volvo's, together "have basically depleted the market for automotive engineers in Sweden," Green told me. "Today, anyone who wants to be in this field is in it. The biggest requirement for us in terms of skill and competence is on the software side—and interestingly, the market for software experts is also almost depleted in our area of Sweden!"

He's confident that Volvo's recently opened facilities in Silicon Valley and in southern Sweden (formerly a telecom hub) will help fill demand. "It's a busy job to find talent these days," Green reported.

Lindsay Brooke, Editor-in-Chief

EDITORIAL

Bill Visnic
Editorial Director
Bill.Visnic@sae.org

Lindsay Brooke
Editor-in-Chief
Lindsay.Brooke@sae.org

Paul Seredynski
Senior Editor
Paul.Seredynski@sae.org

Ryan Gehm
Associate Editor
Ryan.Gehm@sae.org

Jennifer Shuttleworth
Associate Editor
Jennifer.Shuttleworth@sae.org

Lisa Arrigo
Custom Electronic Products Editor
Lisa.Arrigo@sae.org

Contributors

Kami Buchholz
Detroit Editor

Stuart Birch
European Editor

Terry Costlow
Electronic Technologies Editor

Ian Adcock, Steven Ashley, Matthew Borst, Dan Carney, Bruce Morey, Don Sherman, Paul Weissler

DESIGN

Lois Erlacher
Creative Director

Ray Carlson
Associate Art Director

SALES & MARKETING

Joe Pramberger
Publisher
joe@techbriefs.com

Debbie Rothwell
Marketing Director
drothwell@techbriefs.com

Martha Tress
Recruitment Sales Manager
+1.724.772.7155
Martha.Tress@sae.org

REGIONAL SALES

North America

New England/Eastern Canada:
ME, VT, NH, MA, RI, QC
Ed Marecki
+1.401.351.0274
emarecki@techbriefs.com

CT:
Stan Greenfield
+1.203.938.2418
greenco@optonline.net

Mid-Atlantic/Southeast/TX:
MD, DC, VA, WV, TN, NC, SC, GA, FL, AL, MS, LA, AR, OK, TX
Ray Tompkins
+1.281.313.1004
rayt@techbriefs.com

NY, NJ, OH:
Ryan Beckman
+1.973.409.4687
rbeckman@techbriefs.com

PA/DE:
Desiree Stygar
+1.908.300.2539
dstygar@techbriefs.com

Midwest/Great Lakes:
IN, MI, WI, IA, IL, MN
Chris Kennedy
+1.847.498.4520, x3008
ckennedy@techbriefs.com

Midwest/Central Canada:
KS, KY, MO, NE, ND, SD, ON, MB
Bob Casey
+1.847.223.5225
bobc@techbriefs.com

Southern CA, AZ, NM, Rocky Mountain States:
Tim Powers
+1.424.247.9207
tpowers@techbriefs.com

Northern CA, WA, OR, Western Canada:
Craig Pitcher
+1.408.778.0300
cpitcher@techbriefs.com

International

Europe – Central & Eastern:
Sven Anacker
Britta Steinberg
+49.202.27169.11
sa@intermediapartners.de
steinberg@intermediapartners.de

Europe – Western:
Chris Shaw
+44.1270.522130
chris.shaw@chrisshawmedia.co.uk

China:
Alan Ao
+86.21.6140.8920
alan.ao@sae.org

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

South Korea:
Eun-Tae Kim
+82-2-564-3971/2
ksae1@ksae.org

Integrated Media Consultants

Angelo Danza
+1.973.874.0271
adanza@techbriefs.com

Christian DeLalla
+1.973.841.6035
christiand@techbriefs.com

Casey Hanson
+1.973.841.6040
chanson@techbriefs.com

Patrick Harvey
+1.973.409.4686
pharvey@techbriefs.com

Todd Holtz
+1.973.545.2566
tholtz@techbriefs.com

Rick Rosenberg
+1.973.545.2565
rrosenberg@techbriefs.com

Scott Williams
+1.973.545.2464
swilliams@techbriefs.com

SUBSCRIPTIONS

+1.800.869.6882
AEI@kmpsgroup.com

REPRINTS

Jill Kaletha
+1.574.347.4211
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SAE STANDARDS NEWS

Advanced-tech Standards activities at WCX

SAE's Global Ground Vehicle Standards (GVS) staff and committee members have a busy schedule lined up for this year's SAE World Congress Experience (WCX) in Detroit. The GVS team will meet and work on activities that include advanced technologies of automated driver-assistance systems (ADAS), autonomous vehicles, shared mobility, V2X, cyber security, and human factors, in addition to dozens of "traditional" subject areas.

The GVS staff is implementing new methods to expedite the standards development process for these increasingly complex engineering systems and rapid technology advancements, without violating fundamental rules of a consensus-based open process needed to ensure stakeholder participation and adoption. Visit sae.org for more details.

Activities slated for WCX include:

SAE Demo Days

New for 2019, SAE Autonomous Demo Days will be held at WCX. In partnership with **PAVE** (Partners for Automated Vehicle Education), SAE will offer participants the opportunity to experience the future of mobility through this special event that highlights the capabilities of autonomous vehicles.

SAE Autonomous Demo Days is a public-facing event created to give people hands-on experience with automated vehicles and to also reinforce engineering advancements designed to enable safety and show the differences between ADAS and automated functions.

Located on Steve Yzerman Drive (Atwater Street), this city street will be the stage for this driving experience. In addition to the experience of riding in an automated vehicle, SAE will conduct pre- and post-ride surveys to gauge comfort, confidence and trust around the autonomous riding experience. This valuable feedback will aid in product development and adoption.

There will be 3 public days on Friday-Sunday, April 5, 6 and 7, a VIP Day on Monday, April 8, and two days for WCX Attendees on Tuesday April 9 and Wednesday April 10.

Driving Skills Certification Ride and Drive

Sponsored by the SAE Driving Skills Standards Committee, the SAE J3300 Driving Skills Certification Ride and Drive will be held Tuesday, April 9 through Thursday, April 11, at Cobo Center, Hall B.

The SAE Driving Skills Certification Criteria establish skill levels to drive motorized vehicles in various configurations and environments. It includes the certification criteria required for a driver to demonstrate proficiency along with the facility and examiner requirements to accurately confirm a driver's performance.

Experience the driving skills required on the two ride and drive courses. One course will test the base foundational level-one driving skill and the second course will provide a trailer towing and backing course. Check sae.org/wcx or the WCX program for further details.

Jennifer Shuttleworth
Associate Editor
Jennifer.Shuttleworth@sae.org

Focus areas include ADAS, autonomy, shared mobility, V2X, cyber security and human factors, in addition to dozens of 'traditional' Standards subjects.

Auto cybersecurity study

Securing the Modern Vehicle: A Study of Automotive Industry Cybersecurity Practices report was released in February by SAE International and **Synopsys**, Inc. Based on an independent survey of global OEMs and suppliers conducted by Ponemon Institute, the report highlights critical cybersecurity challenges and deficiencies affecting many organizations in the automotive industry.

The Synopsys/SAE team has a robust schedule of activities aimed at sharing results with industry, including several webinars to discuss the survey methodology and finding. 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.

More information from an early-April strategic planning session will be announced at WCX, according to Tim Weisenberger, SAE Project Manager, Technical Programs Global GVS.

Upcoming standards for publication

Among the many standards in the works in the advanced-tech development areas, J2954 from the Hybrid EV Committee was voted on in mid March by the Motor Vehicle Council with plans to publish the document soon after. J3101 from the Cybersecurity team will be discussed during WCX. However, it is estimated to be about three months away from publication.

The second ballot in the voting process was to get underway as this issue of *Automotive Engineering* went to press. ■

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ICE sourcing opportunities throttle down

Ominous news for those suppliers whose core business is in combustion-engine powertrains: The pace of new engine-family launches is steadily slowing. It will plummet precipitously after 2021, as our **IHS Markit** data in the chart below reveal.

This, of course, is being driven by the long march toward a battery-electric future. In the short-to-mid-term, hybrid-electrics will help keep the ICE alive, along with a few unique, low volume, new engine programs. Development of all ICEs going forward will stress thermal efficiency gains, requiring further technology strides. But in the longer term, supplier fallout in this space is not far behind.

In an environment where there is reduced focus on traditional powertrain systems, existing players will hunker down. OEMs will aptly focus their attention to reducing costs—knowing that their bread is buttered elsewhere. Competition to utilize available capacity will heat up and margins will be under pressure—especially in market segments with more than a handful of players and global scale is an issue.

The dynamics look like a recipe for supplier consolidation—especially for regional players.

Michael Robinet
Managing Director
IHS Markit
michael.robinet
@ihsmarkit.com

The dynamics look like a recipe for supplier consolidation.

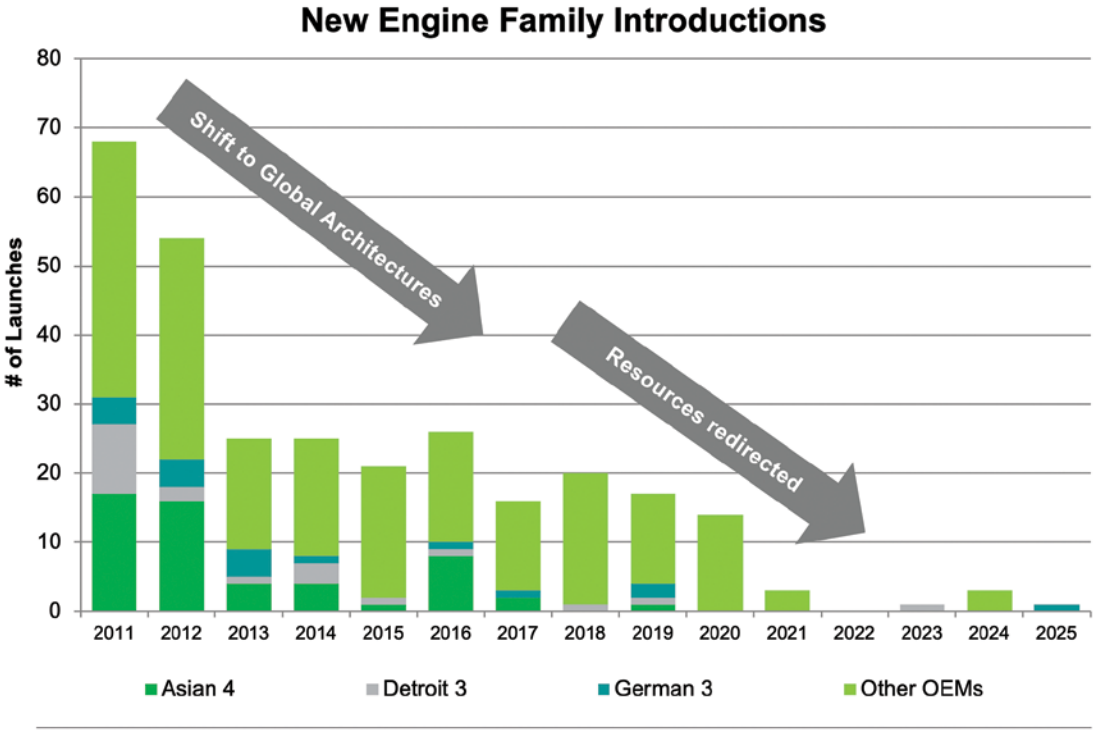
In the face of stronger competition, the supply base mostly looks upstream, but sometimes downstream, for the ability to add value. What may not have made sense in the past, may now be an interesting opportunity given the new market dynamics. Contemplating the capability to source sub-components internally (upstream) or adding further assembly into a larger system (downstream) may blunt pressure from OEMs to reduce costs for low-technology, low turnover components.

Nobody wants to be considered a 'commodity.'

Other factors may exasperate the impact of this shifting value equation and the emergence of new entities such as **GM Cruise**, **Ford Argo AI** or even supplier spinoffs such as **Aptiv** and **Veoneer**. Suppliers in North America which are over exposed to the Detroit 3 OEMs or to sedans/hatchbacks experience this shift in an extreme fashion.

For instance, North American light vehicle production is expected to be off ~1% for 2019 and another ~2% for 2020 on a year over year basis according to IHS Markit. Total Detroit-3 production volume in North America is forecast to be off ~4% this year and another ~5% next year. Several suppliers are over-indexed to these poor-performing market sectors.

In the end, the combination of a plateauing production environment, less-than-favorable volume shifts beneath the top line, and the disruption of declining opportunities for all-new powertrain opportunities, will shuffle tomorrow's supplier environment. ■



IHS MARKIT

WHAT WE'RE DRIVING

2019 Toyota Tundra TRD Pro

Toyota pickups fitted with gonzo oversize tires, long-travel suspensions and M1 Abrams-quality skid plates have been part of the U.S. off-roading scene since before "Ironman Ivan" Stewart won the Baja 1000 in 1993. His victory ride was developed by TRD, the automaker's U.S. race-engineering group, whose work is manifest in 2019 TRD versions of Tundra, Tacoma and 4Runner production models.

As with the off-road-oriented pickups from other OEMs, the Tundra TRD Pro delivers big fun on the rocks. But it demands some compromise as a daily driver, particularly in ride quality, unless your commute is in Colorado's San Juan mountains.

There is peace of mind, however, in knowing that the Pro is suspended by Fox aluminum-bodied shocks packing 46-mm pistons and internal-bypass valving. Those dampers combine with TRD-tuned springs to give two extra inches of body lift and 1.5 in. of additional wheel travel over a stock Tundra. This set-up comes in handy for playing Ivan in the dirt or for traversing suburban snow piles and parking-lot barriers.

But look beyond the tow hooks, hood scoop, forged-aluminum BBS wheels and booming TRD dual exhaust—which evokes a vintage Chris-Craft rumble at low rpm—and it's easy to see how badly **Toyota** needs an all-new base Tundra. The truck's driver interface and infotainment system have fallen behind those of the Detroit 3. Ditto the 6-speed automatic—a high-torque-capacity version of Aisin's 10-speed AWR10L65 can't come too soon. And why no locking rear diff?

Tundra, you need more than great fording ability to beat Ford.

Lindsay Brooke

Suzuki Vitara SZ5 Allgrip

For North American readers of this column, its title could be, in the case of Suzuki's latest turbocharged and all-wheel-drive (AWD) Vitara compact SUV, "What you are missing."

It's been six years since **Suzuki** stopped importing cars to the U.S. as sales dropped to an unsustainable level, its model range then simply not fitting the States' needs. Times change, however, and Suzuki's range now is greatly improved, led by the latest gasoline-engine Vitara SZ5 Allgrip, which we drove in Europe.

Unlike some worthy but dull SUVs, the Vitara Allgrip is more young filly than workhorse, with a smooth and free-revving 103-kW (138-hp) 1.4-L gasoline 4-cylinder that indicates Suzuki cars' links to the company's highly successful motorcycle business. The engine's **IHI**-supplied turbocharger is attached directly to the cylinder head and the exhaust manifold is incorporated into the cylinder head casting.

Curb weight including all options (there is a front-wheel-drive version) is a modest 1265 kg (2789 lb), so the car feels plenty lively, the sensation complemented by its optional 6-speed **Aisin** automatic transmission and 162 lb·ft (220N·m) torque spread from 1500 rpm through 4000 rpm.

The Vitara Allgrip's AWD has auto, sport and snow settings, differential lock and hill hold and descent controls. Ride quality is good and handling fits the car's exuberant performance, although steering is somewhat light for European tastes. What matters, though, is that the Vitara gets high marks as a total package.

Stuart Birch

2019 Hyundai Veloster R-Spec

I can't say the Veloster—even in its faintly less-funky, new-for-2019 second-generation skin—is a beautiful car. Unique and sort of "tuner-bait," yes, but beautiful, no.

Dynamically, the 2019 Veloster R-Spec is in line with the rest of the affordable-sport-coupe class—planted and reliably understeer-ish in fast corners, certainly better than a midsize sedan but mostly one-dimensional. Faintly communicative steering that sure doesn't improve with big throttle inputs in the lower gears.

The Veloster's new independent rear suspension (IRS) delivers enhanced suppleness and cornering/ride refinement, but doesn't do much for the understeer that defines the handling of just about every front-drive sport coupe.

The Veloster R-Spec's 1.6-L turbocharged 4-cyl. is a pleasure: elastic and uncomplaining, although a power peak at just 6,000 rpm is another aspect of this turbo-coupe class that takes some fun off the table. But the 201-hp Gamma is plenty punchy in the midrange and its flexibility means you don't have to overuse the standard (and only) 6-speed manual transmission, even if its action has been enhanced, **Hyundai** said, by short-shift specialist **B&M**. It does seem like the 26 mpg city/33 highway figures could be a little better, though, for 1.6 liters.

Hyundai's got plenty of good going on here with the second generation of its high-value sport coupe: willing engine and satisfying manual transmission, reliable handling, a useful (and unique) 3-door package, agreeable interior furnishings and a healthy list of standard equipment. The Veloster R-Spec is a lot of entertaining car for less than $24,000.

Bill Visnic

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ELECTRIFICATION

Honda E Prototype 'makes it simple,' again

The Honda e Prototype is a close look at Honda's upcoming production EV built on a new, dedicated RWD platform.

In 2017, **Honda**'s Urban EV concept pointed the way for the brand to escape its current busy and contrived design language in favor of clean, modern forms—and at the recent Geneva International Motor Show, the company unveiled the e Prototype, a preview of the production version of Honda's first electric vehicle.

The stark matte white sheetmetal remains in this production prototype, along with the signature gloss black single-frame grille, gloss black charging port in the hood and long-wheelbase, short-overhang proportions. The concept car's fashionable 20-in wheels have not carried over to the e Prototype, however, replaced by more-practical and cheaper smaller-diameter wheels.

The e Prototype gains a pair of rear doors that compromise the car's reference to the original Civic in its sloping C-pillar design, but is otherwise nearly indistinguishable from the Urban EV concept car. The body was switched from a 3-door hatchback to a 5-door design not only because so many customers demand easier access to the rear seat, but because the production version of the car is expected to operate in urban environments where space to swing open the long doors of a 3-door often doesn't exist, lead exterior designer Ken Sahara told *Automotive Engineering*.

The door-mounted sideview cameras on the new prototype would normally be dismissed as showcar bling to be replaced by conventional glass mirrors in production, but the company says that the cameras are production-intent.

Not for the U.S.

The decision to use sideview cameras is one reason why the e Prototype's eventual production successor will not come to the U.S. market, according to Sahara. The car's unsuitability for the U.S. offset frontal crash test is another factor, he added.

In addition to the sideview cameras, the car's sides are kept clean with pop-out door handles of the sort seen on the **Tesla** Model S; these too are production-intent pieces.

The central charging port location in the middle of the hood makes it easy to charge the e Prototype from either side. The car will accept an 80% charge in 30 minutes and it has a driving range of 125 miles (201 km). The lithium-ion battery pack is built into the floor of the dedicated EV chassis and the single electric motor is mounted in back, driving the rear wheels.

