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Software-defined relationships at CES

How SDVs are redefining the link between OEMs and suppliers

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Tremec-trification

The ICE-to-EV supplier dilemma

ChatGPT has entered the car

February 2024 mobilityengineeringtech.com

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ON THE COVER

Software-defined-vehicles were a focus of many suppliers and automakers at CES 2024. Marelli generated the cover's rendering of the realm of SDV functionality. (Marelli)

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REGULARS

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EDITORIAL

EV confidence

Anti-EV voices are having their day. It's easier than ever to find people pointing out ongoing charging infrastructure problems or a notable decline in EV sales. The criticisms are valid and the challenges are real. Recent rosy predictions are easy to find and dismiss, such as GM's statement in late 2022 that it would be able to produce more than a million EVs a year in North America by 2025. In 2023, GM sold around 75,000 EVs in the U.S. You can see how those numbers make easy targets for naysayers.

I'm not saying there aren't problems looming in our EV future. There are. Sales will rise and fall during the shift to EVs. Some people will love their EVs, while others try the models available today and realize they'd rather have an ICE or PHEV. And don't get me started on charging infrastructure.

EVs are not for everyone. Not yet, anyway. But despite the headlines, there's no reason to lose confidence in the overall EV trajectory that's been underway for the last dozen years or so. We should pay reasonable attention to worrying headlines — even more so to the underlying facts and figures — but we can't let them distract from what's actually happening in the industry. Just ask the engineers and development teams busy working on the constant and impressive technological improvements. Magna's improved e-motor or NACS' rapid acceptance by the industry, to cite two examples from this issue. You'll find much more in our ongoing daily reporting at sae.org. This month — and every month — our pages are full of proof that the EV transition won't be stopped. Delayed? Sure. Different than expected? Obviously. Denied? No way. I'm confident about that.

I've been test-driving EVs for more than 15 years, but it was only a year ago that I finally purchased my own. Living with an EV opens up a world of new possibilities, as well as new problems. But one of the changes I didn't fully expect was another variation on the idea of confidence. The simplicity of my Chevy Bolt EV created a subtle but important change in how I feel behind the wheel every day. An internal-combustion engine will still move a car, obviously, but everyday drivers in everyday situations can feel more confident in an EV. Driving an EV gives you confidence that it will dart where you want it to dart. The instant torque, the ease with which you can pass an average ICE vehicle, can be revolutionary. When you live with it every day, something shifts inside.

Living with an EV opens up a world of new possibilities.

Advocates have long called initial reactions to this power the "EV grin," and it's an important factor in the EV discussion. This is especially true for younger people who might be entering their driving lives with equal exposure to gas and electrons as a power source. Along with learning the rules of the road, driver's training programs work to instill a sense of confidence in new drivers. EVs can provide them that confidence sooner and more reliably. We'll see how that all plays out, but you can guess by now what I'm confident will happen.

A separate note: After my first editorial as EIC was published in the December 2023 issue, a reader responded with some kind words. Polite, direct feedback — positive or otherwise — is absolutely appreciated. If you've got something to share, my email's open. I'm confident it will be a good discussion.

Sebastian Blanco, Editor-in-Chief

EDITORIAL

Bill Visnic
Editorial Director
Bill.Visnic@sae.org

Sebastian Blanco
Editor-in-Chief
sebastian.blanco@saemediagroup.com

Chris Clonts
Senior Editor
chris.clonts@saemediagroup.com

Ryan Gehm
Associate Editor
Ryan.Gehm@sae.org

Matthew Wolfe
Assistant Editor
matthew.wolfe@saemediagroup.com

Amanda Hosey
Editor, Custom Content
amanda.hosey@saemediagroup.com

Contributors

Kami Buchholz
Detroit Editor

John Kendall
Europe Editor

Bradley Berman
U.S. West Coast Editor

Don Sherman, Paul Weissler

DESIGN

Lois Erlacher
Creative Director

Ray Carlson
Associate Art Director

SALES & MARKETING

Joe Pramberger
Publisher
joe.pramberger@saemediagroup.com

Kaitlyn Sommer
Marketing Director
kaitlyn.sommer@saemediagroup.com

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

REGIONAL SALES

North America

New England/Eastern Canada:
ME, VT, NH, MA, RI, QC
Brian Hines
+1.647.296.5014
brian.hines@saemediagroup.com

CT:
Stan Greenfield
+1.203.938.2418
greenco@optonline.net

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

NY, NJ, OH:
Ryan Beckman
+1.973.409.4687
ryan.beckman@saemediagroup.com

PA/DE:
Desiree Stygar
+1.908.300.2539
desiree.stygar@saemediagroup.com

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

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

CA, WA, OR, AZ, NM, Rocky Mountain States:
Tim Powers
+1.908.892.2838
timothy.powers@saemediagroup.com

International

Europe:
Sven Anacker
+49.202.373294.11
sa@intermediapro.de
Sabine Schoett
+49.202.373294.13
ss@intermediapro.de

China:
Will Chang
+86.21.6140.8919
Will.Chang@sae.org

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

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

Integrated Media Consultants

Daniel Barrett
+1.973.409.4762
daniel.barrett@saemediagroup.com

Patrick Harvey
+1.973.409.4686
patrick.harvey@saemediagroup.com

Todd Holtz
+1.973.545.2566
todd.holtz@saemediagroup.com

Rick Rosenberg
+1.973.545.2565
rick.rosenberg@saemediagroup.com

Jason Setti
+1.973.874.0271
jason.setti@saemediagroup.com

SUBSCRIPTIONS

+1.866.354.1125
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SUPPLIER EYE

Suppliers' ICE-to-EV capacity dilemma

For decades, there has been a tug-of-war between many suppliers and their vehicle-manufacturer customers with respect to future planning volumes. The stakes are significant. Using volumes that are too high drives an extreme capital commitment and risk suppliers to stranded capital and missed opportunities to employ resources elsewhere. Using volumes that are too low means the OEM may miss potential sales and the supplier would be stressed with extreme overtime to keep up. It is a never-ending balance.

