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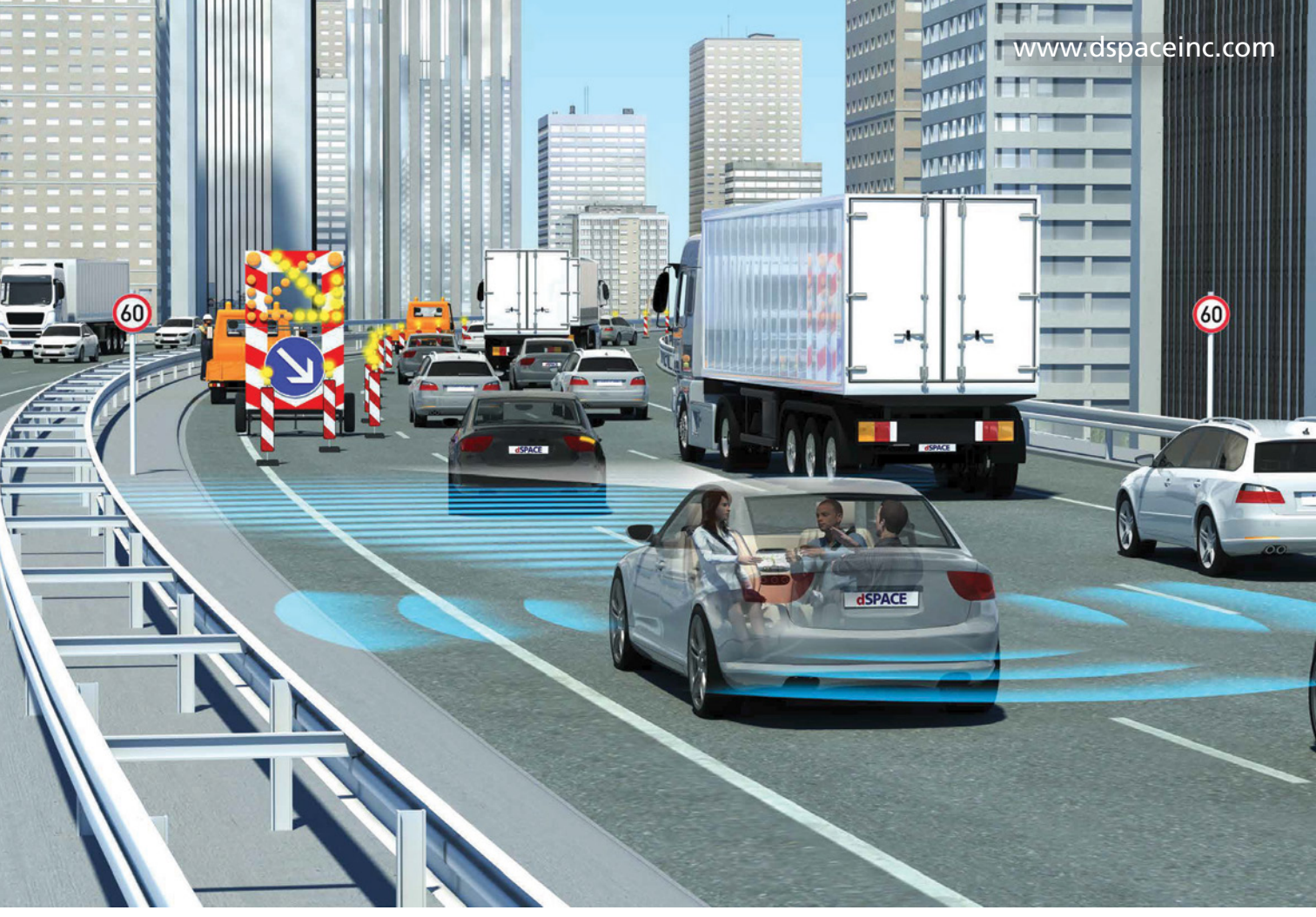

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ON THE COVER

Jeep's 2018 Wrangler, designated internally as JL, is all-new after more than a decade since the iconic off-roader's last major redesign. Larger yet lighter and more nimble—and with new efficiency-enhancing technologies that include an available turbocharged 4-cylinder and 48-volt starter-generator system—the JL's developers say one thing had to remain the same: the Wrangler's famed "go-anywhere" off-road capability that many may find a refreshing counterpoint to today's automated-driving developments.

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EDITORIAL

Making the case for simple, robust 'core' engineering

Automotive designers often draw our attention to styling elements that appear simple, but in truth are incredibly complex. "Complicated simplicity" is a phrase also coined in architecture and fashion, when there's more going on than meets the eye.

The same often is true in vehicle engineering. Prompting my thoughts here: the slot-faced vehicle on this month's cover: a red 2018 **Jeep** Wrangler churning steadily forward through water that is above its hubs—and probably well above its crankshaft axis. Wrangler is the only contemporary vehicle I can think of whose accessory catalogs include a deep-water fording kit (quite popular) and enormous manual jacks—the latter to be used more for levering your high-centered vehicle off some mountainside rock, than for changing flat tires.

Bill Visnic's cover feature details the new JL's development and technology story, and Bill returned from Wrangler's media launch in the Arizona backcountry invigorated by the new Jeep's capabilities. Editors generally respond this way, of course, when we've just spent a day playing Rat Patrol over terrain that would give pause to Erwin Rommel. But as Bill indicates, you need less than five fingers to count the production vehicles built today that can match the Wrangler's overall mobility.

The latest Wrangler, while spaceship-complex compared with its WWII **Willys** and **Ford** ancestors, remains stone-simple by 2018 standards. That's by design. Jeep knows its customers better than any OEM on the planet—except for maybe **Harley-Davidson**—and those ever-expanding worshipers directly drive Jeep engineering, design and feature-content decisions in Auburn Hills.

Like everybody else, Wrangler customers want touchscreens and more USB ports. Self-parking, maybe not so much. But primarily they want the vehicle to resemble a classic military or CJ Jeep and perform superbly in the extreme, even if it never leaves the pavement. That requires focus on what appear to be simple engineering tasks but actually are complex exercises.

Look underneath a new Wrangler and you'll see the "cleanest" underbody in the SUV segment. That was a major achievement to execute, although to some it might seem a finger-snap. No lower shock mounts or suspension links or even errant bolt heads to potentially bend or snag a log on the trail—or scrape a parking-lot divider. Tucking the Wrangler's suspension, axles and exhaust up out of harm's way—almost invisible—took considerable time and fresh technical thinking. Same with the new/old folding windshield. And the unique roll-cage structure. And the hours spent by the metallurgists and CAE jockeys in taking significant mass out of the chassis while improving its stiffness.

Engineers know that delivering robust, light, simple and low-cost products—software included—is as demanding as delivering those that are outwardly sophisticated. Dr. Chris Borroni-Bird echoed that point to me while discussing his solar-powered e-trailer featured on page 26. Such projects require developmental rigor and discipline that are, in my view, increasingly underappreciated in this industry.

Electric and automated/autonomous systems represent the vanguard of mobility technology. And they tend to get most of the attention from the investment community and mainstream media. Ongoing advances in the "core" automotive areas—vehicle structures, joining technology, friction reduction, suspension and braking systems, forming and materials, and torque transfer—deserve acclaim at least equal to that lavished on million-line algorithms. We won't forget that here at **SAE**'s *Automotive Engineering*.

Long live the Jeep Wrangler and its ruggedly elegant simplicity.

Lindsay Brooke, Editor-in-Chief

Driving Greater Efficiency for Tomorrow's Powertrain Requirements

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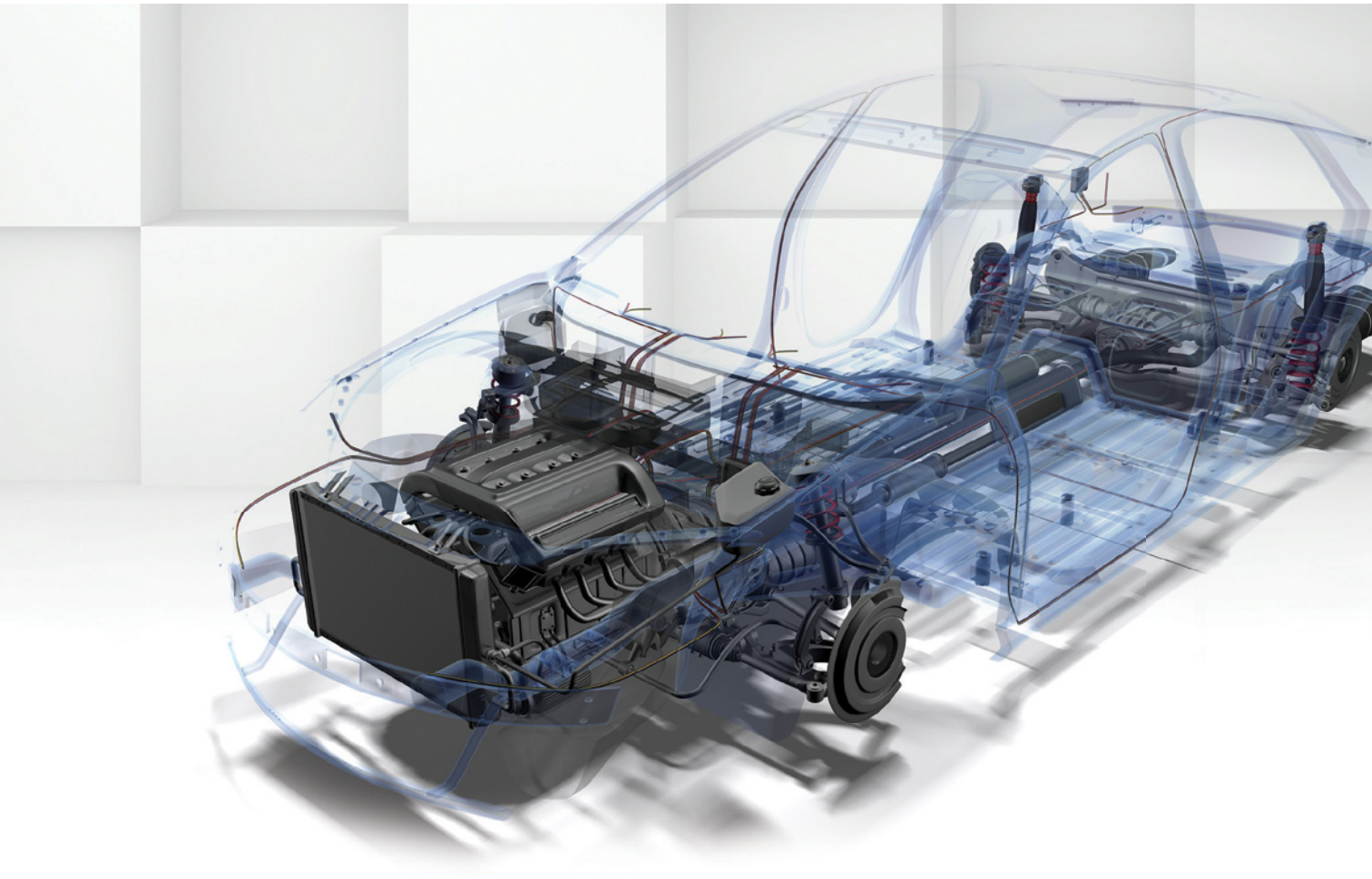

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Learnings from a pivotal year

At some point during the next decade, as they plot their business and technology roadmaps to 2030, industry planners will look back on 2017 as a watershed of events and trends that shaped the mobility future.

Surprises, setbacks, distractions and lessons abounded. From a global perspective, the inflection of future emission regulations across the primary vehicle-making regions are substantively impacting decisions to integrate new technologies to reduce CO_2. Europe and China are expected to maintain and possibly advance their implementation of stricter tailpipe regulations by the middle of next decade, while the U.S. re-evaluates its Federal standards.

Meantime, California and its allied states contemplate their direction while Sacramento wields its 'ZEV mandate' regulatory lever. To ensure their bases are covered, OEMs are committing to greatly expanded electric-vehicle portfolios by 2021-23—but without the customer demand and robust energy grids needed to support them. Electrification's disruptive uncertainty in North America and Europe will continue to alter both future supply chains and the relative importance of several traditional vehicle systems. New combustion engines and drivelines, for example, will be increasingly engineered as elements of the electrified-propulsion architecture.

Changes in the industry's technological hierarchy accelerated in 2017. As I've noted here previously, the 'Super Tier 1s'—**Aisin**, **Bosch**, **Continental**, **Delphi**, **Denso**, **Magna**, **Mobis**, **Valeo**, **ZF** and their own tech partners—will continue to drive development and integration of automated/autonomous and electrified systems. These multinational giants bring scientific, engineering and financial muscle that is vital to their customers' competitiveness and to the industry's evolution.

Without question, scale is more critical than ever. New linkages between **Toyota**, **Subaru**, **Suzuki** and **Mazda** (now collectively over 16 million annual units), **Renault-Nissan** and **Mitsubishi Motors**, and the **GM-Ford** 10-speed transmission collaboration, to name a few, underscore this trend.

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In 2017, over 600,000 units of volume—three assembly plants' worth of capacity—shifted from passenger cars to light trucks.

In terms of overall volume, North America bucked the global trend. It was one of the few regions to retreat in 2017—production declined 4% to 17.1 million units from 17.8 million in 2016. U.S. sales were responsible for most of the reduction with volume off 2.5%, though bolstered later in the year by several weather-related calamities in the U.S. South. The year also witnessed a rare labor action—the four-week strike by Canada's Unifor at GM's **Ingersoll**, Ontario, CAMI plant, which disrupted the launch of the new **Chevrolet** Equinox.

While overall volumes declined, changes in product mix also created challenges. Over 600,000 units of volume (3.5 share points) moved from passenger cars to light trucks. The swift shift—three assembly plants' worth of capacity—left various OEMs with a mismatch of offerings. Some were unable to flexibly shift to SUVs and crossovers; others simply had no new utilities of any kind to deploy.

As a result, North American capacity utilization in 2017 lost roughly eight points, falling to about 85%. That's far from the nearly 95% utilization achieved during the previous several years. In 2017 over one million units of straight-time capacity was added in the region, as several OEMs opened facilities in the southeastern U.S. and in Mexico.

Efficient access to end markets is critical to OEMs and suppliers alike in a well-oiled North American production and vehicle distribution network. The North American Free Trade Agreement that has underpinned efficient commerce between the U.S., Canada and Mexico since the mid-1990s is now under scrutiny by the White House. Any substantive changes in NAFTA's structures will have an impact on the final cost to the consumer and cause dislocations up and down the supply chain.

This industry places capital bets in five-year intervals—not conducive to tariff and trade structural turbulence. More to come on this as the self-imposed deadline to conclude (or abandon) NAFTA approaches. ■

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THE NAVIGATOR

Cooking up the perfect automated-driving system

Ask any group of chefs how to prepare a particular recipe and you'll find general agreement about the list of basic ingredients. However, between that list and the finished product are endless variations of process and proportions.

Consider the humble cup of coffee. In its most basic form, it consists of roasted-and-ground beans to which water is added to create a dark brown caffeinated liquid. Then come the various bean origins (Colombian, Hawaiian, Ethiopian, etc.) and the variety of preparation: drip, percolators, espresso, press pots, cold brew and the latest fad, pour overs. The mind-boggling array of fancy coffee drinks on your local café's menu board shows there is clearly no consensus for making a cup of joe.

The same is true of the pathway to automated driving. From Silicon Valley to Stuttgart to Tel Aviv to Tokyo, there is some technical consensus on how best to create a faultless vehicle system. Precision sensors and sophisticated software—check. Powerful computer platforms and fast actuators—ditto. But that's where things start to diverge.

What's the best way for electronic devices to be aware of the environment around a car? Imaging sensors? Radar? Lasers? Acoustics?

The answer is probably all of the above. Just as much of the coffee (or wine or orange juice) we drink is blended from numerous sources, engineers want multiple types of sensors to deliver the unique characteristics that allow them to detect different elements of the driving environment.

Cameras provide the least abstract view of the world, one that is familiar to our own eyes. They can generally see details that can be fed into pattern-recognition algorithms to enable the software to distinguish between other vehicles, pedestrians, cyclists, animals and static objects as well as the road itself. Cameras however, often struggle in challenging lighting conditions such as the sun shining directly into the imager.

