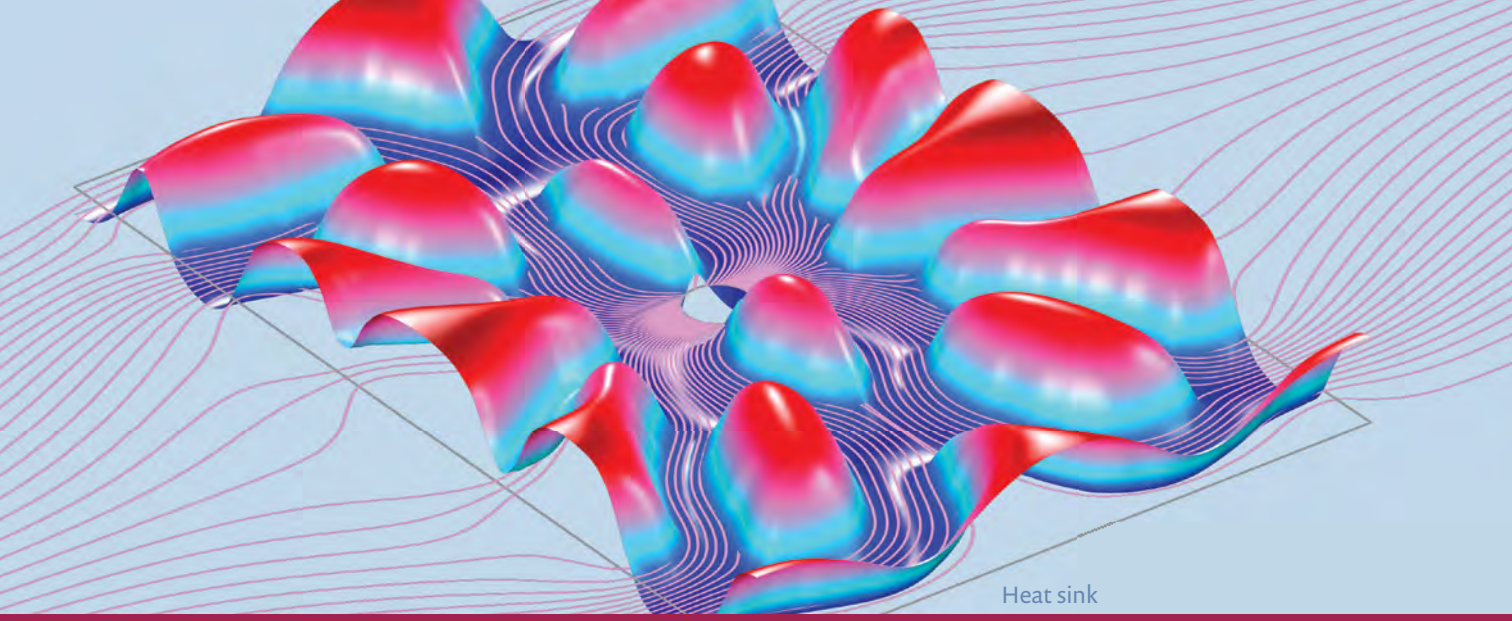

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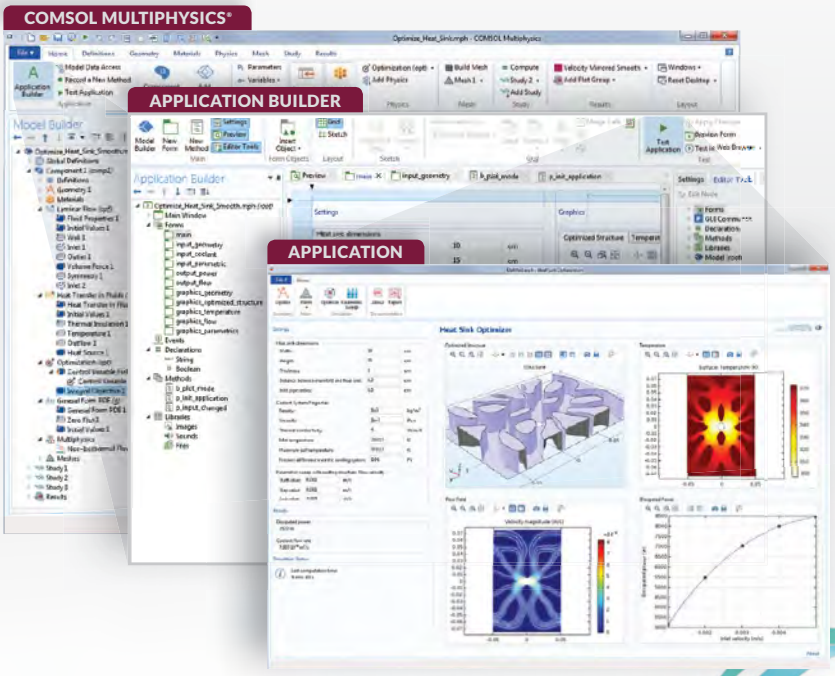

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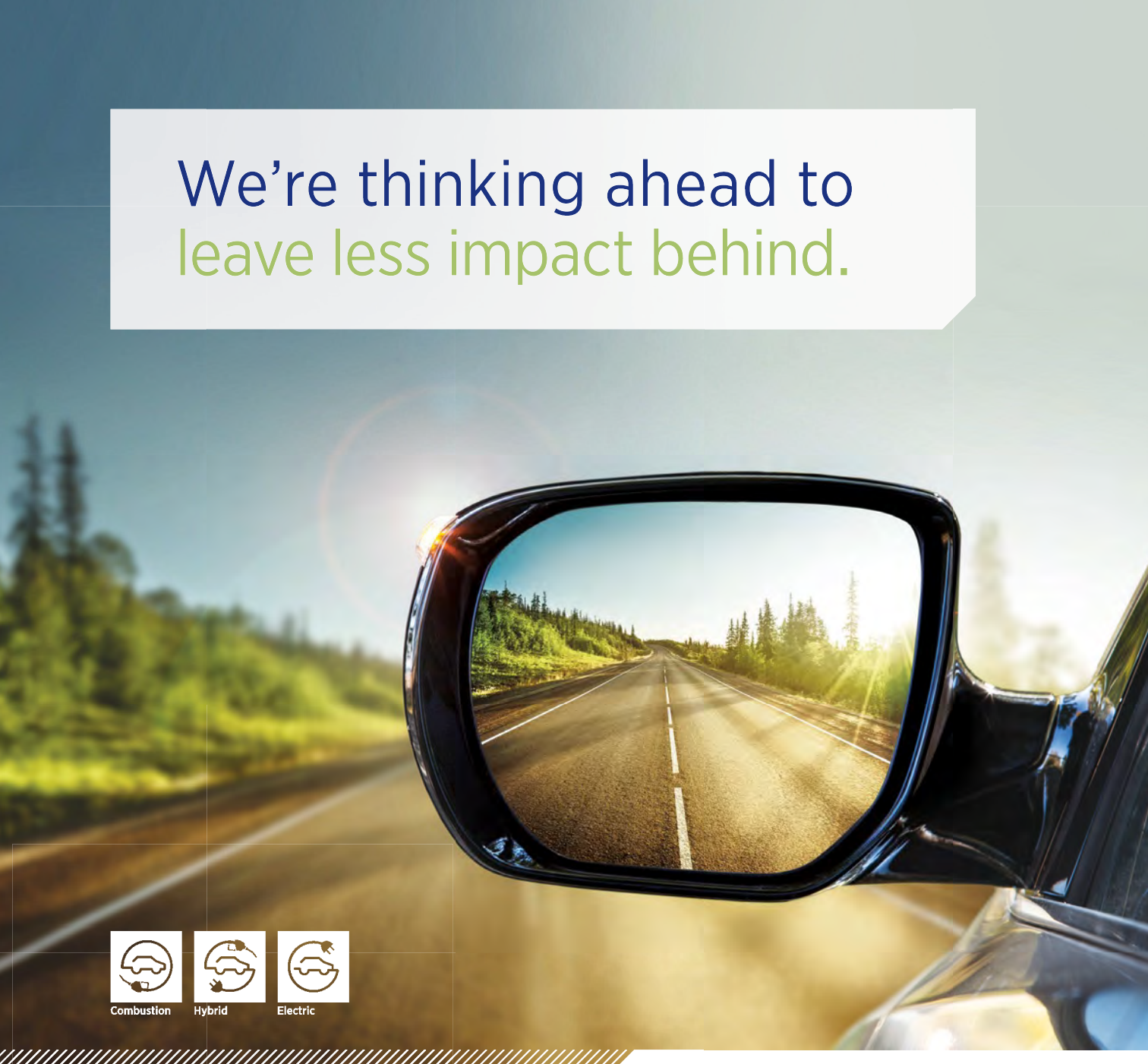

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ON THE COVER

Mobileye Chief Technology Officer and co-founder Amnon Shashua delivers innovative new technologies on a far larger scale than the model car he's holding. Photography courtesy of Mobileye.

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EDITORIAL

Nation of Innovation

"Do you want to be the driving force in generating new ideas, innovations and concepts, move projects forward and put them into practice? Then we are looking forward to your application for this exciting job," read the recent listing on the **Daimler AG** careers website.

Germany's oldest and most prestigious automaker is looking for the best and brightest engineers, scientists and technicians to staff its latest **Mercedes-Benz** R&D center, now under construction—in Tel Aviv. Working for the three-pointed star, under the Star of David, MBRD teams will develop and test pilot projects for new user interfaces, digital controls and mobility services.

Mercedes is expanding its global R&D footprint "with the help of Israel, the high-tech nation," asserted Dr. Thomas Weber, the Daimler board member in charge of R&D ventures.

"The high-tech nation" is a more apt descriptor than mere comparisons with Silicon Valley. Tiny Israel—and its bright, industrious and vigilant people—has steadily become one of the world's premier innovation hubs for mobility companies seeking a competitive edge. Automotive OEMs and Tier 1s interested in artificial intelligence, machine learning, digital mapping, image processing, cybersecurity and 3D sensing have been making so many pilgrimages to visit Israeli start-ups that engineering executives are crossing paths in the process.

Mobileye, the subject of this month's cover story, is Israel's best-known auto-tech success, but there are dozens more. **Foresight**, an emerging player in 3D mapping used in ADAS, developed its technology from stereoscopic perimeter radar—a byproduct, as are many other advanced commercial products, of Israel's defense industry.

Ford is buying Israeli start-up **SAIPS**, whose image and video processing algorithms enable rapid interpretation of sensor data in autonomous vehicles. **GM** is doubling the size of its R&D center in Herzliya while investing in electrical-system fault diagnosis specialist **Sital Technologies** and **Powermat**, a wireless power developer. In anti-hacking, Israel's **Argus Cyber Security** is a leader.

Intriguingly-named **Gett**, **Otonomo** and **Via** are ride-sharing software innovators. **Camtek** and **Orbotek** are on the cutting edge of electronics production processing. The first demonstration of rapid prototyping using stereolithography that I ever witnessed was by **Cubital**, way back in the mid-1980s. Another 3D printing leader, **Stratasys**, has dual headquarters in Rehovot, Israel and Minneapolis, MN, after merging with Israel-based **Objet** in 2012.

Israel's tech ascent is the product of a society that puts a premium on education and a culture in which research and development thrive. "STEM [education] is nothing new to us because it's so ingrained," observes a friend who works in sensor fusion for a Tier 1.

The Israeli government underpins the country's tech-sector growth though access to low-interest capital. One result of their investment: The rate of Israeli university graduates who are likely to become IT entrepreneurs or join startups is roughly twice that of U.S. university grads, reported Charles Holloway, a professor at the **Stanford Graduate School of Business** and co-director of the **Center for Entrepreneurial Studies**.

Not all on the horizon appears to be rosy, however. Experts see a shortage of engineering grads entering the Israeli workforce in recent years creating challenges for industry, both locally and globally, despite the nation being a magnet for immigrants. And even the largest among Israeli companies are comparatively small, or serve market niches, further wedding their success with that of their overseas partners. But such temporary impediments won't likely slow the relentless stream of creativity that's made this nation a leading 'go-to' for the mobility industry.

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SAE STANDARDS NEWS

Sharpening the focus on OBD-II security

SAE Standards News *aims to update readers on the extensive activity in the SAE Global Ground Vehicle Standards development arena, by more than 800 ground vehicle committees comprised of volunteers from global industry stakeholders and SAE GVS staff who support the committee work.*

In Fall 2016, the U.S. House Committee on Energy and Commerce reached out to the **National Highway Traffic Safety Administration** (NHTSA) in regards to addressing OBD-II security. The letter requested NHSTA to "convene an industry-wide effort to develop a plan of action for addressing the risk posed by the existence of the OBD-II port in the modern vehicle ecosystem."

Enter SAE.

"**SAE International,** at NHTSA's urging, has started a working group that is 'looking to explore ways to harden the OBD-II port'—that was their [NHTSA's] language," said Tim Weisenberger, SAE's Project Manager, Technical Programs, Ground Vehicle Standards. SAE set to work by reaching out to a wide range of the industry. A working group of experts was assembled to examine the issue with the goal of developing a set of recommendations.

"The OBD-II port has moved beyond its originally designed intent as a port to check emissions by regulators like the **EPA** and **CARB**," Weisenberger explained.

There are vehicle data access vs. vehicle security issues at hand. Many entities are requesting both legitimate and non-legitimate access to the port.

The "legit" side include inspection and maintenance, workshop/service, insurance/other plug-in telematics and prognostics apps and performance tuners.

On the malicious side are the hackers.

Triggering the industry

The group of approximately 40 gathered for the first workshops on December 1, 2016 and January 30, 2017 to identify common issues, needs and an approach to secure the OBD.

"The group included a couple of our experts that run various committees—Bob Gruszczynski from **Volkswagen** and Mark Zachos from **DG Technologies** were really the lead experts," Weisenberger explained.

SAE staff were also present to facilitate and help to examine how the organization could rapidly move forward. They considered either standards development or expedited standards development that uses what SAE calls a Cooperative Research Project approach. This is a pathway for joint-venture research projects where two or more organizations pool their resources to study a pre-competitive technical area and share in the results.

"It was interesting that this was kind of a trigger for the industry to get together to create something that's a little more open for the entire industry," he said, "not just specific to company."

The new OBD working group SAE has assembled is broad. It is comprised of eight automotive OEMs (**BMW**, **Ford**, **General Motors**, **Honda**, **Hyundai**, **Isuzu**, **Toyota**, VW), a few heavy-truck OEMs and suppliers (including **Volvo** and **Cummins**), various associations (**MEMA** and **ETI**), as well as representation from government and regulators including the California Air Resources Board, NHTSA and the **National Institute of Standards and Technology**.

Jennifer Shuttleworth
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The humble OBD-II port has moved beyond its originally designed intent and is now a potential gateway for vehicle security breaches.

Get to know the TEVDS20

Through this effort, a new SAE committee was born: the Data Link Connector Vehicle Security Committee (TEVDS20). It is important to note that "data link connector" is the technical term for the OBD-II port (which really is more of an industry slang term, Weisenberger told *AE*). With the committee's naming as a trigger, members will begin to use the technical term moving forward.

As this issue of *Automotive Engineering* went to press, the group was set to meet again to define the scope of work and engage a new Task Force under the committee to develop the technical work item (J3138). From there, the committee will continue to meet periodically to examine the issue and begin new work items as needed, Weisenberger explained.

"This new work item is a very specific use case," he said. "It is a deep dive."

The potential is there for other work down the road, but for now the group has its very specific goal to meet the U.S. House Committee's and NHTSA's requirements for "hardening" the OBD-II port squarely in sight.

Watch this column for updates on TEVDS20's progress. ■

Smaller suppliers facing global challenges

Smaller suppliers: How are you coping with globalization?

It's a daunting task to follow OEM or Tier-1 customers around the world. Coordinating with their rapid-fire launch cadences requires a significant investment in people, resources and capital. Several smaller, regional suppliers who were not willing to extend their enterprise and increase their exposure to greater risk have opted to consolidate with larger players, or look for alternative approaches.

Let's consider some context. In 2016, the average volume for the top 20 global vehicle platforms was 1.78 million units. By 2023, this is expected to escalate 37%, to 2.43 million units, with the average platform built in at least four regions around the world, according to **IHS Markit Analysis**. Swimming in such a swift current is not for the faint of heart.