OEMs often use internally built 'Capacity Planning Volumes' (CPVs) to ensure they capacitize to both their annual and peak volume expectations. These volumes are used as the divisor to understand per-part costs and how tooling, machines, infrastructure and other capitalized items are amortized over the life of the program. Suppliers often utilize third-party views such as the S&P Global Mobility Light Vehicle Production Forecasts to gain an impartial perspective of market dynamics, as well as existing and expected vehicle introductions.

Why the concern now? This financial dance between supplier and OEM has been going on for decades. In the past, there were various commonalities with many systems and components between ICE-based platforms and carryover from generation-to-generation. Suppliers would utilize similar machines, processes and sometimes tooling between components — enabling higher capital utilization and enhanced production flexibility. While there are always new technologies and innovations integrated into a new or revised platform, suppliers would try to utilize existing capital when possible to reduce cost and risk. Consider the following: If a supplier capacitized for a component for two programs from the same OEM at 200,000 units each per year, there could be a potential balance between each program — allowing capacity utilization to even out. The results could be less overtime and lower costs and overall risk levels.

Michael Robinet
Executive Director, Consulting, S&P Global Mobility

SAE Foundation Trustee

michael.robinet @spglobal.com

Double capacity for the same vehicle segment is a recipe for low profitability and poor utilization.

Now enter the EV. With virtually every platform being unique with all-new systems, processes and technologies, suppliers are facing significant issues. Many times, these systems have little in common with components that the supplier is already producing for ICE models. This limits the ability to deploy common capital and resources to service these platforms. All is comparatively new in the EV world. Therefore, the level of risk to the supplier rises significantly, as capital is unique.

There's one other issue that's potentially more important when building for BEV platforms: OEMs are trying to reduce the cost-per-component for BEVs to improve affordability and profitability as scale increases. Some assumptions have been, well, somewhat suspect and inflated. Suppliers are being asked to add considerable capacity for BEV components while still holding for peak volumes on the ICE side.

Given the current higher cost of capital (8%+) for borrowed funds, suppliers need to be clever. If there are two 200,000-unit programs with the same OEM, one ICE-based and the other EV-based, chances are there is little capacity in common. Double capacity for the same vehicle segment is a recipe for low profitability and poor utilization. These days, smarter suppliers are seeking the ability to add incremental capital once a program demonstrates a need for more investment.

In the end, the transition from ICE to EV is about more than new technologies and processes. Suppliers need to be keenly aware of the risks assumed as BEV capacity is added. Being on the right program from a volume perspective is critical to supplier viability. ■

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KEYSIGHT

CHARGING INFRASTRUCTURE

SAE completes next step to standardize Tesla-developed EV charging connector

A 2024 Jeep Grand Cherokee 4xe hybrid recharging. Although many automakers have stated their intention to adopt the NACS charging connector, as of late 2023, Jeep parent company Stellantis had yet to confirm it is considering an option to the current SAE J1772 Combined Charging System (CCS) connector.

SAE International announced on December 19 that it has released the Technical Information Report (TIR) for the SAE J3400 standard covering development and implementation of the Tesla-developed NACS (North American Charging Standard) connector to couple public and residential charging units to EVs made by any automaker. In a release, the organization said the SAE J3400 North American Charging Standard Electric Vehicle Coupler Technical Information Report (TIR) "was developed through broad-based industry consensus in the SAE Hybrid-EV J3400 TM NACS Electric Vehicle Coupler Task Force."

The SAE J3400: NACS Electric Vehicle Coupler Technical Information Report can be reached at: https://www.sae.org/standards/content/j3400_202312/

Release of the TIR for the J3400 standard means certain critical engineering and development parameters have been established to allow developers to proceed with certainty about many critical aspects of deployment and commercialization of the NACS connector. Ford and GM this spring were the first in a string of automakers to indicate they would adopt the NACS charging connector. SAE said in June 2023 that it would standardize the NACS connector.

SAE said that in addition to benefiting EV drivers, the standard will help to ensure that any supplier or manufacturer will be able to use, manufacture, or deploy the J3400 connector for vehicles and charging stations in North America. "SAE J3400 provides a blueprint for cost-effective mass electrification of transportation in North America," said Dr. Rodney McGee, Ph.D., P.E., who is chairman of the SAE J3400 NACS Task Force and also is a Research Engineer at the Transportation Electrification Center at the University of Delaware. The standard, he stressed, "facilitates broad interoperability for EV charging solutions by providing a unified, compact connector for both AC and DC charging."

Crucially, the standardized approach also means that the same utility power feeds used for public DC fast charging can be utilized for single-phase AC charging used in homes and other facilities, "eliminating the need for separate circuit panels and additional step-down transformers at charging sites, resulting in lower infrastructure costs and higher efficiencies," SAE said.