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Tesla's Elon Musk and hacker George Hotz both insist that lidar is not needed in automotive sensor systems.

Radar delivers a more abstract view of the space in front of and around the vehicle. It can be used to detect distance to other objects along with their speed and trajectory, but it is challenged by water-filled targets like humans and animals. Lidar's capabilities lie in between; it offers some of the acuity of cameras but with distance- and speed-detection capabilities along the lines of radar.

Between them, cameras, radar and lidar provide some overlap and redundancy. Where one type is unable to read reliably or fails, the others can fill in the gaps.

The proportions of how much to rely on each of these and other types of sensors is still very much a topic of debate among the engineers developing and integrating automated driving systems. Some, including **Tesla** CEO Elon Musk and hacker George Hotz insist that lidar is not needed, since we humans rely mainly on sight. Most others in the industry agree that lidar is necessary, but the reliance on it brings mixed opinions. **Waymo**, **General Motors**, **Ford** and **Delphi** all consider lidar to be a key technology for vehicle automation. Waymo is using multiple lidar sensors on its vehicles for short-, medium- and long-range detection in addition to cameras, radar and even microphones to listen for the sirens of emergency vehicles.

Intel and its subsidiary, **Mobileye**, are taking a more camera-centric approach to the problem. With as many as a dozen imaging sensors on some of their development vehicles, Mobileye engineers believe their systems can reliably detect nearly everything in the vehicle environment. They use radar to provide an assist for speed and distance measurement. Lower cost, lower resolution lidar sensors are only used as backup.

It's too soon to say which recipe, if indeed any, will best satisfy the palette. Just as some prefer a French Roast Ethiopian bean, others go for a medium-roast Kona. As long as they are safe and reliable, future sensor-system 'brews' will be similarly diverse. ■

Moving swiftly to define the shared-mobility future

Public and private partnerships to standardize data, share data, and protect sensitive data are being formed to help understand—and at the same time define—shared-mobility's potential to transform the transportation network.

Shared-mobility operators, for example, compile data such as the origin and destination of shared services, travel time, and trip duration. And many shared-mobility companies have agreed to share data with public agencies voluntarily or as part of regulatory mandate.

For example, as part of Washington, DC's car-sharing parking initiative adopted in 2005, car-sharing operators seeking on-street parking are required to provide the DDOT (**District Dept. of Transportation**) with quarterly data to assess the impacts of their parking program. In 2012, **City CarShare** voluntarily shared data with the **SFMTA** (San Francisco Municipal Transportation Agency) during the city's **SFpark** pilot to assist planners and policymakers with the development of the carsharing parking policy.

In addition to this data sharing with public agencies, a number of shared-mobility service providers make data publicly available for download. **Bay Area Bike Share**, **Capital Bikeshare**, and **Citi Bike** are a few of the operators that provide some of the most expansive publicly available data.

Finally, data standardization is critical to ensuring compatibility for a variety of uses and platforms. More industry-wide standards, either through trade associations or government regulation, could aid in the development of clear and consistent data formats, data sharing protocols, and privacy protections to ensure open data,

TONY WEBSTER, WIKIMEDIA COMMONS

In addition to data sharing with public agencies, some shared-mobility service providers like Capital Bikeshare make data publicly available for download.

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interoperability, and comparability across a wide array of platforms.

Cognizant of the need for continued, focused collaboration in all facets of shared-mobility development and among its various constituencies, **SAE** recently established a Shared and Digital Mobility Committee. This committee is exploring one of the segments the organization has classified as advanced technology areas (connected and automated vehicles, cybersecurity, and shared mobility).

According to SAE Director of Ground Vehicle Standards Jack Pokrzywa, the new Shared and Digital Mobility Committee activity is of interest because it involves three of those advanced technology elements: cyber, connected, and automated. Developing this new committee injects SAE into the future trends emerging at this moment in the shared-mobility sector. "It is really transformative of the transportation space," he said. "We are seeing a lot of interest out there."

An in-person kickoff meeting for the new Shared and Digital Mobility Committee was held in early November with approximately 80 individuals in attendance representing various companies such as **Uber**, **Zipcar**, **Lyft**, **Car 2 Go**, **Catch**, the **Shared Mobility User Center**, and the **Dept. of Transportation**, as well as various OEMs.

The Shared and Digital Mobility Committee met for a second time in December. It worked to develop a preliminary draft of the terms and definition standard. Dr. Susan Shaheen from the **University of California-Berkeley**, who is leading academic efforts in shared mobility, volunteered to be the document sponsor. It was submitted to the committee for review and further work.

"We anticipate that the terms and definitions document will be a recommended practice technical report," said Annie Chang, Project Manager, Technical Programs, Global Ground Vehicle Standards at SAE International. "We are still trying to finalize the scope of this document."

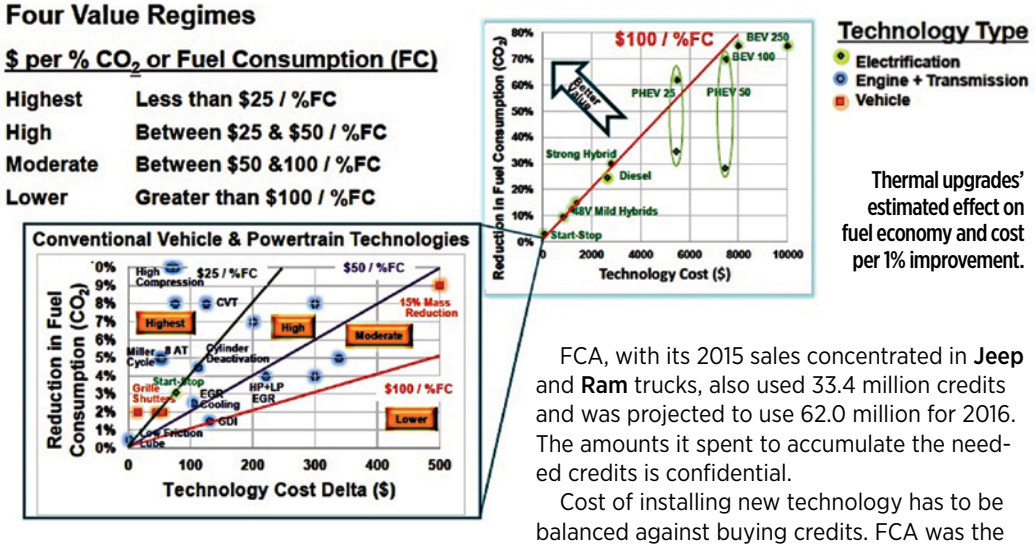
The group was scheduled to meet again in early January for a face-to-face meeting during the week of the Transportation Research Board Annual Meeting in Washington, DC. Technical experts from OEMs who focus on shared mobility are being sought to join the committee.

Chang says the committee hopes to publish the terms and definitions recommended practice sometime in 2018. We will keep you posted. ■

For more information on the Shared and Digital Mobility Committee, contact Annie Chang (annie.chang@sae.org).

POWERTRAIN | PROPULSION

Thermal management plucks CAFE's low-hanging fruit



Thermal upgrades' estimated effect on fuel economy and cost per 1% improvement.

Thermal management systems may offer the most 'bang for the buck' in the quest to improve vehicle efficiency and thus meet stringent U.S. Corporate Average Fuel Economy standards. Although some of the 'low-hanging fruit' in this area has been picked, opportunities still exist to further improve thermal management before engineers must shift to more costly investments.

This was the widely-expressed belief by speakers at the 2017 **SAE** Thermal Management Systems Symposium, led by a keynote from Sean Osborne, director of the **ITB Group**, a consulting firm specializing in the subject.

The need for improvement becomes urgent in 2018. That's because when the 2019 model year begins, the **NHTSA** raises the penalty for missing the CAFE target, from the present $5.50 per 0.1 mpg shortfall. Initially the new penalty was set at $14 per 0.1 mpg, but the industry was granted a review, based on claims of negative economic impact and objection to the way an inflationary adjustment to CAFE was applied. Environmental groups are fighting the review delay.

Market shift to trucks, SUVs an issue

To date, automakers have met the CAFE standards, but the shifting of the market from passenger cars to light trucks and SUVs has tightened the margins, and forced high use of retained and/or purchased CAFE credits. Fines paid by OEMs during the 2010-14 period include $46.2 million by **Jaguar Land Rover**; $28.2 million by **Daimler**; $17.4 million, **Volvo**; $4.8 million, **Porsche**, and $3.6 million **Fiat Chrysler** (FCA).

FCA, with its 2015 sales concentrated in **Jeep** and **Ram** trucks, also used 33.4 million credits and was projected to use 62.0 million for 2016. The amounts it spent to accumulate the needed credits is confidential.

Cost of installing new technology has to be balanced against buying credits. FCA was the first U.S. maker to go across the board with R-1234yf, a low-global-warming refrigerant that when used carries significant credits (13.8 g CO_2 for cars, 17.2 g for trucks).

To stimulate sales, the **Chrysler** Pacifica plug-in hybrid (PHEV) is cheaper in transaction prices than the gasoline-only model for the most popular configurations. FCA has yet to install direct fuel injection on its high-volume 3.6-L V6, but it has a system fully engineered and ready to deploy when its use is more cost-effective.

Flow valves, heat recovery

For conventional powertrains the lowest-hanging "fruit" to date, according to ITB's Osborne, consists of such features as high compression ratio, liquid-cooled EGR, idle stop-start, low-friction lubricants and active grill shutters. Of the energy produced by the engine, 26% is diverted to the cooling system and 32% to the exhaust, according to Jaguar Land Rover estimates based on the NEDC—New European Drive Cycle. Other opportunities in the thermal management area are focuses of attention.

BMW has been using a duty-cycle-controlled electric water pump for more energy-efficient cooling on its gasoline engines for several years. But coolant flow valves may be a less-expensive alternative for engines with complex coolant flow patterns based on temperatures in the cylinder block vs. head(s) and ambient temperatures.

Further, recent research by **Bosch**, in its TMSS presentation, indicated a flow valve system also

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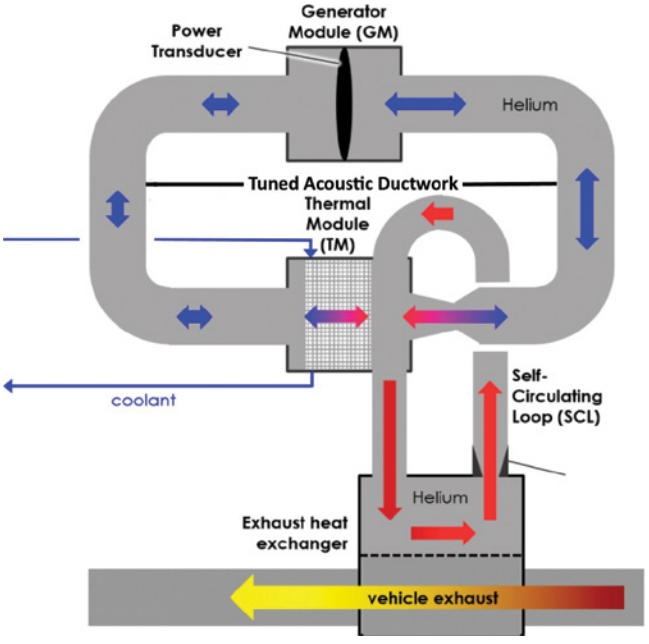


Thermo-acoustic system uses helium as the working fluid. A tuned acoustic ductwork carries amplified thermally-generated heat waves to the generator module to produce work.

could contribute to range extension in battery electric vehicles (BEVs). Using the GT Suite from **Gamma Technologies**, a Bosch team projected that recovering heat from electronics, along with a heat pump, could increase BEV range by perhaps 25 km (16 mi) by avoiding re-use of a battery heater to enhance battery capacity. This approach also was seen as less expensive than adding battery kW·h capacity in cold ambient.

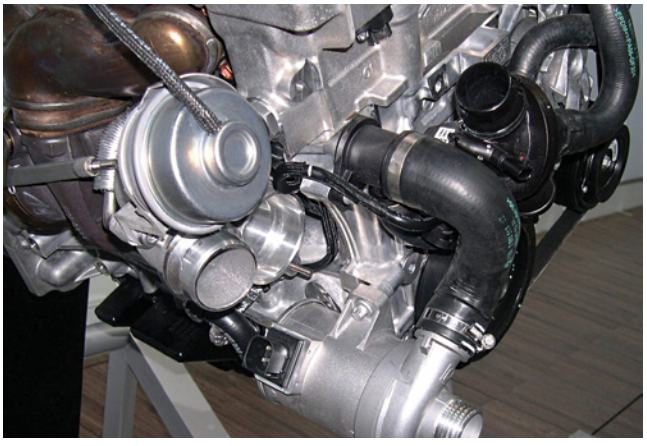
Although exhaust heat recovery seems likely to be among the higher-cost systems available, two already are in use on U.S. market **Toyota** Prius and **Hyundai** Ioniq/**Kia** Niro hybrids. They're basic systems, with a heat exchanger in the exhaust transferring heat to engine coolant for faster warmup.

In the Niro/Ioniq split system, early heating of the block reduces engine friction, increasing use of the all-electric mode. So fuel economy in the EPA city cycle was increased up to 7%, claims Kia for the Niro. This is much more than 1% estimated for such a system by a **Tenneco/Computational Science Experts Group** (CSEG) research team led by Tenneco's Dr. Dipanka Sahoo. It indicates selection of the right application is key.

The Tenneco/CSEG estimate is based on 85% effectiveness in the first 250 s of warmup and an average of 19% heat capture over the entire cycle.

Other systems the Tenneco team also evaluated converting exhaust heat into mechanical work or electricity, which can reduce alternator load and/or serve as hybrid assist devices.

One is the "TEG" (thermo-electric generator), which uses exhaust heat to provide the high temperature of a temperature differential that produces electricity from a solid-state device that is the reverse of the Peltier effect used for cooled-



BMW's electric water pump provides energy-efficient cooling on four-cylinder gasoline engines.

heated seats. The thermo-electric materials are rare-earth type, not inexpensive (particularly those with higher efficiency). However, work in nanotechnology could improve efficiency and minimize need for rare-earth substances, both in TEG and Peltier applications, the Tenneco team believes. Fuel economy improvement was projected at 0.7%.

Thermo-acoustic potential evaluated

The thermo-acoustic traveling wave system also was evaluated. It uses a pair of heat exchangers (one hot from absorbing exhaust heat, one cold). A porous medium called the regenerator, in between, establishes a temperature gradient between the two, using helium as a working fluid. This results in an oscillating gas flow, generating sound (acoustic) waves that are amplified and flow through a tuned duct into a mechanical device (a generator/power transducer) to produce useful mechanical work or convert to electricity.

The device can be compact and requires no rare earth or other exotic materials. In itself it has no moving parts. And although its fuel economy improvement was calculated at just 0.45% on an EPA city cycle, the TA device develops high power on the highway cycle, and including that the improvement was 2.7%.

Organic Rankine cycle was cited as another choice, but because it results in larger-size systems the Tenneco group said it had more likely application in trucks. It's somewhat akin to an A/C system, using an evaporator to capture heat and build pressure on a working fluid (a refrigerant). Then it releases the pressure through an expansion device that performs mechanical work. Residual heat is rejected through a condenser. See related http://articles.sae.org/15755/.

Available data led the Tenneco researchers to develop fuel economy numbers modeling a Class 8 truck, in which three steady-state operating conditions were investigated. Heat recoveries were 56%, 59% and 64%, accumulations of 67.7 kW, 84.9 kW and 121.9 kW of energy, with conversion efficiencies of 11-13%, and fuel economy improvements of 3.6-4.1%.

Paul Weissler

FROM LEFT: TENNECO/CSEG; PAUL WEISSLER

POWERTRAIN | PROPULSION

2019 Corvette ZR1 goes with the (air)flow

The 2019 ZR1 will be the fastest Corvette yet, courtesy of its supercharged 755-hp LT5 V8 and new aerodynamics package.

In developing the last, highest-performance version of the current C7-generation **Chevrolet** Corvette, airflow management was the primary overriding concern for the car's engineering team.