"The EV platform is really good for exterior design, because the rear engine allows for a short front overhang," Sahara said. Packing the batteries beneath the floor raises the cabin by 100 mm (4 in). "I tried to reduce that height visually by painting [the bottom edge of the car] black," he said.

Inside, the higher floor allowed designers to recline the front seats a bit, providing a comfortable position without putting the driver's line of sight too low, reported lead interior designer

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The wide glass dashboard panel incorporates multiple displays into a single pane.

The central hood-mounted charging port is a styling cue that also provides flexible charging access from either side of the car.

Akinori Myoui. "Because the floor was raised, the eye line is higher, so we got the best of both worlds," he said.

"I really love '60s cars and '70s cars because they are so simple," he said, explaining how the 1970s Civic influenced the e Prototype's design. The EV powertrain permits further simplification, with the replacement of the radiator grille with a solid black panel joining the circular headlights. "The cooling area of the car is really small because of the electric motor," he said. An internal-combustion engine would require triple the flow of cooling air, according to Sahara.

Honda anticipates applying the e Prototype's EV platform to other vehicles, as it has illustrated with concept cars like the Honda Sports EV Concept, which was a coupe interpretation of the Urban EV Concept.

"We want to make many types of products," concluded Sahara.

Dan Carney

PROPULSION

GKN demos eTwinster 2-speed, torque-vectoring BEV transmission

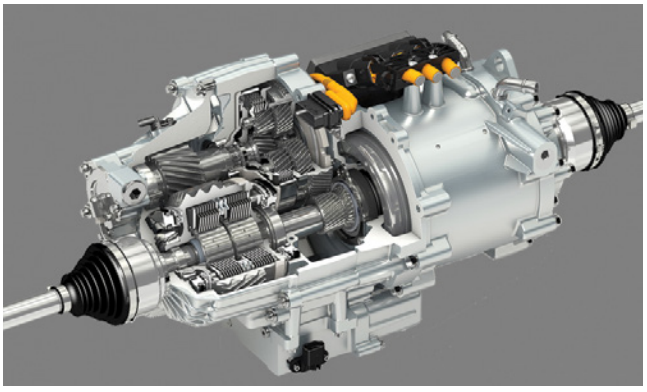
GKN Automotive unveiled what it claims is the world's first 2-speed, torque-vectoring transmission for battery electric vehicles (BEVs). Featured on GKN's 2019 Technology Demonstrator (GTD19)—a **Jeep** Renegade-based prototype—the EV-enhancing tranny was revealed to media during GKN's annual winter testing program in Arjeplog, Sweden.

Combining several advances in GKN's driveline technologies, the coaxial eTwinster transmission could improve BEV efficiency as well as straight-line and handling performance. The new 2-speed "seamless shift" eTransmission has the potential to extend vehicle range while also providing increased torque for improved acceleration and a higher top speed, all while using smaller electric motors. Efficiency and further powertrain downsizing are enhanced by the eTwinster's coaxial layout, while improved stability and dynamic performance are possible thanks to its torque-vectoring capabilities.

"This new technology demonstrator showcases how we are evolving and improving integrated eDrive technologies to help OEMs," said Hannes Prenn, COO of GKN ePowertrain. "Our dedicated focus on production and development of electrified drivelines will enable us to support the rapid acceleration in demand for BEVs equipped with all-wheel drive systems in the coming years."

Two speeds, extended capability

On the GTD19, the donor Jeep Renegade had its entire powertrain removed to turn it into a full BEV, with GKN integrating its new 2-speed eTwinster system onto the front axle. The Renegade's internal combustion engine was replaced with a 120kW (161hp)/220 N·m (162 lb·ft) GKN e-motor, which thanks to the two-speed transmission's reduction ratio can deliver 3,500 N·m to the front axle and vector 2,000 N·m to either front wheel when required. The eTwinster's GKN-developed software manages automatic shifting of the 2-speed transmission, which



The new GKN eTwinster 2-speed e-axle system combines a compact e-drive with a twin-clutch differential, torque vectoring and a two-speed electric transmission.

FROM TOP: HONDA; HONDA; GKN

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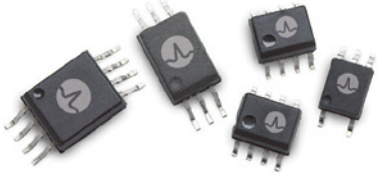
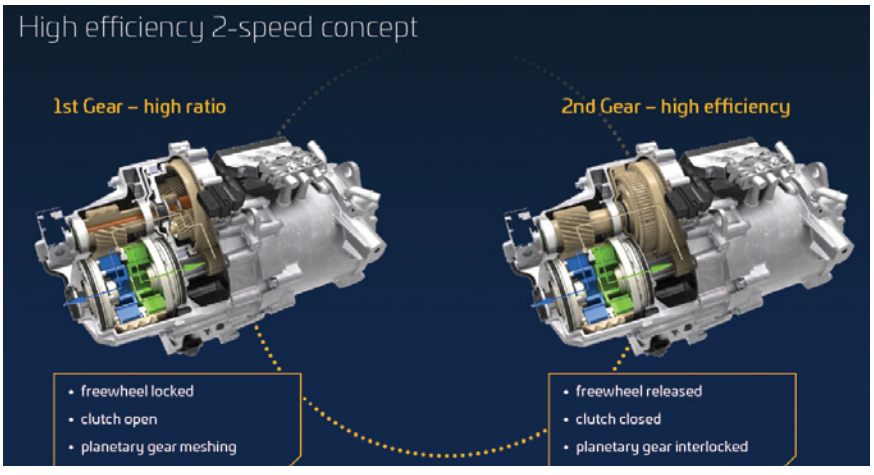


Retrofitted with GKN's new eTwinster, the company's technology demonstrator shreds the snow- and ice-covered Swedish test track.



The eTwinster's 2-speed transmission can enable downsizing throughout a BEV powertrain.

is tuned to minimize power and torque losses during changes.

"It's not a big electric motor," explained Andreas Mair (below), GKN's senior director of AWD and e-drive systems, of the unit installed in the GTD19. "It's permanent magnet, more or less standard traction-motor technology. But with a 2-speed, you reach the required torque for a pure electric vehicle: 220 Newton-meters times 10 would give you around 2,000, which is not enough [torque] for a pure electric vehicle. With our two-speed technology, with a first gear and a reduction ratio around 17:1, you reach 3,500 Nm. That's the perfect fit for a rather small, 120-kW electrical motor, [but] the torque speed range is much larger with a 2-speed."

Torque-vectored FWD

Unless you get to drift your way to work each day, torque vectoring likely provides larger real-world benefits with FWD than in rear- or all-wheel drive (AWD) configurations. These include modulation of an electric motor's high initial torque for improved stability, while also assisting in lateral control for improved FWD dynamics by prioritizing torque delivery to the outer wheel to help correct understeer yaw moments.

"In the front, obviously it helps you to overcome the understeering behavior of a front-wheel-driven vehicle," Mair explained. "And because the Twinster can put the torque to the wheel where it is required, you reach a very nice performance for a [FWD] vehicle."

GKN claims its 2-speed coaxial layout is significantly smaller than systems with equivalent power outputs, permitting the eTwinster to be more easily integrated into existing vehicle platforms. It's also adaptable for use across vehicle-size segments in FWD, RWD or AWD applications as a primary or supporting axle.

Low-mu performance

In the multiple low-traction environments of GKN's Wintertest, media had the opportunity to sample the eTwinster-equipped GTD19 on steep, split-mu setups, as well as on layouts arranged on the Colmis Proving Ground's frozen lakes. Using only active (non-brake-based) assist, the GTD19 was able to easily climb the steep, split-mu gradients absent any significant steering-wheel tugs.

On the dynamic-handling course, the 2-speed allowed the GTD19 to accelerate smartly and with stability, lacking any FWD torque-steer drama thanks to the limited-slip function of the Twinster-based tech. Though seat time in the prototype was limited, the 2-speed's gear changes remained imperceptible.

Paul Seredynski

BOTH IMAGES: GKN

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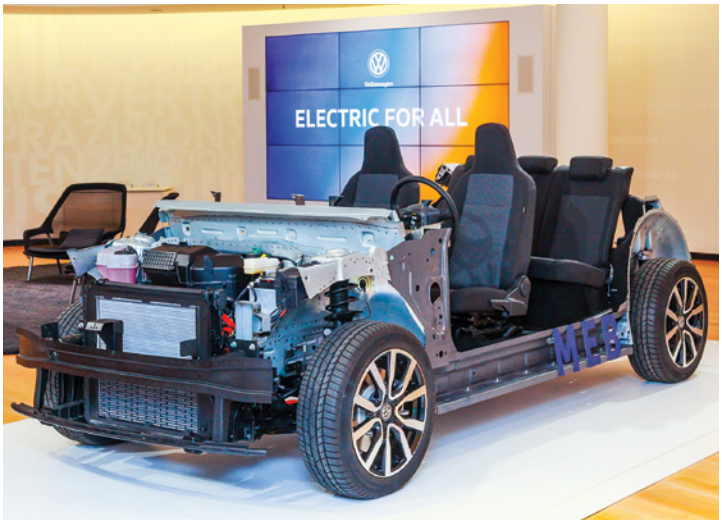
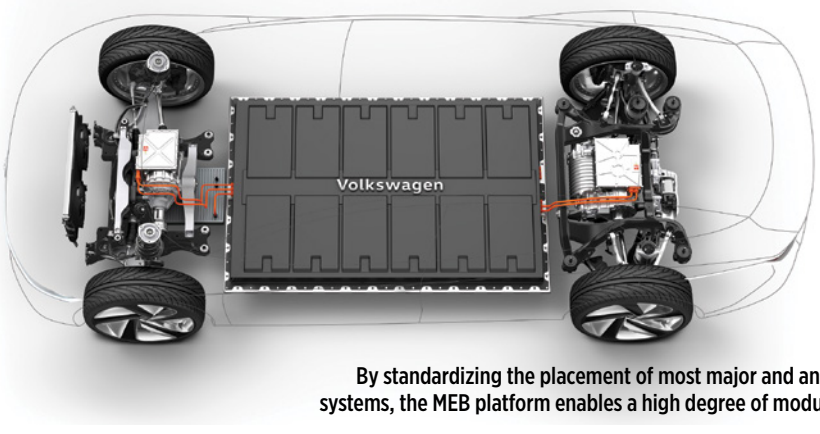
ELECTRIFICATION

VW's MEB platform: a modularity enabler



The MEB platform will be the foundation for compact and midsize EVs, Volkswagen said.



By standardizing the placement of most major and ancillary systems, the MEB platform enables a high degree of modularity.

Volkswagen's MEB, an in-development chassis designed strictly for electric propulsion, enables a modular battery layout that can provide a **Volkswagen Group** electric vehicle (EV) with an estimated 200-mile to 300-mile (322-km to 483-km) driving range. Slated to debut in 2022 as the underpinnings for EVs produced in North America at the automaker's Chattanooga, Tennessee assembly plant, VW's MEB is intended for compact to midsize A- and B-class vehicles.

"What we're investing in with MEB is a dedicated platform for electric vehicles to achieve packaging efficiency, more cabin space and more energy," Matthew Renna, Vice President of the E-Mobility Product Line for Volkswagen North American Region, said during a recent MEB workshop for media in Chicago.

The automaker's work with electric vehicles dates back several decades, but its 2015 model-year introduction of the e-Golf was transformative with its estimated 70- to 90-mile (113- to 145-km) driving range. Four years later, the 2019 e-Golf increased the estimated driving range to 125 miles (201 km) via a 100-kW traction motor and 35.8 kWh lithium-ion battery pack. E-Golf's battery modules are packaged inside the center tunnel, in front of the rear axle and below the rear seats.

"Because the MEB is a dedicated EV platform, we are not packaging battery packs around existing systems and crash structures as we have done with the MQB [e-Golf platform]," Renna said, referencing VW's modular architecture for transverse front-engine FWD or AWD vehicles.

MEB gained engineering momentum with lessons learned from VW's first all-electric compact car for the U.S. market. "The MEB would not exist without the e-Golf," Renna said, "We learned a lot about how battery systems work, how the chassis interacts with batteries and how customers use our electric car.

MEB: The next step

Flexibility and modularity are hallmarks of the upcoming MEB. The flat underbody is designated for battery packaging, with auxiliary power units for HVAC and other ancillary systems integrated into the e-vehicle's front end. The drive motor, power electronics and single-speed gearbox are packaged as an integral unit.

MEB will be configured as a RWD or AWD architecture for a variety of vehicles (likely including 4-door sedan, crossover and minivan) fitted with lithium-ion batteries. "Our strategy is to use pouch and/or prismatic cells because those allow for packaging flexibility and we can cool the cells more efficiently," Renna said.

The biggest engineering challenge with MEB is on the software side. "For us, the future of EVs involves over-the-air updates, autonomous-driving capabilities and additional apps and services," Renna said, adding, "We need all of the e-car's smart devices to communicate information under high-voltage conditions and do that in a really robust way. All of that work is coming along very well."

The VW Group plans to invest $38 billion in electric vehicle technology, which includes 16 dedicated e-mobility factories around the globe. In North America, VW's centerpiece for electric vehicle manufacturing is its plant in Chattanooga. By 2025, the VW Group expects to launch no fewer than 50 EVs. The MEB platform will be used by most VW Group brands, including VW, **Audi**, **SEAT**, **Skoda** and **VW Commercial Vehicles**.

Kami Buchholz

BOTH IMAGES: VW

TESTING

Not drive-by-wire—drive-by-CAN

Test-system specialist **AB Dynamics** has developed new drive-by-wire technology that enables test vehicles—including autonomous vehicles (AVs)—to be driven entirely via a CAN or ethernet connection, without the need for a human driver or bulky physical robotic actuators. Positioned as a cost- and hardware-saving alternative, the Flex-0 system complements existing driving-robot systems and is already in use by Volvo for a range of advanced test applications.

According to Andrew Pick, business director at Track Test Systems, widespread use of electronic vehicles systems permitted AB Dynamics an opportunity to control the vehicle directly through its CAN network, using a path-following approach but eliminating much of the test hardware that is normally required.

"Conventionally, the hardware installed for an objective vehicle test would include a steering robot, pedal robots, control system, data logger and a motion pack," Pick explained. "But a Flex-0 installation requires only the motion pack and a much more compact control system, which simplifies and speeds up installation and intrudes less into the cabin space."

Importantly, the Flex-0 drive-by-wire setup shares the same software interface as the company's driving robots and ADAS targets, allowing users to copy existing test profiles between the two systems. The GPS motion pack installed in the vehicle provides feedback on position, enabling Flex-0 to be used for a wide range of tests. **Volvo** has investigated using Flex-0 in the Euro NCAP AEB test, ISO 3888 double-lane change, steady-state cornering and off-road testing.

Regarding complex test scenarios, such as those that arise during AV and ADAS development, Pick noted that Flex-0 creates new possibilities. "Testing autonomous vehicles requires complex traffic scenarios involving multiple vehicles," he said. For these tests, Guided Soft Targets (GSTs) can be used where there is potential for a collision, but other "background" traffic away from the risk of collision can be populated by regular cars using Flex-0 as a method of synchronized control.

Fiercely protective OEMs

There are situations where robot control is more appropriate than Flex-0, which is why AB Dynamics considers the two technologies to be complementary. For example, Pick explained, individual OEMs are "fiercely protective" of their CAN command formats. This confidentiality means robot actuators are still required where access to the CAN network is denied, such as during competitor-vehicle benchmarking, or testing

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Typical robotic-driving hardware configuration. AB Dynamics' new Flex-0 does not replace it for all scenarios, can be a complementary system.

Space to spare – AB Dynamics' Flex-0 test system for specific tasks avoids hardware cabin clutter.

undertaken by third party agencies.

Robots will also remain for dynamic tests involving extreme steering inputs, where the force required for the maneuver exceeds the vehicle's steering system capability when commanded by-wire. "For those, our established systems can position a vehicle repeatedly to within 20mm thanks to path-following and speed control using GPS feedback," Pick said, "eliminating driver fatigue during arduous off-road and durability testing by enabling control from outside the vehicle."

To minimize constraints imposed by CAN confidentiality requirements, AB Dynamics has configured Flex-0 to output in a standardized format, allowing manufacturers to implement their own conversion to suit the vehicle. OEMs can enable access to their vehicles by providing an interface between the Flex-0 CAN output and the data format required by the vehicle. "This typically requires only a small real-time processor to run the interface," Pick stated, "such as a **dSpace** Micro Autobox, and means that the customer does not need to disclose details of its by-wire interface to third parties."

Stuart Birch

CHASSIS | SUSPENSION

Porsche's 911: Not slippery when wet

Porsche has provided detail on its new Wet Mode technology for its latest, eighth-generation (aka 992-series) 911 coupe. The assistance system, which "listens" for potential wet road danger indicators, has been developed to detect significant wet conditions and deliver a solution for increased driving stability. Described as a "world first" it is a contribution to safety, and something that drivers of early air-cooled 911s (which could present very rapid oversteer situations) would have welcomed with relief.

Unlike some overly enthusiastic ESC systems that can become intrusive—taking the edge off the true dynamic capabilities of a chassis and dulling driver enjoyment—Porsche has undertaken to achieve a "grown-up" solution that supports the driver but doesn't become intrusively dominant.

August Achleitner, internationally known as "Mr. 911" (and until his semi-retirement early this year, head of 911 series), explained: "It does not restrict the maximum power of the engine or limit the top speed and should therefore also not be used as insurance for driving too fast in very wet conditions. Instead, it should be seen as an assistance system in the truest sense."

Aquaplaning is an event that will concentrate the driver's mind in any vehicle, but particularly so with very high-performance sports cars. The new system can automatically detect a wet road via acoustic sensors in the front wheel housings that register "swirled-up spray" and warn the driver of the potential risk. This makes it fundamentally different from windshield-wiper rain sensors, which only react to water droplets on the windshield independently of road conditions, stated Porsche.

System-integration umbrella

Although the rain may have stopped, Wet Mode will detect standing water (and the possibility of aquaplaning), with the Porsche Stability Management (PSM) and Porsche Traction Management (PTM) systems responding "earlier and more sensitively" than in less-challenging conditions. The driver receives a visual warning positioned alongside the car's centrally positioned

Porsche's new "wet mode" recalibrates several individual electronic and mechanical systems to impart more baseline stability for wet-road security.