Why this consolidation? The slow but eventual reduction in the gaps between major-market emission standards and the onset of a "global consumer" are two reasons. As OEMs seek to reduce variability and cost as well as the reduced-complexity benefits of global scale, those suppliers who are sole-sourced on global programs are required to launch facilities in several regions, often with little time between launches.

The era of regional platforms dominating the landscape is long gone, excepting the US full-size pickup anomaly.

Outside of the benefits of scale, there are additional drivers that favor large, global suppliers. Systems integration and optimization is a mandate from the OEMs and Tier 1s, but it can present a burden for sub-tier companies which lack broad design and infrastructure capability. Sure, you can export from one location for global markets, but recent initiatives to reduce inventory and logistics costs, while building in a common currency to that of your customer, are driving the co-location of Tier 1 and Tier 2 supply.

Then there's the constant drumbeat of Research and Development requirements to maintain technical leadership for customers based in multiple regions. Such pressure can tax a smaller, lesser-equipped organization.

New materials, the steady rise of electrification, warranty risk and the sheer speed of the industry are proving to be substantial hurdles for many.

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Are you willing and prepared to follow your customers around the world to support their global product initiatives?

How can small suppliers survive the onslaught of the mobility industry's globalization? Consider that following your customers around the world can tax resources and expand risk—are you willing and prepared to accommodate such activity?

There are solutions and they require creativity. One option is to extend your enterprise with a peer from another region who is facing the same pressures. If a small supplier based in North America is being pressured to expand to Europe or Asia, odds are that there are others in those regions who are under the same gun.

While alliances can be complex and usually demand some level of shared sacrifice, several smaller, regional suppliers have expanded successfully to new regions though a partner. They've reduced their risk and maintained independence. Maintaining a global contract with a reduced risk profile is tricky though achievable.

There are other alternatives. How strong is your company's technology and patent and overally intellectual property (IP) protection? Scale economies of your part/system and having a "logistics-friendly" capability may enable you to ship from a single location for the world. While currency exposure is still a concern, building the best mousetrap still attracts core customers.

Other possibilities include focusing only on regional platforms, close to your geographic comfort zone. This strategy usually does not have a happy ending. Firstly, global suppliers are not willing to overlook regional platforms (only built in one region) just because they have a global footprint. Secondly, OEM procurement teams also understand the dynamics of the market and may use this leverage to reduce margins and squeeze suppliers.

And finally, selling to a larger competitor is always a possibility.

No doubt it's becoming more difficult for small, regional suppliers. The march of technology and increasing global scale are working against this critical group.

Being proactive, opportunistic, open-minded to critical regional partnerships and flexible to emerging possibilities, are your keys to survival and future success. ■

Lucid Motors' David Moseley: EV or ICE, "It is all physics"

As Director, Powertrain, CAE Crash & Safety for electric-vehicle startup **Lucid Motors**, David Moseley may hold one of the most intriguing—and possibly even most-envied—jobs in the auto industry. Leading up to his SAE WCX17 Leadership Summit panel discussion, "How, What and if You Will Drive in the Next Decade" (9 a.m. April 6), Moseley discussed the not-really-different aspects of EV and internal-combustion engineering, why a powertrain's still just a powertrain—and why he ponied up his own money for a deposit on Lucid's Air electric luxury sedan.

David Moseley: An enormous amount of learning is yet to come in BEV powertrain development. (Image: Lucid Motors)

Should the auto industry step away from the term "powertrain" and shift to "propulsion" as the march toward electrification continues?
I'm happy to keep calling it a powertrain–as far as I am concerned it's just the sequence of energy transformations from source to tractive effort, whether ICE, fuel cell, battery/motor or [Star] Trek-y warp-drive. I don't think we need a unique term for each manner by which this is achieved. What I positively like about the term "powertrain" in this context is the picture it generates in my mind of a line of carriages, a sequence of matched components working in harmony to deliver passengers to their destinations.

We're always intrigued by discussion of the parts-count delta between IC vehicles and EVs. Does this meaningfully ease the product-development and bill-of-materials processes?
In truth, it probably only serves to make the ambition of creating both a car and a car company barely feasible for a startup—rather than utterly insane!

More seriously, this goes to the heart of how one develops a product as complex as a car in the context of a startup company. The big picture is that you don't need all that many people and you need to scale their number progressively as the vehicle design develops. Too many people, too soon, perversely acts as a brake on progress: tentacles of premature design begin to grow, which are hard to sever and begin to limit the design.

I'm not really able to quantify where the balance of complexity between the ICE and BEV systems will eventually lie as EV technology matures. I can promise you that we've faced some pretty deep challenges and deployed some sophisticated methods. Whether its 3D X-ray tomography of an individual lithium ion cell as it fast-charges, or a 40-million-element model of a fine oil mist as it cools a stator end-winding, there is an enormous amount to learn and significant science and engineering in developing an understanding of EV powertrain development.

I am prepared to admit, if it salves anyone's pride, that it's easier to develop a new BEV powertrain than it is a cutting-edge ICE powertrain, whether for emissions targets or other attributes. I'm not completely sure this is true—but whatever.

Lucid's drive/traction motors are proprietary. What might make a "bespoke" motor design better than something already developed and in production from a motor manufacturer?
First, we should note how closely-integrated the whole EV powertrain system must be. The technology and winding of the motor is very much linked to the current levels in the inverter and the cell technology, topology and mechanical design of the battery—which all is tightly linked to the thermal management of the vehicle. Then the mechanical design of the transmission must be integrated with that of the motor for maximum efficiency. And everything must be tightly packaged and tuned for installation in the vehicle to serve the space experience of the passengers. Finally, none of the design principles of any of these components are yet matured in their automotive applications to the point where there is anything like a consensus on their optimal features, or even an accepted genealogy of options.

So describing our motor as "bespoke," as one might label a ball gown or Italian suit, makes Lucid's decision sound like a vanity or frivolous option. In reality, it's an expression of our CTO's [Peter Rawlinson] vision that our company will be technology-driven and develop a profound understanding of all the systems that define our USPs [unique selling points].

Bill Visnic

NEW VEHICLES

Chicago Auto Show: All-new 2018 Ford Expedition gets aluminum body, 10-speed

Known internally by its U553 program code, the 2018 Expedition leverages F-Series architecture and AL construction.

When **Ford Motor Co.** leadership made the bold decision to invest in aluminum body structures for its F-Series pickups, they made sure the Expedition was integrated into the product plan. The resulting 2018 Expedition, unveiled February 7 in Dallas, shows the fruits of that wisdom.

Still riding on a separate hydroformed-steel ladder frame (itself redesigned and CAE-optimized for greater strength and lower mass), the new eight-passenger SUV sheds up to 300 lb (136 kg) compared with the incumbent model. The mass reduction enabled Ford engineers to move to a single-solution powertrain format—the 3.5-L turbocharged V6 with auto stop-start and 10R80 10-speed automatic. No V8! Reducing curb weight also allowed the addition of a large panoramic sunroof system, typically a significant mass penalty.

Chief Engineer Todd Hoevener smiled broadly when asked recently by *Automotive Engineering* if he expects significant fuel economy gains with the lighter vehicle. "Typically we're happy with mass parity compared with the outgoing vehicle, due to added feature and safety content. But losing the 300 pounds enabled us to grow the vehicle size a bit," he noted.

The 2018 vehicle will be built in both short and long (Expedition Max) versions, the latter measuring 12 in (305 mm) longer; both are available in XLT, Ltd. and Platinum trim packages. Compared with the outgoing 2017 truck, the new Expedition has a 3-in (76-mm) longer wheelbase, is 4-in (102-mm) longer overall, and is 1-in (25.4-mm) wider overall.

Hoevener, a 15-year veteran of Ford Truck Engineering, claims it is the first full-size SUV to feature a sliding second-row seat. The tip-and-slide functionality improves access to the third row even with a child safety seat in place. The power-folding third row seat now reclines. Second- and third-row seats offer pushbutton fold-flat functionality. The interior design team designed a clever and useful storage-shelf "Cargo

While "floating" roofs are the current trend in SUVs, Expedition customer clinics demanded body-color C-pillars rather than blacked-out ones, said exterior chief George Bucher.

New rear Advanced Cargo Manager system was designed in-house at Ford.

Manager" system for the luggage space behind the third-row seat. "That was done entirely in-house by Ford," Hoevener said.

With the rear passenger seats folded down the cabin will accommodate a 4x8-ft (1.2 x 2.4-m) sheet of plywood with the liftgate closed. Ford Large SUV marketing manager Craig Patterson claims the new vehicle has two times the interior "cubby space" than its predecessor. He noted that the development team extensively engaged in UX (user experience) research with current Expedition owners and even visited their homes to observe daily usage.

The 2018 Expedition is one of the first North American products to utilize Ford's new CAN-3 electrical architecture, Hoevener added. Engineers added a dial-type electric transmission shifter in the center console which saves interior space. An electronically-locking rear differential is offered, as is continuously-controlled suspension damping. Rear suspension is independent.

Body design and surfacing were optimized for improved aerodynamics, explained George Bucher, the veteran exterior design lead. The truck's A-pillars are "faster" than the current model's, a result of using much of the F-Series front architecture. Expedition's aero package includes standard active grill shutters and extensively modeled exterior mirror mounts with subtle concavity on their vertical surface to minimize the "helicopter effect" of turbulent air in that area, Bucher noted.

"This program has a lot of wind tunnel and CFD time in it," he said. "Todd's body engineering team was great to work with—they gave us almost everything we wanted!"

The vehicle is available with a 4x4 driveline that features a 2-speed transfer case and Terrain Management Assist. "Our customers value towing capability in extreme conditions—ever try to pull a boat out of the water?" he asked. "Having low range is a necessity."

Ford claims its latest SUV features over 40 "innovations." We didn't count nearly that many (if you could call them genuinely innovative) but the long list of electronic safety, comfort and convenience items includes a claimed "class-exclusive" enhanced active park assist; wireless charging for mobile devices; up to 10 WiFi hotspots with up to 50-ft (15-m) range; dual-headrest rear seat entertainment and an optional 12-speaker B&O audio system.

The cabin has 12-V power points, six USB chargers and a 110-V outlet. SOP starts in late 3Q17 at the Kentucky Truck Plant in Louisville.

Lindsay Brooke

POWERTRAINS | PROPULSION

Chicago fire: Dodge puts 375-hp Hemi V8 in Durango SRT

"Performance" SUVs are not a new concept, but **FCA**'s Dodge brand opens a new niche-within-a-niche with the unveiling of the 2018 Durango SRT at the 2017 Chicago auto show, calling it "the fastest SUV in its class."

Dodge officials didn't directly say just who's asking for a grocery-getter SUV with 475 hp (354 kW) and 470 lb·ft (637 N·m) from a 6.4-L (or, more historically relevant, 392-in^3) V8 that enables cutting a 12.9-s quarter mile time, but the Durango SRT will be in showrooms for that buyer starting in the fourth quarter. Some of the work of adapting the 6.4-L Hemi for the Durango already was done: it is the same iron-block, pushrod V8 with a 10.9:1 compression ratio that appears in the Jeep Grand Cherokee SRT, which shares its architecture with the Durango.

The new Durango SRT gets its share of special engineering, though: Dodge said the standard 8-speed **ZF** automatic transmission has specifically-tailored shift points and when driven in Sport mode, shift times are cut by up to 50%. Using Sport mode also commands the all-wheel-drive's single-speed electronic transfer case to apportion 65% of drive torque to the rear axle. Change to Track mode and up to 70% of drive torque can be sent to the rear axle, while transmission shift times are cut to 160 ms.

A new-design T-shift handle couples with steering-wheel paddles to encourage manual sequential gearshifting and the Sport shift mode can be used without any change to suspension,

The 2018 Dodge Durango SRT packs a 6.4-L V8, extensive chassis and driveline upgrades and widened bodywork to back up its performance message (Image: Bill Visnic).

Durango SRT interior features a variety of performance- and luxury-oriented changes, including a flat-bottom steering wheel and 180-mph speedometer. (Image: FCA)

stability-control or drive-split parameters.

Dodge said the Durango SRT's suspension—a short-long-arm arrangement in front and an independent multilink at the rear—uses specially-tuned adaptive dampers supplied by **Bilstein** and has 3% stiffer front springs, 16% stiffer rear springs and an 18% stiffer rear anti-sway bar. The entire setup's reactions are controlled through a seven-position drive mode selector that includes snow, towing and valet settings. Brakes are upgraded at each corner with **Brembo** six-piston front and four-piston calipers gripping 15-in slotted front rotors and 13.8-in rear slotted rotors.

Riding on the same 119.8-in (3043-mm) wheelbase as conventional Durangos, the SRT has widened bodywork to accompany the go-fast hardware, while a functional cold-air intake and heat extractors serve to reduce intake-air temperatures by up to 18°, Dodge claims. Apart from the obvious exterior differentiation from standard-issue Durangos, the SRT model also includes special AWD badging and even "392" badges to pay homage to the engine's displacement in "cubes."

The 6.4-L iron-block OHV V8 generates 475 hp from a 10.9:1 compression ratio. (Image: FCA)

Pricing for the Durango SRT was not detailed, but in keeping with the SRT unit's practice, all buyers of the Durango SRT are entitled to a one-day performance-driving course at the **Bob Bondurant School of High-Performance Driving** in Chandler, AZ.

Bill Visnic

INTERIOR | COCKPIT

Visteon tests augmented reality HUD for Level 4 autonomy

Augmented reality (AR) head-up displays are emerging as critical equipment for **SAE** Level 4 autonomous driving, where the operator must completely trust that the vehicle's ADAS sensors and cameras are monitoring and accurately recognizing its surroundings.

Automotive Engineering recently experienced a proof-of-concept demonstrator vehicle fitted with **Visteon**'s latest AR HUD system, at the supplier's Van Buren Twp., MI, headquarters. On the 2015 VW Golf R's windshield, graphics are superimposed over the driver's real-time sight line to indicate objects detected near the vehicle's path. The system also displays relevant driver information, such as lane departure warning,

A halo around an oncoming car and other graphic overlays are shown on the AR HUD in Visteon's VW Golf demo vehicle, which also has an exterior forward-facing camera and two driver-facing cameras.

and navigation guidance.

With a 10 x 4-degree field image, the windshield AR HUD is nearly twice the size of those used on current production vehicles, company engineers claimed. Images are projected 33 ft (10 m) from the driver's eyes in comparison to the typical 6.5 ft (2 m) distance.

The system was designed to display sensor information "in a relevant and comprehensive manner in the driver's field of view," noted Patrick Nebout, Director of Advanced Technologies. He noted that the demo vehicle was developed by engineers at Visteon's technical center in Cergy, France.

Driver-facing interior cameras, located in the A-pillar and the rearview mirror, monitor the operator. They trigger audible and visual alerts to rouse a distracted driver, explained Mike Eichbrecht, a member of Visteon's North American technical sales group. "For instance, if you're looking down at your cell phone, an audible tone and LEDs lets you know that something in the car's vicinity, such as a bicyclist beside the road, needs your full attention," he said.

Nebout believes that an AR HUD will be the fastest, easiest and most effective interface for informing the driver of what the vehicle's sensor array has detected (i.e., moving objects, stationary obstacles, the road lane) as well as the optimum path to follow.

Over the next two years, Visteon's AR HUD vehicle demonstrator will gain capabilities. Improved optics will allow significant increases in the field of view and the size of the image, expanding the scope of driving-environment information, Nebout said.

"Visteon is also developing artificial intelligence technologies," he added, "that will allow more natural and efficient HMI and will optimize the image positioning in accordance with the dynamics of the vehicle."

AR HUD systems also have been in development at Visteon competitor **Continental** AG since 2014.

Kami Buchholz

INTERIOR | COCKPIT

Nissan's new King Cab full of patent potential

For OEMs, promoting a competitive advantage is just as vital as protecting innovative technologies on vehicles—especially on high-profit trucks.

"There's been a big push for us to make sure we're patenting our ideas/our parts," Rich Miller, director of product planning for trucks, SUVs and commercial vehicles at **Nissan** North America, told *Automotive Engineering* during the 2017 Chicago auto show.