That's because the 755-hp (563-kW), 715-lb·ft (969-N·m) supercharged 6.2-L LT5 V8 produces even more heat and speed than the 650-hp (485-kW) LT4 in the Z06. **GM** engineers note that small-block struggled to shed heat when driven hard in warm temperatures, and the ZR1's anticipated top speed of more than 210 mph demands careful management of the airflow to ensure stability at such elevated speeds.

"Managing the airflow around the car was a huge emphasis," explained Executive Chief Engineer Tadge Juechter. "This is the first time we've spent this much time with a moving ground plane wind tunnel."

Of course, computational fluid dynamics was also critical in shaping the ZR1's body shape, pointed out Exterior Design Director Tom Peters. "The CFD work is so important for us to understand where the hot spots are, so we can get right to it."

The LT5 engine producing that heat employs a 2.65-L **Eaton** twin-scroll supercharger inhaling though a 95-mm **Hitachi** throttle body commissioned especially for this car. It features GM's first use of a dual fuel injection system, with direct injection as the primary system and high-flow port injection providing fuel at high loads. The crankshaft includes a wider key slot to handle the extra power and the oil system is dry sump to withstand high cornering forces.

Book-matched carbon fiber elements include the downforce-producing front underwing.

The engine exhales through a two-stage muffler system with both active and passive elements to vary the sound level of what Chevrolet is calling "the loudest and most aggressive-sounding production Corvette in history." This employs new technology for which "we've applied for and expect to get some patents," said Juechter.

Transmissions are either a seven-speed manual transmission or an 8-speed automatic. GM's new 10-speed automatic transmission co-developed with **Ford** won't fit in the Corvette's frame, according to Juechter.

The available ZTK Performance Package includes Beijing West Industries **(BWI)** MagneRide adjustable dampers, **Brembo** carbon ceramic brakes and **Michelin** Pilot Sport Cup 2 tires.

The car's entire front bodywork is unique, providing huge openings for the ZR1's 13 heat exchangers (four more than the Z06) and a hood cutout that lets the supercharger's cover protrude through to the outside. This set-up is not pedestrian protection-compliant, so the ZR1 will not be sold in Europe.

The frame structure beneath the hood is also changed to accommodate outboard heat exchangers added on the left and right sides in addition to the existing central radiators.

The car is dressed in book-matched carbon fiber elements from **deBotech,** Inc. The major parts are the front underwing, which replaces the conventional flat splitter with an inverted wing for maximum downforce.

The inverted wing is needed to balance the downforce of the mammoth rear wing, which applies its 950 lb (431 kg) of downforce directly to the ZR1's frame using mounts that pass through the rear bodywork. Otherwise, the body panels would deflect at speed, causing potentially dangerous changes to the wing angle, Juechter said. That wing includes 5 degrees of adjustability for precise track tuning.

Dan Carney

ALL IMAGES: CHEVROLET

TECH STRATEGY

PSA's plan of action for Opel/Vauxhall: electrification, shared platforms

One hundred days after France's **PSA** group bought **GM**'s **Opel/Vauxhall** European operations, the first and crucial detailed plan of action and its effects for the combined businesses was revealed at Opel's Rüsselsheim HQ.

It includes all Opel/Vauxhall passenger-car lines being electrified by 2024 and a rapid switch to the use of PSA flexible architectures in the same timeframe; a big cut in the number of Opel/Vauxhall platforms and establishment of a Groupe PSA R&D center in Germany.

A financial aim for Opel/Vauxhall is a return to profitability by 2020. As for its factories, cautious phrasing is used: the "intention" is to maintain and modernize all plants and to "refrain" from forced layoffs.

Opel/Vauxhall already makes use of PSA platforms, including that of the new Grandland X; the crossover sits on Peugeot 3008 underpinnings and powertrain, but clad by an Opel-designed bodyshell. Recent experience of the Grandland by this *AE* Editor showed it to be average in most respects—practical and functional but, despite its Gallic DNA heart and skeleton, possessing no particularly standout features except perhaps its connectivity. PSA's message might be: could do better.

CEO of Opel Automobile Michael Lohscheller, says of PSA and Opel/Vauxhall: "Combining strengths will unleash annual synergies.

PSA

Interestingly, Opel and Vauxhall (the latter brand a UK business but with its design and technology centered in Germany with Opel) could also indirectly gain some kudos via the family connection to PSA's premium-targeted DS brand; its new DS7 is aimed very much at image enhancement. DS Director

Opel/Vauxhall's Grandland X is based on the Peugeot 3008.

Peugeot power beneath the hood of the Opel/Vauxhall Grandland X.

General Yves Bonnefont told *Automotive Engineering* that it may take a while, but he is confident that DS models will reach the relatively rarefied premium sector populated by the likes of **Mercedes-Benz** and **Lexus**.

A new Pace

The strategic plan – called "Pace!" – was stated by Michael Lohscheller, CEO of Opel Automobile, to be restoration of financial fundamentals and enhancement of sustainable competitiveness and growth: "Combining strengths will unleash annual synergies on Groupe PSA level of 1.1 billion euros by 2020 and 1.7 billion euros by 2026. All actions will contribute to a lower financial break-even point for Opel/Vauxhall of 800,000 vehicles, creating a profitable business model whatever the headwinds may be."

Bold words in a volatile world, perhaps, but he went on to say that with full access to Groupe PSA technologies, Opel/Vauxhall will become a European low-CO_2 leader. All its vehicle lines will be electrified via battery or in plug-in hybrid configuration, but "alongside efficient internal combustion engines." The Grandland X will be available as a PHEV and there will be a pure EV version of the next generation Corsa. Some of this this may be seen as catch-up, but at least it is being done.

Opel also aims to reduce vehicle cost per unit by 700 euros by 2020, with overall efficiencies increased by reducing complexity across all functions. And optimizing R&D will be a significant part of this as the company continues "seizing synergies."

The two Groupe PSA platforms—CMP and EMP2—will be built in all Opel/Vauxhall plants. An SUV using the EMP2 architecture already is planned for 2019 production in Eisenach, Germany and a D-segment vehicle will be built at Rüsselsheim in Germany.

There also will be a shift from GM to Groupe PSA engines and transmissions.

Although the French connection will be very strong, all new Opel/Vauxhall vehicles will be engineered in Rüsselsheim, which will become a global competence center for the whole Groupe PSA, with salient R&D areas of focus being fuel cells, some automated-driving technologies and driver-assistance systems. This would further guarantee German engineering quality and affordable innovations, stressed Lohscheller.

He revealed that the number of platforms Opel/Vauxhall uses for passenger cars will be slashed from nine to two by 2024 and powertrain families optimized from 10 to four: "Aligning architecture and powertrain families will substantially reduce development and production complexity, thus allowing scale effects and synergies, contributing to overall profitability."

Including all body styles, Opel/Vauxhall plans to launch nine new models by 2020, with Opel entering more than 20 new export markets by 2022, followed by exploration of further global opportunities.

The U.S., meanwhile, is receiving considerable attention. Groupe PSA North America Inc., created in 2017, saw the launch in Seattle of Free2Move, a smartphone-based mobility-aggregation platform. It provides users in the city with the ability to compare location, characteristics and operation costs of available transport options. The service can schedule or immediately access the transportation of a customer's choice for a period ranging from a few minutes to several days. Free2Move is already available in seven European countries.

The PSA and GM Europe link-up will make the new company the second-largest automaker in Europe after the **VW** Group.

Stuart Birch

ALL IMAGES: PSA

ELECTRONICS

Kiekert unveils automatic-door tech for autonomous vehicles

NuEntry side door latch elminates need for handles, so outdoor touch sensors, smartphones or other interfaces are possible.

A new electronic side door latch is the prelude to vehicle side doors that automatically open and close on command.

"Our endgame is about providing a system in which the side doors automatically open when an autonomously-driven car arrives for passengers," said Hector Verde, Director of Product Development for the Americas at **Kiekert**. Those doors would also close automatically after the occupants are in the vehicle. All this could happen with just the push of a button or sensor recognition, he added.

Kiekert recently unveiled its NuEntry latch which uses two actuation chains, with a pawl that lifts via an electric motor. The latch is always mechanically locked. Under normal operating conditions, the latch is released electronically. If the power supply is lost due to a vehicle crash or other incident, the latch mechanically unlocks.

This temporary crash redundancy means the e-latch system doesn't require a dedicated power storage unit or standalone electronics, Verde told *Automotive Engineering*.

Pairing NuEntry with Kiekert's i-move (an electrical actuator system currently under development) and i-protect (a sensor-based system to control the door movement) is part of a three-prong technology strategy being launched by the company.

"When we integrate NuEntry with i-move, that allows the side door to unlatch, open to a specific door-check position, and close automatically," explained Verde. "When you add-in the i-protect system, the door is prevented from opening, or it automatically stops moving, if a pole, pedestrian, bicyclist, or other obstacle is detected by sensors."

Kiekert plans to retrofit its NuEntry, i-move and i-protect systems on demonstration vehicles in 2018. "We have a concept demonstration vehicle in Europe, but in a few months we'll also have concept demonstration vehicles in North America and other regions," said Mike Hietbrink, Global Sales Director and General Manager of Kiekert USA.

Verde expects that i-move and i-protect technologies will be production-ready in the 2020-2021 timeframe.

Kami Buchholz

KIEKERT

2018 Stinger: Kia's track-capable family hauler

Kia's new Stinger shares the Hyundai G70 platform. Wheelbase is 2910 mm.

With the 60/40 split rear seats up, Stinger offers 23.3 ft³ of storage space. With the seats folded down cargo volume jumps to 40.9 ft.

Hyundai's Kia brand calls its 2018 Stinger a "five-passenger sportback poised to redefine a segment currently populated by European automakers" and compares twin-turbo V-6 GT models to similar-size 6-cylinder performance cars from the likes of **Audi** (S5, A7), **BMW** (4-Series, 6-Series), **Infiniti** (Q50), **Lexus** GS350, **Mercedes-Benz** CLS and even **Porsche** (Panamera). The Stinger beats all of those on power, torque and top speed and (at 4.7 s) all but the Audi S5 in 0-60 mph acceleration.

At the same time, it exceeds all but the Audi A7 Sportback and Panamara on total interior volume and (at 23.3 ft³) all but the Audi Sportback on cargo volume behind the rear seats. And at $31,900USD for the base RWD turbo-4-cyl. and $38,350USD for the RWD GT, it handily undercuts the lot of them on price.

Stinger is Kia's second rear-wheel-drive product (after the K900 luxury sedan) and its first to offer all-wheel drive. It shares the basic architecture of Hyundai's G70 four-door sedan. "The first decision was to make it all-wheel-drive," says Chahe Apelian, Senior Manager, Vehicle Evaluation, Test and Development, "because inclement weather requires that for high performance. And from a dynamic standpoint, starting from a clean sheet of paper, it made sense to go with traditional rear-drive and an all-wheel-drive option."

A new 55% advanced high-strength steel chassis provides an ultra-stiff foundation for its MacPherson front (with large-diameter shocks, high-strength wheel bearings and an aluminum strut brace) and reinforced five-link rear suspension.

The available AWD features a new Dynamic Torque Vectoring Control set-up that automatically applies power and/or braking to the appropriate wheels as needed. Up to 50% of engine torque can be distributed to the front wheels, or (in Sport mode) up to 80% to the rear, and it also distributes power side to side. Rear-drive GT2 models offer a multi-plate limited-slip differential to enhance directional stability by evenly distributing power to the rear wheels.

The 2.0L twin-scroll-turbocharged Hyundai Theta II 4-cylinder generates a claimed 255 hp (190 kW) at 6200 rpm and 260 lb·ft (352 N·m) from 1400-4000 rpm—good for 5.9-s acceleration from 0-60 mph). GT models' 3.3-L twin-turbo V6 Lambda II engine offers 365 hp (272 kW) at 6000 rpm and 376 lb·ft (509 N·m) from 1350-4500 rpm. Both drive through Hyundai's 8-speed planetary automatic with a Centrifugal Pendulum Absorber (CPA) torque converter for the 4-cylinder to help reduce torsional vibration.

High-performance, fade-compensating **Brembo** disc brakes with quad-piston front and dual-piston rear calipers are standard on GT models.

Dynamics development in Korea, the U.S. and elsewhere, including many hard-driving miles on Germany's grueling Nürburgring race track, was overseen by Kia Test and High Performance Development head Albert Biermann. "That is part of our global development process," Apelian explains. "That is a very challenging and demanding circuit that pushes not just the dynamics engineers but also the structural engineers quite a bit.

"You go through the whole motions of the suspension, all kinds of G loading, acceleration and braking," he continued. "It is a good tool for vehicle dynamics, like Death Valley is a good tool for high temperatures. We do quite a bit of basic development there for dynamics, then do refinement globally."

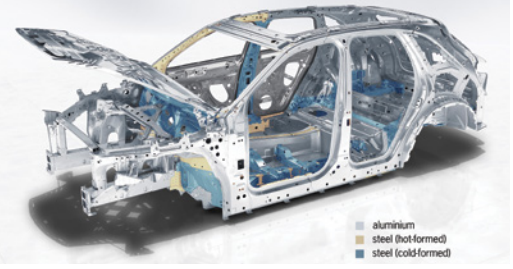
Gary Witzenburg

A center-mounted 7-in touchscreen is standard in the 2018 Stinger.

ALL IMAGES: KIA

2018 Porsche Cayenne rides high on air suspension, lighter unibody

The new Porsche Cayenne Turbo's twin-turbocharged V8 cranks out 550 horsepower.



An infusion of high-strength steel and aluminum whittled 298 lb from the Cayenne's body-in-white.

Porsche's pioneering Cayenne crossover SUV enters its third generation in 2018 following six-year runs of both the first- and second-generation models. In its latest iteration, new technology permits the Cayenne to get ever closer to reconciling the conflicting priorities of the brand's sports-car heritage and its SUV off-road expectations.

The 2018 Cayenne is helped in its progress toward this by a lighter-yet-stronger unibody structure made with both aluminum and various grades of steel; it is Porsche's interpretation of the Volkswagen Group's MLB Evo platform, which debuted in 100 mm-longer form as the **Audi** Q7.

The MLB Evo architecture replaces the previous Cayenne's rubber bushing-mounted steel front subframe with a new bearing-mounted aluminum subframe that is lighter and contributes to improved steering response.

Much of the body-in-white is aluminum, including the roof, floorpan, front section, doors, fenders, hood and hatch. This is strategically reinforced by micro-alloyed high-strength steel and multi-phase steel to produce a body that is 20% more rigid than that of the outgoing model while trimming 298 lb (135 kg) from the bodyshell.

Some of the hard-won weight savings was lost due to the increase in standard equipment that reduced the final curb-weight reduction, reported a dismayed-sounding Karl Heess (pronounced "Hayes"), chassis director for the SUV product line.

The 2,020-kg curb weight of the Cayenne S, for example, is 143 lb (65 kg) less than the previous model. Because of differences in standard equipment, the 4,376-lb (1,985-kg) base Cayenne saves 121 lb (55 kg), while there is a paltry 22 lb (10 kg) reduction for the 4,795-lb (2,175-kg) Cayenne Turbo. Ten kg of every model's savings is attributable to the substitution of a lightweight lithium-ion battery in place of the lead-acid battery used previously.

All-turbo engines

The new Cayenne's base engine is a 340-hp, single-turbo 3.0-L V6, while the S enjoys 440 hp from a 2.9-L twin-turbo V6. Both engines are from the same family, but the larger one has a 3-mm-longer stroke. A plug-in hybrid-electric and a diesel will follow, but the company declined to provide details on those versions.

All three gasoline-powered models use an 8-speed **ZF** Tiptronic S planetary automatic transmission with an added "hang-on" power take-off to drive the front wheels. This is a difference between the rear-drive-biased Cayenne—which can send 100% of its power to the rear wheels—and the Audi Q7's quattro full-time all-wheel drive system that's always dividing drive torque between front and rear axles.

Vibracoustic damping, rear-steer

Heess pronounced the biggest technical challenge for the chassis team to be the development of the new three-chamber **Vibracoustic** air suspension that lets the Cayenne so effectively marry its conflicting goals of comfort and agility. The air suspension is standard equipment for the Turbo, while conventional steel springs are standard on all other models, with the air suspension available optionally.