FROM TOP: AB DYNAMICS; AB DYNAMICS; PORSCHE

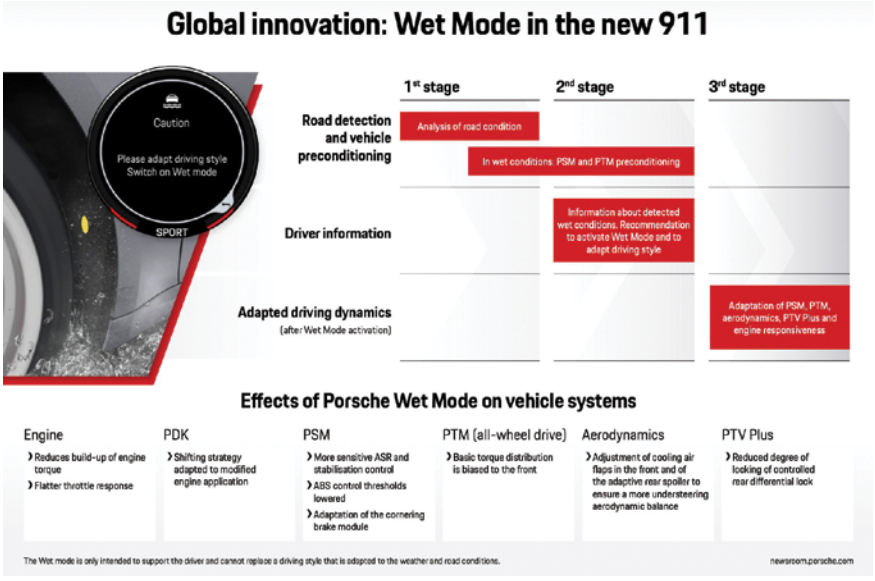
tachometer and has the option of switching on Wet Mode via buttons either on the center console or on the steering wheel, integrated in the mode switch for the optional Sport Chrono Package.

Once activated, the system integrates beneath one technology-management umbrella. The PSM, PTM, adaptive aerodynamics and optional Porsche Torque Vectoring (PTV) Plus all coordinate to support driving stability. Also, from 56mph (90km/h), the 911's rear spoiler deploys to a "performance position," engine-cooling air flaps open, the accelerator pedal action changes and the PSM Off function and Sport mode can no longer be activated.

There's more: Engine mapping also is modified, with torque delivery becoming more smoothly linear and the shift strategy of the optional eight-speed PDK transmission is suitably adapted. The AWD 911 Carrera 4S adds to this list, with torque bias favoring the front axle to support added stability. Reduced locking ratios of the electronically-controlled rear limited-slip differential also change. Wet Mode also embraces snowy conditions with driver selection.

Stuart Birch

PORSCHE



2019 S60 and V60 Volvo's newest chips in the transformation game

The 2019 S60, now in its third generation, comes off the line at Volvo's new assembly plant in Ridgeville, South Carolina.

They're not the crossovers buyers in almost all major world market currently crave, but **Volvo**'s 2019 S60 midsize sedan—and to a lesser extent, its V60 station wagon counterpart—are significant indicators of this niche brand's intent to stay viable in an auto market in upheaval over transformative technology.

And transformative economics: the S60 is the first model to come from Volvo's new $1.1-billion assembly plant in Ridgeville, South Carolina. At least for now, the V60 wagon will be built in Europe; in 2021, the Ridgeville plant will phase in the next-generation XC90 crossover, said Anders Gustaffson, senior vice-president Americas and president and CEO of Volvo Cars USA.

Although most of the new, third-generation S60/V60 range is conventionally-powered, the line-topping T8 and the **Polestar Engineered** performance-oriented variant of the T8 are the real markers for where Volvo's heading. The T8 models inject plug-in hybrid-electric components to simultaneously allow all-electric drive, enhance fuel economy and performance while also reducing emissions—and incorporate standard all-wheel-drive (AWD). This electrification play is important, because Volvo had promised that starting in 2019, all new models will be available with an electrified-powertrain choice.

Apart from the obviously updated (almost entirely for the better), slinkier sheetmetal, there are dimensional changes—an increase of 3.8 in (97 mm) in wheelbase and 4.9 in (124 mm) in overall length—coming from now being on Volvo's Scalable Product Architecture (SPA) meant to underpin virtually of all Volvo's model lineup. Where the plot gets a little hard to follow is the stairstep of driveline options.

The T5 is front-drive only, getting 250 hp and 258 lb·ft (350 N·m) from the slightly stroke-biased turbocharged 2.0-L 4-cylinder that is the modular foundation of all Volvo IC-based powertrains. Easy enough.

Going to the T6 variant of either the S60 or the V60 brings the same engine, but with the addition of supercharging to aid low-speed torque and mitigate turbocharger lag. This arrangement is good for 316 hp and 295 lb·ft (400 N·m); the max torque comes over a lusciously broad range that starts at 2200 rpm and AWD is standard equipment. And stick with us here: for the T6 models, AWD comes old-school way, with a BorgWarner-supplied mechanical coupling linking the transverse engine up front and the differential at the rear axle.

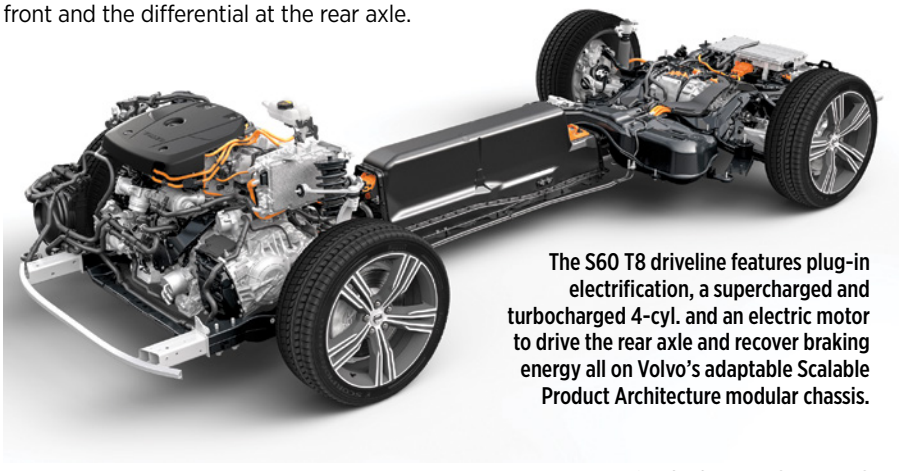
"Twin-Engine" revolution

The technically intriguing (and complex) T8 driveline is what Volvo likes to call a "Twin-Engine" plug-in hybrid-electric (PHEV) setup. Once again, the turbo- and supercharged 4-cyl. is up front, now tuned for 313 hp (3 hp less than the T6 configuration) and the same 295 lb·ft (Polestar: 317 hp and 328 lb·ft).

Meanwhile, the T8's electric rear axle drive (ERAD) comprises a 65-kW (87-hp) permanent-magnet traction motor with a liquid-cooled stator. The motor weighs just 75 lb (34 kg). It drives the S60 on its own when the car is operating in EV-only mode; it imparts all-wheel-drive and acceleration boost when required, plus provides braking/coasting regenerative ability to help recharge the battery pack.

But that's not all; up front, the 2.0-L engine for T8 models features a crankshaft-integrated starter generator. This electric machine has 34 kW (46 hp) peak power used to start the engine, charge the battery and provide its own boost to the engine. This starter-generator also is liquid-cooled and weighs about 40 lb (18 kg). It can inject as much as 150 N·m (111 lb·ft) of torque to the engine crankshaft. Blend all this—IC engine, starter-generator and rear electric motor—and Volvo calculates total system power for the T8 at a thumping 400 hp and 472 lb·ft (640 N·m).

The power for the ERAD comes from 96 lithium-ion cells packaged in the central tunnel; the battery-pack capacity is



The S60 T8 driveline features plug-in electrification, a supercharged and turbocharged 4-cyl. and an electric motor to drive the rear axle and recover braking energy all on Volvo's adaptable Scalable Product Architecture modular chassis.

BOTH IMAGES: VOLVO

The Polestar Engineered variant of the S60 T8 shows the placement of the battery pack in the center tunnel.

VOLVO

10.4 kWh and adds 113 kg (249 lb) to the T8 models' curb weight. It accepts power from the grid-connected plug (Volvo gives owners a clever 110V/220V cable), vehicle regenerative braking or the engine-connected starter-generator. Plugged in at 220V, the company said the battery can be fully recharged in 2.5 hours.

Purposeful performance

Maximum electric-only driving range is 21 miles (34 km), with **EPA** fuel economy figures of 27 mpg city/34 highway and 72 MPGe. The full collaboration of turbocharging, supercharging and two types of electric boosting summons 60 mph (97 km/h) in a blistering 4.4 s; if this is "mild" electrification we'll take it. The offsets are a plump-ish curb weight (around 4300 lb [1950 kg] is our best estimate until Volvo deals out an official figure) and the T8's plump starting price of $54,400—although that's hardly out of line for competitors of similar size and performance, such as **Audi**'s S4 or your pick of the multitude of souped-up **Mercedes-Benz** compact-midsize sedans.

The T6 variant of the new third-gen S60 is no slug, either, and the handsome and comprehensively-equipped R-Design trim shows off the S60's new sheetmetal to best effect. Driving time in the Polestar Engineered was a combination of mostly exhilarating damped by a few downers, not the least of which being the fact that Volvo offered only 20 copies for the U.S.—that's correct, two-zero—through its Care by Volvo subscription service and they all were "subscribed" in less than an hour. Volvo execs said more Polestars will come (we speculate component supplies may dictate some of the measured rollout) and the full electric vehicle (EV) Polestar 2 the brand displayed at the recent 2019 Geneva motor show was a spectacular sight.

But for now, the S60 T8 and Polestar Engineered are immensely desirable performance sedans that are serious examples of electrification's potential. The combination of gasoline engine and rear electric motor seems an almost ideal arrangement and the S60's startling, linear acceleration is inimitable by most conventional standards. We wish the brake pedal wasn't so wooden and the T8's system weight was less obvious, but if and until full EVs are ready for mainstream duty, Volvo's got the best transitional solution we've tried.

Bill Visnic

Honda fills a gap with 2019 Passport

You may think that by now, just about all full-line automakers have every crossover/SUV segment covered. Small, medium and large, just like it used to be with sedans.

Honda didn't see it that way, though. The best-selling CR-V is the company's "small" crossover (assuming you don't altogether consider the smaller HR-V a crossover) and the 3-row Pilot is the large entry—with nothing in between.

With so many new and established "upper-midsize" competitors such as **Chevy**'s Blazer, **Ford** Edge and even the **Jeep** Grand Cherokee, Honda didn't see the CR-V as adequate for the midsize segment, particularly those with upscale aspirations. Honda being one of the more effective re-purposers of existing vehicle architectures, its engineers and planners looked at the Pilot and saw potential for sawing out the third-row seating and creating what essentially is a two-row version. Recalling the Passport nameplate leverages the fairly positive equity the badge had when last produced in 2002.

Two rows, similar dimensions

A Pilot with similar dimensions and just two rows of seats is an efficient way to get a midsize crossover that's roomier and a little more sumptuous inside than a CR-V—and the new Passport's 6.2-in (158-mm) shorter length on the same 111-in (2819-mm) wheelbase as the Pilot imparts a certain purposeful stance; the extra 1 in (25 mm) of ground clearance, at 8 in (200 mm) overall for all-wheel-drive models, collaborates with the new Passport's tougher-looking front fascia to create some visual distance between it and the soccer-mom CR-V and Pilot.

The 2019 Passport's styling projects more offroad potential than any of Honda's other crossovers.

The Passport is based on Honda's Global Light Truck vehicle architecture; its body structure is more than 50 ultrahigh- or high-strength steel.

And yes, you could interpret that difference as being more "off-roady."

Lara Harrington, chief engineer for the 2019 Passport, takes a determined run at supporting Honda's assertion that the new-age Passport sports enhanced off-road capabilities, but apart from the raised ground clearance and the improved approach and departure angles it enables, as well as a bit of up-tuning of the suspension, the Passport doesn't really bring anything tougher than the Pilot's (and Ridgeline pickup truck) Global Light Truck architecture doesn't already offer.

At least give us a couple of vestigial skid plates, journalists beseeched. Or a locking rear differential. But Honda sees the visual cues as sufficient for the purpose. Given how almost all SUVs are used, we can't argue.

Particularly when the 2019 Passport's road manners are so decent. The damping is supple and not at all knobby or wobbly and the slightly quicker steering ratio permits a certain harmony with twisting roads, although the Passport can't quite be called a pleasure to hustle through the curves. And since roughly 56% of the body structure is high-strength or ultrahigh-strength steel, there's a definitive feeling of solidity in cornering or off-road pounding.

The Passport driveline also is taken from the existing GLT-platform models, its direct-injection 3.5-L V6 generating 280 hp and 262 lb·ft (355 N·m). The only transmission is Honda's new-ish 9-speed planetary automatic supplied by ZF, manipulated by Honda's polarizing push-button arrangement in the center console that looks pretty hip and certainly does save space, regardless of your opinion about its functionality. And we do think it could find its favored ratio with a bit more alacrity.

The Passport's three lower trim levels—Sport, EX-L and Touring—are front-wheel-drive, with AWD being a $1,900 option. It's not everyday AWD, though: like the Pilot and Ridgeline, the 2019 Passport is fitted with Honda's over-achieving Intelligent Variable Torque Management (i-VTM4) that imparts "genuine" torque vectoring (single-wheel overspeeding) at the rear axle; up to 100% of the maximum 70% of drive torque that can be directed to the rear axle can be apportioned to either rear wheel.

The i-VTM4 system also incorporates Normal, Sand, Snow and Mud settings that are surprisingly effective at optimizing traction and torque delivery and is another feature that inspired Honda to expound the Passport's off-road poten-

HONDA

tial; the company provided bountiful (and beautiful) off-road driving in Moab, Utah to prove its point—and we'll admit that we put the Passport through banging and pounding that we wouldn't consider advisable for many of its competitors, although the hard-pack and rock trails wouldn't be considered impassible for most crossovers—if taken at slower speed than we blasted through in Passports for which we aren't making the monthly payments.

Purposeful interior

The new-generation Passport's cabin essentially is standard-issue Pilot/Ridgeline fare, which is to say adequately upscale without being overly luxurious. And that's okay—the perception is sufficiently upmarket from the CR-V, while not being so luxurious or fussy as to make one feel irresponsible if it does get smudged with some trail mud.

The most obvious advantage to the Passport's packaging is the abundance of cargo space owing to the absence of a third-row seat. The second-row bench slides fore and aft and with the seatbacks lowered, there's a bounteous 77.7 cu ft of cargo space, plus bonus storage in the clever underfloor locker.

Of course there are USB ports and all the connectivity anyone could desire and all Passports come standard with the Honda Sensing package of advanced driver-assistance (ADAS) features that includes adaptive cruise control, collision mitigation and forward-collision warning, lane-departure warning and lane-keeping assist and road-departure mitigation.

Bill Visnic

Tesla unveils Model Y 'crossover'

TESLA

As *Automotive Engineering* went to press, Tesla revealed the latest addition to its lineup, the Model Y. Based extensively on the structure and steel-intensive body of the 'entry-level' Model 3, the new Model Y has a hatchback instead of the Model 3's trunk and offers the same matrix of single- and twin-motor drive configurations and battery-range capacities. There also was speculation the Model Y could be built at Tesla's battery-production 'gigafactory' in Nevada rather than the company's main assembly plant in Fremont, California.

Nissan Leaf finally gets more range

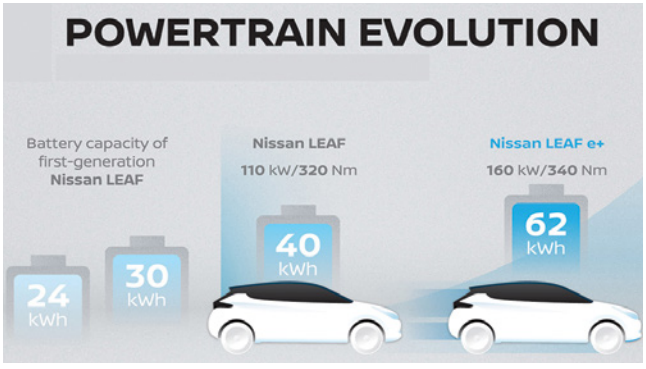
After a long wait, Nissan's Leaf, the seminal affordable EV, gets a higher-capacity battery—plus a more-powerful drive motor.

The 2019 Leaf Plus has a longer driving range and provides quicker acceleration than its platform-sharing counterpart, the second-generation Leaf, thanks to a higher-output motor and additional battery cells. **Nissan**'s most-powerful electric car yet claims a 226 mi (321 km) driving range, outpacing the standard Leaf's 150 mi (241-km) driving range. The Leaf Plus is in league with other longer-range EVs, including the **Chevrolet** Bolt, **Hyundai** Kona and **Tesla** Model 3.

All Leaf models (first introduced in MY2011) package lithium-ion batteries under the floor between the axles. "The key engineering challenge for us was adding 50% more battery capacity into an existing packaging space," said Nathan Herbrandson, North American program development manager for the Leaf, during a recent Leaf Plus media intro in southern California. The Leaf's 40-kW·h battery pack has two layers of modules (192 cells), while the Leaf Plus's 62-kWh pack has three layers of modules (288 cells).

The Leaf Plus uses a flexible modular battery architecture to vary the number of cells that can be stacked in a module, providing a 68 mm (2.7-in) height increase compared to the Leaf. In addition, the 'dead space' between the cells

NISSAN



Nissan Leaf battery pack evolution.

created by the cell-tab jointing process was reduced by 20 mm (0.8 in) through laser welding. There are also fewer structural parts on the Leaf Plus as the first layer of cell modules were affixed directly to the floor.

"Engineers looked for every opportunity to get additional battery capacity using the underfloor space, because customers aren't willing to give up interior space, even for longer range," Herbrandson said. Unlike most of the entrants in the segment, the battery pack in the Leaf Plus remains air-cooled.

While the Leaf's AC synchronous electric motor produces 110 kW (147 hp) and 320 N·m (236 lb·ft), the Leaf Plus motor provides 160 kW (214 hp) and 339 N·m (250 lb·ft). The additional juice translates to stronger acceleration, with Nissan claiming a 10% quicker 0-100 km/h (0-62.5 mph) time, and a 13% quicker 82-120 km/h (50-75 mph) time. "The size of the motor didn't change, we're just getting more capacity," said Herbrandson, noting that additional structural reinforcements were necessary to handle the increased power.

Battery recharge times for the Leaf Plus are estimated at 11.5 hours for a full charge at Level-2 (240V). With quick charging, the timeline is 60 minutes for an 80% charge with 50 kW DC and 45 minutes with 100 kW DC. Nissan officials did not provide specific information relating to battery performance in cold weather, but a cold-weather package (including heated front seats/steering wheel/side mirrors) is offered on both the Leaf and Leaf Plus.

"The cold-weather package has a hybrid heating unit that uses a coil system and a forced-air heat pump system to deliver 30% more efficiency in terms of heat creation," noted Brian Maragno, Nissan North America's Director of Marketing and Sales Strategy for Electric Vehicle Operations. "In doing that, it doesn't require as much energy from the battery, leaving more energy in the battery for driving."