He noted that innovations are the lifeblood of engineering, which in turn is the heartbeat of marketing. "We always have tried to patent things, but sometimes there are things that are patentable that we didn't think we could patent," said Miller. "Then we would see competitors patenting similar ideas. So we want to make sure we're doing that now."

Case in point: the first-generation Titan pickup launched in late 2003. Its factory sprayed-on bedliner and cargo tie-down channels were novel offerings, noted Fred Diaz, Vice President and General Manager of trucks and light commercial vehicles. Those features showed that "even in the truck industry Nissan can be innovative and come up with some really cool things."

Miller and Diaz anticipate similar patentable actions on the current-generation Titan. The 2017 King Cab version, revealed at Chicago, completes the truck's body style lineup. Rear doors on the King Cab open nearly 180° thanks to an innovative rear hinge. The first-gen Titan broke similar ground with a patented door hinge that opened 168°; Miller noted that the latest hinge is a re-engineered version of the original.

The 2017 Nissan Titan King Cab revealed at the 2017 Chicago auto show, completes the body style line-up for the Titan range.

The new King Cab is offered with a rear seat or none at all, a claimed segment-first option. (**GM**'s midsize pickups offer a rear-seat-delete option for cargo capacity, as well.) The Nissan's seat-delete package eliminates the rear heater duct and rear roof-mounted assist grips, while adding a flat rear load floor with tie-downs and a cab-wall panel with removable circular hooks.

"It's easy to stow things in the back because you don't have to jostle around a B-pillar," Miller explained. The 2017 Titan King Cab goes on sale this spring. It will be offered in 4x4 and 4x2 drive configurations with a standard 5.6-L gasoline V8 and 7-speed automatic transmission.

The Titan XD King Cab is offered with that same powertrain or a **Cummins** 5.0-L V8 turbodiesel (see http://articles.sae.org/13829/) mated to a 6-speed **Aisin** automatic.

Kami Buchholz

Early ride: Lucid Motors' 1000-hp Air 'alpha' prototype

Prototype of Lucid Motors' Air electric luxury sedan, camouflaged in the Las Vegas early evening. (Image: Bill Visnic)

Always an early test for the veracity and viability of automotive startups: Ya got a car that runs?

Menlo Park, California's **Lucid Motors**, has at least one. We know because its chief technology officer, Peter Rawlinson, took us for a ride.

Lucid is the electric-vehicle startup that's had the good fortune to often be named as the most viable competitor to **Tesla** and the bad luck to be forming at time when at least one other venture capital-intensive EV startup has been hogging the headlines with its financial straits. But Lucid has attracted a number of seasoned industry engineers and developers (including from Tesla) and appears, at least to equally seasoned media, to be achieving legitimate development goals and advancing on a realistic timeline.

So Lucid came to Las Vegas during the recent Consumer Electronics Show (CES) to make its own positive headlines. That goal centers mostly on the fact there's an actual car in which to ride. Rawlinson will drive the probably almost-priceless mule, an early "alpha" prototype, he says. There's barely any interior, the thing wears creative camouflage—although Lucid has provided plenty of images of the production Air's projected appearance—but the doors work and there are even real (if rudimentary) seats.

Air prototype's interior: large, vivid data screens and some necessary components borrowed from more prosaic production models (Image: Bill Visnic).

Not 1000 hp—yet

Lucid claims 1000 hp for the Air, but I can't say the prototype felt like 1000 hp. First, because Rawlinson made it clear this development-mule's driveline was dialed back from the output stated for a production version and, equally important, I wouldn't know what 1000 hp is supposed to "feel" like, anyway—I've been in neither a Bugatti Veyron or a World of Outlaws sprinter.

Nonetheless, it's clear this "alpha" prototype of the Air has an energetic power-to-weight ratio. Despite its probably curb weight in the 4400-lb (2000 kg) range that includes the undisclosed but undoubtedly substantial weight of the lithium-ion battery pack being co-developed with **Samsung SDI** (its optimized packaging is claimed to be one of the secrets to the Air's extreme range capability), when Rawlinson toes the go-pedal, the car lunges assertively. We don't wind up this prototype to the kind of speed that might give clearer indication of its raw power, but the car shoulders blithely past some traffic that isn't exactly puttering, evidencing mid-range thrust that certainly seems to rival some of the forced-induction V6s and V8s we've recently tried.

Low-roller

What's more revealing about the Air prototype—at least in terms of what it might suggest about this platform and propulsion package—is the pancake-flat cornering behavior. Rawlinson does what he can

to upset the chassis with sharp and abrupt steering inputs or fully unstick it with too much cornering speed. This Air "mule" is having none of it: there's an uncanny lack of body roll and it refuses to slide, even when brazenly provoked to do so.

The low degree of body roll should well serve the Air's luxury-car positioning, as will its seeming refusal to slide, although this behavior may not win many of the budding Lewis Hamiltons of potential owners.

We remark on this and the generally firm—but hardly rocky—ride quality and Rawlinson is quick to remind this prototype also is riding on quite fundamental suspension tuning, a setup that's likely to be far from the final-production state. Will that mean more body roll as a tradeoff for a softer state of primary tune?

Finally, there's not much to say about an interior of a prototype, even a luxury one, but we do try the backseat to test Lucid's claim of a uncannily voluminous rear-seat experience. It's genuinely grand back there: the flat floor definitely contributes. Relax against what will be reclining rear seatbacks in the production Air and you'll need one of those reach-the-top-shelf claw sticks to touch the back of the front seat. It's pretty clear there's more room back there than in most conventional full-size sedans, regardless of whether the interior ends up with those thin and svelte seats Lucid's shown in its press images.

Rendering of the production version of the Air sedan, slated for showrooms—of some sort—in 2018 (Image: Lucid Motors).

Was the Air prototype rough and creaky and full of gear whine? Sure was. That wasn't the intended takeaway, of course. Lucid's prototype is thrusty and flat-cornering and its CTO wasn't afraid it would break while hammering it around the streets of Vegas. That moves the needle on the credibility scale—the real goal for today's startup EV automaker breed. What we've seen so far is convincing.

Bill Visnic

New eye on the road

One of the industry's hottest tech suppliers is blazing the autonomy trail by crowd-sourcing safe routes and using AI to learn to negotiate the road. Mobileye's co-founder and CTO explains.

by Steven Ashley

With 15 million ADAS-equipped vehicles worldwide carrying Mobileye EyeQ vision units, Amnon Shashua's company has been called "the benchmark for applied image processing in the [mobility] community."

Amnon Shashua, co-founder and Chief Technology Officer of Israel-based **Mobileye**, tells a story about when, in the year 2000, he first began approaching global carmakers with his vision—that cameras, processor chips and software-smarts could lead to affordable advanced driver-assistance systems (ADAS) and eventually to self-driving cars.

"I would go around to meet OEM customers to try to push the idea that a monocular camera and chip could deliver what would be needed in a front-facing sensor—time-to-contact, warning against collision and so forth," the soft-spoken computer scientist from **Hebrew University of Jerusalem** told *Automotive Engineering* during a recent interview. "But the industry thought that this was not possible."

The professor was politely heard, but initially disregarded: "They would say, 'Our radar can measure range out to a target 100 meters away with an accuracy of 20 centimeters. Can your camera do that?'

"And I would say: "No, I cannot do that. But when you drive with your two eyes, can you tell that the target is 100 meters away or 99.8 meters away? No, you can't. That is because such accuracy is not necessary."

In fact, Shashua and his engineers contended that a relatively simple and cheap monocular camera and an image-processing 'system-on-a-chip' would be enough to reliably accomplish the true sensing task at hand, thank you very much. And, it would do so more easily and inexpensively than the favored alternative to radar ranging: stereo cameras that find depth using visual parallax.

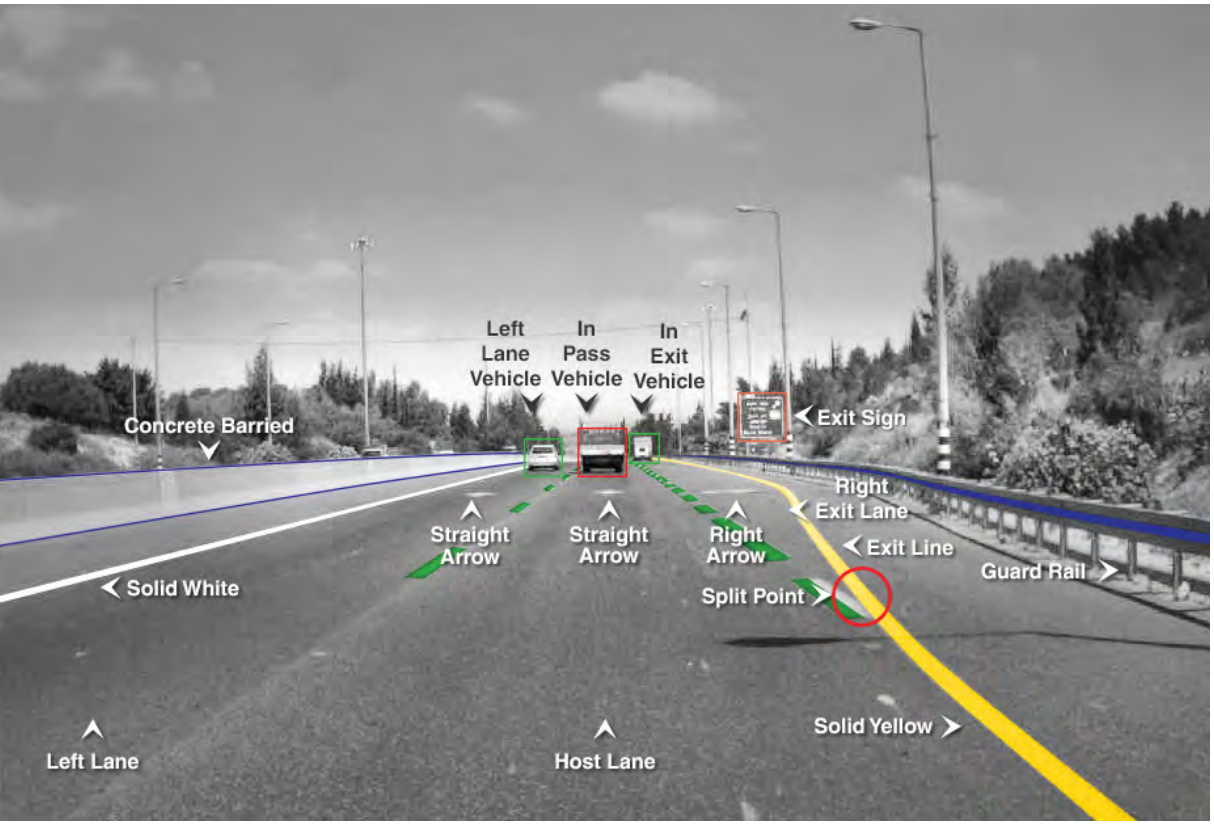
zFAS and furious

Seventeen years later, some 15 million ADAS-equipped vehicles worldwide carry Mobileye EyeQ vision units that use a monocular camera. The company is now as much a part of the ADAS lexicon as are Tier-1 heavyweights **Delphi** and **Continental**. At CES 2017, Shashua found himself standing on multiple stages, in one case celebrated by **Audi**'s automated-driving chief Alejandro Vukotich as "the benchmark for applied image processing in the community."

Vukotich was introducing Audi's new zFAS centralized control computer, which incorporates both Mobileye's latest EyeQ3 product and most advanced driving features and partner **Nvidia**'s powerful image processors. The zFAS box conducts 360° sensor fusion and makes driving decisions based on camera, radar and lidar input.

Shashua called Audi's zFAS "the most sophisticated and ambitious ADAS to date." That's because when it arrives in the 2017 A8, it will debut a 10-s "take over" request, or "grace period" during which the driver can grab control should the vehicle encounter sudden trouble: it delivers an industry-first, **SAE** Level 3 driving autonomy (see sidebar).

When Shashua recounts the industry's early reactions to his vision, he tells the tales without any notion of triumph or self-justification.



By recording only landmarks along roadways and using them to differentiate between landmarks and vehicles, Mobileye creates data-stingy yet detailed route maps.

He seems to be merely making a point about developing autonomous control: focusing on a single component of the system, such as sensing, can lead to costly miscalculations.

Shashua believes that a safe self-driving car needs three capabilities: It must sense the road; it must find its place on the map of the road; and it must successfully negotiate its place among the users of the road. These sensing, mapping and driving policy, or planning, elements—what he calls the three pillars of autonomy—are in fact intertwined.

"They're not separate technology areas, but have to be developed together," he explained. "If not, you can place unreasonable demands on each of the elements."

Somewhere versus everywhere

The first pillar, sensing, already is fairly well-defined, he said. "Sensing is relatively mature because of our many years of experience with driving assist," which is primarily about interpreting sensing to prevent collisions. Cameras provide around three orders of magnitude greater resolution than radars or laser scanners. And resolution when driving matters, he added, because scene details are vital, especially in the city, where density is higher.

The other distinguishing feature is that cameras capture texture and surface info. This "helps identify objects and capture semantic meaning, whereas others sensors see only silhouettes, the shapes of objects."

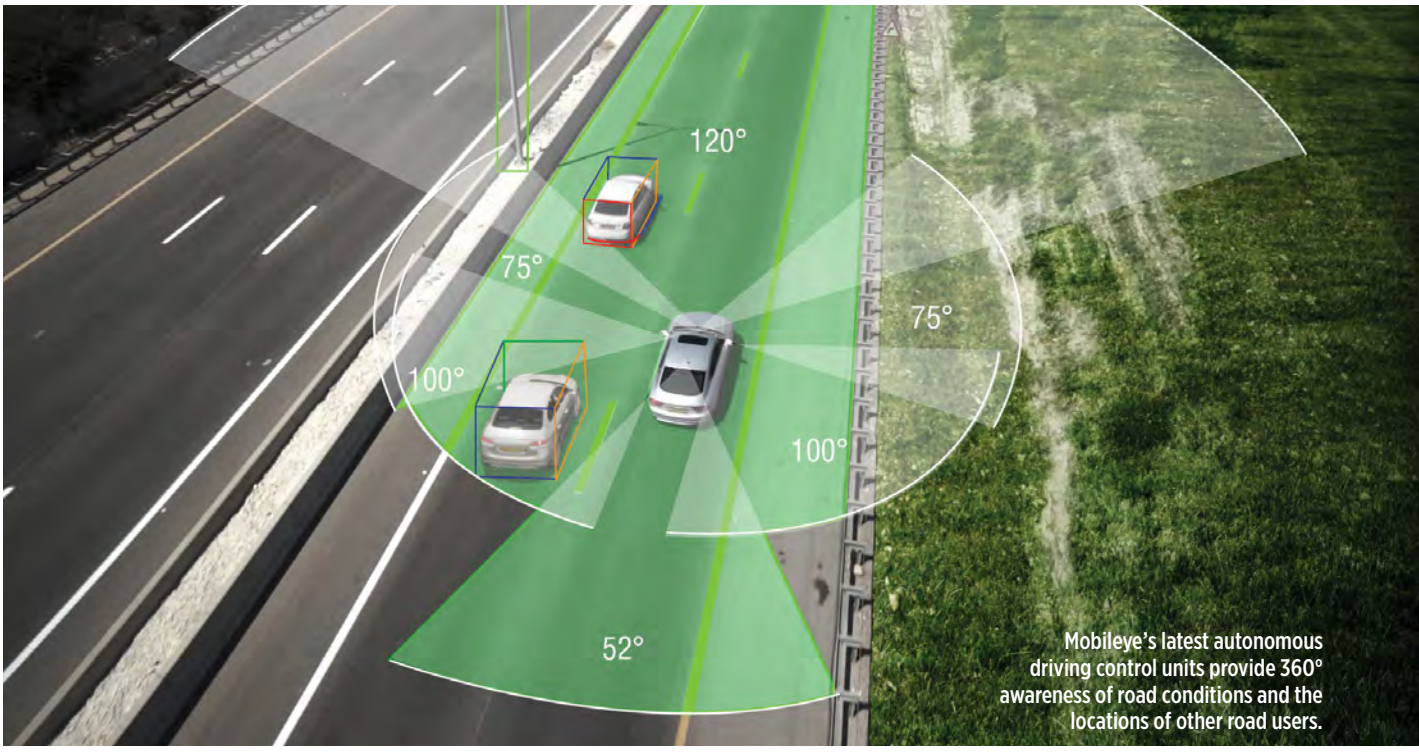
Mapping, the second pillar, is more complicated and less well-defined, Shashua noted. This task requires the development of an extremely detailed mapping system that provides the car with information on its location and the surrounding roads.