The new three-chamber system provides a greater range of damping rates, which is especially beneficial in hard driving because the smallest-volume chamber now provides very high rates, according to Heess.

The Cayenne's balance of sport and comfort also benefits from a new **Schaeffler Group**-supplied 48-volt Intelligent Active Roll Control roll-stabilization system, which can completely disconnect the anti-roll bar, as when driving off road and maximum suspension articulation is desirable and to apply as much as 885 lb·ft (1200 N·m) of resistance to roll during hard cornering.

Another new feature for the 2018 Cayenne is a rear-wheel steering system that can turn the wheels as much as 3 deg in either direction. At speeds below 50 mph (80 km/h), the rear wheels turn in the opposite direction to the fronts, providing improved agility and reduced turning radius for parking. The turning circle is reduced from 39.7 ft (12.1 m) to 37.7 ft (11.5 m).

Above 50 mph (80 km/h), the rear wheels steer in the same direction as the fronts, for improved stability, especially during lane-change maneuvers.

The new Cayenne is the first Porsche model to bring all these disparate chassis-control solutions under the common command of an integrated system dubbed Porsche 4D Chassis Control. Previously, each subsystem had its own sensors and control module, but the new 4D system coordinates all the subsystems centrally, providing control that Porsche considers the fourth dimension—time—by acting proactively to anticipated events.

Dan Carney

ALL IMAGES: PORSCHE

Level Zero HERO

Wrangler Rubicon has 10.9 in of ground clearance and industry-leading approach, departure and breakaway angles to uphold its heritage for off-road dominance.

Jeep's iconic Wrangler is all-new—and unapologetically analog.

by Bill Visnic

Okay, maybe the 2018 **Jeep** Wrangler could be considered **SAE** autonomy Level 0.5—after all, the all-new version of Jeep's icon does offer a couple of automated driver-assist features. If you must. But apart from that concession to contemporary development trends, the new Wrangler is unabashed in its dedication to the analog driving experience: It's updated, upgraded and more refined, but it's unquestionably the most elemental new vehicle of 2018.

After all, name another all-new model that pridefully comes to market at the dawn of the automated-driving epoch with solid front and rear axles, a windshield that folds down and doors that come off.

That's before you get to ground clearance increased to an almost comical maximum of 10.9 in (277 mm), lock-'em-on-yer-own front and rear differentials and four-wheel drive. And forget full-blown electric power steering—the Wrangler's just now progressing from recirculating ball to electrohydraulic rack and pinion.

There's only one reason for all this rawness, of course. It was decided the all-new Wrangler couldn't relent a bit on its go-anywhere legacy. Those ready to embrace the automated-driving future simply need not apply.

"Wrangler built its name on off-road [capability]," said chief engineer Brian Leyes. "We weren't going to compromise on that."

New but familiar design

Those not steeped in the heritage that traces to the Jeep's introduction in 1941 won't instantly identify this new JL-generation Wrangler by its general shape—it looks a lot like the previous-generation JK-series Wrangler (introduction 2007) and not all that different from any Wrangler of recent recollection. Know where to look for that extra second, though, and the "faster" windshield rake, slightly back-sloped grille and markedly lower beltline and larger side windows might be a giveaway to the new Wrangler's 9% slicker aerodynamics—even if its 0.454 coefficient of drag remains more brick than bullet train.

The 2018 Wrangler's grille is all-new, of course, as is the rest of the sheetmetal (which now is a lot less actual metal) and the grille's latest interpretation of the 7-slat treatment—an utterly non-negotiable styling cue—was intended to pay homage to some of the development team's favorite Wranglers of the past. Maybe not surprisingly, the longest-running Wrangler, the CJ5 (1955-83) comes up in many conversations.

"We wanted to put a lot of CJ5 into it," said Mark Allen, head of Jeep design. "The character of the grille is much more CJ5, in my mind."

The fenders, now aluminum, are 2 in (50 mm) higher and 33-in (838-mm) tires, available for the first time for a Wrangler, contribute to the actual and perceived higher stance. Wheelbase for the 4-door Wrangler is up by 2.4 in (61 mm) to 118.4 in (3007 mm) and increases by 1.4 in (36 mm) for the two-door to 96.8 in (2459 mm). It all makes for a larger and huskier footprint, although one would need a current JK-series Wrangler nearby to make the upsizing obvious.

"We want the vehicles to all look a bit 'modded' straight out of the factory," asserted Allen.

ALL IMAGES: FCA

Four-door Wrangler drops nearly 200 lb thanks to high-strength steel in frame, aluminum and magnesium in bodywork.

The new Wrangler's windshield continues its tradition for folding onto the hood if desired and the design team is proud of the decision to retain the feature—as well as its execution. For the outgoing Wrangler, dropping the windshield required the removal of 28 bolts and the curved windshield laying on the hood, "looked stupid. Nobody did it," said Allen. Now, thanks to the new "sport bar"—in effect, a fully integrated, body-color rollcage that, in front, forms an A-pillar-spanning structural header bar foundation for the windshield—one simply removes four bolts and the windshield can be folded down and secured to the hood in less than five minutes, Jeep claims.

Why all the bother for a function few owners will ever really employ? As usual, deference to Jeep tradition. "It felt good to keep it," said Allen.

The three trims—Sport, Rubicon, Sahara—can be had in either the 2-door or 4-door configuration. With a new power folding canvas top, an improved-design full soft top that does away with the accursed zippers and a removable composite hardtop, there is a conglomerate of potential body/top configurations. The removable doors are markedly lighter and have been designed to ease the removal process. There is a unique half-door option coming for 2019.

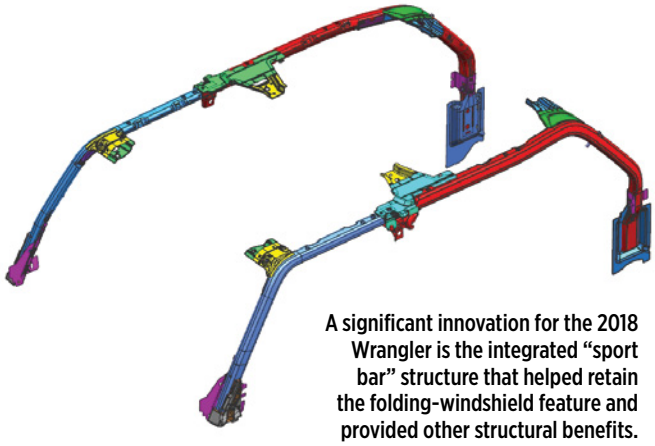
Weight abate

High-strength steel (HSS), aluminum, composites and even magnesium all get into the 2018 Wrangler weight-loss program that delivered a roughly 200-lb (90.7-kg) reduction for the 4-door and a 140-lb (63.5-kg) cut for the 2-door models, said Dave Bustamante, Model Responsible – Jeep Wrangler. The heaviest 2018 Wrangler, the 4-door Rubicon, is listed at 4484 lb (2034 kg).

The 2018 Wrangler's totally new frame is fully boxed, with 80% now formed from high-strength steels. The weight reduction from the new frame alone was nearly 100 lb (45.3 kg), said Bustamante. There are five boxed crossmembers and hydroformed front rails that engineers said better handle loads from the front suspension. The new design and the high ratio of advanced steel enabled an 18% increase in the frame's overall torsional rigidity.

Optional 2.0-L turbocharged 4-cylinder combines with a 48V belt starter-generator for an all-new efficiency statement.

All closure panels, including the hood, now are aluminum, as are the windshield frame and fender flares. The rear swing gate is formed from a cast magnesium inner and aluminum outer skin and is a substantial—and tangible-feeling—50% lighter than the outgoing Wrangler's tailgate.



A significant innovation for the 2018 Wrangler is the integrated "sport bar" structure that helped retain the folding-windshield feature and provided other structural benefits.

Chief engineer Brian Leyes and the 2018 Wrangler in its natural habitat.

The new frame is anchor for the familiar 5-link suspension at each corner, but chief engineer Leyes said care was taken to keep the upper and lower control arms tucked within the frame—a boon for off-roading that combines with a roll center that's hiked up by 2.5 in (64 mm) and those 33-in tires (Rubicon only) for unparalleled ground clearance and fording capability. "When we redesigned, we were tucking things up," Leyes said.

Leyes added that the new Wrangler's suspension geometry is completely revised and new damper tuning, steering angle, hard points and body mounting combine with a wider track to tighten the turning circle by a little more than 1 ft (305 mm)—another significant metric for off-roaders, who value tight turning—despite the newly-lengthened wheelbase.

"We've been on trips going down the mountain where the previous Wrangler had to do 3-point turns. That's where it (the 2018 model's tightened turning circle) really became apparent to me," Leyes said.

Jeep said ride comfort, handling and body roll also are "significantly improved" by the new suspension setup. *Automotive Engineering*'s off-roading of the 2018 Wrangler on quick-ish desert trains seemed to lend credence to the claim: head-toss was nearly nonexistent and the general state of tuning was one of pleasingly controlled compliance.

The Rubicon model gets an electronic front sway bar disconnect to maximize front-wheel articulation for extremely technical trail work. You'd expect industry-leading approach, breakover and departure angles and you'd be correct: the respective measures are 44 deg, 27.8 deg and 37 deg.

New powertrain, 48V efficiency boost

The 2018 Wrangler has the model's first-ever turbocharged 4-cylinder engine, an all-aluminum 2.0-L direct-injected unit charged by a twin-scroll turbo with an electronic wastegate. The engine serves up SAE-certified 270 hp and 295 lb·ft (400 N·m)—more torque than the carryover 3.6-L DOHC V6, which becomes the Wrangler's base engine when the 2.0-L starts availability in the second quarter of 2018.

Wait a minute, though: aren't turbocharged engines and their unpredictable torque "hit" anathema for rock-crawling and tight-trail adventures?

"There's obviously concern about turbo lag," said Leyes. "But the controls associated with this engine are very good. And with the [transmission] crawl ratio we have, you'll very rarely be in the boost."

But he admits hard-core customers may need convincing. "We'll be careful. I think word will get out that it's pretty good."

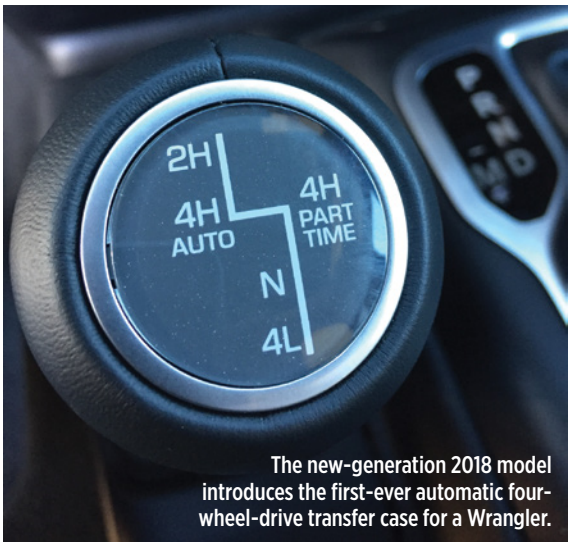
But there's more. The new engine comes standard with a 48V belt-starter generator system called eTorque. It provides mild-hybrid features such as engine start/stop and regenerative braking, but also improves fuel economy with a torque input to "fill in" before the turbocharger is delivering full boost, extend the duration of engine fuel shut-off and enhance transmission shift schemes. The company says eTorque also means the engine and fuel flow may be turned off at idle or when coasting.

Meanwhile, the new Wrangler's 3.6-L V6 isn't exactly carryover: it's the second generation of **FCA**'s widely-deployed Pentastar and now develops 285 hp and 260 lb·ft (353 N·m). It can be backed either by a heavily revised 6-speed manual transmission or a new-to-Wrangler 8-speed **ZF**-designed automatic, a considerable upgrade over the outgoing model's 5-speed auto.

At the time of the media introduction, FCA wasn't yet dealing out fuel-economy figures for the 4-cylinder Wrangler. The V6 model's numbers have improved to 18 mpg city/23 mpg highway for the automatic and 17 mpg city/23 mpg highway for the 6-speed manual.

FROM LEFT: FCA; BILL VISNIC

The new Wrangler's interior is markedly upgraded in terms of bill of materials, NVH and refinement.



The new-generation 2018 model introduces the first-ever automatic four-wheel-drive transfer case for a Wrangler.

Instrument cluster includes a reconfigurable display.

The outgoing 4-door Wrangler V6/automatic is rated at 16 mpg city/20 mpg highway.

In a final "first" for the all-new Wrangler, the Sahara can be specified with an optional **Magna**-supplied Selec-Trac 2-speed transfer case that features automatic engagement of high-range 4-wheel-drive; 4-wheel-drive high and low ranges still can be selected manually. The set-it-and-forget it system is engaged via the same chunky console lever as the Wrangler's two other part-time transfer-case choices.

Starting in 2018, 4-door variants of the new-generation Wrangler will be available with FCA's **VM Motori**-designed 3.0-L EcoDiesel V6, earmarked to develop 260 hp and 442 lb·ft (599 N·m) of torque, with standard engine stop-start. The 8-speed automatic will be the only transmission hooked to the diesel, which is scheduled to feature several design upgrades.

All Wranglers will continue to be built at FCA's assembly plant in Toledo, Ohio.

Refinement not a dirty word

Along with the lengthy list of upgrades for the JL-generation Wrangler is a marked improvement in NVH and refinement. It may sound rudimentary, but the new Jeep's full-length front-door armrests, for example, are a gee-whiz moment, and there's standard HVAC for the rear-seat occupants and a more comfortable degree of seatback recline.

"This is the most refined Wrangler we've ever created," Jeep interior design manager Ryan Patrick Joyce flatly said.

The dash center finds either a 5-, 7- or 8.4-in touchscreen, the largest version featuring all the latest functionalities of FCA's excellent Uconnect interface. The standard driver-information display is a 3.5-in LCD, with a gorgeous optional 7-in version displaying a variety of entertaining and useful information for on- and off-road operation.

Pushbutton start is standard, there is a total of five USB ports and depending on model, the bill of materials throughout is significantly upgraded; the upscale Sahara trim, for example, features a hand-wrapped dash and Joyce said that for all Wranglers, the exposed interior metal is just that—genuine metal.

There are four standard airbags and the new Wrangler also offers blind-spot warning and rear cross-path detection and a standard rearview camera cleverly packaged on the spare-tire carrier.

The new interior may be a mightily more-hospitable place, but traditional concerns still got the final nod. Despite all the new creature comforts and technology enhancements, the 2018 Wrangler continues with fully removable carpet and floor drain plugs to facilitate hose cleaning. If that's not a "touche'" to the forces of autonomy, what is? ■

CLOCKWISE FROM TOP LEFT:FCA; BILL VISNIC; FCA

Researchers are striving to develop optimal techniques for rapidly and accurately combining sensor inputs in vehicles.

Fusing sensors for the AUTOMATED-DRIVING FUTURE

Complex processing architectures, faster networks and even more sophisticated software are vital for 100% accurate Level 4 and 5 systems.

by Terry Costlow

Piloted and autonomous driving systems depend on inputs from many types of sensors arrayed to create a highly accurate view of vehicle surroundings. Fusing all these inputs into a single image of each car, pedestrian and roadway marking takes a sophisticated architecture with hefty amounts of computing power and deterministic communications.

At highway speeds, combining inputs from multiple camera views is a complex challenge by itself. But different sensor types are needed to avoid errors, so vehicle controllers must blend inputs coming from multiple sensors and multiple modalities.

"Camera data comes in at 30 frames per second," said Kay Stepper, Vice President for Driver Assistance and Automated Driving for **Bosch North America**. "Radar can have 20 to 50 or even 100 data sets per second, and lidar has a different time cycle all together. The first challenge is to bring all these data sets together to represent a single point in time, which requires some complex software."

The challenge of merging multiple inputs will only get more difficult as the trek to autonomy continues. As vehicles advance to higher levels of the **SAE** automated driving scale, more sensor inputs will be needed. Some architectures may use more than two dozen sensors to create the 360° view needed for fully autonomous driving.