In the release confirming the completion of the TIR for the J3400 standard, SAE said the U.S.'s Joint Office of Energy and Transportation was instrumental in fostering the SAE-Tesla partnership to expedite plans to standardize NACS. "As the Joint Office supports the buildout of a convenient and reliable national charging network, open and interoperable standards are crucial to ensuring that every EV can charge at any station," said Gabe Klein, executive director of the Joint Office of Energy and Transportation. "We appreciate the commitment and knowledge of SAE and its experts from the automotive, EV charging, academic, and government sectors to make the charging experience easier and more accessible for Americans nationwide."

Bill Visnic

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PROPULSION

GM, Autocar to build fuel-cell commercial vehicles

General Motors announced this week that it entered a joint development agreement with Alabama-based Autocar Industries to build a range of all-electric commercial trucks powered by electricity generated from GM's Hydrotec hydrogen fuel-cell systems GM calls "power cubes." In a video call with journalists, the companies said production of electric trucks at the Autocar Truck Plant in Birmingham, Alabama, will begin in 2026.

"EV propulsion systems like GM's Ultium Platform are great solutions for electrifying passenger vehicles, but larger vehicles like Autocar's Class 8 trucks, garbage trucks and terminal tractors require robust solutions that enable significant energy carrying capacity and fast refueling times," said Charlie Freese, GM executive director, Global Hydrotec, in a press release. "We want to enable zero-tailpipe-emissions solutions for the largest, highest energy-consuming vehicles, and fuel cells are ideal for the most energy intensive applications," Freese added.

Autocar DC-64D dump truck at a construction site.

The power cube is comprised of 300-plus versions of GM's current, second-generation fuel cells in a compact and easily packaged footprint that also incorporates power- and thermal-management systems. GM said each power

AUTOCAR

cube can generate 77 kW "and is much quieter than a conventional diesel propulsion system." The modular power cubes can be arrayed in a multiple arrangement for vehicles requiring more power. The power cubes for the Autocar applications will be manufactured by GM in Brownstown, Michigan.

During a press gathering in July 2023, Freese intimated that the modular power cube format is ideal for larger vehicles that have high-energy demands. He added that the second-generation fuel cell design has markedly reduced loadings of precious metals required for the system's catalyst; the Gen 0 design used about 80 grams of platinum, Gen 1 reduced the amount to around 30 grams — and the Gen 2 technology has cut the amount to the 20-gram level.

The GM Hydrotec fuel cell power cube contains more than 300 hydrogen fuel cells and generates 77 kW.

Zero-emissions, built to order

The JDA between GM and Autocar sees fitment of the modular power cubes in Autocar's vocational trucks such as cement mixers, roll-offs and dump trucks that share a common platform. Later, the companies said refuse trucks and terminal tractors will be added. The fuel cell-powered trucks will be built to order by Autocar and sold directly to customers.

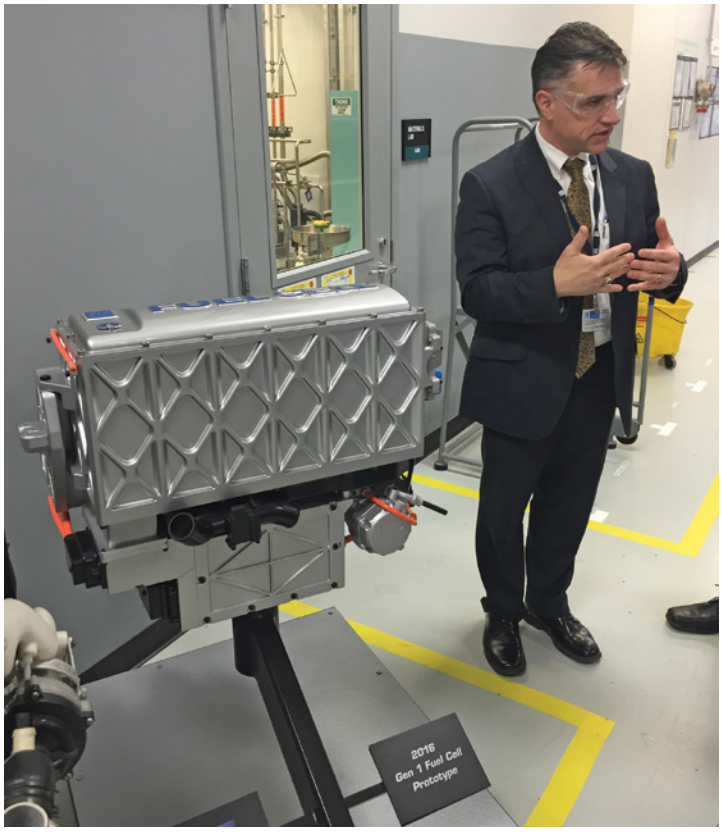
"Autocar provides customized vocational trucking solutions, and as regulations change, we see Hydrotec fuel cells as an additional avenue for our customers to meet their EPA [Environmental Protection Agency] requirements with zero tailpipe emissions vehicles," said Eric Schwartz, Autocar president, in a release. "GM's scale, reliability and the capability of their Hydrotec fuel cell technology will enhance Autocar's existing platforms," he added.

Triz Engineering — a commercial-vehicle engineering company owned by GVW Group, which also owns Autocar — will provide "expert integration support for power distribution between the fuel cell and batteries, which store electricity that is captured from regenerative braking or is created by the HYDROTEC power cubes," the companies said.

"We have carefully studied existing severe duty vocational trucks to understand their specific demands and requirements," said Johann Vorster, president of TRIZ Engineering. "With GM and Autocar, we have built a fuel cell application that is unique within vocational vehicles — giving severe duty trucking more options to be truly rugged and capable of achieving zero tailpipe emissions."