"The big difficulty with high-definition (HD) maps is finding how you can do it efficiently at a low cost," he explained. "In mapping right now there is the 'somewhere' camp and the 'anywhere' camp," he said. The 'somewhere camp' follows **Google**'s strategy: Start with an autonomous car and map with it until you have full [autonomous driving] capability somewhere. Then send out a vehicle that records a high-resolution 'cloud-of-points' laser scan along routes to map out an area until full capability exists there. And so on.

But one of the things that makes HD mapping problematic is coping with the huge amount of roadway data needed to capture enough scene details to support a safe interpretation. In the case of the 'somewhere' approach, road data rapidly grows to gigabytes per kilometer—a logistical nightmare, Shashua noted.

Even so, "Once you have finished recording the cloud-of-points map, you can then subtract all the stationary objects, which leaves you with only the moving objects"—quite enough to navigate by, he asserted. Another plus is that "only a small number of sensing points are needed to localize any moving object."

New eye on the road



Mobileye's latest autonomous driving control units provide 360° awareness of road conditions and the locations of other road users.

But at some juncture, the 'somewhere' camp has to face this fact: All safety-critical maps must be updated in near-real time. "How to do that, I don't know," he said. In contrast, the 'everywhere' camp—Mobileye's and the auto industry's approach—aims to develop "partial self-driving capabilities that can be activated everywhere."

Judging that automatic driving controls would need near-human-level perception capabilities, and to some extent even cognition, the 'everywhere' camp has pinned its hopes on "strong artificial intelligence and machine-learning algorithms," he said. Such a strategy is risky "because you're not sure exactly how long it might take and there are no guarantees of success."

Despite the many recent successes of AI-based agents in tasks such as image recognition, strong AI is still hard to come by. So the industry instead is currently settling for limited AI capabilities but compensating for it "with very detailed maps."

Crowd-source the routes

On the critical question of how to get sufficiently detailed, up-to-date maps at low cost, the professor offers a novel idea. Rather than wrestling with detailed cloud-of-points-type HD maps, driving-assist technology can be leveraged to take advantage of crowd-sourcing. "We harvest the collective road experiences of many connected vehicles fitted with forward-looking cameras and other sensors that send the collected data wirelessly via the cloud to update the HD map," he explained.

Each time a vehicle equipped with a Mobileye EyeQ vision unit passes through any route, it collects critical road data that precisely defines it—especially the position of landmarks like lane markings, road signs, lights, curbs, barriers and so forth. Though these landmarks are comparatively few on the ground, these "path delimiters" and "semantic signals" nonetheless enable the system to localize the position of vehicles on the road continuously within 10 cm (less than 4 in) using multiple 'triangulations' in successive road scenes.

It currently takes nine ADAS passes for Mobileye's Road Experience Management (REM) system to HD-map-out a safe path through any roadway for the road book. And since REM, a collaboration with Delphi, needs to record comparatively few landmarks on the final detailed map, a rather 'sparse' data set of only 10 kilobytes per km is enough to reliably localize each car's safe routes.

"The density of the data source—millions of connected vehicles on the road—is what makes this detailed-yet-sparse HD map highly scalable and updatable at almost zero cost," Shashua said.

Negotiate the road

The third and possibly most problematic 'pillar' of autonomous car tech is what Shashua calls driving policy: emulating how human drivers not only negotiate the road but with other independent road users, so traffic still flows smoothly and safely. In other words, how humans know what moves to make in any driving circumstance.

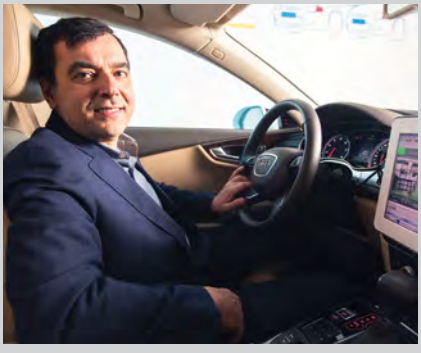
"This is the reason we take driving lessons. We do not take lessons in order to train our senses; we know how to see. We take lessons to

New eye on the road

From start-up to on-top: Mobileye's road thus far

Israel and Boston, two places with bad reputations for road manners, also are known for breeding high-tech entrepreneurs. So perhaps it's no surprise that Amnon Shashua spent most of his 56 years living in both locations. In fact, they may explain the pioneering professor's unblinking focus on and success in developing vision-based driver-assist and self-driving car technology.

"Driving in Israel is not like driving in Boston," the **MIT**-trained CTO of Mobileye told a CES 2017 audience. A big screen behind him displayed bird's-eye views of truly appalling road behavior: overaggressive drivers crossing multiple lanes at a time or failing to yield, with many repeatedly disobeying traffic laws and jeopardizing fellow road users.



At the wheel: Shashua and business partner Ziv Aviram established Mobileye NV in 1999 after licensing basic image-processing technology they'd created from Hebrew University in Jerusalem.

"The laws are different and the drivers are different," he said, smiling a bit ruefully.

The fascinated Las Vegas crowd chuckled nervously as anonymous drivers attempted to navigate through various nightmare road mazes and tricky lane merges. Success here, Shashua explained, requires drivers to learn how to successfully negotiate with other drivers using only motions for communication. Such subtle skills are the "Achilles heel" that is delaying further progress, he told them.

In truth, astonishing progress has been made in driver aids and automation since Shashua first established Mobileye NV in 1999, when he licensed from Hebrew University in Jerusalem some of the image-processing technology that he and colleagues had created there.

Together with co-founder and business partner Ziv Aviram, Shashua built the company and its product line: the EyeQ series camera/system-on-a-chip image processors and software algorithms. They reached a milestone in 2011 when Mobileye introduced the first OEM-produced and NHTSA-compliant vision-only forward collision warning system on multiple BMW, **GM** and **Opel** models.

Meanwhile, Shashua and Aviram also have another highly regarded tech firm, OrCam, which produces a smart vision-based device for blind and partially blind people. It attaches to eyeglasses and reads aloud any text the wearer points to.

Mobileye gained further prominence as the vehicle-autonomy era arrived. In 2015 it partnered with Elon Musk's **Tesla Motors** to supply forward-looking camera sensors for his Autopilot product—the first semiautonomous driving technology. But in July 2016, Mobileye and Tesla parted ways after a controversial Model S crash that killed a Florida man while the car's Autopilot was engaged.

After encountering criticism, Shashua asserted that Tesla had been "pushing the envelope in terms of safety" when it allowed its Autopilot system to offer hands-free driving.

Today the company dominates the global driver-assist market. Its 600 employees continue to develop vision-based ADAS products that are available on more than 220 car models manufactured by nearly 27 OEMs worldwide. The firm is also pursuing five programs to develop SAE Level 3 semi-autonomous driving capabilities. Its partnerships with BMW and Delphi, in collaboration with chipmakers Nvidia and Intel, aim to produce next-level self-driving vehicle controls.

Add in recent deals with Europe's **HERE**, Japan's **Zenrim** and possibly other HD map makers and Shashua is angling to lead an industry-wide consortium of OEMs, Tier 1s and other parts and systems suppliers that may eventually create a shared operating environment for self-driving car tech. Negotiations are on-going and the outcome remains unclear.

What is clear, however, is that for driving autonomy to succeed, self-driving cars will need to vastly outperform the human drivers in Boston and Israel. ***—SA***

understand how to merge in chaotic traffic and other maneuvers."

The task is to help driverless cars learn, even understand, the unspoken rules that govern road behavior. "Our motions signal to the other road users our intentions and some of them are very, very complicated," he noted. Further, traffic rules and driving norms change from place to place: In Boston, people drive differently than they drive in California, for example.

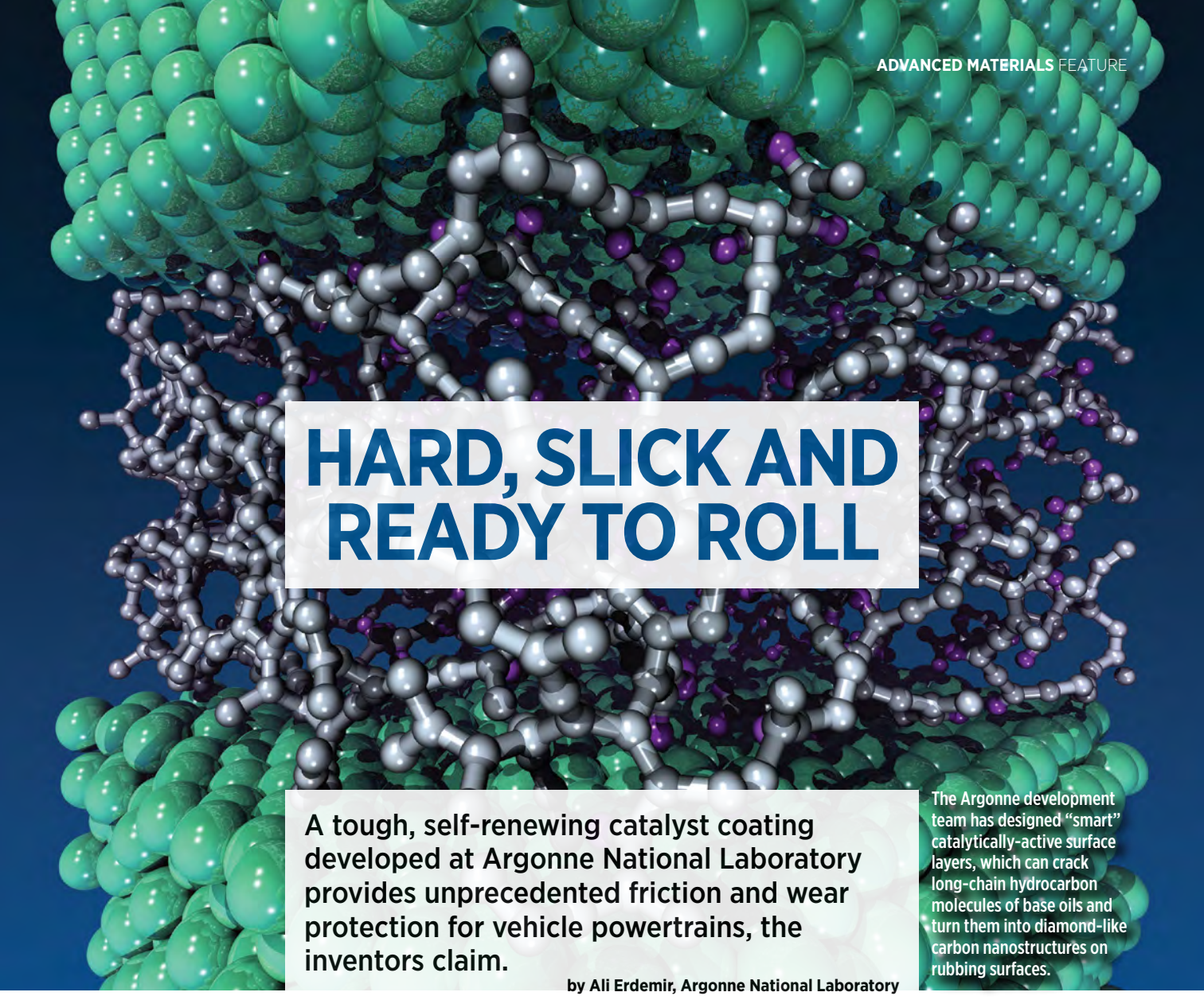
Mobileye is teaching ever-more powerful ADAS processors to better negotiate the road, step-by-step, by using AI neural networks to optimize performance and machine-learning algorithms that "learn by observing data instead of by programming." Such technology actually teaches the car to behave in a human way," according to Shashua, by repetitively viewing various realistic simulations that his company's engineers film and then feed into the vehicle's computer.

"For the most part, the ingredients for autonomy exist," he asserted. "At this point it is mostly a matter of engineering."

By the end of 2017, around 40 modified **BMW** 7 Series sedans will be roaming U.S and European roads as part of a global trial conducted by development partners Mobileye, BMW and **Intel**. As *Automotive Engineering* went to press, BMW and Mobileye announced an agreement to begin using the REM data-generation system in some 2018 BMW models.

Mobileye's fifth-generation EyeQ5 system-on-a-chip is designed to perform sensor fusion for self-driving cars that will appear in 2020.

This is the start of a five-year plan where in 2021, "we are going to launch thousands of vehicles that are autonomously driven—tens of thousands of vehicles that will be autonomously driven on highways and a few thousands of vehicles that will be autonomously driven inside cities," Shashua said. ■



HARD, SLICK AND READY TO ROLL

A tough, self-renewing catalyst coating developed at Argonne National Laboratory provides unprecedented friction and wear protection for vehicle powertrains, the inventors claim.

by Ali Erdemir, Argonne National Laboratory

The Argonne development team has designed "smart" catalytically-active surface layers, which can crack long-chain hydrocarbon molecules of base oils and turn them into diamond-like carbon nanostructures on rubbing surfaces.

Powertrain system engineers know that of the energy consumed in transportation, 10% to 15% is lost due to parasitics in engines and drivelines. Researchers at **Argonne National Laboratory** have developed a new breed of nanocomposite coatings, which are made of the nitrides of transition metals and metal catalysts. These coatings provide a catalytically active, hard, and slick surface on metal components. They could have a major impact on improving the efficiency of automotive engines and gearboxes.

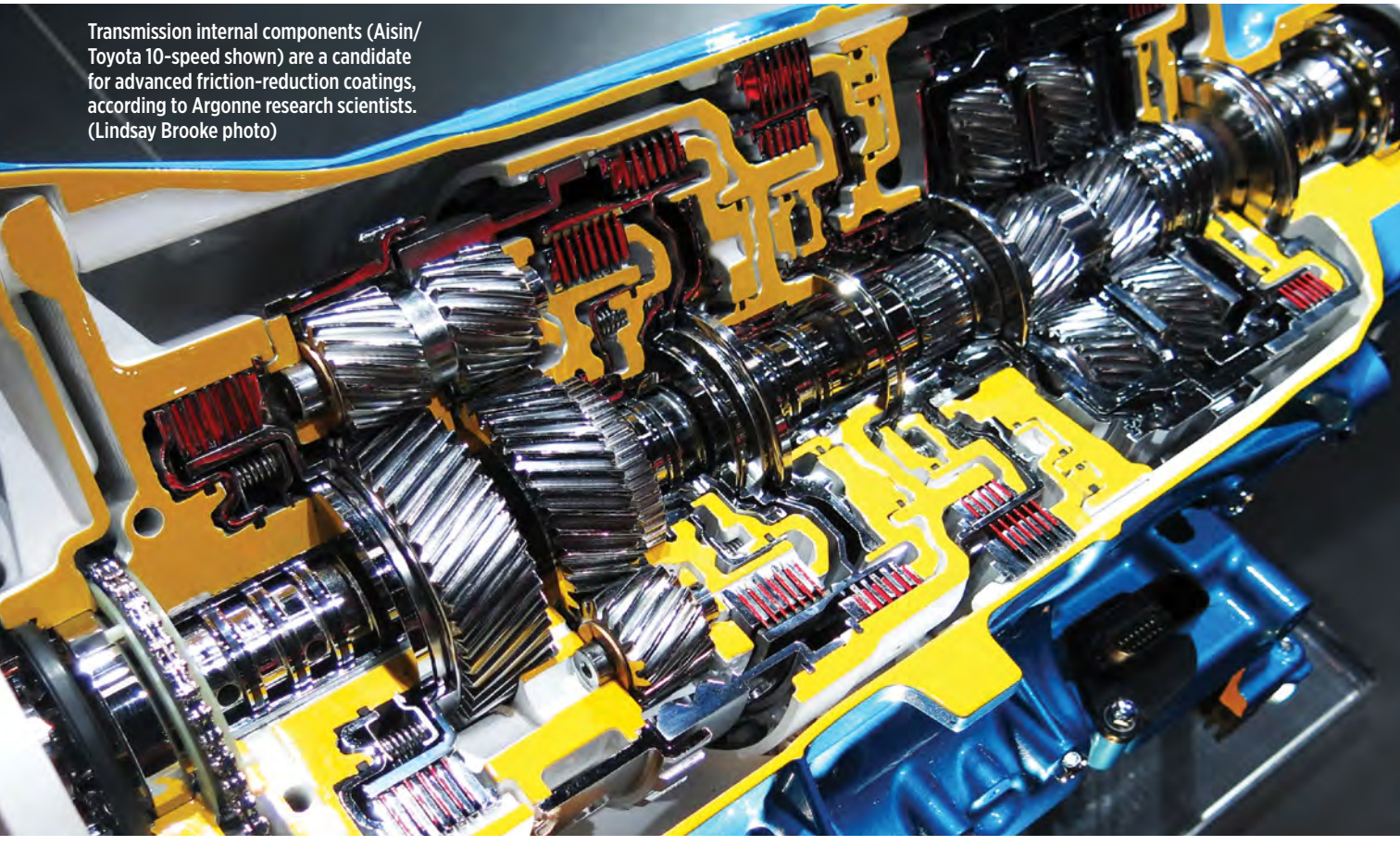
Transportation vehicles account for about 19% of annual world energy consumption and approximately 23% of total greenhouse gas emissions. With the global vehicle parc steadily growing, these numbers will likewise swell and present serious challenges for a sustainable mobility future. The new nanocomposite coatings also can work in concert with engine start-stop, downspeeding and cylinder-deactivation systems to further reduce vehicle fuel consumption.