"Going from [SAE] Level 1 to Level 5, the sensor count goes from one or two up to 30 or more," said Wally Rhines, CEO of **Mentor Graphics**, acquired by **Siemens** in early 2017. "To fuse all those inputs, you need software that lets you look at thousands of variations to get to an optimal design."

Those programs will be complex, so techniques for continuing upgrades will need to ensure that much of the software can be reused. These programs will need to run on successive generations of hardware that will be deployed over many makes and models for years. Today, much software is written by the teams that create the hardware. Going forward, many planners want to move away from that model so it's easier to upgrade and make changes like switching suppliers.

"Software reuse and hardware-software separation are becoming major issues," said Paul Hansen, Editor of the respected *Hansen Report on Automotive Electronics*. "AUTOSAR and Automotive Grade Linux can help companies separate hardware and software so they can more easily switch vendors."

More power

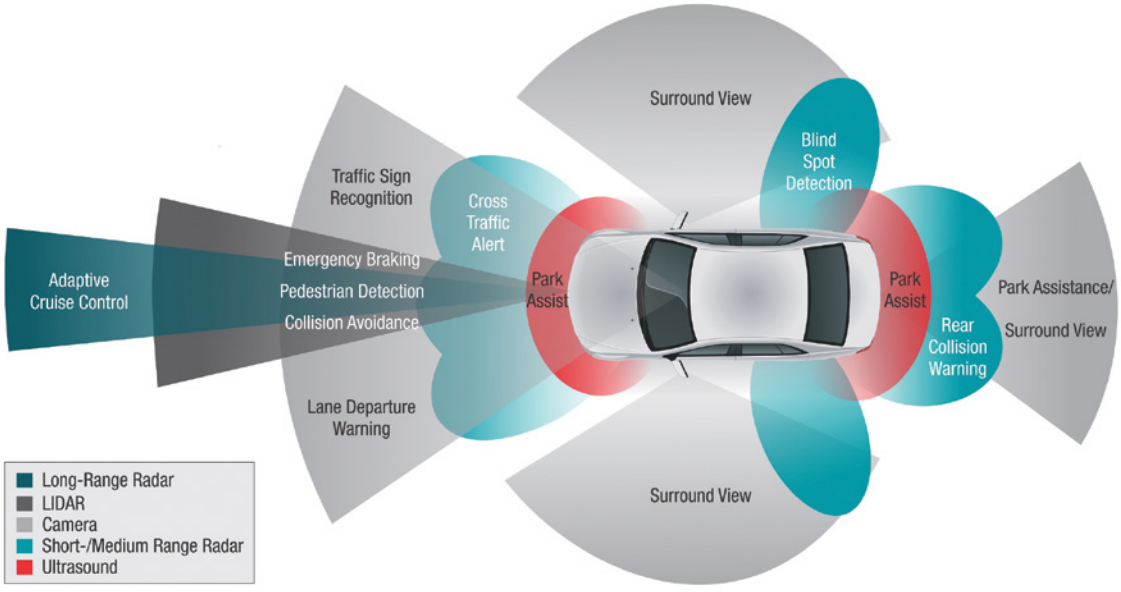
It will take a lot of computing power to collect all these inputs, analyze the data and make life-and-death decisions. The microcontrollers that have dominated electronic designs for decades will soon become one element in controllers that add graphics processors and custom devices that use parallel processing to handle images.

Many suppliers have partnered with **Nvidia**, which popularized the concept of graphics processors. However, Nvidia faces competition from FPGA suppliers like **Xilinx** and **Intel**, as well as mainstream automotive CPU suppliers like **NXP** and **Renesas**. They have licensed **Tensilica**'s programmable technology, planning to move it from infotainment applications to safety systems.

Once these devices are combined with conventional controllers, the ongoing advances in microprocessors should provide the processing power needed for successive generations.

"Graphic processing algorithms need very high-performance processors or specialized processors, which opens the market for companies known for gaming processors like Nvidia and Intel," said Karl-Heinz Glander, Chief Engineer for **ZF**'s Automated Driving Team. "Devices that were used in infotainment are now going into safety applications. Given the advances tied to Moore's Law, computing power will not be a limiting factor."

ZF



Experts predict that some autonomous cars will use more than two dozen sensors to provide a 360° view.

MENTOR GRAPHICS

These advanced architectures rely on real-time communications. The volume of data from sensors is a key factor that will drive a change in networking architectures, but it's not the only aspect. Complex algorithms use concepts like occupancy grids, which consume bandwidth. Understanding where components are and routing the right data to them also increases bandwidth and timing requirements.

"The choice of bus communication depends strongly on the chosen vehicle architecture, number of sensors and fusion approaches taken. Additionally, the communication of occupancy grids and high definition maps between components, if necessary, enlarges the bus load requirements," said Aaron Jefferson, Director, Global Electronics Product Planning at ZF. "We see a likely preference for CAN, CAN-FD and Ethernet."

Going beyond CAN

Properly combining all the inputs to create a cohesive image requires exacting precision. Networks need to ensure that latency and other issues don't cause timing glitches.

"CAN is no longer sufficient; you need a time triggered network," Stepper said. "CAN-FD has time triggering, but there's a clear migration to Automotive Ethernet because it has deterministic behavior and has the speed and bandwidth."

Cyclist and pedestrian detection is a focal point for sensor-fusion development.

Cameras generate data at 30 fps and faster.

Many companies plan to reduce some of these communications requirements by moving everything into a centralized controller. Most systems today use dedicated electronic control modules that don't communicate at nearly the levels that will be needed by autonomous vehicles. That's prompting many design teams to look at using one very powerful ECU.

"We prefer a centralized vehicle controller with a scalable architecture that goes up to SAE Level 4 and 5," Stepper said. "Our centralized vehicle controller houses sensor data fusion and decision-making in one box."

The ability to scale is always critical, but will be especially important as technology marches forward. Sensors improve, processors get more powerful, and engineers figure out ways to do more every year. Advances in one area typically beget progress in other fields.

"3D capabilities come from different ways to create and receive signals," ZF's Glander said. "As processing power increases, we can use higher and higher resolution imagers to extract more information and get wider sensing angles. Cameras are going from two to eight and even 10 mpixel resolution." ■

FROM TOP: BOSCH; VALEO

Big picture requires big data

The sensor count will rise, resolution will soar and the mix of sensors will evolve as automakers roll towards driverless cars. Together, they'll create large volumes of data that must be fused together to continuously give vehicle controllers a full view of their surroundings.

Four terabytes per day is the measure established by **Intel**, which wants to become a major player on the processor side. A mix of processors will have to handle the constant inflow of data from multiple sensors.

Today, many vehicles have five or fewer safety sensors. A camera and radar look forward, while a second camera and two radar face rearward for blind spot detection and rear traffic detection. Building a full 360° view for autonomous vehicles takes substantially more sensors.

"You quickly get to five radars, adding two more on the front corners for true 360 degrees sensing," said **Bosch**'s Kay Stepper. "You need two types of cameras, for mid to far ranges and medium to near range. So a basic system will need five radars and a minimum of five cameras."

A single lidar sensor generates around 1 Gbyte/second.

Going beyond this minimalist setup generally means adding lidar, which combines cameras and laser scanning to provide a wealth of data. A single solid-state lidar sensor will generate around 360 Gbytes every hour, more than a third of a Tbyte of data.

"Lidar helps OEMs meet requirements for a 360-degree view at 200+ meters," said Anand Gopalan, CTO at **Velodyne** Lidar. "The volume of data going through a sensor's analog-to-digital converter is around 12 Gbits/second; data comes out of the module at about 1 GByte per second."

Sensor sets use different technologies and placement positions to get a full view of the surroundings. It's critical that their strengths and weaknesses offset each other so critical objects aren't missed and false positives don't cause unwarranted actions like emergency braking.

"Cameras widen the field of view and make it possible to see up to 250 meters in front of the vehicle," said Guillaume Devauchelle, Vice President of Innovation at **Valeo**. "Radars sweep the vehicle's surroundings up to 75 meters with several separate beams. Lidar scans the vehicle's front environment and detects static or moving obstacles such as cars, motorcycles or pedestrians. Ultrasonic sensors detect any object close to the vehicle within a radius of 5 meters."

Some observers have relegated ultrasound to parking systems, but that's not a unanimous decision. Inexpensive components may play a larger role in autonomous driving.

"You need to account for deficiencies in each sensor modality," Stepper said. "Ultrasonic can provide a very valuable sensor fusion element; it's a completely different technology that works on time of flight that can play a role in automated driving."

T.C.

VELODYNE

Who wants Afreecar?

Simplicity and low-cost, robust construction are vital to the solar e-trailer/bike combo as a sustainable concept, as this rendering shows. The roof's angle of incidence is designed to be adjustable so that the solar cells can best optimize the sun's energy.

One billion people globally survive on less than $2/day but desperately need personal mobility and electric power. One of the auto industry's most creative minds offers what could be a unique and sustainable solution.

by Lindsay Brooke

Game-changing ideas come to engineers in countless places and circumstances. For Dr. Chris Borroni-Bird, it was in a tiny village in Mali. The year was 2009, and Dr. Borroni-Bird, then director of **GM**'s EN-V program for the 2010 Shanghai World Expo, was on a typical vacation: working on clean-power and clean-cooking initiatives in sub-Saharan Africa.

"I noticed some solar panels donated by **BP** which were being used by the village's resident entrepreneur to charge lead-acid batteries, the type used in cars," he recalled. "The guy would then lease the fully-charged batteries out to villagers who needed electricity."

During his ten days working in the village, Dr. Borroni-Bird witnessed three use cases for the batteries. One provided cheap LED lighting, enabling the local work day to be extended without using kerosene lamps. Another battery application was for grinding corn. A third use was to pump water from deep in the ground; the village's fetid-gray well water was undrinkable.

Another piece of the idea came while Dr. Borroni-Bird was walking 10 miles to the next village—a typical trip for millions who cannot afford powered vehicles. "Then it hit me—what might work here is a simple and cheap battery-powered vehicle that could be charged with solar panels, which are increasingly inexpensive. Such a vehicle could provide both transport and electric power to Africa's poor. Transport, no matter how humble, enables economic development," he said.

Personal mobility, mobile power

The incumbent means of personal mobility in sub-Saharan Africa are costly and inefficient. Walking is limited to distances of under 10 miles and a payload of about 10 kg. Oxen and other typical beasts of burden have greater capacity but can cost $200—and require food. Small motorcycles offer greater range and payload capability but can cost $2,000 to purchase and require regular fueling. So what sort of 'new' vehicle would work best?

A small electric 3- or 4-wheeled 'golf cart' might be too large, heavy and costly, he calculated. And it might lack the 5-to-10 miles (8 to 16 km) range needed for a typical rural African duty cycle. But a small, lightweight trailer coupled to a bicycle, would combine the rider's pedal power with a battery and electric motor. This 'e-trailer' would have a roof covered with solar panels to charge the battery. The battery would power a small electric motor which would in turn drive the trailer wheels through a chain and sprockets.

The 3 kW·h of energy that 100 kg (220 lb) of lead-acid batteries can store on a solar-powered electric trailer can deliver a minimum 30 km (almost 19 mi) daily range to allow inter-village travel, Dr. Borroni-Bird calculates. He realizes that heavy lead-acid batteries will be most widely available and affordable until secondary use of lithium battery pack modules from EVs become a viable approach.

The solar e-trailer could be built from a kit that utilizes some 'repurposed' items—bicycle or scooter wheels, for example—and locally-harvested materials for the frame, axle and roof that supports the small solar-cell array. It would provide supplemental motive power to the bike rider when traveling up hills, and serve as a mobile electric-power unit for charging phones, pumping water, milling grain,

ALL IMAGES: CHRIS BORRONI-BIRD

The proof-of-concept e-trailer built by prototyping specialists Pratt & Miller. Marketable vehicles may be offered in both kit form and as ready-to-use fully assembled units.

Dr. Chris Borroni-Bird retired as Qualcomm's VP of Strategic Development in 2016 to focus on global sustainable-mobility solutions. At GM he led development of the EN-V, Autonomy and other advanced concepts. In the 1990s he led Chrysler's gasoline fuel-cell project. He holds over 40 patents, many on the 'skateboard' platform concept, and is co-author of *Reinventing the Automobile: Personal Urban Mobility for the 21st Century*, with Dr. Larry Burns and the late Prof. Bill Mitchell, published by MIT Press.

running small refrigerators—and hauling.

During Africa's planting season, people can't easily access fertilizer. Villagers often walk up to 15 miles (24 km) per day to buy a 50-kg (110-lb) bag of fertilizer and carry it back home.

"Entrepreneurs with the bike-trailer system which I've dubbed 'Afreecar'—a play on the word Africa— could ride to the distribution center, pick up three bags of fertilizer," he envisioned. "They'd haul it back to their villages and get paid by the farmers. More food could thus be grown and it could be transported to market much, much easier."

Researchers at the **University of Michigan** who did early work with Dr. Borroni-Bird have modeled a typical rural-Africa duty cycle in which bike-and-solar-trailer rigs could deliver reasonable 50-100-mile (80-160 km) daily operation. He sees similar multi-use opportunities for the mobile power system in the cities of Africa and those of other continents.

With support from the university and automotive prototype specialists **Pratt & Miller**, he helped finance a proof-of-concept trailer developed and built by Pratt & Miller, as shown in the photo above. But a marketable unit needs to be lighter, less costly and more robust.

Locally sourced components

To achieve favorable economics that stimulate local manufacture, the solar e-trailer solution must be very low cost and robust to generate profit. When integrated with a cellphone, which are ubiquitous in Africa, the Afreecar concept becomes "a low-cost, locally made 'hub' that can transform lives and create a vibrant manufacturing and service economy," he said.

The vehicle or hub might be owned and operated by the same company that makes or distributes it, or by an entrepreneur who buys or leases the vehicle from the company. In either case, the operator generates revenue by providing mobility, electric power and wireless communications—and perhaps by monetizing data generated by the service.

"The cell phone is an important tool in the solar e-trailer concept," Dr. Borroni-Bird explained. "Besides providing direct operator communications, the phone's GPS map would provide route information, battery monitoring, and even inform the rider of the optimum angle to set the solar-panel roof in relation to the sun at any given time of day. It could offer predictive maintenance and data analytics."

Readers who admire Dr. Borroni-Bird's idea will ask, "What's to keep this idea from being co-opted by others?" He concedes that "there is no competitive advantage in the hardware—it has to become a commodity if the vision is to be realized."

More detailed analysis and planning is required for creating a sustainable business model. "Local communities around the world could take the standardized electrical kit, produced in scale perhaps in Taiwan or China, and provided by company or foundation for integration into whatever version of the vehicle is developed locally. Let those communities figure that out, using a reference design and specifications," he said.

Dr. Borroni-Bird also believes "it would be a good idea to provide complete vehicles, but the foundation is the electric system. Some [local operators] may make the solar trailer for bikes; others may cut up a motorbike and make a 3-wheeler or golf cart," he surmised.

Versions of the solar e-trailer for developed markets might also include a low speed autonomy kit, such as for **MIT Media Lab**'s Persuasive Electric Vehicle (https://www.media.mit.edu/galleries/persuasive-electric-vehicle/).

What are the next steps? Dr. Borroni-Bird now has a half-time appointment at MIT Media Lab in the City Science Group, directed by Kent Larson.

At MIT, Chris is keen to study community needs and to develop a rugged "solar e-trailer" prototype that pulls all these ideas together. He hopes to secure support to build the electric kit consisting of the battery, motor, controller and solar panel.

Those interested in collaborating can contact Dr. Borroni-Bird at MIT Media Lab or by attending the Automobili-D exhibit at the 2018 North American International Auto Show. ■

DANA OPENS NEW CHAPTER ON CVTs

The view into one of four driveline dynamometer cells at Dana's Cedar Park, TX, VariGlide development facility.

A dedicated development center is hustling the unique VariGlide "spherical traction drive" toward 2020 production.

by Lindsay Brooke

Any emerging technology that warrants its own dedicated development center—40,000 ft^2, staffed by 40 engineers and loaded with state-of-art design engineering, analysis, metallurgy, machining, prototyping and test cells with four dynamometers—must be considered a competitive threat. That's the buzz within the powertrain community about **Dana**'s Cedar Park, TX, tech center, and the highly anticipated VariGlide continuously-variable planetary transmission under development there since 2014.