Although GM or Autocar did not mention potential prices for the for the fuel-cell trucks, Freese suggested initial costs will be higher than their internal-combustion counterparts. He said the fuel cell-powered propulsion is "not yet on cost parity" with a diesel powertrain in the vocational trucks the companies are targeting for fuel-cell fitment.

Bill Visnic



Charlie Freese, executive director of GM Hydrotec and GM Defense, details GM's first-generation fuel-cell prototype in 2016.

FROM TOP: JIM FETS FOR GENERAL MOTORS; SAE/BILL VISNIC

ARTIFICIAL INTELLIGENCE

CES 2024: VW, Cerence integrate ChatGPT in IDA voice assistant

ChatGPT has entered the car. At CES 2024, Volkswagen and technology partner Cerence introduced an update to IDA, VW's in-car voice assistant, so it can now use ChatGPT to expand what's possible using voice commands in vehicles.

VW said the ChatGPT bot will be available in Europe in current MEB and MQB evo models from VW Group brands that currently use the IDA voice assistant. That includes some members of the ID family – the ID.7, ID.4, ID.5 and ID.3 – as well as the new Tiguan, Passat and Golf models. VW brands Seat, Škoda, Cupra and VW Commercial Vehicles also will get IDA integration. VW hopes to bring IDA to other markets, including North America, but did not make any timing announcements.

Currently, IDA understands five languages: U.S. English, German, UK English, Spanish and Czech. Eight more are on the way: French, Italian, Dutch, Polish, Swedish, Portuguese, Norwegian and Danish.

SEBASTIAN BLANCO

Axel Heinrich, head of innovation and system architecture for the Volkswagen brand, and Maik Rohde, VW's head of connected infotainment development, pose with the ID.7 at CES 2024.

Ida's connection to ChatGPT comes from Cerence, which was spun out of Nuance as an independent company in 2019. Ida's behavior is governed by

Cerence Chat Pro, which uses a smart arbitration mechanism in VW's voice command software to distinguish between three types of queries and route them to the right service for a response.

The embedded system handles simple functionalities that do not need a connection to function, like adjusting the temperature or the radio. For higher-level tasks, like providing real-time weather data, the system uses cloud services provided by Cerence. Everything else — "the queries that the system today cannot tackle," as Vania La Rocca, Cerence's director of product operations, told SAE Media — goes to the new integrated third-party large language model (LLM), in this case, ChatGPT. Cerence enabled the chat service on the cloud side without requiring any changes to the embedded software.

"The goal is to reduce as much as possible the cases where the system will answer, 'I don't know how to do that,'" La Rocca said.

At CES, the companies showed that IDA can understand natural speech, but it wasn't a perfect score. During an on-stage demo, the car misunderstood the cheeky "Who makes the best cars?" as "Who makes the best cases?" and returned a list of places to buy protection for a smartphone.

IDA is limited by legal problems, as well, particularly when it comes to how the AI responds to location-based questions. Asking "What's the weather here?" will work, for example, but maybe not "What's that castle on my left?"

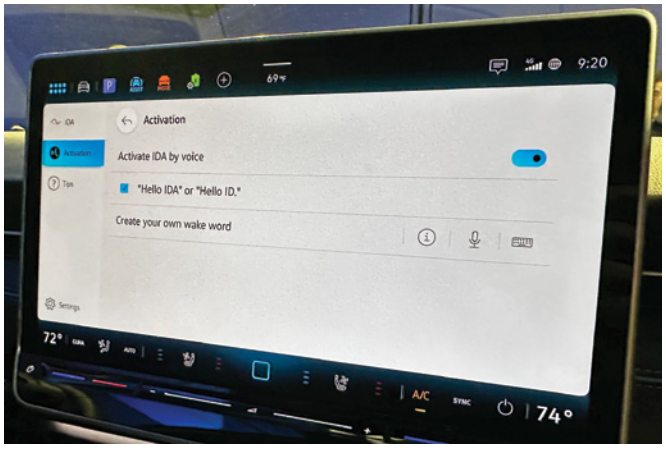
VW used an ID.7 as the demo vehicle for IDA at CES 2024.

VW's IDA chatbot can speak answers to questions about local landmarks, but only in some circumstances.

The reason lies in privacy rules. For weather data, for example, VW and Cerence have an agreement so the car can share its location with Cerence, which then finds out if it's raining or not. But VW and Cerence can't give ChatGPT this location information so it can then determine where "here" is to identify the castle.

"Today, due to legal reasons we are not allowed to forward the position of the customer to ChatGPT," VW's head of innovation and system architecture, Axel Heinrich, told SAE Media. "But if you're asking, 'Hey, IDA, I have reached Hamburg, and I have two more hours before my next appointment. Can you give me a recommendation?' You will get the answer because you have included Hamburg as a destination question."

IDA has four built-in privacy levels that an owner can select, ranging from zero personal data to the most open, which shares location, destination and some anonymized details. But even if the driver gives consent to use localization data,



VW's IDA chatbot uses ChatGPT to understand some spoken commands that the previous system could not parse. By default, it responds to "Hello Ida" or Hello ID."

ALL IMAGES: SEBASTIAN BLANCO

not all of that data can be sent to all of Cerence's connected services.

"We're not allowed to give all the geo data to some other database outside the car," Maik Rohde, VW's head of connected infotainment development, told SAE Media.

Finding alternative routes

To get IDA to respond when drivers use positioning words like "here" or "on my left" or "behind me," VW and Cerence designed the system to provide a list of nearby points of interest. Karim Amor, function owner of IDA at VW, told SAE Media that finding alternative ways to get IDA to respond correctly shows how privacy concerns and technological advances can co-exist.