In automobiles, tribological inefficiencies due to friction and wear in machine components are some of the greatest sources of energy and material losses. This has perhaps been recognized since man first fit a wheel on a wooden axle. By the 16th century, the great Leonardo da Vinci—considered the "father" of the modern study of friction and lubrication—had invented a self-oiling system for axle ends. Today, friction in a vehicle's engine, transmission, brakes and other moving parts consumes nearly one-third of the fuel's energy. Also, progressive wear that takes place between moving parts causes component breakdown and eventually costly repair and/or replacement.

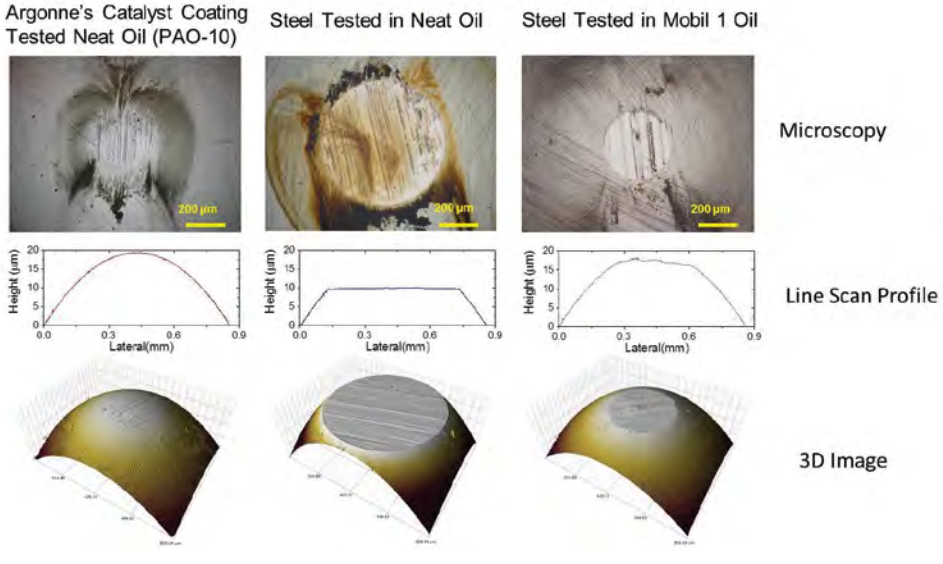
Argonne's smart, slick technology

Current lubricants are made of two key parts. One is a base oil, which accounts for nearly 80% of the total volume. The other is an additive package, which is literally a "soup" of various types of chemicals—many of which, unfortunately, are now considered environmentally harmful. These additives also poison the catalyst in exhaust systems. Without the additive package, however, the base oil is useless: in a car's engine, neat oils will cause instant engine failure due to severe wear and scuffing.

HARD, SLICK AND READY TO ROLL



Transmission internal components (Aisin/Toyota 10-speed shown) are a candidate for advanced friction-reduction coatings, according to Argonne research scientists. (Lindsay Brooke photo)



Friction and wear behavior of nanocomposite coating in poly-alpha-olefin (PAO 10) oil, and comparison with uncoated steel in PAO 10 and fully formulated 5W30 oils. Optical micrographs show the condition and difference in wear scar size on the rubbing surface for the three tests; line scan and 3D images beneath the optical images show the extent of wear damage more clearly. (Argonne images)

The Argonne development team has designed "smart" catalytically-active surface layers, which can crack long-chain hydrocarbon molecules of base oils and turn them into diamond-like carbon "tribofilms" and other forms of carbon nanostructures on rubbing surfaces. The result is an ultra-low-friction carbon film on metal components that is slick and highly protective. When worn away, the film self-heals by a catalytic reaction with the lubricant.

This invention might even one day eliminate the need to lubricate an engine or gearbox more than once during a vehicle's entire life cycle. The Argonne team's discovery may redefine the whole lubrication field by dramatically cutting friction and wear losses of moving parts and by potentially enabling fill-for-life lubrication possibilities.

See this Argonne video on the technology: https://youtu.be/iSOidHIMsmc.

The 10-hour test and simulations

Argonne scientists Giovanni Ramirez and Osman Eryilmaz determined the friction and wear behavior of test pairs with a ball-on-disk test rig. In this set up, a stationary ball was pressed against a rotating disk of the test material lubricated by a poly-alpha-olefin (PAO) oil for 10 hours. The catalyst test pair consisted of a molybdenum nitride and copper coating on stainless steel and the results were compared with a test pair of uncoated bearing steel. In these tests, the catalyst coating in pure ("unadditized") PAO oil reduced friction by about 50% and essentially eliminated wear thanks to the formation of a blackish diamond-like carbon tribofilm in and around the rubbing surface.

By contrast, during the same 10-hour test, an uncoated baseline steel wore out catastrophically when tested with the unadditized oil. When a fully formulated, state-of-the-art synthetic engine oil was used with full additive package (Mobil 1), some wear of the uncoated steel still occurred.

After testing, Ramirez and Yifeng Liao characterized the tested materials down to the nanoscale. High-resolution microscopy of the tribofilm revealed the presence of a large amorphous area with some nanocrystals and onion-like carbon. Spectroscopic analysis indicated the film is made of mainly graphitic carbon.

To understand the mechanism of tribofilm formation at the atomic scale, Argonne team scientists Subramanian Sankaranarayanan, Badri Narayanan, and Ganesh Kamath performed extensive computer simulations. They started from an initial configuration consisting of olefin lubricant chains sandwiched between sliding tribological interfaces. In these simulations, they observed that on the non-carbide forming surfaces such as copper, the olefins catalytically convert to tribofilms reminiscent of an amorphous carbon combined with hydrogen.

At the start, the olefin molecules are uniformly distributed. Under the sliding action at the copper/olefin interface, the olefin molecules degrade via two competing steps: (1) splitting of carbon-hydrogen bonds near the copper surface leading to carbon chains with the hydrogen removed and (2) random breaking of the carbon-carbon bonds in the coating backbone to form shorter hydrocarbon fragments.

Subsequently, the short-chain hydrocarbons recombine to form the graphitic tribofilm. This knowledge about the catalytic mechanism will allow Argonne scientists to further improve their technology.

HARD, SLICK AND READY TO ROLL

Many internal combustion engine components, including piston rings and tappet friction faces, would benefit from Argonne's nanocomposite coating for reduced friction and wear. (Lindsay Brooke photos)

Benefits and applications

The co-principal investigator, Osman Eryilmaz, summarizes the many benefits of this new technology: "The discovery can make automotive engines and gearboxes more energy efficient, reliable and 'green' in the sense that it may eliminate the need for phosphorus- and sulfur-bearing additives to the lubricant, which interfere with catalytic converters and (exhaust) aftertreatment devices," he noted. "Because of its self-healing effect on rubbing surface, it might also eliminate the need for changing the lubricant during the vehicle's entire life span."

As these experimental and computational results suggest, the technology is fully demonstrated and will require minimal tweaking or tailoring to apply to a potential product. This discovery is not limited to automotive applications. For example, it could be used in wind turbine gearboxes. Moreover, it has been shown that graphitic tribofilms can even form in vivo on the rubbing surfaces of metal-on-metal hip replacements, which are made of cobalt, chrome, and molybdenum.

Proteins are suspected to be the main carbon source in tribofilms forming due to the catalytic nature of the cobalt and molybdenum in the metal-on-metal alloy. In this case, the formation of a tribofilm from olefin molecules is due to the catalytic nature of the composite coating.

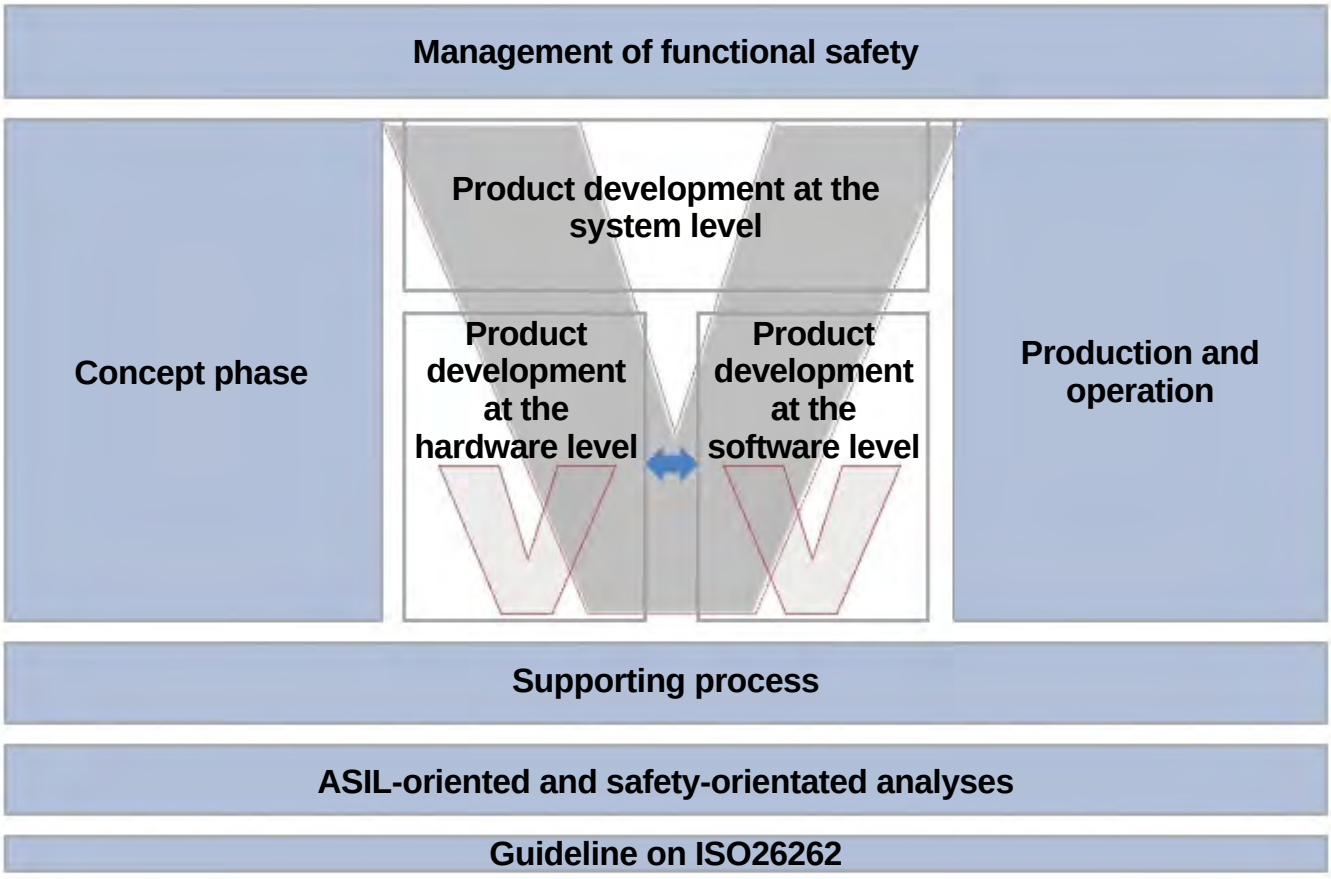
Work at Argonne National Laboratory was supported by the **U.S. Department of Energy** under Contract DE-AC02-06CH11357. ■

Ali Erdemir is a Distinguished Fellow and Senior Scientist at Argonne National Laboratory working in the fields of materials science, surface engineering and tribology. His discoveries of nearly frictionless carbon and superhard nanocomposite coatings, as well as a range of novel nanolubricants and lubrication additives, have been hailed as major achievements in the field.

Sensor ICs, semiconductors and safety

To achieve ISO 26262 compliance, engineering practices must be taken to a higher level. The following insights may prove valuable for getting there.

by Mark Smith and Luyang Zhang



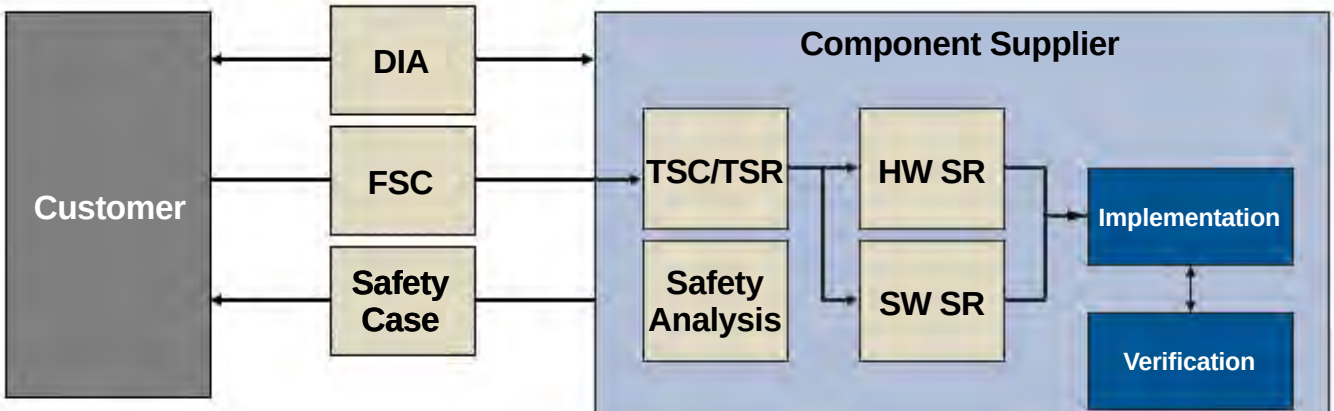
The goal of ISO 26262 is to create a safety culture within a company wherein safety is regarded as an integral element in the product development process, including semiconductor products.

What system-level risks and related safety implications are lurking within the vehicles you're developing? Electrification, greater overall electronics content and the trend toward autonomous vehicle operation have engineers concerned that any related failures do not reduce the safety levels already achieved by systems or peripherals.

ISO 26262 was created to standardize development processes, to ensure that functional safety is maintained if a vehicle's electrical and/or electronic systems fail. The goal is to create a safety culture within a company wherein safety is regarded as an integral element in the product development process. The **ISO** standard also relates to semiconductor products. It requires that a qualification process be applied to the tools (schematic capture, layout, simulation, etc.) utilized to develop integrated circuits (IC.) The compliance of said tools must be verified well before development begins (see figure above).

Any firmware embedded within the IC product must also be developed under safety-compliant processes. The resulting code must be verified for compliance to coding standards—a must for automotive-quality semiconductor products. ISO 26262 influences the

Sensor ICs, semiconductors and safety



DIA: Development Interface Agreement
FSC: Functional Safety Concept
TSC: Technical Safety Concept
TSR: Technical Safety Requirements

The customer/vendor interface is defined through the Development Interface Agreement which specifies the responsibilities assigned to each party at their respective interface levels.

customer/vendor relationship by requiring a more structured and defined set of responsibilities for each party. Prior to the standard, it may have been acceptable to maintain a more informal interface between a customer and vendor wherein responsibilities could be loosely defined and flexible.