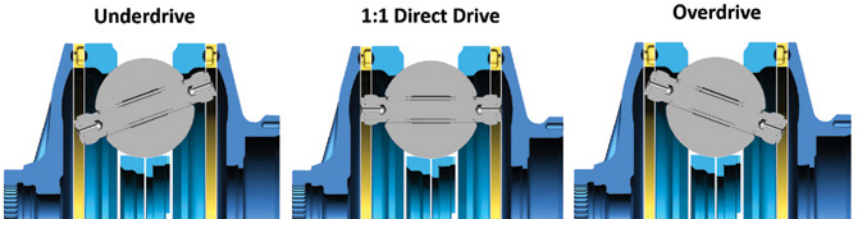
VariGlide is slated to enter production at one or more light vehicle OEMs in 2020. Dana engineers claim it will offer up to 10% greater fuel efficiency than incumbent CVTs, with improved drivability and NVH characteristics. It is "highly scalable" according to company engineers and its compact design enables it to effectively slot into existing transmission housings without significant modification.

"We think Dana's going to be a serious player in more efficient, next-generation transmissions," said an engineering director at a European OEM, who spoke with *Automotive Engineering* at the 2017 Frankfurt Motor Show. "From what we know already about VariGlide, it may open a new chapter for the CVT."

Heart of the Cedar Park facility is a formidable engineering and manufacturing team of industry veterans hailing from global automakers, equipment makers such as **JCB**, and tech suppliers including **Bosch**, **Ricardo** and **Tremec**. They're doing manufacturing process development in parallel with component and systems engineering. Working on the critical path has resulted in a 97% reduction in cycle time on some of

LINDSAY BROOKE

The VariGlide variator unit showing the torque-input ring (on right, purple) and output ring (at left). The planetary spheres rotate on small axles.



Tilting the spherical planets changes the relative contact diameters. A variable ratio sweep is possible in 0.2 s.

the key internal hardware, noted Ed Greif, Dana's Senior Director-Powertrain Innovations.

As *AE* readers know, the basic technology has been brewing for a decade and a half. **Fallbrook Technologies**, originally based in San Diego, initiated its development in 2004 (see **SAE** Technical Paper, *Configuration Analysis of a Spherical Traction Drive CVT/IVT*; http://papers.sae.org/2004-40-0009/). Seeing potential commercial markets in various industry sectors, Dana in 2012 took out an exclusive technology license for light duty (less than 10,000 lb GVW) on-highway applications. Three other primary licensees include **Allison** (10,000-lb GVW), **TEAM Industries** (ATVs) and **Continental** (e-bikes).

"Importantly, none of us compete directly," explained Greif. "We meet monthly to exchange data and information; it works out really well. Each company has specializations and feed info back into 'the pool."

Fallbrook "lacked the commercialization capability that Dana has," said Bob Pyle, President of Dana Light Vehicle Driveline Technologies. "It was our job to figure out how to apply the technology to automotive applications, and we've taken it to a higher level.

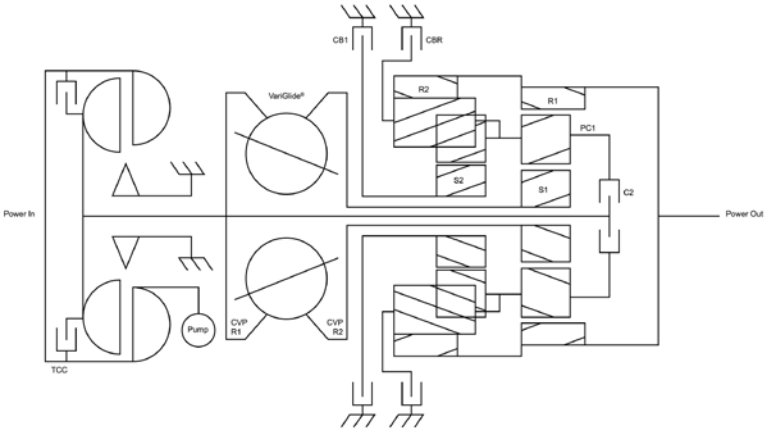
When Fallbrook passed the design to us [then known generally as CVP, for Continuously Variable Planetary, and still called NuVinci for e-bike use], it was at an efficiency level of about 89%. We've taken that to north of 95% efficiency."

4-mode capability

Operationally, VariGlide offers the best of both worlds: the utility of a conventional planetary automatic with the smooth continuous ratio change of a CVT—but without the former's gear and clutch mechanisms, and without the latter's belt or chain and two pulleys (known in CVT-speak as the 'variator'). During our visit to Cedar Park, we briefly tested a **Cadillac** ATS demonstrator fitted with the latest prototype VariGlide and found it to be as buttery-smooth as the stock **GM** 8L45 8-speed automatic (which is benchmark), but with quieter, quicker ratio changes—at least the ones that were perceivable. It has electric-motor-like operating characteristics.

Inside the VariGlide's compact case, a set of hardened steel "planet" spheres rotating on dedicated axles is arrayed around a central "sun" that transfers torque between two carrier rings. One ring serves as the torque-input side; the other output ring transfers that torque to the driveline. Tilting the spheres on one carrier ring by up to 7°, while the other ring remains stationary, changes their contact diameters on the rings. This permits an infinite range of speed ratios.

"Kinematically it works like a planetary gear set, when you think about the ratios between two points," said Gordon McIndoe, a Dana transmission expert. "It provides only a 4:1 native ratio spread so it is



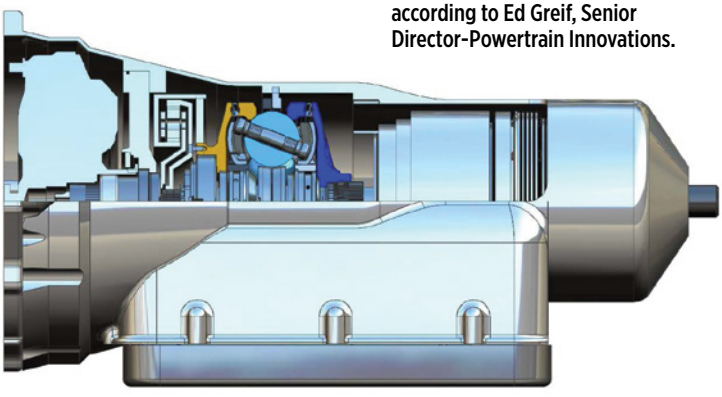
Schematic of VariGlide 2-mode that offers up to 8:1 ratio spread. The power flow direction changes with each forward motion change.

ALL IMAGES: DANA

DANA OPENS NEW CHAPTER ON CVTs

VariGlide doesn't use a hydraulic pump, enabling high internal efficiiencies, said Engineering Director Patrick Sexton.

Close cooperation among Dana design and manufacturing engineers is paying off in reduced component processing time at Cedar Park, according to Ed Greif, Senior Director-Powertrain Innovations.



Four-mode Variglide begins testing in 2019. Neat packaging.

application dependent. We can deliver stable ratio control, electrically or hydraulically, in 2-mode or 4-mode operation. Our ratio control is independent of load. The continuous transition to any ratio within its range maximizes overall powertrain efficiency and accessory performance, on demand."

He said VariGlide is capable of supporting more than 300 power-path configurations and can sweep through all ratios in 0.2 s, compared with the two seconds it takes typical CVTs to do so.

A key to the unit's internal efficiency is a proprietary lubricant developed for the unique transmission. The fluid temporarily transitions to a solid under high pressure. Its fluid properties provide internal 'grip' which helps torque transfer within the mechanism, Sexton explained, proven in nearly 90,000 hours of durability testing racked up on the core technology as of fall 2017.

McIndoe and Patrick Sexton, Engineering Director-Light Vehicle Driveline technologies, claim VariGlide is capable of higher torque density than other CVT types and lower NVH compared with gear-and-clutch devices. The unit also is capable of splitting torque, as in a conventional fixed planetary automatic. The co-axially-mounted system also affords more flexible drive inputs and outputs that helps optimize packaging in the vehicle, they said.

The design reduces driveline and vehicle energy consumption by continuously optimizing ratio between the driving and driven devices, allowing them to operate in their most efficient speed range. Without the belt-and-pulley variators of traditional CVTs, there is no need for the high (up to 900 psi/6205 kPa) hydraulic pressures required for belt-clamping control. "This means VariGlide doesn't use a hydraulic pump, so we've eliminated the parasitic losses associated with that," explained Sexton.

Overall, the VariGlide's mechanical characteristics lend themselves to lower cost manufacturing than those of traditional CVTs, the Dana experts claim, with simple part geometries. According to Greif, Dana will manufacture the variator and supply it to OEMs and to transmission Tier 1s. Dana has over 1000 U.S. and international patents issued or pending, some generated from Cedar Park and including a potentially more efficient 4-mode VariGlide under development.

Powersplit for forklifts

To vehicle OEMs, each tenth of a percent of a fuel efficiency improvement will be worth pursuing in the next decade, as global emissions regulations tighten. All seek to avoid compromising performance in the quest for reduced CO_2. Decoupling engine accessories from crankshaft speed is another potential benefit of the VariGlide transmission, the Dana team notes. It creates a 'cascade' effect that enables use of a smaller accessory package without hindering performance.

That ability to decouple engine speed from a vehicle's travel speed convinced Dana leadership to pursue VariGlide development for the global materials-handling industry.

The transmission's performance characteristics align with the rapid and abrupt acceleration, deceleration, and pinpoint positioning required for forklift-truck duty, without the need for forward and reverse clutches (see 2015 SAE Technical paper http://papers.sae.org/2015-01-1104/).

During our Cedar Park visit, we observed a VariGlide-equipped 2.4-ton **Hyster** "high-low" practicing pick-and-place work in the facility's loading dock area. According to engineers, Dana projects fuel savings of up to 20% for a standard-size forklift operating in a typical duty cycle. The technology can be scaled for use in forklifts up to 3.5 tons ratings.

Dana is expected to implement VariGlide technology in select Spicer powershift transmissions. It will also offer the technology to forklift OEMs as a module offering a standard powersplit configuration.

VariGlide's 2020 market entrance underscores not only Dana's faith in the fundamental Fallbrook technology, but also the fact that the next decade will see many exciting new driveline solutions emerge beyond the battery-electric "revolution" that is taking longer to arrive than some expected. ■

FROM TOP: LINDSAY BROOKE; DANA

PLASTICS KEY TO MOBILITY INNOVATIONS

The 2017 SPE Innovation Awards highlight the design, engineering and materials-science collaborations between vehicle OEMs and their tier suppliers.

by Lindsay Brooke

Ford's U553 program team and their Celanese and Magna supplier colleagues after receiving the 2017 SPE Grand Prize award.

Ford and **General Motors** and their composite-materials and tooling suppliers dominated the 2017 Automotive Innovation Awards competition, held for the 47th consecutive year by the **Society of Plastics Engineers** (SPE) Automotive Division. The SPE Automotive awards are the oldest and largest recognition event in the automotive and plastics industries. **BMW** and **Hyundai** and their suppliers also won major categories.

Automotive Engineering was again honored to participate in the Blue Ribbon Judging process, that reviews the finalists in nine major materials-technology categories and votes on the winners in each.

Grand Award and Body Exterior Award—2018 Ford Expedition structural active grille shutters

Tier Supplier & Processor: Magna Plastcoat
Material Supplier / Toolmaker: Celanese / Integrity Tool
Material / Process: Celstran 40-20 PP GF/ injection molding
Possibly the largest two-shot active grille shutter unit in production, the Ford Expedition (U553 program) structure was designed with an integrated locating and attaching system for consistent fit between the grille and headlamps. This helped eliminate the need for front-end module (FEM) assembly, dunnage and shipping. In addition to reducing variable and piece costs by an estimated $5 with an entirely thermoplastic solution, the enhanced design achieved $16 internal assembly cost reduction per vehicle and eliminated around $45 auxiliary costs by negating the need for a FEM.

As a result, Ford avoided an estimated $2 million in dunnage, assembly plant line and handling costs. Improved parts consolidation also phased out the need for four separate fasteners and associated labor.

Using LFRT technology to develop a structure with polypropylene (PP) offset an estimated 3 lb/1.37 kg mass gain over alternative metal and nylon hybrid designs considered. An equivalent steel structure would weigh 18 lb/8 kg more than the long-fiber reinforced thermoplastic (LFRT) design to deliver the required durability. According to Ford engineer Dave Glickman, the LFRT structure "looks to replace all FEMs at Ford Truck."

LINDSAY BROOKE

Body Interior Award—2017 BMW Countryman instrument panel carrier

Tier Supplier / Processor: International Automotive Components (IAC)
Material Supplier / Toolmaker: Sabic / Siebenwurst
Material / Process: Stamax PP LGF/ injection molding
Long-glass-fiber polypropylene (PP) injection molding via structural chemical foaming with core-back process enabled the production of this part with very low VOC emissions, meeting VDA 278 specification. Extensive CAE work predicting warpage of the foamed part provided valuable insights, allowing for the modification of tooling in advance. Use of foaming means less material is required resulting in a claimed 15% weight savings, fewer emissions and less cost.

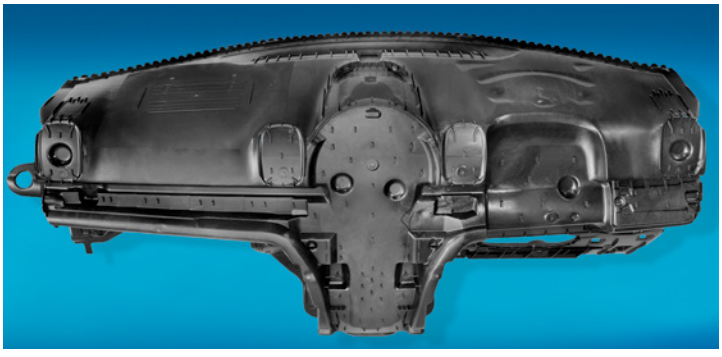
Chassis/Hardware Award—2017 Cadillac XT5 V6 mounting clevis bracket

Tier Supplier / Processor: Hutchinson
Material Supplier / Toolmaker: BASF Corporation / not stated
Material / Process: Ultramid A3WG10 CR BK00564 PA66+50%GF / injection molding
This engine clevis bracket is the first composite mount designed for a V6 engine, passing peak loads of 25 Kilo-newtons of force. The injection molded part replaces metallic solutions (stamping, welding and die-casting) used previously resulting in a claimed 45% weight save. A reduction in cabin noise was also achieved due to the damping characteristics of the polyamide compared to aluminum.

Corrosion resistance is improved and the part can be recycled at end of life. Seven clevis brackets were developed for different powertrain combinations with no warranty claims after 1.5 years of production.

Pioneered on the 2018 U553 Expedition, Ford's new PP LFT structural active grille shutter is expected to replace front-end modules across the truck range.

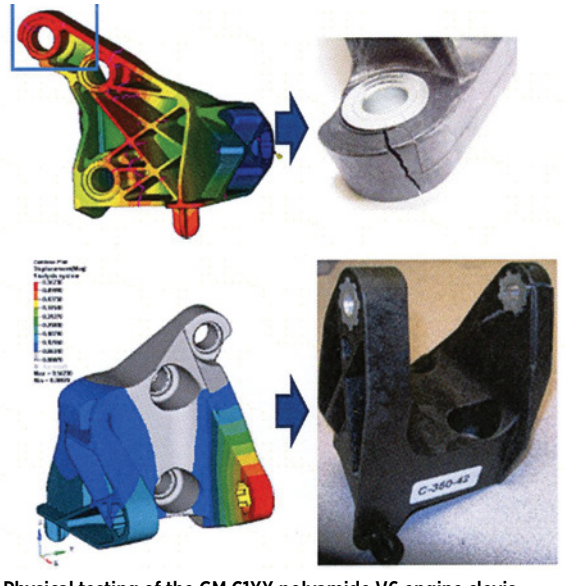
Ford spec'd Celstran PPGF40-20 for the new active grille shutter. An equivalent steel fabrication would weigh 18 lb more.