"From where I stand, we have not hit any hard boundary that hinders us from implementing any use cases that customers really need," he told SAE Media. "Currently, we are seeing so many opportunities with LLMs now being available that don't require any additional personal information in the cloud, and that will definitely be the next thing."

That "next thing" is likely to be ways to make ever-more-complicated cars easier to use, so you can just ask to connect your smartphone via Bluetooth instead of hunting through multiple menu pages.

"What customers really like is some kind of help with functionality, like the car manual," Amor said. "That will probably be the next step with integrating the LLMs because that's something we see where there is a real customer need and it doesn't imply any personal information."

La Rocca said Cerence has data to back this up.

"The UI of the system is becoming more and more complex, with more functionalities and menus that you need to navigate," she said. "Being able to reach what you need via voice is going to make it much easier to interact with the system. We're also seeing that the more complex HMIs are becoming, the more we see an increase in the usage of the voice interface."

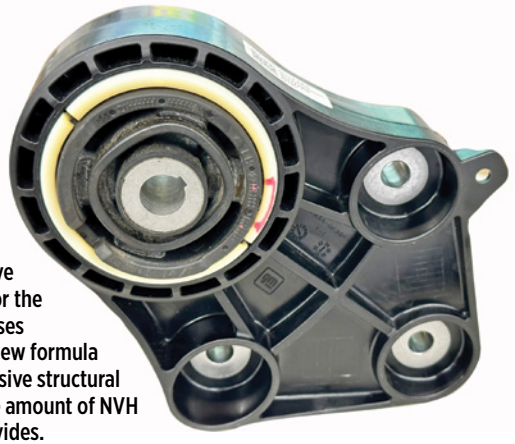
IDA's voice interface isn't as bad at answering "Who makes the best cars?" as the press conference in the basement of a Las Vegas hotel suggested. During a later product demo held outside in a cold Nevada afternoon, Ida's smart arbitration mechanism correctly heard the question and routed it through its approved list of behaviors.

"As an in-car voice assistant for Volkswagen, I might be a bit biased," IDA said. "But in my opinion, Volkswagen makes amazing cars."

Sebastian Blanco

NVH

NVH-fighting plastic EV motor mount wins lightweighting award



The electric drive motor mount for the Cadillac Lyriq uses Zytel PA 66, a new formula that has impressive structural strength for the amount of NVH damping it provides.

Celanese Global Marketing Manager Gabriel Knee said the winning EV motor mount has as much lifetime structural integrity as a metal version but dampens the high-frequency vibrations that are problematic in electric motors

Most motor mounts, even for EV applications, are made of metal alloys. It makes intuitive sense: It's a vibration-intensive mounting application that demands durability that matches the life of the vehicle itself. But there is another way. Now, a composite nylon-based motor mount on the **Cadillac** Lyriq has won the **Society for Automotive Analysts**' Innovation in Lightweighting Award.

The mount is a collaboration between GM, anti-vibration parts maker DN Automotive and chemical company Celanese. It is made with Zytel PA NVH Gen 2, a new polyamide (PA 66). The results not only showed up in development data, but in the end product, which has reviewers raving about how quiet the Lyriq's cabin is — "crypt quiet," according to *Automotive News*.

Gabriel Knee, global marketing manager of engineered materials for **Celanese**, said that almost all discussions at his company talk about using "the right material for the right location and the right application. He still had a sense of wonder when he summarized the part again. "This is, you know, a plastic mount that's being used on the main drive motor of the Lyriq. So when you think of the electric motor, and the amount of torque that goes through that, it's a pretty phenomenal amount of mechanical strength that's required there."

Knee said that mount is made from the polymer, which is filled 35% with glass, and not only saves 30% of the weight of an alternative standard metal motor mount, but it also eliminates the need for several other components (primary mass dampers) in the vehicle. This also reduces costs. And, of course, it offers the mechanical strength to last through the end of the vehicle's life. Knee said improvements were the key to Cadillac's adoption of the part. "One thing I did not realize was within the electric vehicle, you're dealing with much higher frequency noises and, to damp those high frequency noises, it turns out that this material is ideal," he said.

Lindsay Brooke, former editor of *Automotive Engineering* and one of three judges for the competition, lauded the partnership's work on the mount. "Celanese and Cadillac engineers have brought an elegantly simple solution to the multiple challenges of EV lightweighting, NVH abatement and cost reduction," he said. "Zytel PA66 is once again the workhorse material for this vehicle application, proving its ever-widening scope."

Dave Andrea, a supplier-relations partner at **Plante Moran** and a judge, said the primary factors the judges considered were

- Technical complexity. "Was it a reuse of an existing material or existing process? They just found it a new home? Or was it truly something innovative?"
- Total savings of the product. Just saying lightweighting wasn't enough, Andrea said: "We had some entries that came close to a 40 percent cost reduction."
- Overall parts reduction.
- Scalability.
- Serviceability. For instance, a gigacasting solves complexity, but can it be serviced?

Abhay Vadhavkar, a retired engineering director now consulting for **Envorso**, was the third judge on the panel.