Other Leaf Plus features include a new infotainment system with an 8-in display and customizable home screen, a next-generation navigation and audio platform that enables software updates to be wirelessly downloaded directly to the vehicle, as well as standard intelligent forward collision warning and rear-door alert.

Kami Buchholz

NISSAN

Transforming ZF

Steering toward the AV future in a ZF driving simulator.

The Tier 1 giant re-gears for the new-mobility *zukunft* by adopting a new way to drive technology innovation. It still makes transmissions, too.

by Lindsay Brooke

"*We are looking for a new colleague in the Digitalization department*," announced the job opening posted online February 28, 2019. The position: Artificial Intelligence Engineer.

If hired, your responsibilities will include "designing and implementing AI algorithms in a big data environment, and developing new methods to improve production processes and products such as Hybrid Transmissions." You'll collaborate to develop competency for data analytics and coordinate an agile AI team.

Well-qualified candidates should be experienced in "development and application of data mining algorithms and artificial intelligence," the posting said. They should have "good coding skills in the languages and toolkits of your choice for Machine Learning and data visualization."

If hired, you'll be working in a picturesque city alongside one of the world's most beautiful bodies of water. A view of San Francisco Bay, perhaps? No—but Lake Constance is just as fetching. This opportunity is in Friedreichshafen, in southern Germany. Your new employer: **ZF** GmbH.

Zed Eff? Artificial intelligence and data mining? The company that's been making transmissions of all sizes

ZF

Zukunft Ventures head Torsten Gollewski: "We want to connect the big ZF ship with the 'speed boats.'"

ZF

and types since Zeppelins roamed the sky has been deftly re-gearing itself in recent years. It has rapidly expanded its product portfolio beyond the traditional mechanical driveline, steering and chassis systems that underpin its brand globally.

Those profitable core businesses fund future-tech developments in what ZF executives dub "system houses"—electrification (e-mobility), vehicle motion control, integrated safety, and autonomous driving.

"In e-mobility and autonomy alone, we're investing 12 billion euros over the next five years," Aine Denari, ZF's senior VP of advanced driver-assist systems, told *Automotive Engineering* at CES 2019 during a taping of the Autoline TV show. The major outlay, she noted, shows "the huge growth we see in this industry" as it transitions from combustion engines to electric power,

"In the Electromobility race, you have to speed up. And we need the smaller companies to speed us up."

and from personal vehicle ownership to various mobility alternatives.

The industry dynamics are "a tsunami," observed Mamatha Chamarthi, ZF's new chief digital officer, at CES. Software, and the data stream, are "the new treasure trove," she says. And because tech companies, generally, are more optimally versed than most Tier 1s in these spaces, ZF made strategic decisions—"radical and controversial at the time," says one top manager—to leverage that expertise in a swift, transformative way.

Filling key tech gaps

First came the $12.4 billion purchase of **TRW** Automotive Holdings, finalized in 2015. Integrating the U.S.-based safety systems giant, with virtually no business overlap, created a dynamo in occupant safety and driver-assistance tech. "The companies were a remarkably good fit in terms of talent, resources, and ZF's vision," noted Andy Whydell, a TRW veteran who is ZF's VP of global systems product planning. TRW brought a strong foundation in electronics and controls know-how. Then came Zukunft Ventures.

Formed in 2016 as ZF's private equity unit, Zukunft (German for "future") Ventures is charged with identifying and investing primarily in start-up companies whose technologies could be profitable products, game-changers, or both.

"While you can find interesting technology start-ups in Europe, Israel and the U.S., and so on, what we're aiming for with **Zukunft Ventures** is to accelerate ZF's transformation from a transmission-based 'big group' into a company which addresses the main future challenges in mobility," explained Torsten Gollewski, head of ZF's advanced R&D group and general manager of Zukunft Ventures.

Internal VCs are not unique to ZF, nor is building advanced-tech muscle through industry partnerships. And it seems every automaker is calling itself "a software-driven mobility company" today. But as ZF contemplated the electrified and autonomous-driving trends, "we recognized early on that the speed of the market, and of technology adoption, is very high," Gollewski noted. "And we had technology gaps that we had to fill—LiDAR, for example.

Transforming ZF

ZF veteran engineer-execs Andy Whydell (left) and Aine Denari are working to drive speed and agility into their organizations.

"We therefore needed a convention to connect small-to-medium-sized tech start-ups with the 'ZF world' in order to implement these products, quickly, into the marketplace."

For a company or technology to be considered, the Zukunft team first considers if it fits ZF's 'system houses' strategy. Then it looks at the company's main markets—passenger-car, commercial vehicle and industrial/off-highway—and decides if the new technology can be used in the product portfolio.

"We need to have flexibility in the use of the technology, like with **NVIDIA** or **Baidu** or **Faurecia** we go into the 'collaboration mode' where everyone keeps their own product portfolio," he noted. "But in the case of **Ibeo** or **Astyx** [sidebar], this can be integrated into the ZF product portfolio at a later stage. This is one of the main drivers when we go into an M&A—it must fit into one of the three markets."

Accelerating product to market

The new dynamic created through Zukunft engagements is already visible within the industry. Engineers working at three U.S. locations tell *AE* that their impression of ZF, once seen as monolithic and overly conservative in its business processes, is changing. "Nimble and proactive" and "technologically advanced" are terms they used to describe their organizations.

"ZF is a very big ship, so to speak, and we wanted to connect it with the 'speed boats,'" Gollewski said. "We needed to find a solution for how to keep the keys to success of the smaller companies—their speed, simplified processes, and so on—and connect them to the broad product portfolio of the large company. Our idea is not to take a majority stake when we invest in start-ups. In the Electromobility race, you have to speed up. And we need the smaller companies to speed us up."

Finding the right balance is challenging, he admits—to ensure "we don't tie in these companies too tightly to the ZF group by acquiring a greater stake and by doing that reduce their speed. Legally, as soon as one company takes 100% of another you have to adapt your internal processes to them. That would slow them down."

He said ZF might have call options for a greater stake in some new partners. But it doesn't exercise them, in order to "to keep their success factors intact," he said. Accepting this new mindset—part of the cultures of much smaller, faster moving organizations—"is daily work for us to manage, let me say!" Gollewski admitted. "The process doesn't run itself and is not usual for large organizations. And it required us to set up specific processes—including a special team within Zukunft Ventures who are working on our collaborations."

Whydell noted that the working interfaces with ZF's small partners are typically handled by the advanced-engineering groups, who "tend to be our

ZF

A steady drumbeat of tech alliances

The transformation strategy that began with the TRW acquisition in 2015-16 continues to build ZF's new-mobility tech base in methodical cadence:

2016—ZF acquires a 40% stake in Hamburg, Germany-based Ibeo Automotive Systems GmbH, giving it significant expertise in LiDAR sensor and software technology. During the same year, it also acquires a 40% share in vehicle-networking software specialist doubleSlash Net-Business GmbH.

2017—ZF purchases a 45% stake in Astyx Communication & Sensors GmbH, developers and manufacturers of ultra-high-frequency radars for automotive, aerospace and industrial applications. Based near Munich, the small company was founded in 1997 as a spin-off from the former Daimler-Benz Aerospace.

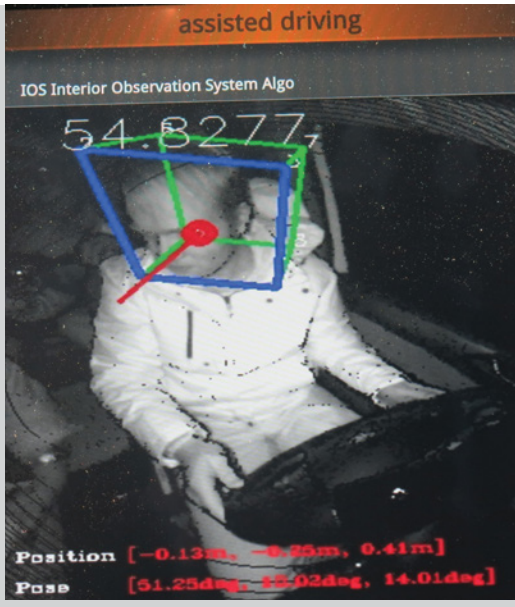
2017—ZF forms a strategic partnership with NVIDIA and **Hella** to deliver AI technology with the New Car Assessment Program (NCAP) safety certification, aimed at self-driving vehicles. NVIDIA, of course, partners with nearly everyone in the mobility space and the agreement is non-exclusive. But this is a formidable triad to develop a platform that scales from driver-assistance to SAE Level 4/5.

2018—Another partnership with NVIDIA, this one including Baidu, to create a production-ready AV platform for the China market using ZF's ProAI onboard computer.

2019—ZF and **Xilinx**, the San Jose-based maker of adaptive processors, form a strategic collaboration. Xilinx is credited with inventing field-programmable gate array integrated circuits, and system-on-a-chip (SoC) technology that's deemed vital for advanced AI development.

ZF will use Xilinx's Zynq UltraScale + MPSoC platform for real-time data aggregation, pre-processing and distribution, through its new modular-and-scalable ProAI controller. Running on open software, the ProAI unit can be customized to each OEM customer's specifications.

–LB



LINDSAY BROOKE

Demo of ZF's new 3-D interior observation system for occupant and object detection and classification.

more creative, free-thinking engineers, so they're generally like-minded people." The point is to get the start-ups who are involved with Zukunft Ventures "engaged with our automotive, truck, and industrial divisions to first establish the pre-development project—to be an accelerator," he added. "Then get accepted into projects and help those businesses grow."

The pace within Zukunft can be intense, Gollewski said. One question the team regularly asks internally is, "How far away are we from entry into the market?"

"Staying at the forefront with the traditional-side investment, while allocating capital for the new technology directions, is definitely a challenge, even for a big Tier 1 like ZF," observed Dave Andrea, a principal in Strategy Practice at consultants **PlanteMoran**. "There's a long transformational path here. How do you not starve the cash cow that's feeding your start-up partners?"

ZF's expertise in the hardware and software sides, and in systems integration, "should enable it to keep a competitive advantage," Andrea offered.

What about fostering a "start-up culture" within the mothership ZF? Gollewski notes the example of **Sound.AI**, which was created in 2017 by two ZF non-engineers—Florian Ade and Julian Fieres—kicking around how they might include sound recognition within a vehicle's exterior sensor array, basically giving it capability to "hear" as well as "see."

ZF had recently launched a Pitch Night activity, where internal teams and external start-up companies "sell" their ideas in a few minutes' time to ZF product development leaders. Success at Pitch Night takes your team to the annual Innovation Challenge, an internal competition aimed at bringing those ideas into further development and, potentially, to market.

Remarkably, Ade and Fieres were able to transform their idea into a minimum viable product (MVP) in under one year, with encouragement from ZF engineers and a bit of assistance from an Aachen-based research institute.

Sound.AI detects approaching sirens on first-responder vehicles and alerts the driver via display screen about the emergency vehicle's direction, and suggests a course of action.

"Those two guys are currently working with a major OEM on a big pre-development project and they received an RFQ for a serious contract," Gollewski explained. "It was 12 months from the Pitch Night to receiving the RFQ! This is a good example of transferring processes from the start-up world to, potentially, the market." ■

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2019 Vehicle Technology Review

Reviewing the latest tech applications in the automotive space and the trends they're serving.

by Paul Seredynski

With massive shifts looming in the automotive engineering space – the titanic trio of Autonomy, Mobility and Electrification (AME) – it's easy to forget that the pace of innovation continues unaltered in the here and now. We've reviewed the latest technologies on the newest OEM models and how they point to current trends in the automotive landscape. Though the AME macro trends represent the majority investment in the automotive space, and work on traditional engineering projects including new powertrains continues, small features that resonate often serve as a guideposts to what's next.

Parts from sustainable materials

To reduce a vehicle's overall environmental impact, sustainable materials are being implemented (slowly) in manufacturing. Substituting for a material such as carbon fiber, this can mean not just sequestering but actively capturing CO_2 while source materials are grown. The new **Porsche** 718 Cayman GT4 Clubsport (shown above) is the first production track-day/race car to feature body parts made of a natural-fiber composite material, Porsche claims. The outer door panels and rear wing of the GT4 Clubsport are made of an organic-fiber mix, sourced from agricultural by-products including flax and hemp fibers, exhibiting properties similar to carbon fiber in its weight and stiffness.

BMW's i3 uses eucalyptus (one of the world's fastest-growing tree species) for sections of the dashboard and trim, and Kenaf (a sustainably grown and harvested type of hemp) to reinforce the dashboard and door trims. A similar material from **International Automotive Components** called "FiberFrame" is used as a weight-saving sunroof frame of the **Mercedes-Benz** E-Class.

Biometric control

The keyless car fob has become ubiquitous and using a smartphone in its place recently became an option. Soon, however, a dedicated object needed to gain access and engage a vehicle might be passé, as the age of biometric control is here. **Hyundai** is offering a fingerprint scanner in select markets on the 2019 Santa Fe that allows owners to unlock doors and start the vehicle. The system also can store driver preferences automatically, adjusting seating positions, connected car features and side-view mirror angles.

Sensors located on the Santa Fe's door handle and ignition button send the encrypted fingerprint information to the fingerprint controller inside the vehicle. The scanner uses capacitance recognition in various parts of the fingertip to prevent forgeries and faked fingerprints. Hyundai claims the technology's chance of misrecognizing another person's finger print as the driver's is only 1 in 50,000, making it five times more effective than conventional vehicle keys, including "smart" key fobs.

Can AWD stop the sedan slide?

The unprecedented marketplace shift away from sedans and into SUVs is not just about all-wheel drive (AWD). An SUV's profile, ride height and driver H-point often bring perceived traits such as visibility and capability, along with a more practical and functional package for transporting people and stuff. But that hasn't stopped manufacturers from adding part-time AWD systems to long-running sedan

PORSCHE

The outer door panels and rear wing of the Porsche Cayman GT4 Clubsport (left) are made of an organic-fiber mix sourced from flax and hemp fibers and exhibiting properties similar to carbon fiber.

Hyundai is offering a fingerprint scanner in select markets on the 2019 Hyundai Santa Fe that allows owners to unlock doors and start the vehicle, and uses capacitance recognition to prevent faked fingerprints.

The new e-AWD system debuting on the 2019 Toyota Prius installs Toyota's first-ever magnet-less, induction-type electric motor within the independent rear suspension.

nameplates for additional all-conditions traction, while minimizing the fuel-efficiency penalty.

The all-new 2019 **Nissan** Altima and 2019 **Mazda** 3 are both adding mechanical part-time AWD to their option sheets, but one of the slickest new part-time AWD applications is debuting on the 2019 Toyota Prius. The new e-AWD system installs **Toyota**'s first-ever magnet-less induction-style electric motor (7 hp/5 kW; 40 lb·ft/54 N·m) within the independent rear suspension of the Prius to provide full-time AWD assist from 0-6 mph (0-10 km/h), then part-time assist up to 43 mph (69 km/h). With no mechanical connection to the FWD powertrain, the e-AWD setup adds only 150 lb (68 kg) to the Prius, while still permitting an EPA-estimated rating of 50 mpg combined.

Trick tailgates expand truck demographics

As domestic production continues to rely more on profit-generating pickup trucks, expanding their demographic is a savvy business goal. **Ford** introduced its first tailgate step in 2008 on its SuperDuty pickups, with an updated, enclosed design debuting on the 2015 F-150. This has recently morphed into a mechanical engineering tailgate tour-de-force that is expanding the usability and appeal of the traditionally trade-focused vehicles.

The 2019 **Chevy** Silverado and Silverado HD feature fully-powered (lowering and closing) tailgates. The 2019 **Ram** 1500 pickup features a swing-gate function similar to what debuted on the 2006 **Honda** Ridgeline, but configured in a 60/40 barn-door arrangement. One of the craftiest so far is the 2019 **GMC** Sierra MultiPro six-way tailgate that offers a flip-up "load stop" spoiler, and an "inner gate" that permits greater proximity to the load floor and converts to a tailgate step, a second-tier loading platform and/or a horizontal work shelf.

Quiet in the age of voice control

The quest for quieter interiors has been a goal since the industry's inception, but now there's new motivation to control cabin noise: voice control. The smart-device revolution taking place with Amazon's Alexa, Apple's Siri and Google's Assistant is already taking hold in the car, with some Alexa functionality already available in models from BMW, **FCA**, Ford, Hyundai, **Jaguar**, Mercedes-Benz, Toyota, and Nissan.

As consumers grow to expect more consistent performance of voice commands, a quiet cabin will become a more important enabler for this functionality. A host of NVH materials, techniques and electronics are evolving constantly throughout the automotive space,

CLOCKWISE FROM TOP LEFT: PORSCHE; TOYOTA; HYUNDAI

The MultiPro six-way tailgate on the 2019 GMC Sierra offers a a second-tier loading platform and/or horizontal work shelf.

and Ford recently demoed several advances for its upcoming 2020 Explorer. These including unique materials for body cladding, advanced Active Noise Cancellation for hybrid models and a dual-wall engine shroud to attenuate powertrain NVH close to its source.

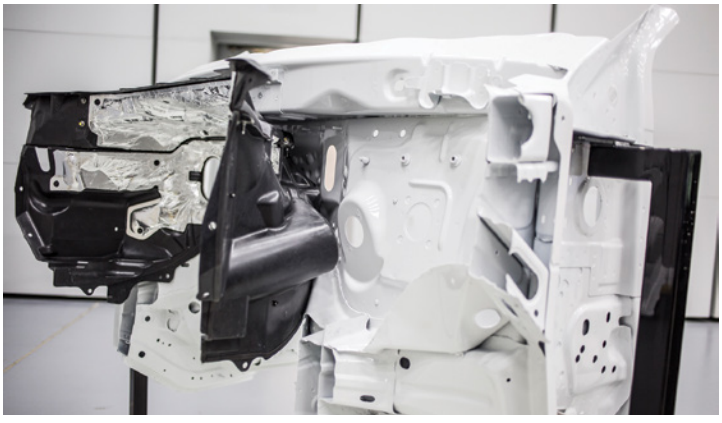
Electronic soft-roader capabilities

Traditional off-road vehicles continue to offer robust, full-time, mechanical 4x4 systems that typically provide low-range transfer cases and mechanically locking differentials to enable extended rock-crawling capability. However, the latest crop of what have been traditionally been labeled "soft-roaders" are adding digital tools to more fuel-efficient part-time AWD setups to provide impressive on-demand capabilities, widening the sales base for already popular SUVs.

Upper trims of the 2019 Chevy Blazer make smart use of the new twin-clutch rear-drive unit (RDU) in Off-Road mode to provide a low-speed, locking-type function with relaxed yaw and traction-control parameters to ably handle occasional loose or slippery terrain. Honda's new Passport and Pilot/Ridgeline apply smart controls to dedicated modes within its i-VTM-4 AWD system, keenly apportioning torque and the brakes to enable surprising off-road prowess. Toyota's new 2019 RAV4 uses a sophisticated AWD Integrated Management (AIM) system and condition-specific Multi-Terrain modes to provide surprisingly off-pavement grip to match the tougher looks of the new Adventure trim.