Standard-IC challenges

To comply with the standard, the customer/vendor interface is now defined through a document known as the Development Interface Agreement (DIA). The DIA specifies the responsibilities assigned to each party at their respective interface levels, including the information required and the work products of the activities to be exchanged; the joint tailoring of the safety life cycle and the appointment of a safety manager on both sides (see graphic above).

An important part of ISO 26262 is the classification of hazard, referred to as the Automotive Safety Integrity Level (ASIL). This is determined through HARA (hazard analysis and risk assessment) normally, by OEMs. For each potential hazard, the probability of exposure, severity and controllability are analyzed before ASIL can be assigned to each safety goal. The standard identifies QM, ASIL A, B, C and D wherein ASIL D is the highest safety level.

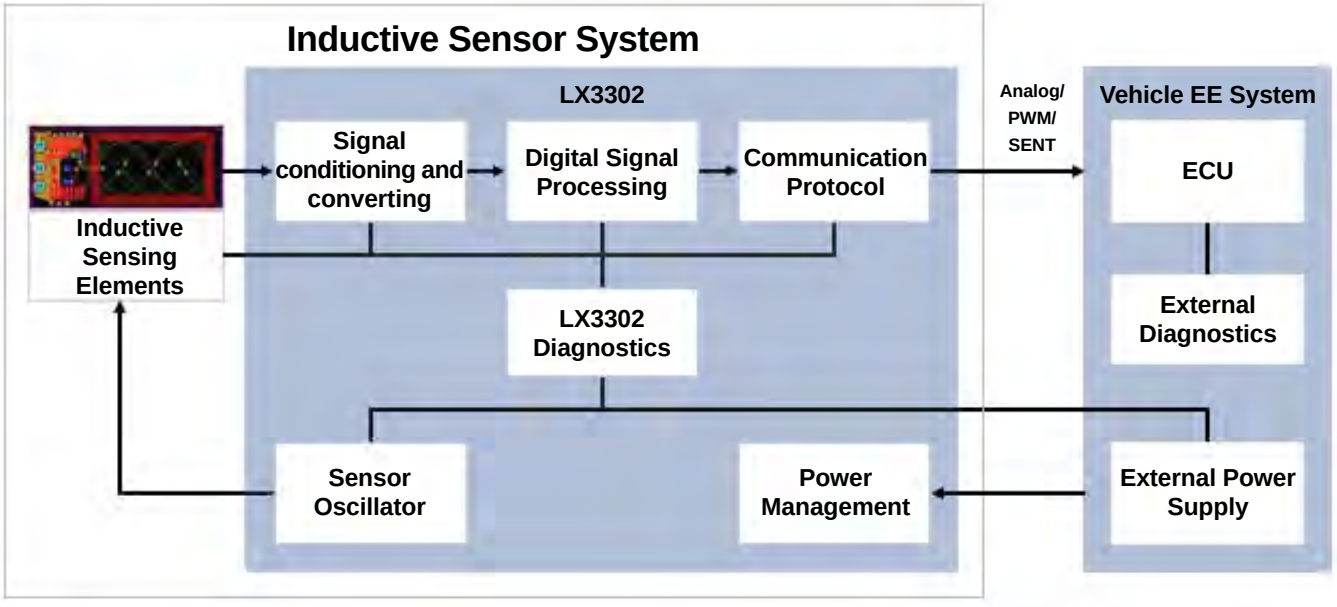
For example, designs compliant with ASIL C or D face a much more stringent review process, verification and validation activities, and documentation process relative to designs for levels A and B. As can be expected, elements in the system which are assigned ASIL D will likely have the most comprehensive Technical Safety Concept which provides the mapping between technical safety requirements and architecture elements.

How the technical safety requirements (TSR) flow into a given element's development process will depend upon where this element exists in the hierarchy of the vehicle development process. For example, the overall safety goals and associated functional safety concept of the vehicle itself are determined at the most initial stages of the vehicle-level concept phase through HARA. Functional safety requirements (FSRs) then flow down to the major subsystems and eventually to individual components. Typically, the further down an element is in the hierarchy, the longer it may take before the FSRs are assigned to the suppliers.

Once the FSRs are assigned, the supplier can then generate the technical safety requirements (TSRs) which will be implemented by the architecture and design of the individual component.

This potential delay in assignment of FSRs can pose a challenge in the development of a complex component such as an IC. The development of an IC product for automotive applications can take several years. However, the FSRs relating to a given IC function may not be well defined until later in the vehicle development process, after the safety requirements have eventually cascaded all the way down to the IC element. In cases where the IC is a custom device (defined specifically for a given purpose in the vehicle), the FSRs are often included in the specification for that specific IC. This makes it somewhat easier for the IC developer to follow the ISO 26262 development process and achieve the assigned safety requirements.

Although custom ICs are often utilized in automotive applications, in many cases a standard product IC may be capable of achieving a given function within the vehicle. The development of the standard IC often starts well before safety requirements are available. Herein resides one of the challenges for automotive-IC developers: how to ensure that a standard IC covers the safety requirements for its target applications.



Inductive Sensor System utilizing the Microsemi LX3302 Sensor Interface IC.

Cost vs. performance tradeoffs

To further complicate matters, a standard IC may find its way into a variety of systems or subsystems within the vehicle. For example, an inductive sensing IC which measures mechanical motion, such as the **Microsemi** LX3302 (see above graphic), may be utilized for detecting gear movement in a transmission, angular motion detection for steering torque, proximity detection as a brake lamp switch, position detection for electric seat control, and/or a variety of other mechanical motion applications. Although the LX3302 may satisfy each of these applications, the application itself may have different ASIL ratings and safety goals.

As can be expected, the functional safety requirements for the control of an electrically-adjustable seat (ASIL A) will be significantly different than the safety requirements for detecting the torque on a steering wheel (ASIL D).

For a standard product IC, the supplier shoulders the burden of defining the FSRs and writing the TSR for a given product, then implementing safety features and

Sensor ICs, semiconductors and safety

diagnostics which satisfy those TSRs. In such cases, the IC developer treats the IC as a safety element out of context (SEooC). This means the element (in this case the IC) is developed without a specific vehicle, system, subsystem, and/or customer in mind. In other words, the vendor may have several target applications in mind and will then predict the FSR and TSR necessary to address the ASIL level for these applications.

As can be expected, a vendor who is new to the safety requirements of automotive applications may have limited knowledge and/or experience relating to TSRs. As a result, the TSRs generated by this novice vendor may be composed largely of 'best guess' requirements. As the vendor gains experience with actual applications, the knowledge base improves and the TSR become more accurate and more comprehensive.

Another challenge faced by the IC developer relates to the trade-offs between the level of diagnostics provided within the IC and the associated impacts to cost and/or performance. The primary goal of ISO 26262 is to ensure that an electronic device does not produce an unsafe behavior, even when a fault occurs within and/or around that device. Given this goal, the IC developer must analyze the IC architecture to determine how IC faults may occur, either through failures within the IC itself or by conditions relating to the environment and/or interfaces around and to the IC.

This can be a complicated analysis, given the number of combinations of conditions which may result in an IC fault or failure. To help constrain this analysis to an achievable level ISO 26262, in most cases, limits the analysis to dual-point fault. In other words, the analysis usually does not need to consider failures which may occur when three (or more) faults occur in parallel.

Implementing safety features

An initial step for the IC developer is to conduct a Failure Modes Effects and Diagnostic Analysis. The FMEDA determines the causes of faults within the IC and the associated effect of that fault on the system. In addition to analyzing the possible faults, the FMEDA identifies the diagnostics implemented to detect these faults. The percentage of faults covered by the diagnostics will be an important indicator to determine if a safety goal violation (due to random hardware failure) is within the requirement of its corresponding ASIL level.

Note that the FMEDA document is a work item which is commonly requested by the customer early in the IC development process.

In many cases the diagnostics will take advantage of existing resources within the IC, so the cost impact and/or complexity may be minimal. For example, an IC which already includes an analog-to-digital converter (ADC) may multiplex critical analog signals into this ADC in order to perform diagnostics. In this case the added hardware is limited to the multiplexer switches. In other cases performing a diagnostic may require adding a circuit and/or firmware for which the sole purpose of that circuit (or firmware) is to perform a diagnostic function. This can add cost and increase the complexity of the fault analysis because the new circuit and/or firmware can also fail.

Once the FMEDA is complete and the associated diagnostics are identified, the IC vendor must implement the safety features into the product and verify their effectiveness with traceability back to the top-level safety goal. Safety-centric meetings and audits are conducted throughout the design and verification process in order to achieve this goal.

This verification process, as well as the other added activities required for ISO 26262 compliance, are essentially good engineering practices and disciplines. However, to achieve that compliance these practices are taken to a higher level requiring training, dedicated resources, infrastructure—and a company culture which understands and respects safety as a critical element for automotive component suppliers. ■

Mark Smith is Product Line Manager, Sensor Products and Luyang Zhang is Systems Applications Engineer, at Microsemi Corp., a manufacturer of semiconductor and system solutions for automotive and other markets.

Targeting 40% BTE with advanced VCR

French engine technologists MCE-5 push their variable-compression-ratio program with new tech.

by Lindsay Brooke

The MCE-5 VCR mechanism includes the guided piston and combustion rack on the left side and the 'control jack' and control rack on the right side, activated by inertia and gas forces. The connecting rod big end is at bottom; it links to the central gear wheel in the center.

Nissan's announcement at the 2016 Paris Motor Show that it will bring a variable-compression-ratio engine to production in 2018 (see *AE* November, 2016, p. 6) energized those in the advanced-ICE development community who also have VCR technologies in the works. Varying compression ratio according to load, speed and other parameters is a significant 'lever' that has yet to be pulled, in series-production volumes, to further optimize 4-stroke efficiency.

"The automakers have picked the low-hanging 'fruit' and are now climbing higher in the technology 'tree' to pick what will enable them to achieve the 2025 CO_2 regulations," explained Henri Trintignac, Chief Executive Officer at **MCE-5 Development**. The Lyon, France-based engine-tech company has been focused on its unique VCRi system for 17 years and has documented its progress via many **SAE** technical papers and presentations over the past decade. Its first development contract, signed in 2015, is with China's Dongfeng Motor.

"The customer is interested in an engine family covering from 70 kW up to 200 kW. We do that with only three displacement variants and one bore, one stroke. Two-, three- and four-cylinder engines," he said.

MCE-5's system uses a dedicated cylinder block, cranktrain and actuators to provide continuous compression ratio control, ranging between 8:1 and [geometric ratio] 18:1 to each cylinder (see http://articles.sae.org/6043/). Trintignac, a former **Valeo** powertrain systems executive, said the turbocharged VCRi can switch from minimum to maximum compression ratios in less than 100 ms.

"We can vary the compression ratio infinitely and we can go from 15:1 to 18:1 in just one combustion cycle," he told *Automotive Engineering*. Running at part load, the effect is to minimize BSFC and maximize the "sweet spot" area on the fuel consumption map.

The company now is demonstrating the thermodynamic synergies of combining VCR with infinitely variable valve actuation. The aim is to enable enhanced Miller/Atkinson-cycle operation and thus improve part-load efficiency by reducing heat and pumping losses and optimize the compression-expansion ratio. With this combination of technologies, the inlet valves are open only during half of the compression stroke, so the effective compression ratio is in the range of 10:1.

"We can move three points of compression ratio in less than two cycles," Trintignac reported. "And yes, we spend a lot of time on controls development!" He said 3D combustion simulations [conducted with IFP-C3D, a parallel solver] correlate closely with data from single-cylinder bench work. The tests show an indicated efficiency increase of 12-13% between 10:1 and 18-20:1 compression ratios at low loads, with BMEP less than 8 bar, he said.

CEO Henri Trintignac: "We can vary the compression ratio from 15:1 to 18:1 in just one combustion cycle." (Lindsay Brooke photo)

The MCE-5 development team is targeting 50% brake thermal efficiency (BTE) by 2030, using a step-phase process. "For the first application by 2020, we are aiming for 40% BTE, 260 g/kW," he said. "Next, we can increase the BTE to 44-45% by 2025" then beyond through methodical technology steps.

Refinement of the VCR mechanism and controls continues while combustion engineers play with geometric compression ratios as high as 23:1. Work proceeds on high rates of external cooled EGR (up to 60%)—heavy charge dilution described by Trintignac as HCCI (homogeneous-charge compression-ignition)—aided by a super-high-energy ignition necessary for stable and rapid combustion. Engine-heat recovery strategies also are under review.

The new ignition system is dubbed SSP, or Stratified Spark Plug. Trintignac would say only that it was developed internally and it's not a plasma-based system. He claimed SSP can deliver 1 joule of ignition energy, compared with the 50 millijoules of a conventional ignition system.

Trintignac invites OEM engineers to Lyon to drive MCE-5's demo vehicle and find out more. "To the industry it's all about cost-to-benefit ratio—how many euros or dollars they have to spend to save each gram of CO_2," he noted. "Hybrid 48-volt systems save almost 15 grams on the WLTP cycle and we're in the same range, 10-15 grams.

"But the 48-volt hybrid costs 60 to 70 euros per gram saved. Our VCR costs 30 euros per gram." ■

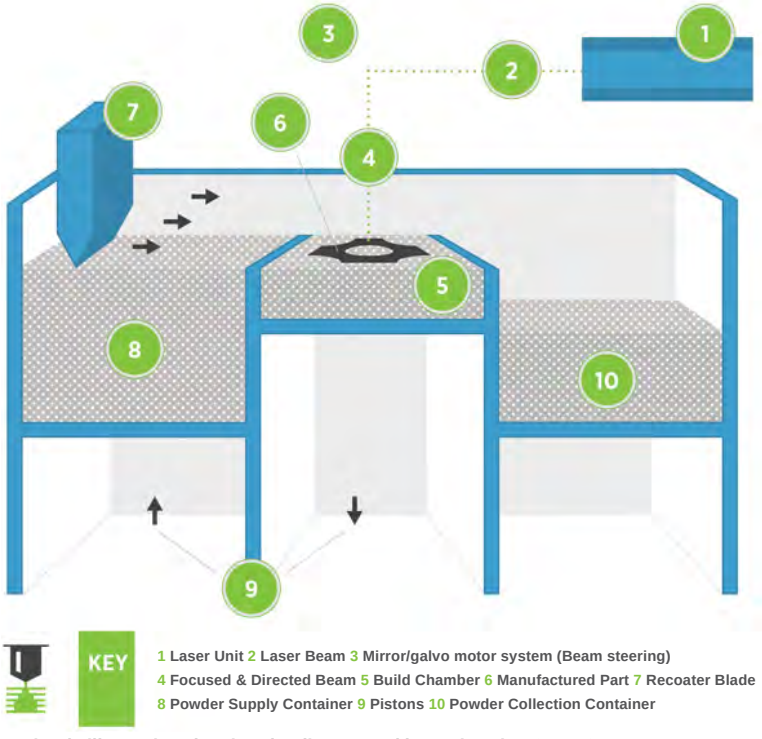
DESIGN TIP: 3D PRINTING

Get to know the benefits and parameters of DMLS in this primer from Proto Labs.

A basic tenet of traditional manufacturing says that as part complexity increases, so do machining and assembly costs. But what if there were a different way to produce metal parts, one with fewer limitations than traditional milling, turning and grinding processes?

And what if such a process was capable of building complex parts in less time and with little human intervention?

Enter direct metal laser sintering (DMLS), more commonly known as industrial 3D printing. Through additive manufacturing technology, DMLS produces fully functional metal prototypes and end-use parts. It simplifies assembly by reducing component counts and offers virtually unlimited part complexity with no additional cost.



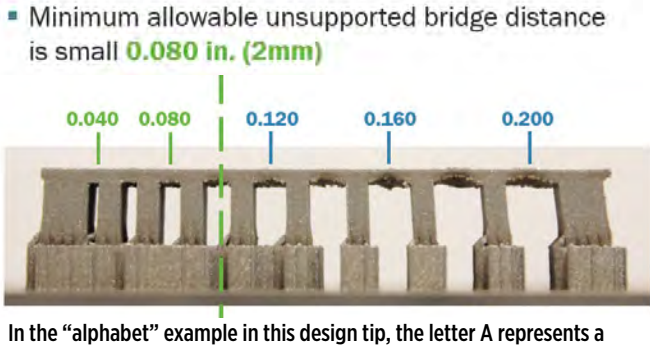
A simple illustration showing the direct metal laser sintering (DMLS) process.