Another Celanese project won an honorable mention: a Zytel-based air-conditioning compressor bracket being used on the **Ford** Mustang Mach-E. Other innovations earning honorable mention were:

- **Meridian** Lightweight Technologies | Ford Mustang Shelby GT500 Magnesium Strut Tower
- **Teijin Automotive Technologies** | Hexacore Class A Body Panel process
- **IRMCO** | New sustainable lubricant
- **Mubea CarboTech** | Composite underbody protection system
- **eLeapPower** | Integration of EV charging and powertrain components
- **Plasma Bound** | CPA surface preparation technology
- **Bocar** | Toyota Tunda rear-end post

Chris Clonts

BOTH IMAGES: SAE/CHRIS CLONTS

PROPULSION

Hyundai's Uni Wheel creates space for EV powertrains

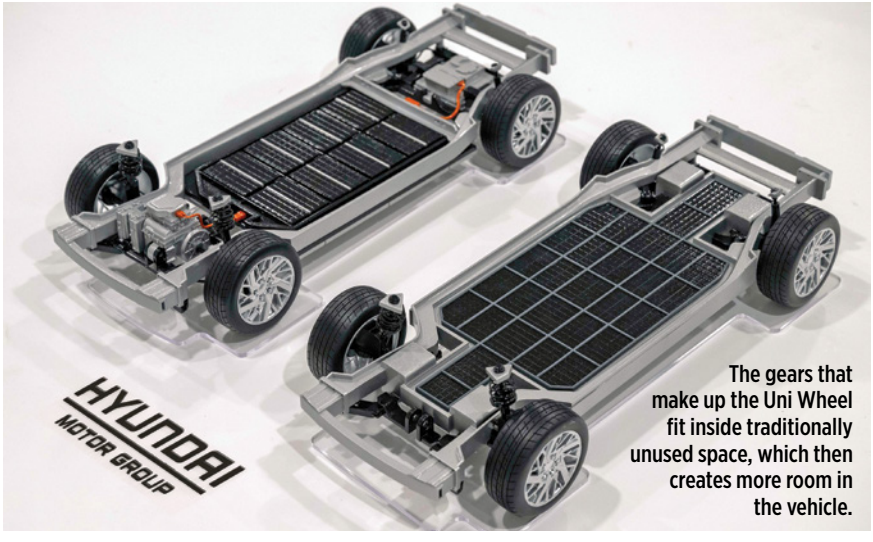
Hyundai Motor Group's visual design team has been on a roll in creating unusual and attractive passenger vehicles. Now, the automaker's engineering team has come up with its own unique creation: the Universal Wheel Drive System.

The Uni Wheel is a significant development for both **Hyundai Motor Company** and the **Kia Corporation**, which jointly unveiled the device at a "Uni Wheel Tech Day" in Seoul, South Korea, in November. The Uni Wheel is not a hub motor, but it does move some of the main drive system components to the available room inside the wheel hub.

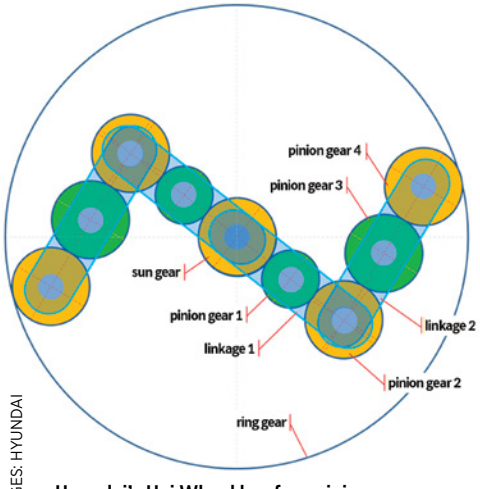
Hyundai calls the Uni Wheel a "functionally integrated wheel drive system." The Uni Wheel has a newly designed planetary gear configuration made up of a central sun gear and four surrounding pinion gears. These all sit inside a ring gear that makes up the outside of the Uni Wheel and then rotates the tire. The pinion gears are arranged so that, with their multi-link connections, they enable "Uni Wheel's multi-axis movement to allow a wide range of suspension articulation," the company said.

The Uni Wheel also does away with traditional CV joints to transfer power from the motor to the wheel at a constant speed. CVs themselves found a home in EVs because they have long been used with ICE powertrains, but Hyundai wanted to use some of the space near the wheels for other components. To do this, engineers put small, individual motors near each wheel and moved the reduction gear to inside the wheel hub. They also reduced the length of the drive shafts.

Hyundai's Uni Wheel has four pinion gears on each side of a sun gear, with multi-link connections between each.



The gears that make up the Uni Wheel fit inside traditionally unused space, which then creates more room in the vehicle.



Hyundai's Uni Wheel has four pinion gears on each side of a sun gear, with multi-link connections between each.

ALL IMAGES: HYUNDAI

One of the reasons Hyundai wanted to invent the Uni Wheel was to create more room in an EV's interior, either for powertrain components, more cargo space or a larger flat-floor configuration. The space benefits are real, but many questions remain about the Uni Wheel's durability, effects on unsprung weight, issues with heat dissipation and potential repair costs.

A Hyundai spokesperson told SAE Media that it's too early to discuss these aspects in detail but said that price competitiveness is not one of the ways the Uni Wheel will distinguish itself. "If the Uni Wheel is applied to replace the CV joint and the reducer that make up the existing system, there will be no significant difference in cost," the spokesperson said.

Hyundai Motor and Kia have applied for or registered eight patents related to Uni Wheel globally, including in South Korea, the U.S. and Europe.

Sebastian Blanco

Lucid Unveils Gravity Electric SUV with more than 440 miles of range

The Gravity rear hatch opens wide like the Lucid Air for large items.

Lucid CEO Peter Rawlinson's focus on efficiency permeates the automotive startup. The boss doubles as the company's CTO. That close connection to vehicles coming out of the Newark, California HQ is likely closer than that of the average automotive CEO.