Fuel cells quiet down

Three manufacturers currently offer limited availability of production fuel-cell electric vehicles (FCEV): Honda and Toyota with their Clarity and Mirai sedans, and



The 2020 Ford Explorer will feature a dual-wall engine shroud to attenuate powertrain NVH close to its source.

The fuel-cell stack on the 2019 Hyundai Nexo features an integrated air-processing system that helps make the FCEV as quiet as a typical BEV.

Hyundai with its new Nexo SUV. Of the three machines, the newest Nexo not only optimizes its SUV packaging, but operates without the whirring and clicking "haunted house" noises of its competitors. Unless told it was a fuel-cell vehicle, you'd think the nearly silent Nexo was just another BEV, making it an FCEV milestone.

According to Dr. Bo Ki Hong, fuel-cell research fellow for Hyundai Motor R&D, the fuel-cell process itself is silent, so any powertrain noises arise from supporting systems such as the intake pump, which provides more air to the stack under higher demand. The Nexo's new integrated air-processing system manages this without any noticeable racket from the driver's seat. Hyundai says one of its next goals is to scale up the technology for commercial applications, including commercial trucks and buses, which may soon become the tech's first large-volume applications.

Head-up displays preview AR prompts

Head-up displays (HUD) appeared in light-duty vehicles in the late '80s, but a new crop of brighter and customizable displays will prime the market for the next phase of driver assistance: augmented reality (AR). New full-color HUD entries from **Acura** (on the 2019 RDX) and Jaguar (2019 I-Pace, 2020 XE), provide customizable data to supplement driver info with minimal distraction, and **Lincoln** now boasts the largest and brightest full-color HUD, available on its Continental and Navigator models.

CLOCKWISE FROM TOP LEFT: GMC; FORD; HYUNDAI

The new Lincoln display is driven by a digital micro-mirror device (DMD), a computer chip housing 400,000 tiny movable mirrors to help project a brighter image unaffected by polarized sunglasses. Selected info is only displayed when relevant, and as its importance increases (i.e., for an upcoming navigation prompt or incoming call), the physical placement and size of the information presented becomes more prominent. The next step is adding AR cues to the HUD, which supplier **Continental** has been previewing for several years and is due in-market soon.

Camera magic

As camera and display technologies have become sharper and more compact, the "view" from the driver's seat is constantly improving. Surround-view displays have become common and camera-based rearview mirrors – which permit unobstructed aft vision regardless of passengers and cargo – are already available on models from **GM**, Toyota, **JLR** and Nissan. Ford's F-150 Raptor has an off-road camera that lets you see what's directly in front of the vehicle, while the **Range Rover** Evoque's Ground View overlays the vehicle's chassis on a similar live display to show where you might contact obstacles in your path.

Applying a sort of movie magic, the Transparent Trailer View available as part of the ProGrade Trailering System on the 2020 GMC Sierra HD lets you "see" right through a trailer you might be towing. When paired with an available accessory camera mounted on the rear of the trailer, the Sierra HD uses the feed from the tailgate camera and some innovative processing to create an unobstructed rearward "view" as if the trailer were transparent. The feature should provide a huge boost in confidence when navigating with a large trailer. ■

GMC

The Transparent Trailer View feature available on the 2020 GMC Sierra HD lets you "see" right through a towed trailer.

One of two newly-launched J.D. Power engineering awards for highest-rated all-new vehicle and highest-rated redesigned vehicle.

J.D. Power launches new vehicle-engineering award at **SAE's WCX 2019**

Globally-respected automotive analytics firm J.D. Power recognizes outstanding vehicle-integration engineering with two new annual awards.

By Bill Visnic

Long known for its groundbreaking surveys measuring automotive customer satisfaction, quality and dependability—and presenting corresponding awards to top-achieving OEMs—marketing information and analytics firm **J.D. Power** is launching two new engineering-related awards for development teams responsible for each year's best all-new vehicle and best redesigned vehicle.

J.D. Power is partnering with SAE International to announce at this year's SAE World Congress Experience (WCX) the winners for the inaugural 2018 Engineering Award for Highest-Rated All-New Vehicle and Engineering Award for Highest-Rated Vehicle Redesign.

Doug Betts, J.D. Power Senior Vice President and General Manager, Global Automotive Operations, conceived the awards. A mechanical engineer, he thought it was time the firm known for intensive consumer metrics used those same measures to acknowledge the work of engineering teams that develop all-new vehicles or significantly redesigned models.

"Having been in the industry for a long time and working towards winning J.D. Power (consumer) awards or other achievements, I recognized that there was not an opportunity or a venue where engineers are sort of publicly rewarded for what they have done among their larger group of peers," he told *Automotive Engineering*.

"It started with my personal interests in creating some opportunity for engineers to be recognized based on what they'd done. And when you start thinking about that, then obviously the first thing you think of is SAE."

Engineering all-new, redesigned vehicles

Betts said the criteria for the new awards are based on merging the results of J.D. Power's annual initial-quality study (IQS) and APEAL (Automotive Performance, Execution and Layout) survey. The APEAL Study measures owners' "emotional attachment and level of excitement across 77 attributes, ranging from the power they feel when they step on the gas to the sense of comfort and luxury they feel when climbing into the driver's seat," the firm said. The well-known IQS New-vehicle measures new-vehicle quality by the number of problems experienced per 100 vehicles (PP100) reported by consumers during the first 90 days of ownership.

A description of the awards, given for the first time for the 2018 calendar year:

- The **J.D. Power Engineering Award for Highest-Rated All-New Vehicle** is presented to the engineering team responsible for the highest-rated new entry into the market for the 2018 Model Year. The award, based on consumer evaluations of Initial Quality and Appeal, is for the vehicle introduced for the 2018 Model Year that is furthest ahead of its direct competitors.
- The **J.D. Power Engineering Award for Highest-Rated Vehicle Redesign** is presented to the engineering team responsible for the highest-rated redesigned vehicle for the 2018 Model Year. The award, based on consumer evaluations of Initial Quality and Appeal, is for the 2018 Model Year vehicle that is furthest ahead of its predecessor.

Betts emphasized that the new awards—and the metrics behind them—are particularly rewarding not just of engineering teams execute their core functions with particular excellence, but also those who learn from and act effectively on customer feedback.

"Just to make sure we're clear on the background or the motive behind this, to do the things that we're rewarding—especially given that the feedback is coming from the owners of those vehicles—the skill we're trying to reward is really collecting data and the listening to customers. Because if you don't—and there are some industry's methods of doing that—but if you don't do that, well, you can be a great engineer and make a vehicle for engineers, but vehicles that are made for engineers usually are failures because people who own cars don't think the same way as engineers.

"This is about listening to the voice of the customer," Betts continued, "understanding what they're saying and why they're saying it, then trying to make a new product that will really answer those

JD POWER

needs that they have. And that's the skill which is not a natural skill for an engineer."

Each year's award for the all-new vehicle will be based on "a new entry into segment that that company has not been in and it comes in at the highest position relative to the others in that segment," Betts said. It seems likely that the expanding universe of electric vehicles (EVs) will produce many new vehicles—and new segments, potentially—in the coming years, as electrification transitions into the current combustion-dominated market.

Meanwhile, Betts said that although there's often disagreement about what constitutes a redesigned vehicle, but "most everybody in the business sort of knows what a refresh is versus an all new generation of something. I doubt you'll truly get much argument about this in the future."

He said both awards are meant to address something that's not been acknowledged before: the combination of understanding the voice of the customer and merging that with the task of vehicle integration. "It's like taking all these pieces and putting them together and making a great overall car. And a great overall car needs to be judged that way by the owners of the car."

"It's not about what J.D. Power the company thinks about anything," he stressed. "This is a unique combination of data that we think is appropriate for what we're trying to recognize here, which is an achievement by a team of engineers to do something better than their colleagues. It won't necessarily be the best vehicle or something that's already been won, because each of our studies covers a different subject."

JD POWER

Doug Betts, J.D. Power Senior VP and General Manager, Global Automotive Operations, is a graduate mechanical engineer.

J.D. Power's two new vehicle-engineering awards will be presented at the SAE's WCX in Detroit on April 9, 2019. ■

Powering back to the FUTURE

Chrysler Turbine Car from the 50-car build in 1963-64.

Rotaries, gas turbines, hybrids—even nukes! Propulsion tech from the past, present, and beyond the horizon is revealed at the SAE Mobility History display at WCX'19.

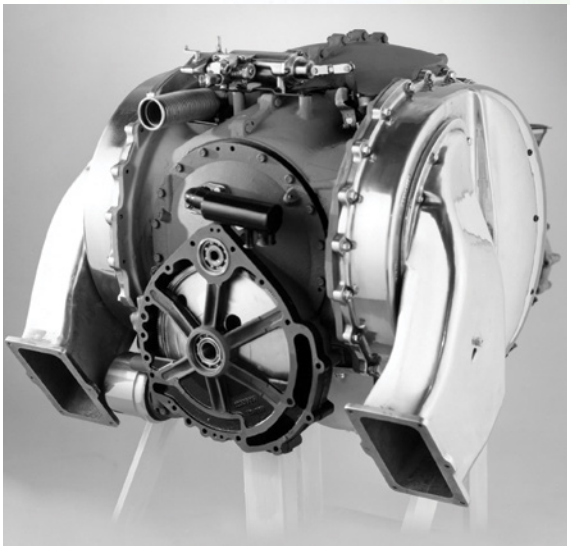
by Lindsay Brooke

Credit Leonardo DaVinci for creating what many historians believe was the first depiction of a self-powered vehicle. It was powered by springs. And in the centuries since then, engineers have found increasingly complex and interesting solutions for vehicle propulsion.

Steam came first. Nicolas-Joseph Cugnot's 1769 steam tractor is generally believed to be the first self-propelled road vehicle. By the 1830s, steam carriages carried passengers on roadways in Britain. During this period another technology was emerging: in the 1830s, American blacksmith Thomas Davenport's experiments with electricity and electromagnetism led him to patent an electric motor. When battery technology finally caught up with this vision in the 1880s, the recipe for the first electric cars was born.

By the early 20th century, EVs accounted for 38% of all cars manufactured in the U.S., nearly eclipsing the popularity of steam. But the boiler bunch didn't die easily. Stanley, the Massachusetts-based company most closely associated with steam cars, stayed in business until 1924.

Ironically, it was Thomas Edison who predicted that horseless vehicles wouldn't run on electricity or steam. In 1895 he rightly opined that future vehicles likely "will be run by a gasoline or naptha motor of some kind."

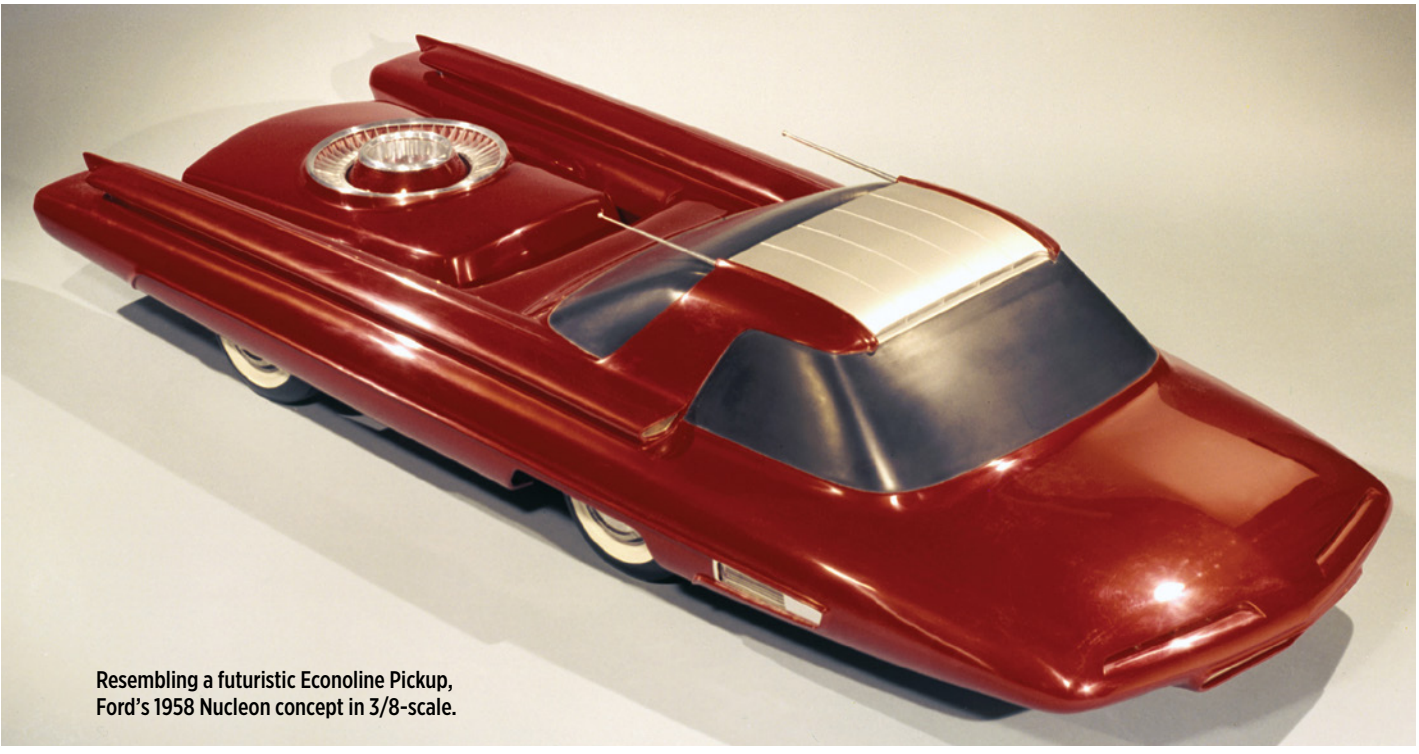


The A-831 was Chrysler's fourth-generation gas turbine, developed in-house.

The key enabler emerged on January 10, 1901 at Spindletop, a presumed oil field near Beaumont, Texas. When the prospectors struck oil there, the resulting gusher raged for nine days at an estimated rate of 100,000 barrels per day. This set off the Texas oil boom, making the U.S. the world's biggest petroleum producer—and making an abundant motor fuel available for mass consumption.

With cheap oil and easy-to-use cars that could be produced at an affordable price—led by Henry **Ford**'s Model T in 1908—the internal combustion engine finally had everything required to establish its dominance for over a

BOTH IMAGES: FCA



Resembling a futuristic Econoline Pickup, Ford's 1958 Nucleon concept in 3/8-scale.

FORD

century. Over the years, various challengers to the ICE have appeared, some of them produced in volume. This year's ever-popular SAE Mobility History Committee display and presentations at WCX'19 highlight some of the more interesting alt-power propositions.

Gas turbines: Vehicle OEMs began exploring the potential for gas-turbine-powered cars and trucks soon after World War II. **Chrysler Corp**. created a dedicated R&D group that ultimately developed seven generations of small turbine engines through the 1970s. They were installed in a series of testbed vehicles, the most famous being the 50 identical 1963 "Turbine Cars"—based on two-door Chrysler coupes painted in "Turbine Bronze" livery. They were demonstrated to the public at the 1964 World's Fair. One example of the nine that are known to exist today is owned by FCA and on display at WCX'19.

The Turbine Cars were powered by the fourth-generation Chrysler-engineered and manufactured A-831 engine. It was rated at 130 hp (97 kW) at 36,000 rpm, and 425 lb·ft (576 N·m). Idle speed was 18,000-22,000 rpm. The engine weighed 410 lb (186 kg) and could operate on a variety of fuels—even tequila, as Chrysler engineers proved during a driving demonstration with Mexican president Adolfo López Mateos at the wheel.

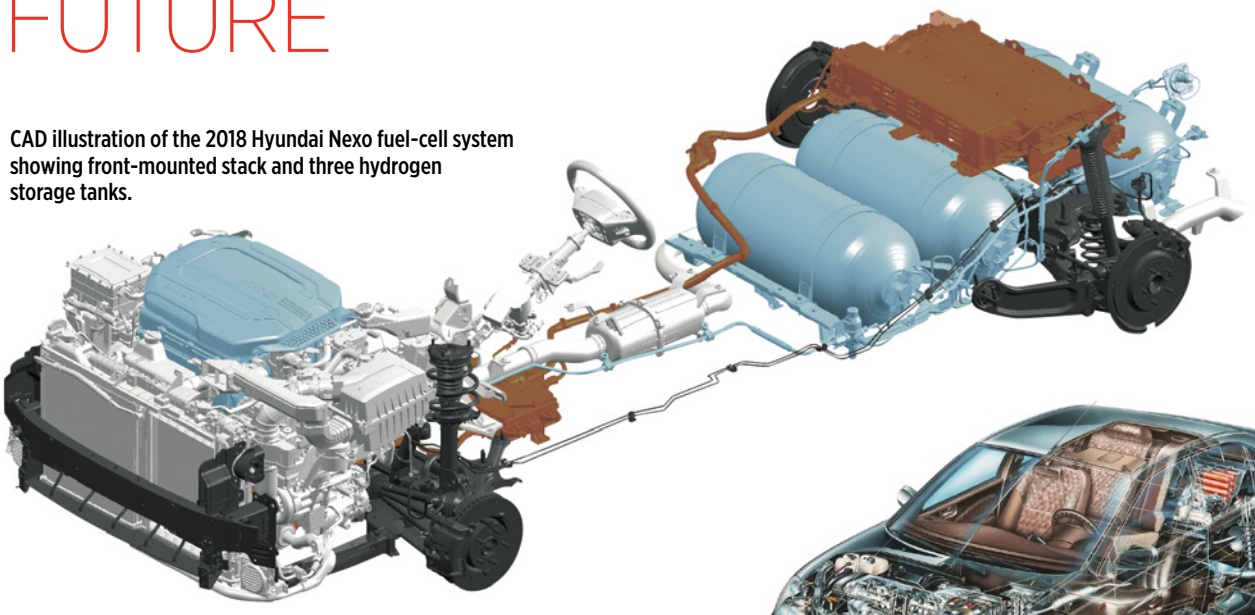
Nuclear reactors: Another propulsion idea that emerged from the technologies of World War II was that of nuclear power for ships, aircraft—and ground vehicles. Ford's Nucleon, a 1958 concept, was a modernistic pickup theme that explored how the future of energy might impact automotive design. It was to be powered by a small reactor mounted under the cargo bed at the rear. A lead shield was envisioned to protect occupants from the radioactivity.

Ford believed a production Nucleon could deliver 5000 miles (8,047 km) of operation before the reactor core would require uranium refueling—something that planners surmised could be done at dedicated refueling stations. The Nucleon concept never made it past a single 3/8-scale model (above) that resides in The Henry Ford museum in Michigan. Ford revived the nuke idea on its Seattle-ite XXI concept in 1962. **Studebaker-Packard** also showed an atom-splitting concept, the Astral in 1957.