IAC, Sabic and BMW engineers used a high-flow LGFPP for the Mini IP carrier, enabling initial mold thickness of 1.9 mm.

Environmental Award—2018 Ford Fusion next-gen sustainable bio foam

Tier Supplier / Processor: International Automotive Components (IAC)
Material Supplier / Toolmaker: BASF Corporation / not stated
Material / Process: Elastoflex 3496/102 Resin, 113/4 Iso PU/ / foam in place
This application provides a sustainable alternative to conventional petroleum-based foams, at a lower weight and cost with more design flexibility, Ford engineers claim. Castor oil-based foam provides for lower molded density, the ability to be foamed in as little as 4-mm cross sections, and superior bond strength to mating materials. Foam in place tooling, where a cast PVC, TPE, or TPU skin is placed in the mold with a hard plastic retainer and the foam is injected between these two components, is used for processing. A claimed weight savings of 20-40% (depending on foam thickness) and a cost savings of $2 per average foamed-in-place instrument panel is achieved.



Physical testing of the GM C1XX polyamide V6 engine clevis bracket co-developed with BASF and Hutchinson showed 28 kN ultimate strength.

Powertrain Award—2018 Hyundai G80/Kia Stinger turbocharger outlet T-joint

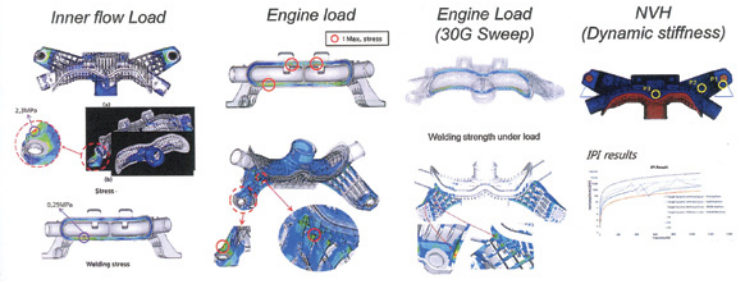
Tier Supplier / Processor: Hwaseung R&A Co., Ltd. / Songwoo Industrial & Seji Solotech, Inc.
Material Supplier / Toolmaker: DuPont Korea Inc. / not stated
Material / Process: PA66 / injection molding
A claimed 42% weight and 35% cost reduction, and improved airflow reducing the pressure drop (-8 kPa) to increase fuel economy and improve NVH performance, were achieved by designing and molding this part with plastic compared to the previous aluminum die casting. Airflow noise was also reduced and long-term durability increased via the rib pattern design.

Special three-gate positioning tooling was designed to minimize stress in weld-line area for strength and durability and for processing optimization. A new 35% glass fiber reinforced, heat stabilized polyamide-66 resin was developed for good retention of properties over time at temperatures up to 220°C (428°F).

Materials Award—2017 Ford F-150 and Mustang timing chain tensioner arms

Tier Supplier / Processor: BorgWarner
Material Supplier / Toolmaker: DSM / not stated
Material / Process: Stanyl HGR2 PA46(+PTFE) / injection molding
This usage of a modified PA46 (nylon 46) resin to enhance stiffness, on vehicles powered by a 5.0-L V8 was a drop-in replacement for PA66, for enhanced wear and friction performance. The resultant fuel economy savings (0.4%), from rotational torque reduction in the camshaft (0.5 N·m) was equivalent to a 40-lb (18-kg) mass reduction, and at 1/10th the cost. Claimed annual environmental benefits include reduction in fuel consumption by 12,000 bbl and greenhouse gas emissions by 5000 t. This innovation will be utilized on more Ford vehicles beginning in 2018.

CLOCKWISE FROM TOP LEFT: SPE; SPE; FORD; GM



Engineering the Hyundai/Kia turbo outlet in Zytel also helped improve engine performance. The 3-gate design boosted part strength.

Safety Award—2018 Ford F-150 Gen-3 four-way head restraint

Tier Supplier / Processor: Windsor Machine and Stamping
Material Supplier / Toolmaker: Ravago / Integrity Tool & Mold
Material / Process: Hylon N1000STHL PA / injection molding
This low-cost, low-mass head restraint provides exceptional rigidity for whiplash protection, Ford engineers claim. Its flexible design allows the front surface of the head restraint to be translated closer to or further from the occupant by 60 mm (2.3 in) without incurred costs, allowing for the precise balancing of comfort and safety. Using plastic, in place of steel, as the primary load bearing component is new to front-row head restraints.

The part design eliminates manufacturing complexity making use of intelligent geometries so that readily available materials could be used. A $10.73 million savings ($2.80/vehicle) is projected by the end of MY2020 as this technology is extended to new vehicle programs.

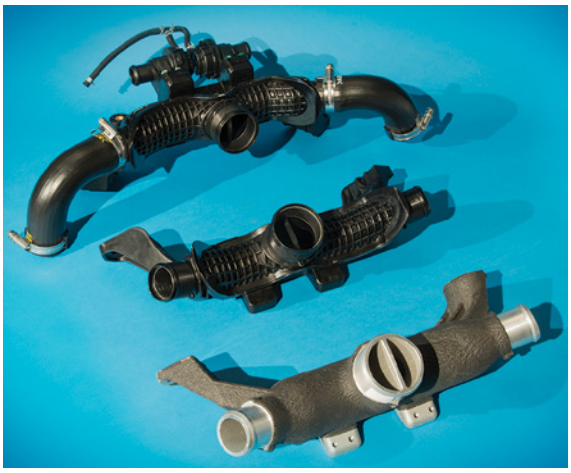
Process/Assembly/Enabling Technologies Award—2018 Ford Fiesta two-shot interior bezel

Tier Supplier / Processor: Faurecia Interior Systems
Material Supplier / Toolmaker: Lotte Advanced Materials / JP Grosfilley SAS
Material / Process: INFINO LT1220 PC & Starex LX0760 ABS / 2-shot injection molding
This unique 3-D decorative effect was achieved with 2K "reverse" injection molding (1st shot tinted PC) with overmolding of grained surface with 2nd shot (self colored pigmented ABS). Ford and its suppliers claim this is the first time this process was used to achieve the 3-D visual effect (color and texture) for a part of this size and geometry. A 30% cost save was achieved vs. IMD/IML/high gloss painting and there was a 20% scrap reduction vs. conventional two-layer high gloss piano black appearance.

Aftermarket Award—2017 Chevrolet Silverado integrated bedliner divider

Tier Supplier / Processor: Penda Corp. / Penda/Durakon
Material Supplier / Toolmaker: A. Schulman / Penda Corp.
Material / Process: Polytrope TPP1026EU TPO / twin sheet thermoforming
This is claimed to be the first twin-sheet thermoformed divider that is integrated into the bedliner as one piece. A $275 cost avoidance resulted by not having to manufacture a separate floor divider part.

FROM LEFT: HYUNDAI; SPE



Hyundai's new injection-molded/infrared welded turbo outlet in DuPont Zytel (shown top/center) replaces an aluminum casting (bottom) at 65% of the cost.

The divider incorporates a molded-in locking feature to secure the divider into the truck wall when it is raised. It eliminates the need for a cargo net or separate divider allowing the customer to put smaller items in the bed without having the items move and slide around while the vehicle is in motion. Dual textures are achieved on both sides of the part. The design can be applied to different vehicle models and brands via an insert for different logos.

Vehicle Engineering Team Award—2018 Chevrolet Traverse

The 2018 Traverse team introduced a first-surface-appearance, thin-wall, structural, long-glass-fiber polypropylene on the floor console carrier saving the program 30% mass (2.2 lb/1 kg). This eliminated the need for metal reinforcements to take $1.50/assembly out of the part as well.

The team also launched the first serial production polyamide clevis bracket, reducing the part weight by 45% relative to the previous aluminum design while increasing damping by a factor of 10. Other innovative applications included development of a new LED headlamp system that includes nine tailored elements producing about 720 lumens; and extended the use of low density (0.96 g/cc) TPO on the front and rear fascias, wheel opening moldings, claddings and rocker moldings. The use of plastics and composites in Traverse contributed to enhanced performance (a claimed 8% power gain with the 3.6-L V6), weight savings (7% lower than the previous program), improved fuel economy (17% increase) with best-in-class cargo space. ■

For more on the annual SPE Automotive Awards program, see www.speautomotive.com

WHAT WE'RE DRIVING

2018 Volkswagen T-Roc

Karsten Schebsdat's surname may be difficult to pronounce, but the ace **Volkswagen** chassis engineer's contribution to the T-Roc was evident the moment I entered the first corner in the new crossover.

Sampled with front-wheel drive in low ambient temperatures on slippery U.K. roads, the T-Roc felt absolutely secure. Schebsdat, the chassis development chief formerly with **Porsche**, and his team have fine-tuned VW's versatile MQB architecture to deliver a crisp-handling edge to VW's high-quality new 5-seat compact SUV.

Volkswagen's new T-Roc rides on the MQB chassis given some fine-tuning via Porsche expertise.

T-Roc's emphasis is equally on engineering and distinctive style, the latter demonstrated via a range of color combinations that might give a (pleasant) shock to the more conservative buyers of Wolfsburg's wares.

Five gasoline and five diesel engines are available, coupled with slick-shifting 6-speed manual or efficient 7-speed DSG gearboxes. The gasoline 2.0-L rated at 140 kW (188 hp) hits 62 mph in 7.2 s.

The T-Roc won't likely get stuck in a hard place of the market. It's expected to sell strongly, although VW has not confirmed that it will join the company's range in the U.S. With a 2590-mm (116-in) wheelbase and measuring 4234-mm (167-in) long overall, T-Roc is a substantial 252 mm (9.9 in) shorter than the Tiguan, currently VW's smallest SUV in the U.S.

Stuart Birch

2018 Ram ProMaster 2500

Pickup or van? When it's critical that cargo and tools stay dry and secure, only a van will do. My dad was a residential carpenter who owned various **Dodge** and **Chevy** panel trucks and B-vans during his career, but all were of the old-school variety. Their low rooflines and relatively cramped confines often made loading and unloading a headbanger; ask me how I know. In those days, a tradesman could only dream about having a hauler as commodious and capable as the **Ram** ProMaster 2500.

This rebadged **Fiat** Ducato offers an ideal combination of high roofline and reasonably low load floor, enabled by the 16-in wheels and front-wheel-drive platform that's unique to the segment. The ProMaster I tested was the long-wheelbase (159-in) model; the short 136-in version would have been too small to fit the large antique dressers and hutches that needed to be delicately transported on their backs rather than standing up.

The big ProMaster's 16-in wheels keep the load-floor low.

Exceptional features of this eminently useful machine include Greyhound-like driver visibility and seating comfort, an urban-friendly turning radius and surprising fuel economy (17.8 mpg) with the **FCA** corporate 3.6-L, 260-lb·ft (352 N·m) gasoline V-6 and 6-speed transaxle.

Yes, the big van has a face that only a mother could love, but those headlamps are placed up high to be out of harm's way. Everything about the Ram ProMaster 2500 was engineered for practicality—for when only a van will do.

Lindsay Brooke

2018 Lexus LC500

Nobody's going to argue that **Lexus** designers didn't walk the walk when transitioning the LC500 from the sharkish LF-LC concept car to the production LC coupe. I found it tough to take my eyes off the thing and the LC500 attracts exotic-car attention everywhere it goes.

The production LC is barely changed from Lexus' widely acclaimed LF-LC concept car.

The LC500's 5.0-L DOHC V-8 is a brilliant synthesis of brawn and refinement and its 7,100-rpm redline is just high enough to telegraph there's heavy performance intention, while the 471 hp and 398 lb·ft (540 N·m) output figures are sufficiently premium to avoid direct comparison with V-8-packing Mustangs and Camaros and such.

This coupe's performance essentially matches expectations, but there's usually the sense that you're not quite getting at *all* the power—and it's because the otherwise brilliant 10-speed automatic transmission appears to have been geared more for high-efficiency, high-speed cruising than low- and even midrange performance.

I'm surprised by a couple of odd details in the LC's luscious interior. For all the tactile glory of the knurled-metal radio-tuning and drive-mode control dials, there's a disappointingly hollow feel to the turn-signal stalk. And the way-too-distracting Remote Touch Interface touchpad remains a driver-interface fail with a capital "F."

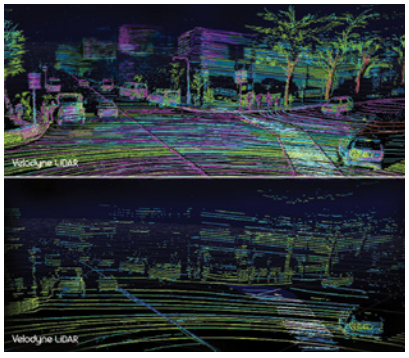
But I don't much care about the LC's foibles or whether it's got the all-out dynamics of a **Porsche** 911. This is exactly what I would expect—and want—a Lexus grand-touring coupe to be: sneaky fast, deliciously designed and masterfully crafted.

Bill Visnic

FROM LEFT: VOLKSWAGEN; FCA; BILL VISNIC

SPOTLIGHT: LIDAR AND RADAR TECHNOLOGY

Lidar sensor



The VLS-128 lidar sensor from **Velodyne** (San Jose, CA) is designed for the rapidly-expanding autonomous-vehicle market. It provides three advances for autonomous driving: reduction in vision system compute complexity, highway driving and robotic assembly of the sensor itself. Velodyne claims that the VLS-128, with 128 laser channels, offers the highest resolution, longest range and the widest surround field-of-view of any lidar system available today. Velodyne's new flagship model, which succeeds its HDL-64, has 10 times higher resolving power than the HDL-64, allowing it to see objects more clearly from greater distances, while its highly-accurate object-identification and -detection system can provide what the company says is "superior" collision avoidance in a moving vehicle. Comparison of the VLS-128 point cloud (as seen in top portion of image) to the HDL-64 point cloud (bottom) highlights how the new flagship model delivers markedly superior resolving performance compared with the HDL-64, delivering much-improved clarity and range.

For more information, visit http://info.hotims.com/69502-400

Vehicle radar test system

Engineers can use **National Instruments**' (Austin, TX) vehicle radar test system (VRTS) to test 76-81 GHz radar technology from the R&D lab through high-volume production test and from individual radar sensors to integrated advanced driver assistance systems (ADAS). The VRTS combines NI's mmWave front-end technology, a PXI vector signal transceiver (VST) and application-specific software. The VRTS integrates a 76-81 GHz vector signal generator/analyzer designed for dynamic obstacle generation and comprehensive RF characteristic measurements. Using a more comprehensive approach to radar test that includes both traditional and hardware-in-the-loop test techniques, engineers can deliver more robust autonomous driving technology to comply with evolving regulatory requirements. Key VRTS attributes include the ability to simulate Doppler effect velocity of up to 250 km/h (155 mph), minimum obstacle range of 4 m (13 ft), object distance resolution down to 10 cm (4 in), support for multiple angles of arrival and variable radar cross sections.

For more information, visit http://info.hotims.com/69502-401

500°F cabinet oven

No. 994 is a 500°F (260°C) special cabinet oven from **Grieve** (Round Lake, IL) suitable for heating the end of long parts at the customer's facility. The oven's workspace dimensions are a tapered 10 in (254 mm) at front and 20 in (508 mm) at rear wide x 20 in (508 mm) deep x 21 in (533 mm) high. According to the company, 9 kW (6.7 hp) are installed in Nichrome wire heating elements, while a 600 ft^3/min (16,990 L/min), ½-hp (0.37 kW) recirculating blower provides vertical upward airflow to the workload. This Grieve cabinet oven has 4-in (0.16-mm) insulated walls and an aluminized steel interior and exterior. Features also include safety equipment for handling flammable solvents, including explosion venting door hardware. Controls on No. 994 include all applicable **NEMA** (National Electrical Manufacturers Association) 12 electrical standards and a tower light to indicate machine status.