Rawlinson's obsession with efficiency has paid off with the unveiling of the company's second vehicle, the all-electric Gravity SUV. With a targeted range of more than 440 miles (708 km) from a three-row SUV, the EV startup is putting other automakers on notice.

During a presentation at Lucid's HQ ahead of the Los Angeles Auto Show, Derek Jenkins, senior vice president of design and brand, told SAE Media, "there's still an opportunity to optimize what an SUV is and can do."

A luxury power

The automaker is eking nearly 450 miles (724 km) out of a battery pack with a capacity that, according to a Lucid spokesperson, is likely slightly higher than the 118 kWh found in the higher-trim levels of the company's Air sedan. Lucid has not shared an official capacity number, but based on that rough estimate, the company is targeting an efficiency rate of roughly 3.7 miles (5.9 km) per kWh. For comparison, the **Rivian** R1S electric SUV rolling with a 149 kWh pack has 400 miles (644 km) of range, which works out to 2.68 miles (4.3 km) per kWh.

To help it achieve those range numbers from a pack smaller than those seen in three-row models from GM and Rivian, the automaker aimed for a drag coefficient of less than 0.24. It helps that the design essentially is a Lucid Air stretched up and out, and the Air is already a slippery vehicle.

Like the Air, the Gravity is built on a 900-volt electrical architecture that Lucid said supports DC fast-charging that should add approximately 200 miles (322 km) of range in about 15 minutes at a suitable charging station. Lucid didn't share the exact charge rate, but based on data from the Lucid Air, that should be about 250 kW.

Performance-wise, Lucid said the Gravity will do 0-to-60 mph (0-to-97 km/h) in 3.5 seconds from its dual-motor setup and has a payload capacity of 1,500 lb (680 kg) and can tow up to 6,000 lb (2722 kg).

The Lucid Gravity offers three-row space in an efficient package.

BOTH IMAGES: ROBERTO BALDWIN

Revamped interior tech

Sitting behind the wheel is where drivers will see huge differences between the Air and Gravity. Gone is the portrait-mode touchscreen, replaced with a single 34-inch (864-mm) OLED display that stretches from the driver's A-pillar to the center screen, which now has a landscape orientation. The lower screen is still available and Lucid has finally implemented multi-tasking between the screens. On the Air, even with both screens, one could not have the navigation and media player on the screens at the same time. That capability is available in the Gravity thanks in part to a new chipset that Lucid would not comment on.

Lucid has moved the display above the steering wheel to be higher in the driver's sightline; the automaker wanted to offer unobstructed views of the dash cluster and the rest of the display. To achieve this, the steering wheel underwent a design change. The top and bottom of the wheel have been squared off in a happy medium between a traditional steering wheel and a yoke.

Jenkins told SAE Media that engineers went through 30 iterations of the steering wheel before they felt they got it right. Sitting in the driver's seat, the steering wheel and its position felt correct without the compromises that come with outfitting a cabin with a yoke. A better understanding of its use in the real world will come when media is first able to drive the Gravity.

On the steering wheel are two touch controllers that have taken a cue from an Apple TV remote. Thumb movements select items on the infotainment screen and adjust display elements in the dash cluster.

Lucid is also using that huge OLED screen to offer up 'relaxation modes' for use while sitting and waiting for a charge. For those less about yoga and meditation and more about singing and games, a karaoke feature will be available. "We're specifically looking at gaming opportunities that are unique to this display layout," Jenkins said.

Bring the Family

The three-row Gravity seats seven with a third row that will accommodate someone six-feet tall — but not for long trips. The second row can slide to accommodate larger third-row passengers, but comfort back there is more related to headroom. The second row is equipped with convenience tables that fold down from the front seats, similar to those found on an airplane.

Lucid has updated its interior technology with a larger display and more processing power.

There is room for medium-sized suitcases behind the third row and there's additional storage under the removable floor. The rear seats fold down into that underfloor area. Folding the second row results in a flat cargo area from the trunk to the front seats. According to Lucid, that expanse is 7.5 feet (2.3m) long and offers up to 112 cu ft (3.2 cu m) of cargo space, more than enough for bikes, surfboards, skis and most trips to the local lumber yard.

"It's just more usable, more utilitarian with fewer compromises," Eric Bach, Lucid's senior vice president of product and chief engineer, told SAE Media while showing off the vehicle's storage capabilities.

Elsewhere, the center console's sliding storage area components replace the behind-the-screen storage area of the Lucid Air. Yes, it was cool, but this seems to be used more often without the need to have an entire screen recess into the dash. The Gravity's oddest use of space, though, is found up front. Lucid showed SAE Media the SUV's large frunk with an optional seating package. A soft seat cover is draped over the frunk's interior to allow for, well, if not tailgating, perhaps frontgating? Trying the seat found it comfortable; the raised hood is high enough that even those more than six feet tall don't have to concern themselves with hitting their heads.

As for actual cargo area under the hood of the Gravity, Lucid told SAE Media that it's close to the 10 cu ft (0.3 cu m) of space available in the Air sedan. An official number wasn't yet available.

All of this is in a package that seats up to seven, has all-wheel drive and — in a first for Lucid — can be equipped with rear-wheel steering. Lucid didn't share the amount of rear-wheel pivot. Like other vehicles equipped with the feature, it should increase the Gravity's nimbleness in tight areas and give the impression that the vehicle is smaller than it is.