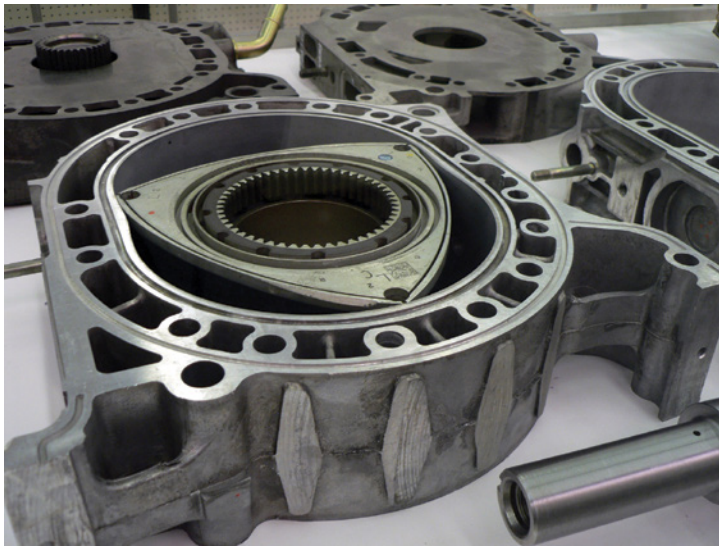
Fuel cells: During the Cold War, an old technology began its slow trek into automobiles. The hydrogen fuel cell, originally conceived in 1801 and first built in 1842, returned as an important power source during the space race. In the 1960s and '70s, NASA used fuel cells as onboard power generators in the Gemini and Apollo capsules and in the Space Shuttle. During this period, **General Motors** began testing the use of fuel cells in vehicles. The stacks and their fuel tanks consumed so much space that GM developed an entire vehicle, the ElectroVan, around the propulsion system.

Interest in FCVs as a potential solution for reducing vehicle and well-to-wheels emissions began to grow. But fuel cells didn't become viable for mass-production vehicles until 2001 with the invention of the 700-bar (10,153-psi) hydrogen storage tank. This technology greatly reduced the required package space and extended the FCV's range. Since then GM, **Daimler**, **Hyundai**, Honda and **Toyota** launched FCV development programs. Hyundai's latest FCV, the Nexo, debuted in 2018. It is on display at WCX'19 in Hyundai's floor exhibit.

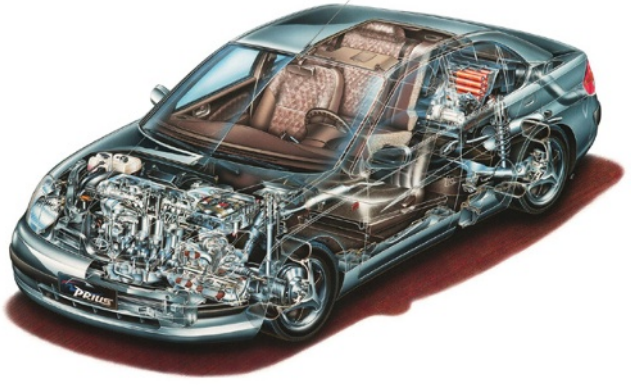
Powering back to the FUTURE



CAD illustration of the 2018 Hyundai Nexo fuel-cell system showing front-mounted stack and three hydrogen storage tanks.



Mazda 13B rotary components showing rotor and housing.



Original NHW10-series Toyota Prius sold from 1997-2001 is an automotive technology landmark.

According to Hyundai engineers, the Nexo achieves 60% fuel cell system efficiency, compared to 55% on the previous-generation (Tuscon-based) FCV. Based on this improvement, along with an increase in the hydrogen storage available on board—three tanks that each hold 6.3 kg (13.9 lb) of hydrogen—the Nexo's driving range could reach over 800 km (497 mi) in NEDC city mode, and over 370 miles on the U.S. test cycle. The Tuscon FCV's range was rated at 265 miles in the U.S.

The Mazda rotary: In 1961, Mazda parent **Toyo Kogyo** was pursuing engine technology to differentiate it from the Japanese mainstream. Company leaders saw great promise in the smooth running, power-dense and package-efficient rotary invented by Felix Wankel. They licensed technology from **Wankel GmbH** and **NSU Motorenwerke**, and a team of 47 young engineers under Kenichi Yamamoto began development. At the time, sealing of the rotor tips against their friction surface was an ongoing challenge. It took the R&D team nearly two years to design, engineer and validate a robust seal made from aluminum-carbon composite. Their innovation enabled the rotary engine to blossom at Mazda.

Single-rotor engines led to twin-rotor units, first available in the 1967 Cosmo Sport 110S. Its 10A engine generated just 110 hp and 96 lb·ft (130 N•m), but the car's low mass made it peppy and nimble. Mazda put many iterations of its rotaries in sports cars, sedans, pickup trucks, even buses. Twin-turbocharged versions of the three-rotor 20B engine delivered 300 hp and 300 lb-ft (407 N•m) in the RX-7. A 700-hp, four-rotor race version powered a Mazda prototype to overall victory at Le Mans in 1991.

Mazda engineers worked hard to keep the rotary emissions-compliant under tightening global air-quality regulation. They developed a unique thermal reactor to burn HC residuals and continued to make significant efficiency gains. An all-new 'Renesis' version debuted in 2003 to power the RX-8, but by then Mazda had moved primarily to a piston-engine strategy. A hydrogen-fuel development program showed promise for extending the rotary's life, and in 2006 Mazda offered H2-powered RX-7 RE models for lease.

While the 13B rotary became a favorite of homebuilt aircraft builders, Mazda also never gave up on it. New, highly optimized single-rotor engines are under development, aimed at range-extender duty in hybrid-electric vehicles in the 2020s.

Pioneering Prius: Say the word "hybrid" and the obvious association is "Prius." Launched by Toyota in late 1997, the first mass-produced gas-electric hybrid vehicle was the fruit of a five-year development program

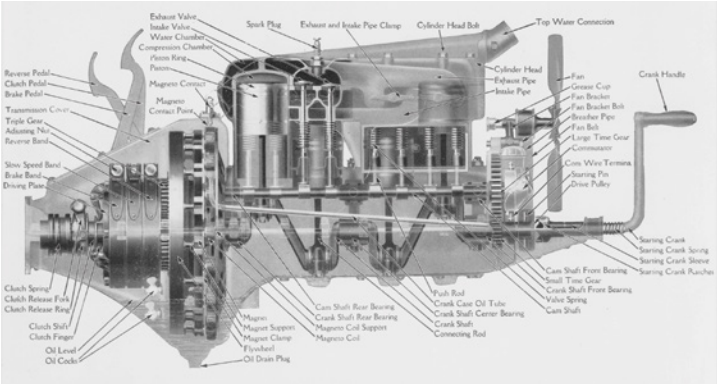
CLOCKWISE FROM TOP: HYUNDAI; TOYOTA; 160SX/WIKICOMMONS

to create a scalable, practical, low-emission family of vehicles. To date, more than 7 million Priuses have been sold globally, representing the majority of the world's hybrids—a propulsion concept first explored in 1898 by Ferdinand Porsche.

Three elements were critical to the new Toyota Hybrid System's success. First was the 1.5-L 1NZ-series gas engine running the Atkinson thermodynamic cycle. Second was stable and reliable nickel metal-hydride batteries. Last was the novel 2-motor power-split drive unit. The system delivers 50-mpg economy and has proven so bulletproof-reliable that Prius has become a popular choice of the world's cabbies.

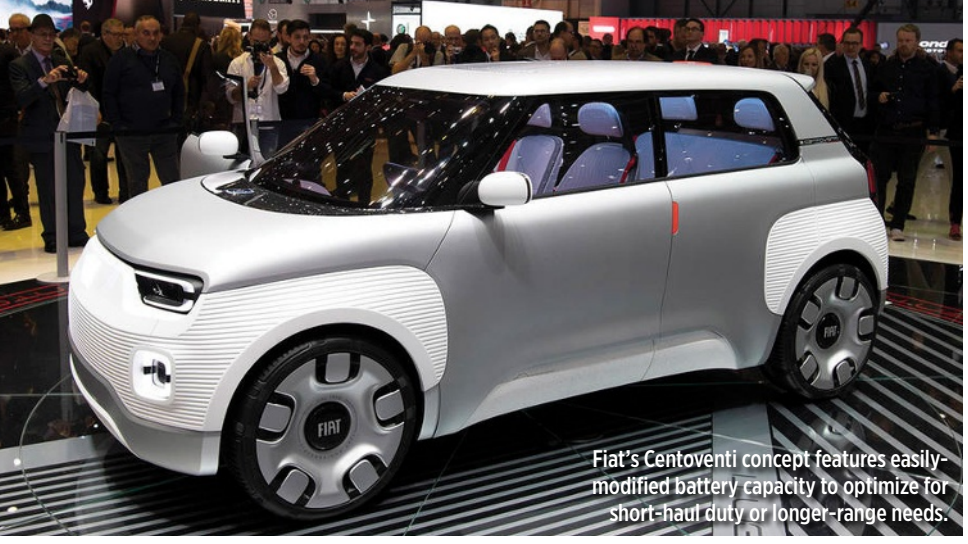
Ford's titanic T: The early automakers frequently used cutaway illustrations to tout the technical features under the skin of their cars. The image to the right shows the brilliant simplicity and overall robust design of Ford's 2.7-L, 22-hp gasoline four-cylinder in the iconic Model T. Note the compact flywheel magneto and two-speed planetary transmission—today these would be considered good examples of "systems engineering."

Compared with previous transmissions, vanadium steel alloys allowed Ford to reduce the size of the gears in its planetary drive. This helped reduced the unit's overall size and allowed it to be fully enclosed; the transmission shared the engine's crankcase oil. This view shows (from left) the planetary gearset; the three bands controlling reverse, low gear, and high gear; the clutch and clutch spring. With the simple addition of a torque converter and hydraulic control, this unit would be functionally equivalent to a modern automatic transmission. ■



Simple to build, simple to operate, cheap to own—the world-changing Ford Model T's "power module."

—with Erika Anden, SAE Mobility History Committee



Fiat's Centoventi concept features easily-modified battery capacity to optimize for short-haul duty or longer-range needs.

Horsepower, kilowatts compete at 2019 GENEVA MOTOR SHOW

Is Europe getting serious about electric vehicles? Look no further than the EV-intensive 2019 Geneva motor show.

by Bill Visnic

There still was plenty of old-school horsepower making news at this year's Geneva motor show in early March, but there was no question it's fast becoming a kilowatt kinda world. The number of electric and electrified vehicles—concept and production-ready—on display made it abundantly clear that at least in Europe, electrification's "if" definitely is no longer a question. And the "when" appears to be pretty darn soon.

Although there were legitimate newsmaking vehicle introductions all over the Geneva show, the poster child for Europe's intensifying enthusiasm for electrification had to be **Honda**'s E Prootype (see page 10), a near-production version of the universally praised Urban EV Concept shown at Frankfurt in 2017. The Urban EV's funky front bench seat is replaced by a familiar seating setup and the twin suicide doors also have morphed into four conventionally-hinged doors, but the e Prototype remains alluringly proportioned for the European market. And its rear-drive layout indicates Honda may not intend the production version to be a dull urban-transport pod.

But equally significant, Honda used the Geneva show to announce its entire model lineup in Europe will feature some form of electrification by 2025.

Audi chimed in by confirming it will have a full dozen EVs on sale globally by 2025 and unveiled the Q4 e-tron concept, a compact crossover that seems to be the bullseye for merging EV technology (and cost?) with consumer preference on both sides of the Atlantic for crossover packaging. The production version of the battery-electric Q4 is slated for the second half of next year.

Appearing to be in near-production guise and riding on parent company **Volkswagen**'s MEB EV-specific architecture, the Q4 e-tron concept, Audi said, packs 225 kW (302 hp) in its twin electric motors that of course impart the famed "quattro" all-wheel-drive—although under normal conditions, tractive power is biased to the 150-kW (201-hp) motor that drives the rear axle. The Q4 e-tron's 510-kg (1124 lb!) lithium-ion battery pack can contain 82 kWh of energy for a maximum driving distance of more than 450 km (280 miles), which the company said is a class-leading figure.

EVs to cover mainstream and niche

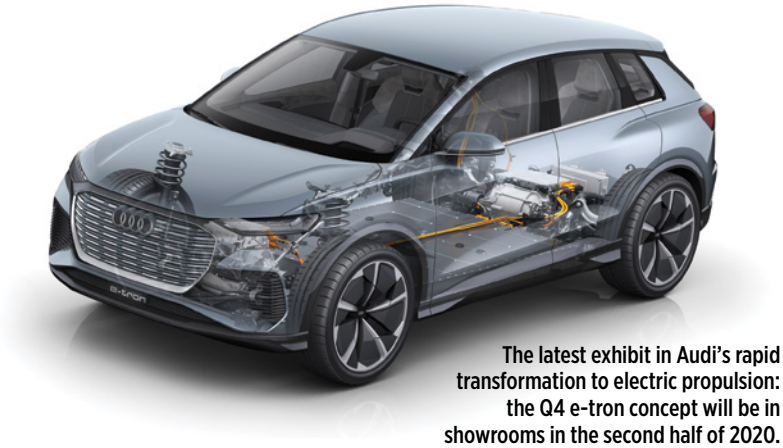
Also building on VW's projected-to-be-prolific MEB platform was the company's lighthearted ID. BUGGY concept, an EV tribute to the Beetle-based Meyers Manx dune buggies closely identified with California beach culture starting in the 1960s. The ID. BUGGY—the nomenclature itself is funky—was shown at Geneva with a 150-kW electric motor at the rear. But VW was quick to mention, "An additional electric motor in the front axle is also conceivable in order to realise a four-wheel drive with an 'electric propshaft.'"

Maybe as titillating as the concept itself is the ID. BUGGY as concrete symbol for the company's recent statement that it will make MEB available to any company—from established to startup—wishing to develop an EV. Meanwhile, to underscore the fun-factor positioning of such a vehicle, VW said it's the first concept derived from the MEB architecture to deliberately omit any accommodation for electronic driver-assist functionality.

Fiat's become all but invisible in the U.S. market, but its traditional place on Europe's small-car game-card means it remains a viable brand for the Continent's EV expansion. Fiat's Centroventi concept was another of the Geneva show's intriguing variations of the EV recipe by showcasing a modular battery arrangement that allows for quick and simple modification of battery capacity. The base battery delivers a range of about 100 km (62 miles), Fiat said, but up to three

Volkswagen's ID. BUGGY concept is an EV tribute to the famed Beetle-based buggy.

FROM TOP: FIAT; VOLKSWAGEN



The latest exhibit in Audi's rapid transformation to electric propulsion: the Q4 e-tron concept will be in showrooms in the second half of 2020.

Kia's Imagine concept previews the brand's first dedicated EV platform.

more battery modules can be purchased or rented to hike total range up to 500 km (310 miles).

French maker **Citroen** had its own quirky EV at Geneva, the Ami One concept. The tiny 2.5-m (8.2-ft.) long, 1.5 m (4.9 ft.) high Ami One has two asymmetrically-positioned seats and a top speed of 45 km/h (28 mph) and range of 100 km (62 miles); recharge time using typically available public charging equipment is about two hours, the company said, with further details of drivetrain to come later.

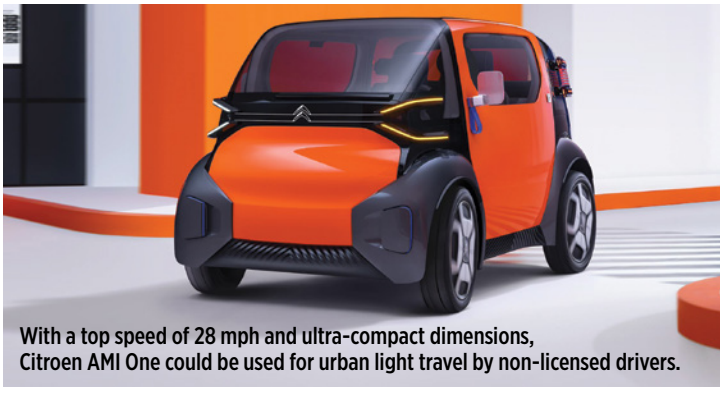
Ami's quirkiest feature probably is the identical doors that open right and left in opposite directions. Other components such as front and rear fenders are also identical to save manufacturing costs. In France, a production Ami One would be graded a light quadricycle, which would not require users older than 16 to have a driver's license.

Kia unveiled the Imagine concept at Geneva as its first dedicated EV passenger car. Sized at the upper end of Europe's midsize C-segment, the company said the husky crossover with intimations of muscle car "is intentionally designed to not sit within the industry's predefined vehicle categories."

Kia didn't provide detail of the Imagine's driveline or architecture, but did say it partnered with **Goodyear** to create the 22-in. (559-mm) Intelligrip EV concept tires, which are embedded with sensors "to detect road conditions and communicate with the Imagine by Kia to ultimately deliver improved driving performance" and are designed for the unique performance requirement of EVs.

Supercar, super batteries

Far less prosaic than most of Geneva's EVs was the Mark Zero from European startup **Piëch Automotive**, co-CEO'd by Toni Piëch, son of



With a top speed of 28 mph and ultra-compact dimensions, Citroen AMI One could be used for urban light travel by non-licensed drivers.

Startup Piëch Automotive has a unique battery-cell design that is resistant to temperature gain from discharge and quick-charging, permitting air cooling.

gifted engineer and auto executive Ferdinand Piëch who is part of the Porsche family. The Mark Zero's developers, who started the company in 2016, said in a release—without providing detail—that the concept uses new type of battery cell design that is markedly more resistant to temperature increases related to fast-charging and energy depletion, keeping temperature hikes to within just 10-15 deg.

The batteries are supplied by China's Desten Group, said the startup automaker, adding that the batteries' unique properties mean air-cooling is sufficient; the elimination of a liquid-cooling system for the batteries cuts approximately 200 kg (441 lb) from the battery pack's weight, helping to keep overall weight of the vehicle to less than 1800 kg (3968 lb).

The unique batteries also help the Mark Zero eschew the now-typical "skateboard" design arrangement for EV battery packs and chassis—instead, the Mark Zero places batteries in a central tunnel area and over the rear axle, which the developers say enables a sportscar-like low seating position and optimized weight distribution.