Gaining Support

DMLS works by slicing part models into paper-thin layers and then "drawing" them with a laser in a bed of powdered aluminum, stainless steel, titanium, cobalt chrome, Inconel and other metals. Starting from the bottom layer and working up, each metal particle is melted and fused to its neighbors, one layer at a time until the part is complete.

The result is a fully-dense metal product with mechanical strength and fatigue characteristics little different than—and in some cases exceeding—one machined from comparable wrought, forged, or cast material. However, tooling costs are minimized and setup times and scrap are significantly reduced.

Product designers and engineers who are ready to climb aboard the DMLS express should be aware of a few things first. Although DMLS technology produces fully dense parts from high-strength, corrosion-resistant metals, certain part features are prone to warping and curl if not supported properly during the build process. The design of build supports isn't something you need to be concerned with. But you do need to know that some shapes are exceptionally difficult to build. And by altering your part design somewhat, costs may come down while product quality goes up.



In the "alphabet" example in this design tip, the letter A represents a part with a horizontal crossbar. Unless that crossbar is less than 0.080 in. (2 mm) across, vertical supports will be required beneath it to prevent warping, as this example shows.

Learning the ABCs

Let's take the entire alphabet for example. One of the cool things about DMLS is you can print a number of different components in the same build, provided they fit within the machine's build chamber. In **Proto Labs**' case, that space is a volume measuring roughly 10 x 10 x 10 in (250 mm^3).

Let's start with the letter A and reference the accompanying illustration.

Unless the horizontal crossbar is less than 0.080 in (2 mm) across, vertical supports will be required beneath it to prevent warpage. Not a problem, but it's going to cost a bit to grind or machine those supports away after the build. Same with a T — without supports beneath the overhanging top section, it's going to curl up like a goalpost.

Letters B, D, P and R are especially problematic because the supports will be left inside the part, where they're most difficult to remove. Curved shapes like O and Q fare no differently, unless the letters are quite small, about the diameter of a soda straw. In fact, about the only letters that won't need any form of support are X and Y, provided the arms are angled at least 45° from the horizontal.

Orientation Day

So why not just lay the letters on their backs? "Voila!," you exclaim and go home early. In this case, all of the letter's walls are vertical and the only support needed is a series of interconnected vertical braces between the bottom of each letter and the DMLS build plate. This is rather like scaffolding used to support construction workers. These are easy to remove once the build is complete and avoids direct contact with large, flat part surfaces that can warp or damage the build plate.

This approach also provides the best surface finish, since roughness increases as walls deviate from vertical in DMLS-printed parts. It is worst on angled down-facing surfaces.

Wall thickness is another consideration. Thin walls below 0.040 in (1 mm) must maintain a wall height-to-thickness ratio of less than 40:1 or the structure may tumble. On the other end of the spectrum, very thick walls are wasteful and take a long time to build—better to hollow them out with a honeycomb or lattice structure. This reduces material costs and processing time while preserving structural integrity.

Indeed, lattice structures are one of the best tricks up an additive "magician's" sleeve. They're virtually impossible to produce via conventional machining methods, but are fairly simple with DMLS. So too are treelike structures, gentle twisting seashell curves and other organic shapes, all of which are cost-effective to produce with 3D printing. All that's required is a little imagination and the right CAD software.

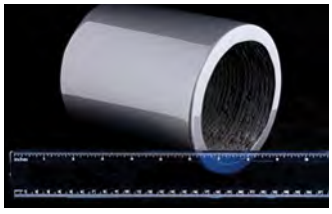
One final consideration: While Proto Labs encourages product designers and engineers to think outside the box, it's important to keep an eye on the finish line. DMLS provides the opportunity to push the limits on prototype and low-volume part design, but it's not yet viable for high-volume production because of economic factors.

It is therefore an excellent idea to explain the entire product life cycle to someone knowledgeable in all types of manufacturing, so you don't inadvertently design your product only to find it's not scalable beyond a few hundred pieces.

Proto Labs: www.protolabs.com

SPOTLIGHT: ADDITIVE MANUFACTURING/3D PRINTING/WCX17 PREVIEW

Advancing 3D-printed NdFeB magnets



Magnet Applications, Inc. (DuBois, PA), a **Bunting Magnetics** Co., has made a technology advancement in 3D-printed neodymium iron boron (NdFeB) magnets. According to Magnet Applications, engineers from the company, working together with researchers at **Oak Ridge National Laboratory** (ORNL), have proven that permanent magnets produced by additive manufacturing outperform bonded magnets using traditional methods with less waste. The company claims they manufactured the starting composite pellets with 65 volume % isotropic NdFeB powder and 35% polyamide nylon-12 binder in a precise ratio, blended to a consistent texture. The 3D printing was performed at ORNL with the Big Area Additive Manufacturing (BAAM) system. "Additive manufacturing in magnets provides multiple benefits," said Magnet Applications' Dr. John Ormerod, Senior Technical Advisor. "They have more design flexibility." NdFeB magnets are the most powerful on earth, and are used in a variety of applications including robotics, wind turbines, electric vehicles, electric motors and other consumer and industrial equipment. The complete study is published in *Scientific Reports*.

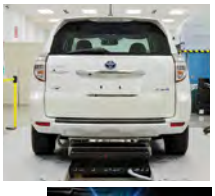
For more information, visit http://info.hotims.com/65849-400

3D printer

Methods 3D Inc. (Sudbury, MA) introduces the **3D Systems**' ProX SLS 500 Selective Laser Sintering production 3D printer featuring fast speeds, high print resolution and a range of engineered composite materials. According to the company, the printer delivers parts with high precision, durability and quality, all in a compact production-grade system. Created for the manufacturing floor, the ProX SLS 500 printer is designed to produce exceptionally smooth surfaces and high-resolution thermoplastic parts, claims Methods 3D. Ready-to-use functional parts and complete assemblies are suitable for automotive applications, among others. The ProX SLS 500 was developed in tandem with the DuraForm ProX materials line to produce smoother wall surfaces, high print resolution and edge definition, generating injection molding-like part quality. The ProX SLS 500 uses three DuraForm ProX materials—the DuraForm ProX PA, DuraForm ProX GF, and DuraForm ProX HST Composite.

For more information, visit http://info.hotims.com/65849-401

High-power wireless charging technology

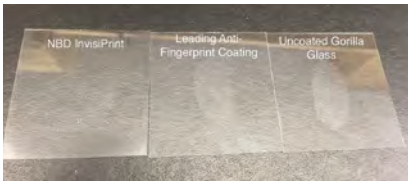


Oak Ridge National Laboratory's (Oak Ridge, TN) 20-kw wireless charging system has achieved 90% efficiency at three times the rate of the plug-in systems commonly used for electric vehicles today. According to ORNL, this ability can help accelerate the adoption and convenience of electric vehicles. Industry partners such as **Toyota**, **Cisco Systems**, **Evatran**, and **Clemson University International Center for Automotive Research** contributed to the technology development. ORNL's power electronics team achieved what they claim is the world's first 20-kw wireless charging system for passenger vehicles by developing, in less than three years, a unique architecture that included an ORNL-built inverter, isolation transformer, vehicle-side electronics and coupling technologies. When demonstrating the process at ORNL, researchers integrated the single-converter system into an electric Toyota RAV4 equipped with an additional 10-kw hour battery. Visit Booth 3413 at SAE WCX17.

WCX17 WORLD CONGRESS EXPERIENCE
EXHIBITOR

For more information, visit http://info.hotims.com/65849-403

Fingerprint-free coatings



NBD Nanotechnologies (Boston, MA) features a new coating solution that renders fingerprints invisible on metal and glass surfaces. According to the company, its patented InvisiPrint solution allows manufacturers to meet the long-standing demand by consumers for a solution that reduces or eliminates the appearance of fingerprints on products such as electronic displays and automotive interiors, among others. The InvisiPrint system is a coating that combines hydrophobic and oleophilic properties, making it unlike any coating solution available today, claims the company. The result of this patented approach is to spread the oil of the fingerprint on the surface. This spreading allows light to pass through the fingerprint undeterred, which makes the fingerprint invisible. NBD Nanotechnologies will be presenting at an **SAE** WCX17 Technical Session on "Advances in Coatings," April 6.

For more information, visit http://info.hotims.com/65849-404

Handheld surface gauge

4D Technology's (Tucson, AZ) 4D InSpec surface gauge is the first handheld, non-contact instrument for measuring surface defects and features on precision machined surfaces, with micrometer-level resolution, claims the company. The 4D InSpec employs patented technology, which enables rapid measurements that are unaffected by vibration and noise. According to 4D Technology, for the first time, QA/QC personnel using the 4D InSpec can take repeatable, high resolution surface measurements in factory floor, machine shop and field service environments. The 4D InSpec surface gauge fundamentally changes precision surface measurement by enabling direct inspection of defects and fine features, right on the shop floor. Rugged and lightweight, the handheld gauge is designed to handle the rigors of daily use. The system measures surface defects between 0.1 and 100 mils (2.5 to 2500 micrometers) deep/tall on a wide variety of part geometries. Visit Booth 4000 at SAE WCX17.

For more information, visit http://info.hotims.com/65849-412

Long body LED indicators

Wilbrecht LEDCO, Inc. (St. Paul, MN), a **Microprecision Electronics** SA company, offers a long body nickel-plated panel mount LED suitable for various applications, including industrial control panels, transportation dashboards, gaming/vending machines and aircraft/military instrumentation. The housing is designed to easily fit panel thicknesses of up to 9.0 mm (0.35 in) even with additional gasket. The front mounted prominent and recessed bezel shaped forms come with termination options leads or Faston-style quick connects. The fully potted leads version with additional gasket offers front and backside IP67 sealing for water resistance and outdoor use. The rugged vibration- and water-resistant LED indicators are U.S. made and can be modified to fit custom needs for special wires, connectors or marking. All versions are available in a range of colors and intensities, including daylight readable red, yellow, green, orange as well as bicolor, blue, white, flashing, infrared and night vision compatible LEDs.

For more information, visit http://info.hotims.com/65849-413

UPCOMING WEBINARS

VIRTUAL PRODUCT DEVELOPMENT OF AUDIO SYSTEMS WITH COMSOL MULTIPHYSICS®

Thursday, March 16, 2017 at 2:00 pm U.S. ET

In this 60-minute Webinar on acoustic simulation, expert François Malbos from the Harman Virtual Product Development team presents the audio simulation projects he developed to support consumers and OEM business lines, including loudspeaker, subsystem, and car cabin simulations. The Webinar also includes a comparison between COMSOL Multiphysics® simulations and measured data.

Speakers:

François Malbos
Principal Engineer, Engineering/R&D, Harman Lifestyle Audio

Mads J. Herring Jensen
Technical Product Manager, COMSOL

For additional details and to register visit: www.sae.org/webcasts

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TRULY AUTOMATED LIGHT AND COLOR MEASUREMENT FOR TELL-TALES AND INDICATORS

Available On-Demand

Evaluating the accuracy of light and color across instrument clusters is a challenge compounded by several factors. This Webinar explores Auto-POI, the latest technology for light and color measurement of multi-point inspection areas using an Imaging Colorimeter, enabling automated evaluation across entire instrument clusters.

Speaker:

Shannon Roberts
Product Manager
Radiant Vision Systems

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PRODUCT BRIEFS

Oil- and abrasion-resistant cable

ÖLFLEX 409 P PUR control cable from **Lapp Group USA** (Florham Park, NJ) is an oil- and abrasion-resistant cable for industrial machine tools and appliances. According to the company, a special interstice filling functional layer on a PVC base enables more efficient and reliable stripping and ensures improved stripping characteristics, reduction of damage to core insulation, less subsequent manual processing and reduced material waste—compared to common PUR jacketed cables. Due to a robust polyurethane outer sheath, the cable delivers increased durability under harsh conditions. ÖLFLEX 409 P is also resistant to contact with many mineral oil-based lubricants, diluted acids, aqueous alkaline solutions and other chemical media.

For more information, visit http://info.hotims.com/65849-405

Stationary laboratory data acquisition system

Diversified Technical Systems' (Seal Beach, CA) SLICE PRO LAB system offers the same electronics and flexibility as its crash-hardened SLICE PRO data acquisition modules, but in laboratory enclosures, making it suitable for a variety of static testing such as crash-test dummy calibration. System modules can be configured into any combination in the SLICE PRO LAB Rack and are compatible with other Diversified Technical Systems hardware. The system is a standard 19-in x 3U that holds up to four modules as well as an Ethernet controller. The racks can be daisy-chained to support high channel-count tests. The company claims the standard rack configuration features sleek handles that make it quick and easy to reconfigure systems.

For more information, visit http://info.hotims.com/65849-406

Linear potentiometers

H.G. Schaevitz LLC **Alliance Sensors Group** (Moorestown, NJ) expanded its sensor product offering by adding resistive technology to its portfolio of linear position products. Environmentally sealed to IEC IP-64, the LP-22 series of linear potentiometers offers a cost-effective solution to sensing requirements in the factory automation market. The company claims LP-22 series potentiometers are constructed to satisfy applications like robotic control, X-Y table feedback, injection-molding machine slides, press or die arm position, control valve shaft position, and mil/aero test stands. Features include full ranges from 25 to 300 mm (1 to 12 in), self-aligning swivel-rod eyes on both ends, and -40 to +150°C (-40 to +302°F) operating temperature.

For more information, visit http://info.hotims.com/65849-407

Signal conditioning, filter and instrumentation amplifier

Alligator Technologies (Costa Mesa, CA) offers x10000 amplifier gain enhancement for the company's USB controlled USBPIA-S1 single channel programmable signal conditioning instrumentation amplifier and the USBPGF-S1 instrumentation amplifier with low pass filter. The device is configurable in a wide variety of applications. The completely software configurable USBPGF-S1 low pass filter is available in a wide range of filter characteristics and, along with the USBPIA-S1 instrumentation amplifier, can now amplify signals below 1mV to standard ADC resolvable levels. The company claims each USBPxx-S1 has intelligence built in to configure itself from power-up with changeable but non-volatile parameters and operates independently in both a turn-key or host computer controlled scenario.

For more information, visit http://info.hotims.com/65849-409

Silent timing chain

Designed for lighter weight, smaller space and lower cost than gear drives, **BorgWarner**'s (Auburn Hills, MI) silent-chain technology provides durable performance, even under high speeds typical in hybrid applications. The company produces silent chains for **Suzuki**'s Solio hybrid vehicle. When driving under electric power, two chains transfer power from the electric motor to the transmission to propel the vehicle. During braking or deceleration, the chains transmit power back to the motor to recharge the battery. BorgWarner also supplies the silent timing chain for the 1.2-L gasoline engine. According to the company, in both applications, lower friction improves durability and increases efficiency.

For more information, visit http://info.hotims.com/65849-408

High-temperature pressure sensor

The Endevco model 8523 high-temperature pressure sensor from **Meggitt Sensing Systems** (Irvine, CA) uses silicon strain gages to enable gage and differential measurements. Designed for static or dynamic pressures, sensor applications include inlet distortion pressures in turbine engines, transmission pressures in automobiles and rocket motor analysis. Key features include: 15, 50, 100, 200 and 500 psig ranges; 300 mV full scale output for higher signal-to-noise ratio; high temperature, up to +500°F (+260°C) continuous use; accuracy with 1% linearity at two times full-scale range; and high resonance frequency for dynamic response.