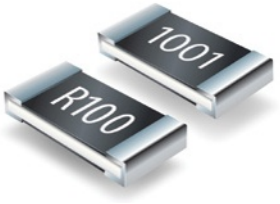
For more information, visit http://info.hotims.com/69502-402

1.0 megapixel imaging SOCs

Two highly integrated 1.0 megapixel CMOS image-sensing products from **ON Semiconductor** (Phoenix, AZ) provide a complete solution with the image sensor and processing functionality integrated within a low power SoC (system on chip) that simplifies and speeds adoption in applications such as rear and surround view cameras. According to the company, the AS0140 and AS0142 can be used to improve driver comfort, convenience and safety through a growing range of advanced driver assistance systems. The AS0140 and AS0142 are both 1/4-in (6.35-mm) format devices capable of supporting 45 frames per second (fps) throughput at full resolution or 60 fps at 720p. Key features include distortion correction, multi-color overlays and both analog (NTSC) and digital (Ethernet) interfaces.

For more information, visit http://info.hotims.com/69502-403

Thick film chip resistors



Bourns, Inc.'s (Riverside, CA) two new series of thick film chip resistors offer enhanced power ratings up to 2 W at 70°C (158°F). The Bourns Models CRMxxxxA and CRSxxxxA are sulfur-resistant and AEC-Q200 compliant, making them suitable for automotive driver assistant, information, entertainment and lighting applications, as well as commercial, automation, industrial, power supply and stepper-motor drive designs. Available in six different footprints, Bourns' latest resistor series are designed to operate in harsh environments where there are elevated levels of sulfur contamination. In addition, the resistors have been tested in accordance with ASTM B809-9 methods. Made using a thick-film element printed onto a ceramic substrate, Bourns says the resistors offer additional product lifespan benefits compared to standard film resistors when exposed to a sulfurous gas environment.

For more information, visit http://info.hotims.com/69502-404

S series connectors

LEMO (Rohnert Park, CA) recently redesigned the outer shell for its S series connectors with LEMO's chocolate block design (shown). Using the half-moon insert configuration, the S series is fully compatible with the existing S series connectors. Both the straight plug-and-free-receptacle now use the same collet as LEMO's B series, offering a slightly different cable range than the previous S series. Available in sizes 0S, 1S and 2S for cables ranging from 1.4 mm to 9.9 mm (0.05 in to 0.38 in), LEMO's S series offers multipole contacts from 2 to 10, as well as unipole, coax, triax and multi-concentric configurations. Applications include broadcast, audio/video, communications (GPS, antennas, and transmitters), test and measurement (high-end probes), battery chargers, and high current and high power.

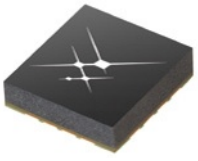
For more information, visit http://info.hotims.com/69502-405

Photodiode chips

Osram Opto Semiconductors (Sunnyvale, CA) offers what they claim is the world's first surface-mount technology (SMT) package for large-area photodiode chips. Suitable for use in rain sensors, the new SFH 2200 A01 and SFH 2200 FA A01 are mounted behind the vehicle's windshield. When a raindrop falls on the windshield, the diodes detect a change in the incidence of light. This change is then translated by the system to control the windshield wipers and the rate at which they operate. According to Osram, the photodiode chips comply with the strict demands of the automotive industry and are approved to operate at temperatures up to 125°C (257°F). The photodiodes also meet the requirements for AEC-Q101-C qualification.

For more information, visit http://info.hotims.com/69502-406

Dual-band front-end module



Skyworks' (Woburn, MA) SkyOne WiFi is a new family of highly-integrated wireless networking solutions for mobile and IoT ecosystems. The new devices incorporate all the key radio frequency (RF) blocks between the Wi-Fi system-on-a-chip (SoC) and the antenna, unburdening customers of complex RF design challenges while reducing time to market. According to Skyworks, this unique platform improves the Wi-Fi system performance compared to standard SoC platforms and mitigates interference with other radios, extending range and increasing throughput to improve the user experience. The SKY85812-11 SkyOne WiFi dual-band 802.11ac front-end module is the first in the SkyOne WiFi family and is geared for Wi-Fi-enabled handsets, tablets, mobile/portable systems and IoT devices.

For more information, visit http://info.hotims.com/69502-407

SAE Eye on Engineering: 2018 Nissan Leaf

The **Nissan** Leaf was the first modern, fully electric car from a major automaker when it debuted in 2010. In this episode of *SAE Eye on Engineering*, Editor-In-Chief Lindsay Brooke looks at Nissan's newest low-cost battery-EV offering. *SAE Eye on Engineering* can be viewed at **video.sae.org/12326/**. It also airs Monday mornings on WJR 760 AM Detroit's Paul W. Smith Show. Access archived episodes of *SAE Eye on Engineering* at **sae.org/magazines/podcasts**.

Ford plans to move self-driving and electric vehicle teams to Detroit

Ford is returning to its roots as the company looks to its future with the move of its key autonomous vehicle and electric vehicle business and strategy teams to Detroit in early 2018.

The teams, including Team Edison, are moving to a recently refurbished 45,000-ft² historic industrial complex known as The Factory in Detroit's Corktown neighborhood. According to the company, the Motor City location will enable Ford teams to immerse themselves in urban mobility challenges and solutions. Sherif Marakby, Ford vice president of autonomous vehicles and electrification, will lead the Corktown team.

"We're excited to choose this inspirational location in one of Detroit's resurgent neighborhoods to accelerate our work on electric and autonomous vehicles," said Jim Hackett, Ford president and CEO, in a release. "This move and our exciting Dearborn campus transformation are important steps as we move toward our aspiration to become the world's most trusted mobility company—designing smart vehicles for a smart world."

"Returning to Detroit is particularly meaningful, because it is where my great-grandfather originally set out to pursue his passion and where we have always called our home," said Executive Chairman Bill Ford. "We are planting a special piece of our company's future in one of the city's great neighborhoods, because we believe in Detroit, its people and what we can build together."

Ford says it is focused on driving its electric vehicle business forward, both with hybrid vehicles and full battery-electric vehicles with research led by Ford's Team Edison. The team is working to accelerate both the development and adoption of electric vehicles.

Read full article at **articles.sae.org/15804/**.

Acura teases RDX replacement for Detroit auto show

Acura confirmed it will join what's certain to be a number of other automakers revealing new or revised SUVs at January's Detroit auto show, releasing before the holidays a teaser image of the prototype for the next generation of its strong-selling RDX midsize crossover.

The company said the new third-generation RDX Prototype represents "the most extensive Acura redesign in more than a decade," and added the crossover was for the first time designed and developed in the U.S. Significantly, the brand also said the new RDX is built on an Acura-exclusive architecture.

Perhaps equally important, by drawing on Acura's Precision Cockpit concept, the next-generation RDX will feature an all-new user interface and operating system, a tantalizing promise as automakers and suppliers scramble to improve the HMI experience in general and in particular continue to explore the best ways to integrate increasing ADAS features and automated-driving capabilities.

Read full article at **articles.sae.org/15803/**.

READER FEEDBACK

Super Cruise, HCCI, and EV challenges

Your report on GM's 'Super Cruise' automated driving system [Nov./Dec. 2017] was among the most balanced and comprehensive 'tests' of this technology from any publication I've read. Clearly the industry has made rapid progress in developing the sensors and processors needed to make SAE Level 4 and autonomous Level 5 a reality. But as your report indicates, much more design/engineering/validation—and testing, testing, testing!—is needed before any of these alleged 'self-driving' vehicles can safely share the road with today's 'dumb' human-piloted cars and trucks.

Sidney Cohen
Columbus, IN

Good story on the Cadillac Super Cruise system. After reading it my impressions are: 1. We are still many years away from SAFE self-driving technology; 2. These systems with their biometric 'driver checking' cameras and haptic alarms, don't really allow you to relax behind the wheel. On the contrary, they require you to be MORE alert than if using today's automated cruise control systems. Worry-free automated driving is a myth.

Robert Kline
Minneapolis, MN

An EV 'boondoggle'

Lindsay Brooke's recent editorial regarding electric vehicles started out hopeful enough by speaking of the enormous hurdles we face in upgrading the electrical grid to handle the charging of these white elephant affectations. Unfortunately, his last sentence pretty much says it all: Where do you think these billions (more like hundreds of billions, once the government finishes sticking its bungling bureaucratic nose into this boondoggle) are going to come from? That's right, the ratepayers and taxpayers. And for what? A specious environmental improvement that will have no measurable impact on the climate, human health or anything else.

David Bowers
Roseville, MI

From your November issue: "Meeting increasingly stiff emissions regulations..." [Electrification] is a disruptor for the global regulatory bodies. Their regulatory function will change as mobility is electrified. What will their mission be? What will they regulate in the industry?

Colin Stava

Mazda's SpCCI

I appreciate your articles on HCCI [October 2017 cover story] but do take issue with Mazda's compression ignition (CI) claim as untrue. Having run GDI HCCI (early injection) on a two-stroke double-ended free piston engine, unencumbered by the crank-rod mechanism, it is the holy grail of Gasoline combustion in that every combustion event is, for all practical purposes identical, with NOx values at or near the gas analyzer noise floor.

Normal SI combustion is like snowflakes: they're all different. Having no spark plug we had to start with stratified-charge (late injection) CI and combustion was erratic. Mazda overcomes this with SI and a flame front. In terms of spark plugs, HCCI is like having an infinite number of spark plugs in the cylinder to create an instant flameless chemical energy conversion.

I'm a big fan of Mazda's powertrain leadership but most OEMs could run Mazda's Lean-Burn GDI SI strategy where the workload is on cleaning up the NOx that you don't have with HCCI aforesaid.

Patrick McCarthy

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

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January 22: Truck & Off-Highway Engineering
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January 29: Automotive Engineering (Connected Car edition)
Technology eNewsletter

February: Automotive Engineering
Print Magazine
- Special coverage: NAIAS '18 and CES '18
- New Vehicle Tech
- Hybrid & EV Systems Spotlight

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Q&A

As Polestar CEO, Thomas Ingenlath will oversee spearheading technology programs, some of which may throw off benefits for upcoming high-volume Volvo EVs.

Polestar CEO aims to "democratize" performance EVs

As construction starts in Chengdu, China of the new production center for **Volvo**'s **Polestar** high-performance EV brand (see http://articles.sae.org/15714/), *Automotive Engineering*'s European Editor Stuart Birch talked with company CEO Thomas Ingenlath. Previously Senior Vice President Design of Volvo Cars, Ingenlath is described by the company as being the inspiration behind its design renaissance in recent years.

What were the salient reasons for the creation of Polestar as the Volvo Car Group's standalone electric-performance brand?
First, Polestar is an integral part of the electrification strategy of Volvo. It will spearhead the electrification with cars that are offered as BEVs only. Second, Polestar will add to the well-defined and -positioned Volvo portfolio a brand that offers performance-oriented electric cars. And third, Polestar will use the well-established and experienced structures and resources of the Volvo Car Group to add value by creating the new and exciting brand Polestar.

Why is your first car [Polestar 1, based on Volvo's Scalable Platform Architecture (SPA)] to be a very powerful and, for many, a financially unreachable "halo" hybrid model, rather than perhaps a more affordable BEV sports coupe or roadster?
Polestar 1 will indeed be a halo model for the Polestar brand and sets the tone and future direction of the new electric-performance brand. The statistics of an output of 600 hp (441 kW), delivering the longest range of any hybrid in the world and with world-class chassis components from **Öhlins** (Continuously Controlled Electronic Suspension) and **Akebono** (6-piston brake calipers), best demonstrate the attributes of the car and brand.

That said, Polestar is very keen to see the democratization of performance electric cars and that's why, at the launch of the Polestar 1, it was confirmed that Polestar 2 would be a higher-volume, more-accessible car in the competitor set of the Tesla Model 3 and feature a full electric powertrain.

Will the advanced technologies and weight-saving techniques (in modified form, perhaps) used in Polestar 1, cascade into future models? And could you give examples (maybe next-generation composites but not carbon)?
It's too early to go into material or construction details of future Polestar cars. However, one of the main roles that Polestar will play within the Volvo Car Group is as a technology spearhead, testing and experimenting with new products, services, materials and developments in lower-volume cars to see if there are applications for the higher-volume Volvo Car products. This is a significant benefit that Polestar brings to its parent company.

The Tesla Model 3 has a maximum projected range of around 500 km and vigorous performance. Are you aiming to better this figure and if so, how—e.g. lower weight, significantly lower Cd figures, multi-ratio transmissions?
At the launch of the Polestar 1, we confirmed that Polestar 2 would be a car that competes in the competitive set of the Tesla Model 3. However, we also confirmed that the launch of the Polestar 2 would take place around the turn of the decade. It's therefore too early to confirm the projected range and performance of the car and how we might achieve those levels. That said, we wouldn't be suggesting the Polestar 2 was in the competitive set of the Tesla Model 3 if we didn't believe it wouldn't be competitive with that car when it arrives!

Can you detail the synergies that higher volume Polestar models will share with Volvo vehicles?
We will share the new developed electric platforms within the Volvo Car Group.

Are you confident that lithium-ion battery technology has the development potential to meet your needs in cost and energy density over the next decade? What alternative battery technology looks promising for the mid to long-term?
For products currently in our cycle plan and for the foreseeable future, lithium-ion batteries are the best match to our prerequisites. That said, together with Volvo, we are constantly exploring both established suppliers and startups to identify promising technologies—and there are already many promising solutions identified. But there's no point in taking specific battery technology decisions prematurely, as most of these technologies are quite easily exchangeable within our new electric propulsion architecture. (To read this interview in its entirety, see : http://articles.sae.org/15765/). ■

VOLVO

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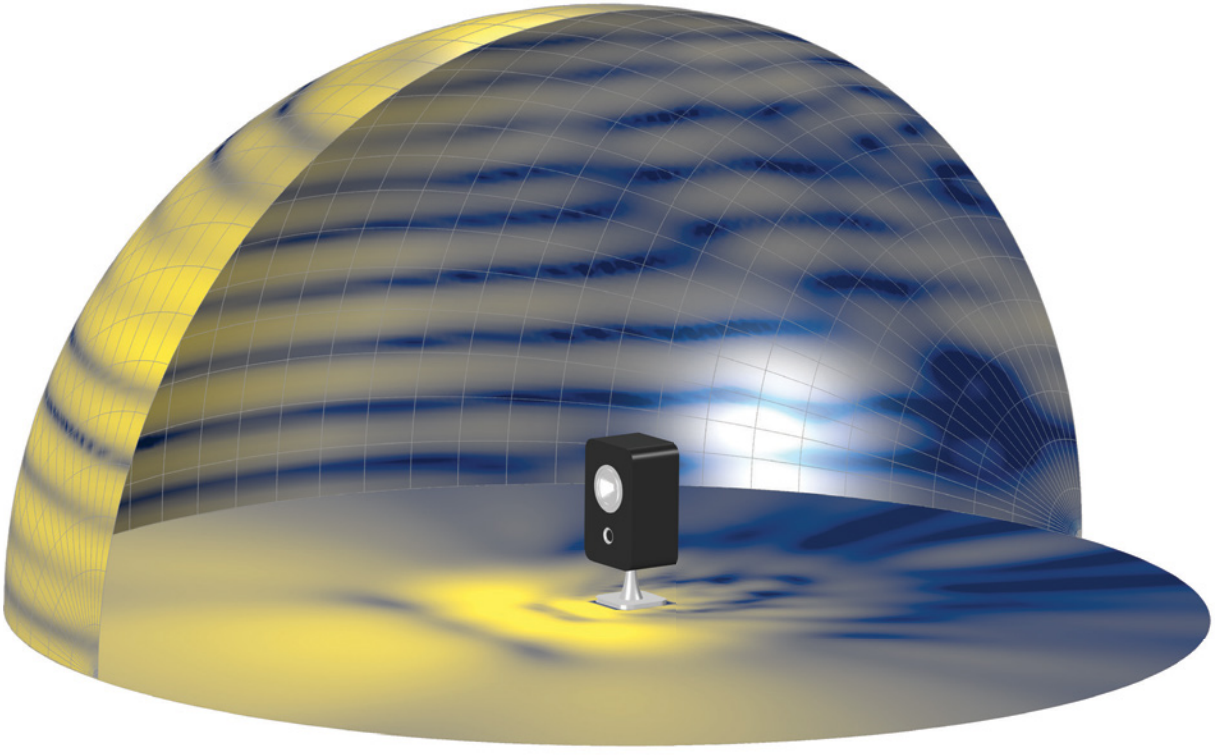

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