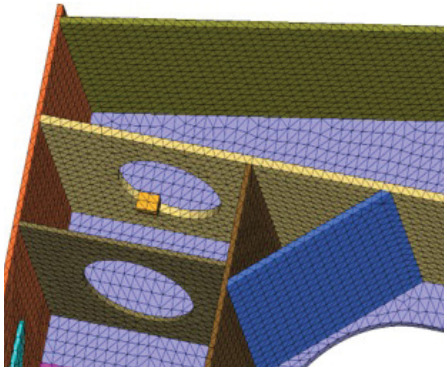
"We designed a sports car that we would also buy ourselves," said Toni Piëch in a release. "And we have long talked to many enthusiasts about what's missing in the marketplace. We want to offer a modern classic that is not subject to cycles of consumption." ■

CLOCKWISE FROM TOP LEFT: AUDI; KIA; PIËCH AUTOMOTIVE; CITROEN

PRODUCT BRIEFS

SPOTLIGHT: WCX EXHIBITOR PREVIEW

Weldment CAE module

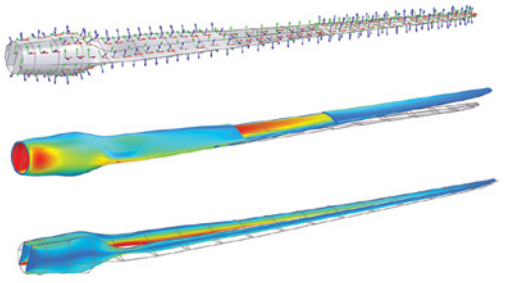


Detroit Engineered Products' (DEP) (Troy, Mich.) newest patented module within the MeshWorks suite addresses all facets of weld optimization, lightweighting, and fast FEA/CAE modeling for welds. Weld profiles include flat, concave, convex, tapered, circular, arc, oval, etc. According to DEP, all CAE models are quickly created and "weld nodes" automatically line up perfectly for all meshes (tetra, hexa, tria). The MeshWorks weld module can reduce CAE activities for fabricated frames and structures by more than 70% and produce better optimized results. CAE steps including meshing can be automated (like a macro), allowing junior-level engineers to achieve senior-level results. Engineers can quickly create welds with specific profiles and HAZs to analyze stress and crack propagation. The module is suitable for brackets, tubes, structures, and any joined metals. Visit Booth 1638 at SAE WCX.

WCX WORLD CONGRESS EXPERIENCE EXHIBITOR

For more information, visit http://info.hotims.com/73004-400

Multiphysics software



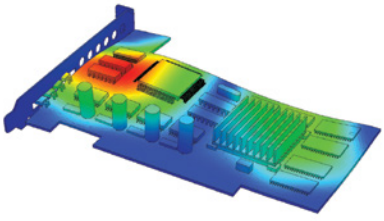
The latest version of **COMSOL** (Burlington, Mass.) Multiphysics Version 5.4, which in addition to two new products, provides performance improvements and additional modeling tools. COMSOL Compiler allows users to create standalone COMSOL Multiphysics applications. Compiled applications are bundled with COMSOL Runtime—no COMSOL Multiphysics or COMSOL Server license required to run. By combining the Composite Materials Module with new functionality for layered shells available in the Heat Transfer Module and the AC/DC Module, users can perform multiphysics analysis such as Joule heating with thermal expansion. COMSOL Multiphysics version 5.4 comes with numerous productivity improvements such as the ability to use multiple parameter sets in a model, including parametric sweeping over multiple parameter sets. Furthermore, users can now organize the Model Builder nodes into groups and assign custom coloring schemes to geometry models. Visit Booth 1518 at SAE WCX.

WCX WORLD CONGRESS EXPERIENCE EXHIBITOR

For more information, visit http://info.hotims.com/73004-401

SPOTLIGHT: WCX EXHIBITOR PREVIEW

Design analysis software



WCX WORLD CONGRESS EXPERIENCE EXHIBITOR

DfR Solutions' (Beltsville, Md.) Sherlock Automated Design Analysis software version 6.1 has two new features, Locked IP Models and Thermal Mechanical BGA Life Predictions. Combined, these new features give users more powerful predictive capabilities along with the ability to protect critical competitive design advantages across the supply chain. These new features are particularly suited to automotive, avionics and other industries that use cutting-edge technology in challenging environments. The Locked IP Model satisfies the different needs of suppliers/OEMs across the product development supply chain. Designs can travel between suppliers/OEMs and preserve sensitive design details without disclosing the intended use, environmental conditions or reliability requirements. Thermal Mechanical BGA Predictability's enhanced analysis surpasses existing FEA strain value data by empowering users to predict the reliable lifetime of Ball Grid Arrays (BGAs) based on actual conditions. Visit Booth 1621 at SAE WCX.

For more information, visit http://info.hotims.com/73004-402

PRODUCT BRIEFS

SPOTLIGHT: WCX EXHIBITOR PREVIEW

Engine timing system chain

AdvanTech International (Somerset, N.J.) and global chain manufacturer **Daido Kogyo** (Kaga, Japan) have developed a new 6.35 mm (0.25 in) pitch silent chain with the thicker plates for the engine timing system. To meet the customer's requirements specific to durable performance, the company adopted the thicker chain plate, which are processed by a unique press technology. This advancement has proven successful in improving fatigue strength. Daido Kogyo's technology to enhance lower-friction, better wear resistance and lower noise also apply to this chain. Daido Kogyo's engine product portfolio supports the complete engine timing system. The company's advanced engine timing system reduces friction and weight to help improve fuel economy. Visit Booth 1712 at SAE WCX.

WCX WORLD CONGRESS EXPERIENCE EXHIBITOR

For more information, visit http://info.hotims.com/73004-403

Hybrid ceramic ball bearings

C&U Bearings (Plymouth, Mich.) hybrid ceramic ball bearings (HCBB) are engineered to maximize the benefits of precision steel ring construction and lightweight ceramic balls. Suitable for use in electric motors, generators and EV applications, the bearings offer electric insulation properties along with high-speed/high-temperature capabilities and can deliver a longer service life than all-steel bearings. Bearing design is optimized to lower maintenance costs, extend grease life, increase service life, and reduce wear from vibration and contamination. C&U HCBBs are available in a variety of configurations with bores from 17-90 mm (0.67-3.5 in), ODs from 40-190 mm (1.6-7.5 in), and speed ratings as high as 21,600 rpm. Visit Booth 1512 at SAE WCX.

WCX WORLD CONGRESS EXPERIENCE EXHIBITOR

For more information, visit http://info.hotims.com/73004-404

Signal conditioners

The Model 700+ Series signal conditioning instruments from **S. Himmelstein and Company** (Hoffman Estates, Ill.) are powerful, yet flexible, one or two channel signal conditioners/displays. They feature fast, accurate readings, user-settable digital filters, real-time cross channel calculations, built-in data acquisition and control functions, serial communications interface, user assignable logic I/O and auto-scaled ±5 and/or ±10-V analog outputs. Selecting from seven available input cards, these instruments can be configured to interface with torque transducers (rotary transformer and slip ring), load cells, pulse output speed pickups and flow meters, voltage output transducers, current output devices, linear variable differential transformers (LVDT), rotary and linear encoders, etc.

For more information, visit http://info.hotims.com/73004-405

Current sense resistors

KOA Speer Electronics' (Bradford, Pa.) SR73-RT Series of low-resistance anti-sulfuration current sense resistors features a new 0402 package size. The SR731E-RT is available in ±1%, ±2%, and ±5% tolerances with resistance values from 1Ω up to 10Ω, a power rating of 1/8 Watt and an operating temperature of -55°C to +155°C (-67°F to +311°F). SR73-RT series current sense resistors offer excellent anti-sulfuration characteristics due to the use of a special high sulfuration proof inner top electrode material and are designed for use in harsh environments with a high level of sulfur contamination. The AEC-Q200 qualified SR731E-RT current sense resistor is suitable for use in outdoor environment applications in mining, agriculture, wine making, and oil/gas. It is also suited for use in automotive electronics and factory automation.

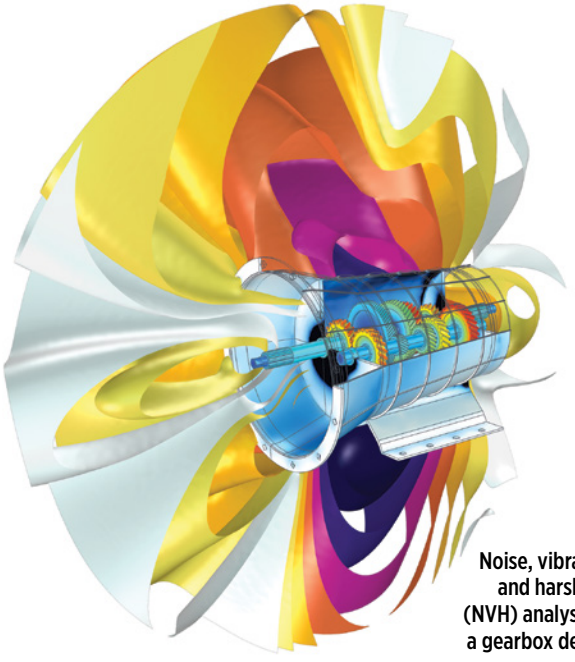
For more information, visit http://info.hotims.com/73004-406

COMSOL

COMSOL, INC.
100 District Ave.
Burlington, MA 01803
Phone: 781-273-3322
Fax: 781-273-6603
E-mail: info@comsol.com
www.comsol.com

Company Description

COMSOL is a global provider of simulation software for product design and R&D. Its platform product, the COMSOL Multiphysics® software, is an integrated environment for modeling designs, devices, and processes. Features for specialized analyses are available with add-on modules, and CAD designs can be imported and analyzed with interfacing products. The built-in Application Builder tool can be used to create simulation applications, which can then be deployed using COMSOL Server™ or COMSOL Compiler™.



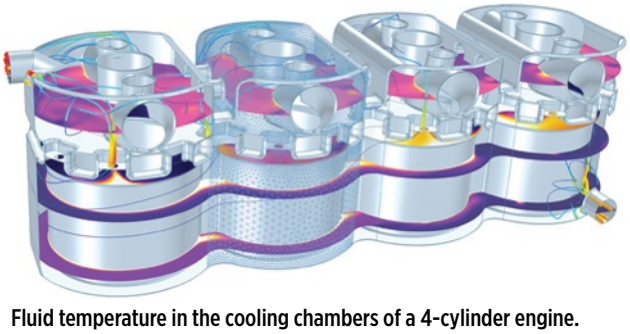
Noise, vibration, and harshness (NVH) analysis for a gearbox design.

Products/Services Offered

Designing a vehicle and optimizing its different components requires collaboration throughout your company. COMSOL provides automotive engineers with the tools they need to account for all relevant physical processes simultaneously and enable the input of other departments and teams. The COMSOL Multiphysics® software and its add-on products enable the modeling of designs such as batteries, battery packs, fuel cells, corrosion processes, thermal cooling processes, pumps, electrical sensors, piezoelectric valves, heads-up displays, lidar system components, and more.

COMSOL Multiphysics® is an integrated environment for modeling designs, devices, and processes in all fields of engineering, and it is particularly well suited for modeling multiphysics phenomena in systems such as sensors, actuators, and batteries found in vehicles. A suite of add-on products extends the core functionality of COMSOL Multiphysics® with specialized features for electromagnetics, mechanical, acoustics, fluid, thermal, and chemical analyses that can be used to evaluate and optimize automotive components and engine systems. There is also a selection of interfacing products for integrating COMSOL Multiphysics® simulations with all major CAD tools. LiveLink™ for MATLAB® interfaces with the MATLAB® software to design control systems and perform statistical analyses of simulation results, for example.

The Application Builder, a built-in tool in COMSOL Multiphysics®, can be used by simulation experts to transform complex numerical models into simulation applications and digital twins for use by other design teams, manufacturing departments, test labs, customers, and more. Applications can be made available to project stakeholders with the COMSOL Server™ and COMSOL Compiler™ deployment products. The COMSOL Server™ deployment product can be used to make simulation applications available through a locally installed client or via a web browser, and COMSOL Compiler™ can be used to compile applications into standalone, executable files for access anytime, anywhere, and by anyone. Simulation applications are a more efficient and inclusive way to implement numerical modeling in your automotive R&D processes.



Fluid temperature in the cooling chambers of a 4-cylinder engine.

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Troy, MI 48084
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Company Description

Royal DSM is a global science-based company active in health, nutrition and materials. By connecting its unique competencies in life sciences and materials sciences DSM is driving economic prosperity, environmental progress and social advances to create sustainable value for all stakeholders simultaneously.

DSM delivers innovative solutions that nourish, protect and improve performance in global markets such as food and dietary supplements, personal care, feed, medical devices, automotive, paints, electrical and electronics, life protection, alternative energy and bio-based materials.

DSM and its associated companies deliver annual net sales of about €10 billion with approximately 23,000 employees. The company is listed on Euronext Amsterdam. To learn more, visit dsm.com.

Products/Services Offered

DSM Engineering Plastics is a global leader in advanced automotive material solutions for automotive, electronics and specialty industries. DSM has a strong track record of material science innovation, particularly in high-performance polyamide resins. Our material brands include Akulon® (PA6/PA66), Arnite® (PBT), Arnitel® (TPC), EcoPaXX® (PA410), ForTii® (PA4T/PPA), Stanyl® (PA46) and Xytron™ (PPS).

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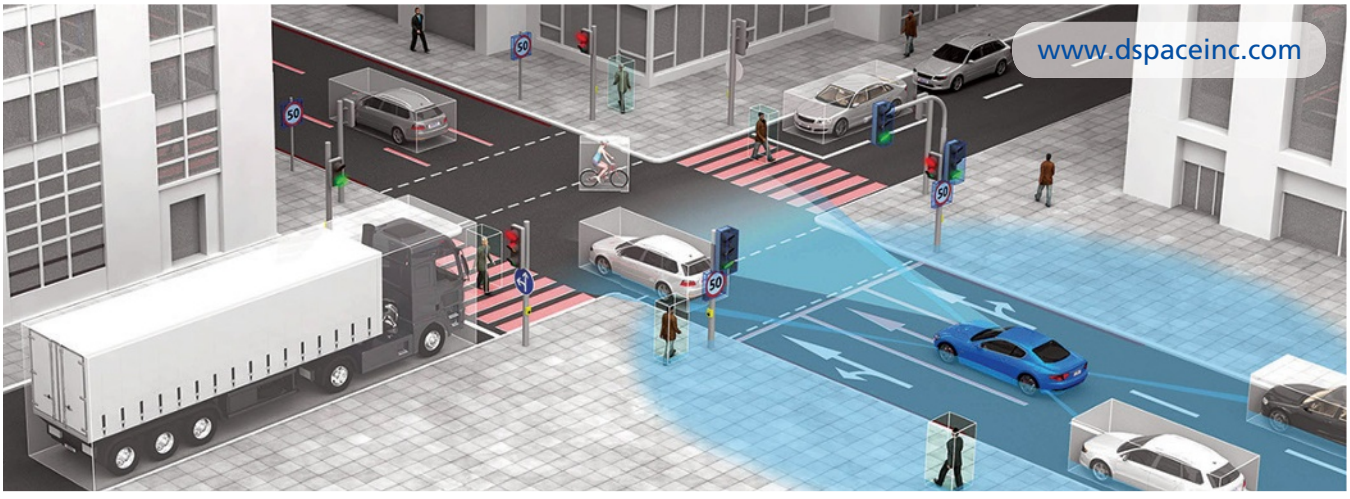

One Integrated Tool Chain for ADAS and Autonomous Controls Development

Requirements such as 360° redundant surround view with numerous heterogeneous sensors, high-precision positioning and car connectivity are challenging topics for automated driving development activities. dSPACE has responded to these needs with an end-to-end tool chain from a single source. From unique rapid prototyping solutions and early software-in-the-loop (SIL) testing to hardware-in-the-loop (HIL) simulation and mechanical test benches, dSPACE is the only provider for the end-to-end testing of complete multi-sensor vehicle applications.

Rapid Control Prototyping

The dSPACE MicroAutoBox Sensor Processing Unit is a compact in-vehicle prototyping unit with high processing power for AD applications. Use with the dSPACE Data Storage Unit to store large volumes of data.

Sensor Fusion

Capture, record, playback, develop, test, validate and deploy data from various sensors and vehicle buses and manage time coherency among numerous software tasks with RTMaps.

DARTS for Sensor Testing

Use dSPACE Automotive Radar Test Systems (DARTS) for accurate over-the-air simulation of radar echoes in real time. Precise characterization and validation of all types of radar sensors.

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Conduct thousands of comprehensive tests 24/7 for highly automated driving functions and self-driving cars right in the lab using dSPACE VEOS®.

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Test complete chains of effect of ADAS and automated driving systems in the lab with dSPACE HIL systems. Integration options available for camera, radar, LIDAR, ultrasonic, V2X, GNSS sensors.

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dSPACE Ethernet and V2X communication blocksets offer a complete solution for in-vehicle and V2X testing for a wide range of applications.

Embedded Success dSPACE

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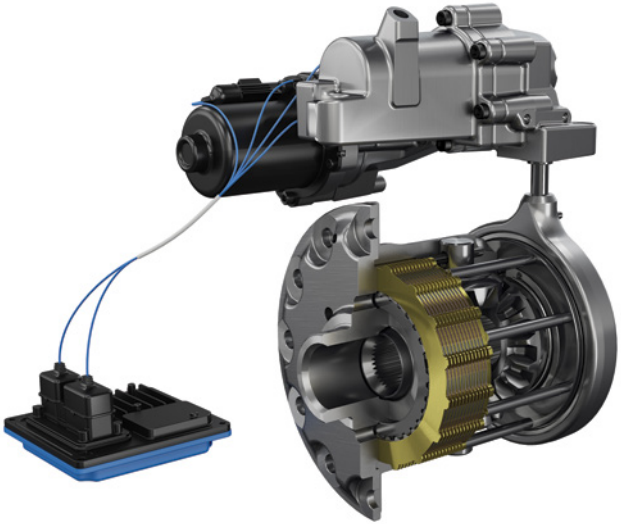
Company Description

At Eaton, we make what matters work. Our energy-efficient solutions help customers effectively manage electrical, hydraulic and mechanical power more reliably, safely and sustainably. We are dedicated to improving the quality of life and the environment through the use of power management technologies and services. Eaton employs 99,000 people worldwide and sells products to customers in more than 175 countries. Eaton generated sales of $21.8 billion in 2018. For more information, visit Eaton.com.



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Products/Services Offered

Developing tomorrow's vehicles requires nothing short of big ideas and Eaton is a global supplier uniquely positioned to answer the demand. Our highly engineered valvetrain technologies provide the fuel economy and reduced emissions required by increasing global regulations. Innovative traction control devices provide enhanced stability and improved performance. Our award-winning TVS® technology delivers precise air flow for a wide variety of applications from enabling advanced combustion processes to fuel cells. Our new eMobility group brings together our strengths in electrical and vehicle know-how to deliver the latest in electric vehicle technologies. So, bring us your technical challenges, and we'll bring you innovative, forward-thinking solutions.