For more information, visit http://info.hotims.com/65849-410

Plasma polymerization deposition systems

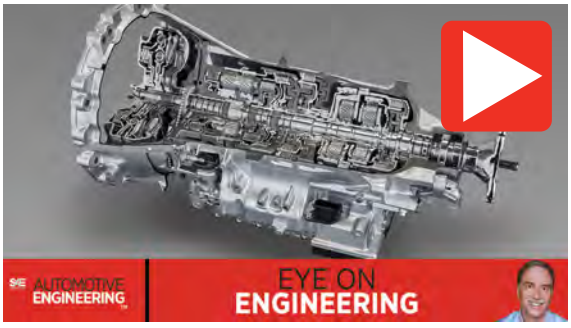
The PD Series Plasma Deposition Systems family from **Nordson MARCH** (Concord, CA) uses plasma polymerization to deposit thin films uniformly during precision manufacturing and assembly processes to change the surface characteristics of a substrate. Plasma deposition can be used for applications in a wide range of industries, including industrial, semiconductor, MEMS, plastics and electronics. The PD Series family uses a gas vapor or heated liquid monomer vapor delivery system to deposit coatings that can reduce, and in certain cases eliminate, tackiness, provide a tie layer, make surfaces more slippery or resistant to corrosion, and change desired surfaces from hydrophobic to hydrophilic or vice versa. Nordson MARCH offers three models to meet a broad spectrum of manufacturing requirements. The PD-1000 and PD-1500 are suitable for batch prototype, pilot, or production processing of substrates. According to the company, the PD-Pro has a large plasma processing cavity to treat big substrates or multiple smaller substrates.

For more information, visit http://info.hotims.com/65849-411

WHAT'S ONLINE

VIDEO

SAE Eye on Engineering Quick Take: 10-speed transmissions



Bicyclists know that 10 gears are better than five and the same is true with the latest cars and trucks. In this episode of SAE *Eye on Engineering*, Editor-In-Chief Lindsay Brooke looks at the new 10-speed transmissions making their debut on a number of models in 2017. SAE *Eye on Engineering* can be viewed at **video.sae.org/12246/**. It also airs in audio-only form Monday mornings on WJR 760 AM Detroit's Paul W. Smith Show. Access archived episodes of SAE *Eye on Engineering* at **video.sae.org**.

WHAT'S NEW

Honda and GM pioneer new fuel-cell manufacturing venture

The first time **General Motors**' global product development chief Mark Reuss got an up-close look at **Honda** technology was as a kid when he tore apart his QA-50 minibike in the family garage. The little Honda's 50-cc engine contained infinitely more parts than are in the hydrogen fuel cell stack GM plans to manufacture (ironically) with joint-venture partner Honda beginning in 2020.

Now Reuss, along with the GM Global Propulsion team and their Honda R&D colleagues, are preparing to bring the fuel-cell program into the manufacturing stage. After three years of co-developing a new-generation fuel cell stack aimed at light vehicles, military, aerospace and other applications, the companies announce the establishment of Fuel Cell System Manufacturing LLC—the industry's first joint venture for fuel-cell production.

Read the full story at **articles.sae.org/15234/**.

WHAT'S NEW

Daimler, Uber team up to bring more self-driving cars to the road

Daimler and **Uber** announce the companies signed an agreement to cooperate on the supply and operation of self-driving vehicles. Under the agreement, Daimler plans to introduce self-driving vehicles for use on Uber's global ridesharing network in the coming years. Daimler is the first auto company to join with Uber as it opens its platform for manufacturers to introduce their own self-driving vehicles, the announcement claims.

Image courtesy of Uber.

Each company claims it will benefit from the other's capabilities in research and development of automated driving and network operations, according to the January 31 announcement.

With its new corporate strategy titled CASE (Connected, Autonomous, Shared & Services, and Electric), Daimler's **Mercedes-Benz** said it is marking out the cornerstones for its future and the reshaping of mobility. Daimler added that the agreement with Uber is the automaker's next step into the future of shared and autonomous driving.

Read the full story at **articles.sae.org/15237/.**

SAE INTERNATIONAL

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

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READER FEEDBACK

10-speeds, 2000-bar injection and Interrobangs

ISO 26262 and ADAS tech

I work for a Tier 3 supplier producing electronic components for use in light-duty vehicles. In the SAE magazines many articles about the latest ADAS systems that are driving our business, you have not touched an important topic. That is, the ISO 26262 standard that is increasingly influential in our work. The ISO standard is also behind German product-liability laws, as I understand them.

Douglas J. Browning, M.E. and E/E
Long Beach, CA

We agree that ISO 26262 is important and draw your attention to a feature article related to it on page 25 in this issue. - Ed.

The GM-Ford 10-speed collaboration

For nearly a year we have heard how Ford and GM "cooperated" on the design of their new 10-speed automatic transmission, in every magazine, on every website, in newspapers, etc. A very cursory, essentially empty statement that tells people nothing about why Ford and GM would work together on this project, while Honda managed to make their own 10-speed all by themselves [February AE, p.10].

What, exactly does their cooperation mean? How did it come about? Why was it necessary? What did each contribute and what parts remain proprietary? Is manufacturing and costs shared? Who is accountable for problems? Etc. Perhaps a story like this would be of genuine interest to readers of your publication.

Tom Uryga
Owner, BT Precision, LLC
Hillsboro, OR

Tom: Perhaps you missed the 8-page cover story that Bill Visnic wrote on the GM-Ford 10-speed program. That feature article appeared in the July 2016 (digital only) issue of AE. It can be accessed via the SAE website at http://magazine.sae.org/auto/ . - Ed.

2000-bar diesel injection

In your article on the Achates OP engine (Feb 2017, p.17) you stated that the injectors are fed by a 2000-bar fuel rail. Now, 2000 bar is equivalent to 30,000 psi, which happens to be high enough to erode metals (Waterjet cutters use 30,000 psi of pressure). I noticed the same two months ago in your article on the new Range Rover. Please check your facts.

Mark Haynes
Senior Engineer
Composite Technology Development
Lafayette, CO

Mark: The 2000-bar figure is indeed correct for the Achates engine. Diesel and gasoline-DI injection pressures have been steadily climbing for over a decade. This is not an uncommon injection pressure for mainstream diesel, while state-of-the-art GDI engines are more commonly 400-500 bar. The 2000 bar is not a unique or special requirement of the Achates engine. - Ed.

Use the Interrobang⁉

I read and enjoyed Bill Visnic's editorial in the February 2017 *Automotive Engineering*. But the English language has had a punctuation symbol that combines the exclamation point and the question mark since about 1968: the Interrobang.

Keep up the good work.

Dan Doerer
St. Louis, MO

Have a look at https://en.wikipedia.org/wiki/Interrobang for a hybrid of the interro (?) & the bang (!). In the day of the IBM Selectric typewriter you could generate an interrobang with the backspace key and the ? and ! (symbols). You can't get one out of your computer, even with the Alt nnn or Alt 0nnn, but you can get the idea across with !? or ?!.

Thoughty editorial though.

Karl W. Schweickardt, Jr.
via email

Dan and Karl: We thought we'd seen most every punctuation available to the English language, but were utterly unaware of the Interrobang. It figures—just as in automotive, if you can conceive of something, you can almost count on the fact someone else already has, too.

I can at least reciprocate with some knowledge: there is a way to get an interrobang out of your computer—provided you have Microsoft Word, at least. You'll find it in symbols/general punctuation (character code 203D) under the Insert tab in Word. - Bill Visnic

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

COMPANIES MENTIONED

UPCOMING FROM THE EDITORS

March 2: Electronics & Connectivity Technology eNewsletter

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

March 15: Truck & Off-Highway Engineering Technology eNewsletter

March 16: Aerospace Engineering Technology eNewsletter

March 20: Vehicle Engineering Technology eNewsletter (all markets)

March 24: Heavy-Duty Technology eNewsletter

March 29: Automotive Engineering (SAE World Congress Preview) Technology eNewsletter

April: Automotive Engineering Print Magazine
- SAE WCX17 (World Congress)
- Disruptors & Disruptive Technologies
- WCX17 Exhibitor Preview (SAE World Congress) spotlight

April: Truck & Off-Highway Engineering Print Magazine
- Connected vehicles (Webinar feature)
- Powertrain management
- Vehicle testing & simulation
- Engine Components product spotlight

April 12: Automotive Engineering Technology eNewsletter

April 17: Truck & Off-Highway Engineering Technology eNewsletter

April 3: Aerospace Engineering Technology eNewsletter

April 19: Vehicle Engineering Technology eNewsletter (all markets)

April 20: Aerospace Engineering Technology eNewsletter

April 27: Automotive Engineering Technology eNewsletter

May: Automotive Engineering Print Magazine
- Lightweighting
- Advanced ICEs & new fuels: SAE Convergence Preview
- Materials spotlight

AD INDEX

Q&A

Horst Binnig, Rheinmetall Automotive CEO: E-mobility also brings societal risks including the threat of potential job losses.

Shifting to an e-mobility product portfolio

How does a traditional powertrain component and systems supplier stay relevant in an increasingly electrified- and autonomous-mobility future? Horst Binnig, CEO of **Rheinmetall Automotive** AG (formerly Kolbenschmidt Pierburg/KSPG), a company with more than a century of ICE technology expertise, spoke with *Automotive Engineering* on this topic at the 2017 North American International Auto Show.

Why pursue an electro-mobility portfolio when the internal combustion engine still dominates production vehicle applications?

Forty percent of our product portfolio today is suitable for internal combustion engines as well as for hybrids and for e-driven vehicles. For us, it has never been a decision to do something and leave something else behind, so e-mobility products are an add-on to our portfolio. Our content on an e-car could be substantial.

For perspective, the **London Taxi Company**'s next-generation cabs will be purely e-driven. We'll have four oil pumps on those e-cars with the content per car exceeding €200. That's more than what we have today on an ICE-driven car, which is €100-€150 in content per car excluding the engine cylinder block.

What are other Rheinmetall Automotive e-mobility product application examples?

Not all of the products we offer for an ICE-driven vehicle are needed for an e-mobility application. You don't need a cylinder head for an e-driven vehicle, but you do need an engine. We're leveraging our aluminum die-casting expertise for an e-engine being done for a German supplier. It's being produced on the IC engine block machine, using the same process.

We recently received a €65 million order from another German supplier for battery housings. These die-cast aluminum battery boxes, which start production in mid-2018, will house the rechargeable battery cells for a crossover utility vehicle and a sports limousine. Both battery electric vehicles are for the European market.

How is the company committing to electro-mobility in terms of R&D and the workforce?

The big challenge is having the right people on-board. One of the reasons why we changed our name from KSPG to Rheinmetall Automotive is because we want engineers to view us as a technology company.

We cooperate with universities around the world. And we're looking to partner with companies. On the R&D side, roughly 6% of sales goes to R&D work with a payback time typically in two to three years. It would be difficult to reduce the amount spent on R&D for ICE technologies since this is still our mainstream business.

We will dedicate a certain amount of R&D spending for electro-mobility and other specialized technologies, but we expect a longer payback time.

You talked about e-mobility rewards, but is there a risk with a shift to electro-mobility?

E-mobility can help the automotive industry move forward, but that doesn't mean there won't be challenges. There is a potential societal risk.

The ICE powertrain has roughly 3500 parts, but an electric powertrain has approximately 35 parts. You don't need a gearbox. There is no crankshaft or camshaft. At the OEM-level, you have big plants with workers assembling combustion engine parts and gearboxes.

If you do not need ICE products, you have an employment problem. On the supplier side, there are Tier 4 and 5 companies that produce a specific combustion engine part and that's their only product. Companies that build the machinery for the assembly lines would be affected. The ripple goes on and on.

As an industry, we've got to take care of this jobs-loss threat. And that requires us to be aware of the risk.

Kami Buchholz

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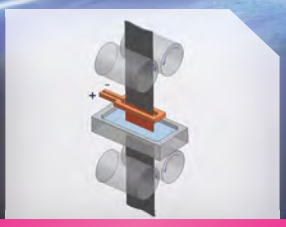

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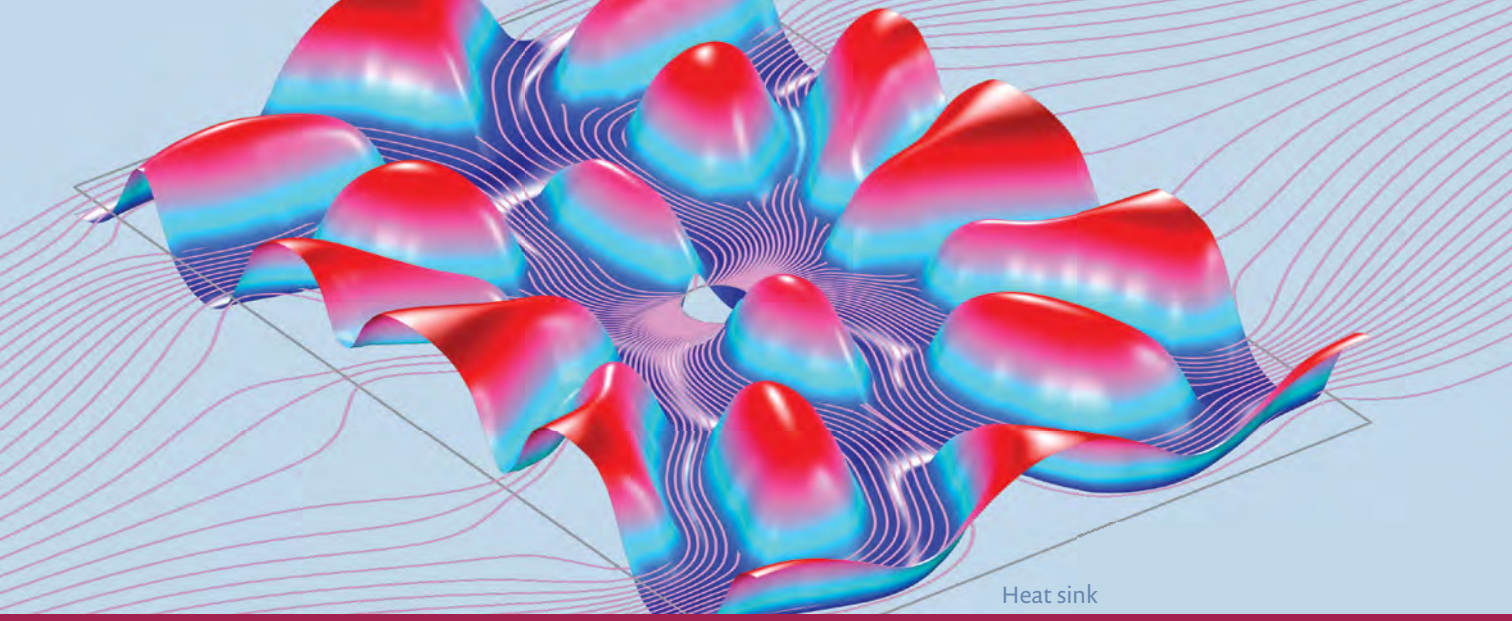

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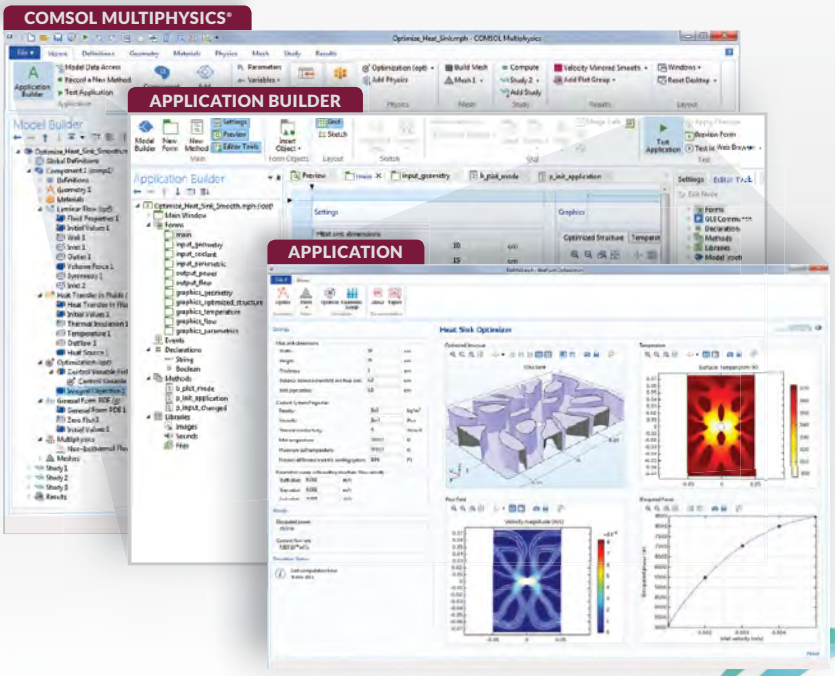

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