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www.gras.us

Company Description

For 25 years, GRAS has been the leader in innovation by constantly developing cutting-edge test microphones and acoustic sensors. Since 1994, new and exciting products from GRAS have covered the entire acoustic sensor field and have opened the door to a new world of high-performance and rugged testing in the automotive and aerospace and defense industries. Many advances have also been made in the development of specialized acoustic sensors in the audiology and consumer and electronics industries.

Since its inception, GRAS has always pushed the limits of what was possible in microphone design and development to help our customers improve the performance of their products. We offer the most advanced, reliable and sophisticated microphones and acoustical test solutions for critical applications.

For the widest range of high-performance, reliable test microphones and acoustic solutions, GRAS is the best choice for your NVH testing challenges.

Products/Services Offered

As a world leader in developing cutting-edge acoustic sensors, GRAS has recently launched an expanded line of new and improved microphones for more efficient and reliable automotive NVH testing. The 147AX CCP Rugged Pressure Microphone is a surface microphone optimized for cold and hot engine noise testing, and ensures more efficient testing and repeatable results. The 147EB CCP X-Rugged Microphone Set is an extremely robust microphone specially designed and optimized for wheelhouse brake noise testing.

Together with the robust 146AE CCP Free-field Microphone Set, these new products make up a full portfolio of microphones covering all application areas within automotive NVH testing.

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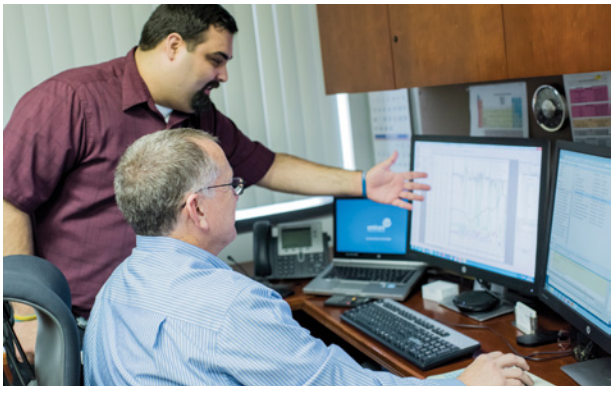
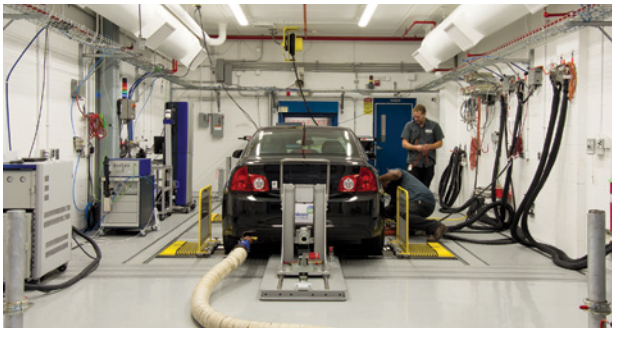


Company Description

Umicore is a global leader in advanced emission control technology and offers solutions for: gasoline vehicles, light- and heavy-duty diesel vehicles, hybrid and electric vehicles, fuel cells, motorcycles, small engines, and stationary. With an extensive technology portfolio, Umicore's engineers help manufacturers as they develop and test lighter weight vehicles, new GDI and diesel engines, new drivetrains and other approaches.

The Auburn Hills, Michigan, Technical Center features a state-of-the-art analytical room equipped with six analytical benches for HC, CO and NO_X measurement and two FTIRs for other gas measurement (NH_3, N_2O) plus equipment to measure particle mass and particle number. In addition, dual-roll, 48-in. dynamometers can test 4x4s, all-wheel-drive (AWD) vehicles and hybrids per the U.S. Federal drive cycles as well as for Europe and Japan.



Products/Services Offered

Umicore Technology Highlights

Catalysts for all diesel applications:
- Selective Catalytic Reduction (SCR)
- SCR on Diesel Particulate Filters (SDPF)
- Catalyzed Diesel Particulate Filters (cDPF)
- Diesel Oxidation Catalysts (DOC)
- NO_X Storage Catalysts (NSC)
- Passive NO_X Adsorbers (PNA)
- HC-based NO_X Control (HC-DeNO_X)
- Ammonia Slip Catalysts (ASC)
- Corrugated SCR Catalysts

For gasoline and hybrid vehicles:
- Three-way catalysts (TWC)
- Catalyzed Gasoline Particulate Filters (cGPF)
- Gasoline Direct Injection (GDI) Lean NO_X
- HC Adsorbers

For hybrid and electric vehicles:
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For fuel cells:
- Catalysts
- Anode/cathode materials

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ArcelorMittal

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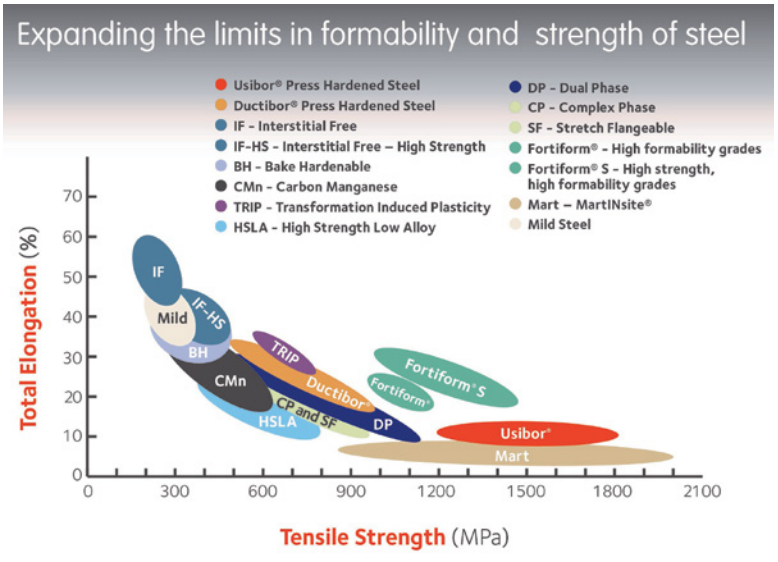
1 South Dearborn Street, 18th Floor
Chicago, IL 60603
Phone: 800-422-9422
E-mail: automotiveNA@arcelormittal.com
automotive.arcelormittal.com

Company Description

ArcelorMittal is the only automotive steel producer with a worldwide presence, delivering a large scale of products, solutions and services to automotive customers with the same quality focus in all regions. Almost every car on the road contains ArcelorMittal steel.

ArcelorMittal is a technology leader in advanced high-strength, galvanized and coated steels. More than one third of our investment in product research and development (R&D) is allocated to the automotive industry, and we have six laboratories that are dedicated fully, or partly, to R&D for the automotive market. Our R&D engineers work with carmakers throughout the lifecycle of their products to develop automotive steels that are stronger yet lighter than existing materials. We also develop new, cost-effective coatings to improve corrosion resistance, paint appearance and application processes.



Products/Services Offered

S-in motion® is a set of steel solutions developed by ArcelorMittal for automakers who wish to create lighter, safer and more environmentally friendly vehicles. We offer a wide range of affordable, lightweight steel solutions for cars, trucks, SUVs and battery electric vehicles, including body-in-white, closure and chassis components.

ArcelorMittal has developed and commercialized advanced high-strength steels and ultra high-strength steels to expand the traditional trade-off limits between formability and strength. Our extensive product offering includes Usibor® and Ductibor® press hardened steel (PHS) grades. These hot stamping steels reduce weight in structural and safety components that require greater tensile strengths, up to 2000 MPa. Our MartINsite® line, ranging from 900 MPa to 1700 MPa, helps automakers shed weight from simpler, roll-formed shapes. ArcelorMittal also offers a full spectrum of dual phase (DP) steels with tensile strengths ranging from 500 to 1180 MPa, ideal for lightweighting applications requiring high energy absorption.

automotive.arcelormittal.com

BorgWarner

BORGWARNER INC.
3850 Hamlin Road
Auburn Hills, MI 48326
Phone: 248-754-9200
borgwarner.com

Company Description

BorgWarner Inc. is a global product leader in clean and efficient technology solutions for combustion, hybrid and electric vehicles. With manufacturing and technical facilities in 66 locations in 18 countries, the company employs approximately 29,000 worldwide.

Products/Services Offered

Whether in a highly efficient combustion engine, an intelligent hybrid system or the very latest electric drive, BorgWarner is driving mobility for today and tomorrow. Our vision is a clean, energy-efficient world. That's why we develop mobility system solutions that reduce energy consumption and emissions, while at the same time improving performance. As the product leader with more than 130 years of experience in the field of powertrain systems, we are supporting the automotive industry in realizing clean propulsion and efficient technology solutions for light-, medium- and heavy-duty vehicles as well as off-highway applications.

borgwarner.com

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READER FEEDBACK

Kill the EV Tax Credit!

Your EV taxpayer-funded subsidy is on target. For a Federal budget of over $4T and a national deficit over $20T, any low-hanging fruit to help reduce the hemorrhaging of taxpayer dollars toward programs with little or no benefit for the masses should be plucked now. Not five years from now. This taxpayer giveaway has been no more effective than Cash for Clunkers, when one considers the average age of vehicles on the road right now. You have the stats.

Let EV's stand or die on their own merit in the marketplace. The vehicle battery-charging infrastructure is way behind where it needs to be for practical long-range use, in addition. I know that this thinking doesn't square with the socialist Green New Deal inside the Beltway. My suggestion has a touch of sanity to it that is non-existent with the GND.

The staff at SAE *Automotive Engineering* continues to do a really good job bringing timely topics to our attention.

Steve Lyman
President, All American Dynamics

I agree with editor Brooke's prescription to end the EV tax credit, which has already lasted too long and produced almost nothing. I believe electric vehicles are viable for the future, but it should be the market that drives their adoption, not government subsidies. I would give the existing credits two more years at most.

Stu Kaplan
Madison, Wisconsin

Thanks to AE for taking a stand on the electric vehicle tax-credit boondoggle. Let the market decide if EV technology can be self-sustaining.

Harold Chu

Your editorial "Kill the EV tax credit by 2025" makes a great argument for saving "taxpayers about $20 billion over the next decade." However, according to recent articles, the U.S. has already spent $5.9 trillion on the wars since 2001 that are essentially subsidies for the U.S. oil/gas industry. The wars are gifts to the oil industry. Without U.S. military support, the oil industry would have to pay for its own "security forces," mercenaries, or private paramilitary organizations.

In addition, the U.S. provides many other subsidies in the form of tax exemptions, write-offs and other legal-weasel tactics that have been in progress since the early 20th century. If we eliminate the tax incentives for EVs, we should also eliminate all subsidies and incentives for the oil/gas-fueled internal combustion engine (ICE) vehicles. If we did that, the EVs would easily outsell the oil-burners. The price of the multi-trillion-dollar wars would then have to be carried by the ICE vehicle owners. I do understand that ending such oil/gas industry subsidies would impact homeowners who heat with oil or gas, but that is a separate issue that can be addressed via a combination of better home insulation, passive solar heating and electrically-powered heating.

Constantine Kortesis, CMfgE

The writer was part of GM's EV-1 team and involved in the NASA development of hydrogen fuel cells for the U.S. space program.

Needed: A step beyond STEM

Sam Abuelsamid is right on in his article "Needed: a step beyond STEM" [February]. We need to include the arts in our education and consideration in all things engineering. What is interesting is that I am seeing this in what seems to be a grassroots effort to promote STEM with the arts included here in Central Iowa and they are calling it "STEAM." Far too many engineering decisions are made without consideration of the fellow man.

If we all were a little more educated in the arts, just maybe we would see more products that are truly engineered for the betterment of mankind in mind.

Richard W. Job
Ankeny, Iowa

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

COMPANIES MENTIONED

AD INDEX

Q&A

Engineering Volvo's next big leap

Volvo Cars has set one of the industry's most ambitious engineering goals: to have zero traffic fatalities in any of its new models beginning in 2020. It also aims to have one-third of its new-vehicle range be capable of SAE Level 4 autonomous operation by 2025. First to arrive with Level 4 capability will be the next-generation XC90 due in 2021.

Henrik Green (below), the senior VP of research & development, is pleased with his company's progress in both the electrification and automated-driving areas. As a computer-engineering graduate, Green joined **Volvo** in 1996. He's since led engine development, powertrain-controls, and the 40-series vehicle program, and has headed global product strategy. He spoke recently with editor-in-chief Lindsay Brooke on Volvo's technology trajectory.

Some OEMs say LiDAR is necessary while others say it's not. Does Volvo's relationship with Luminar validate LiDAR's future with your company?
Yes, it does. We're coming from the safety perspective so we pay close attention to the algorithms that will ultimately control an autonomous vehicle. In that sense we need to understand the objects around us—what they are and what they're going to do in order to predict their path. And we need that to determine our path forward and to avoid any false positives. So, need super perception. And we believe long-range, very high-resolution LiDAR is the key to that.

When do you expect LiDAR sensors to be commercially available with a form factor that Volvo's vehicle designers will love for their compact size?
Our next-generation 'SPA-2' [scalable product architecture] vehicles that we're launching at the beginning of the next decade are being engineered from scratch with the necessary electronics and software to have full autonomy. So, the form factor of the sensors is a key thing here. It's a challenge because we want to be able to access the absolutely-latest technology. At the same time, we need to make the car look amazing in the consumer's eyes. It's a matter of physically integrating sensor hardware into the vehicle so it looks great—but doing it as late as possible in the vehicle-development stage.


Henrik Green

The energy consumption of these vehicles—for the compute and sensor platforms—is significant.

With up to 80 companies now claiming to be 'LiDAR suppliers,' how do you as Volvo R&D boss sort them out?
It boils down to three things: Range, resolution at maximum range, and scalability. With that, I think we have a really good partnership going with **Luminar**.

Do you see unit costs for LiDAR coming down?
In general, I would say 'yes' to that for all the parts of the technology. We will have to deal with the cost as we get close to launch, but at that point we will always prioritize safety. We want a capable system—and that will not come cheaply in the beginning. But over time the cost will come down from both the technology evolution and from scale.

How are you managing thermal challenges in development?
The energy consumption of these vehicles—for the compute platform and sensor platform—is significant. Power supply and thermal management are among the issues we're dealing with. These have been less important in past vehicles.

Electrified vehicle platforms offer sufficient power for this.
Absolutely. The programs we're running today, current initiatives, use our plug-in hybrid platform. It's good to have a plug-in battery of that size because we need the power to run the processor. But when we launch the next generation SPA-2 we will have full EV capabilities and a great deal of energy capacity on board.

How difficult has it been for Volvo to transition from ICE to pure-EV platforms?
The scaling challenge is, I think, interesting. Anybody can build one good EV, and now nearly everybody is doing that. We'll see a number of new EVs coming out within a few years and we'll be among them. Our SPA-2 architecture is engineered for EVs from the ground up. We'll be able to scale EVs across our vehicle 'top hats' as market demand grows. ■

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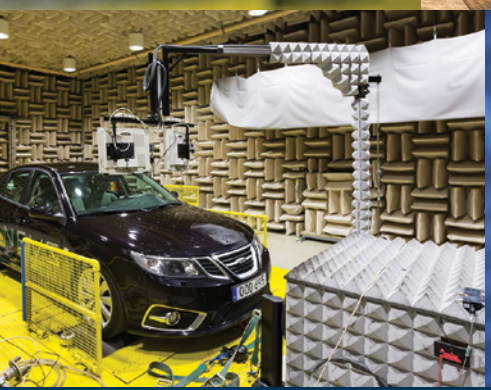
- Electric & Hybrid Vehicle R&D
- Vehicle Interior NVH
- Road Noise Testing
- Wind Noise (Aeroacoustics)
- Squeak and Rattle Testing
- Pass-by Noise





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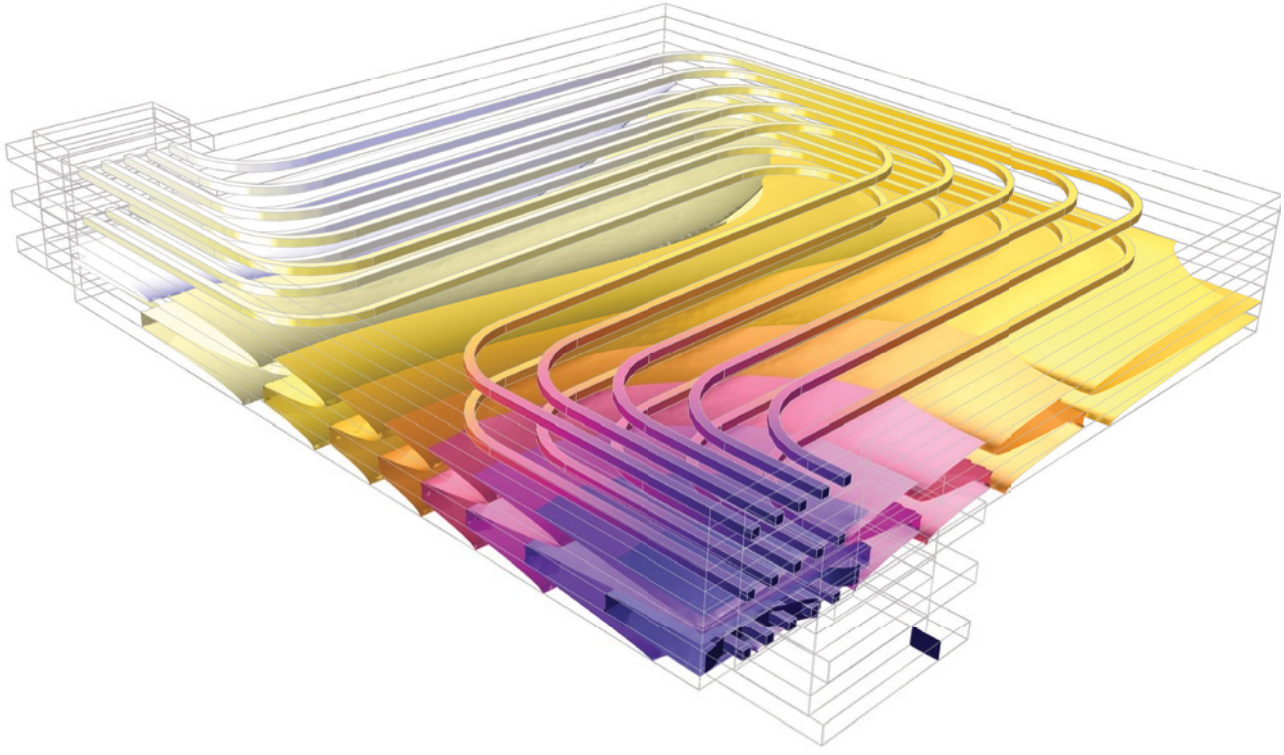
Autonomous vehicles require batteries with lasting power.



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.

The COMSOL Multiphysics® software is used for simulating designs, devices, and processes in all fields of engineering, manufacturing, and scientific research. See how you can apply it to optimizing battery designs for self-driving cars.

comsol.blog/autonomous-vehicle-batteries

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