Roberto Baldwin

LUCID

Regardless of powertrain, 2024 Hyundai Kona benefits from EV-first design plan

The 2024 Hyundai Kona will be available with both an all-electric or a gasoline powertrain.

As **Hyundai** was starting design work on the new 2024 Kona in March 2020, the company decided to focus on making the youth-oriented SUV's design work for the EV version first, with the idea that, later on, the ICE and hybrid powertrains could be adapted to fit.

"Normally, you look at ICE and you have an EV version," said Kevin Kang, senior design manager for Hyundai Design North America. "The EV design is kind of an afterthought, but for the Kona, we decided to design it first as an EV model, and that really let us break free from the norm."

Designing a vehicle around an electric drivetrain while keeping in mind room for ICE components resulted in two main areas of improvement, Kang said: better aerodynamics and more interior space. The result is a more cohesive front end, with a right-sized grille and an overall aerodynamic and efficient shape.

Kang said his design team took input from the engineers to define the height of the suspension shock towers to ensure that the hood was low and sleek, for example, and to determine the minimal possible size for the grille.

"When you design an internal-combustion SUV, for example, one of the typical things you do is actually exaggerate the height of the hood," he said. "I mean, even if there's nothing in there, you want to make sure that it looks really brutal and almost very masculine. But we wanted to go the other way. Because we went in the EV-first direction, both EV and ICE are able to benefit from a basically lower drag coefficient" of 0.30, compared to the previous model's 0.32.

"We were kind of happy to find out that ICE vehicles don' need a big grille," he said. "Believe it or not, internal-combustion engines and EVs actually share a lot of things that go in front of the hood."

The ICE-powered 2024 Kona will use one of two engines in the U.S. The base model has a 2.0-L Atkinson-cycle 4-cyl. that produces an estimated 147 hp and 132 lb-ft (179 Nm). The more powerful option in the N Line and Limited trims is a 1.6-L direct-injected, turbocharged 4-cyl. that produces an estimated 190 hp and 195 lb-ft (264 Nm). The Kona Electric's motors produce either 99 kW (133 hp) and 188 lb-ft (255 Nm) in the shorter-range model with a 48.6-kWh battery or 150 kW (201 hp) and 188 lb-ft In the extended version with a 64.8-kWh battery.

The EV-first design also resulted in more interior cargo space, Kang said. Since EVs can have a completely flat floor, the design team asked the powertrain engineers if they could optimize the transmission tunnel for height. That meant playing around with the size of the battery pack, the thickness of the carpet and the sheet metal beneath.

"When you look at a big, all-wheel drive vehicle, there's almost no console storage because the tunnel is so high because all of the drivetrain is in there," he said. "But for this car, we're able to push that down and optimize the console storage so that it conveys a sense that it's more airy."

Sebastian Blanco

The center console of the 2024 Hyundai Kona provides more storage due to the SUV's EV-first design brief.

BOTH IMAGES: HYUNDAI

EXPERT Insight

TE Connectivity advancing the technology of EV battery wiring, connectors

As the transportation sector transitions to increasing degrees of propulsion-system electrification, there's expanding emphasis on efficiently and effectively managing onboard low- and high-voltage electrical systems. TE Connectivity has supplied electrical components for internal combustion-powered vehicles for 75 years and now leverages its focus on reliability and durability to help automakers in the electrification era. For this Expert Insight interview, SAE's Automotive Engineering *spoke with Boris Ketscher, TE Connectivity's global product strategy manager for Battery Solutions-Automotive, for insights on EV battery module-to-module and cell-to-cell connection.*

***Automotive Engineering:* Has designing and manufacturing connectors for battery management systems affected how you approach LV214 and USCAR standards?**
Ketscher: LV214 and USCAR require reliable low-voltage components so that battery temperature and voltage levels are ensured for lifetime. Our target is to fulfill these requirements by 100%, but we don't see big changes from these standards regarding the signal connections for battery-management systems.

Boris Ketscher, global product strategy manager for Battery Solutions-Automotive, TE Connectivity

***Automotive Engineering:* Do aspects of integrating low-voltage connectors into high-voltage systems require you to develop new products or design approaches, or adapt new materials?**
Ketscher: We need to separate the metal part and the plastic part of the connection systems. The metal parts are the terminals plugged into the connectors that send voltage inside the plastic part. For metal parts, it doesn't matter if we work with low-voltage or high-voltage. It's more important to consider the air and creepage distance in the plastic parts and requirements like finger protection and pollution degrees. The metal part is not important for signal connections but is important for the voltage level. Above 60 volts, we focus on air-creepage distances and finger protection. For PC boards, we have a deviation between the high-voltage part and low-voltage part.

***Automotive Engineering:* Has TE Connectivity created specific product lines to address footprint and flexibility requirements for an ever-expanding range of battery pack and battery-management system configurations?**
Ketscher: We have both. We can handle a lot of products used in first-generation and next-generation batteries with our NanoMQS portfolio. The connector system and its surrounding plastic are linked to the requirements, especially air and creepage distances. Standard connectors have a pitch of 1.8 millimeters, which we increase for some applications. Part two of our portfolio, for MEB batteries, is the PicoMQS terminal system, which has a very short terminal connection to allow a lower-height battery box and fit everything in a smaller space. We're getting more requests for flat-foil cables for next-generation battery requirements.

***Automotive Engineering:* What are the benefits of using an FFC or FPC connection instead of a round-wire connection?**

Which terminal-connector system technologies for FFC and FPC are available?
Ketscher: Our FFC systems are based on the Nano and PicoMQS portfolio. The body or contact area is the same. Where the wire terminates, there is crimping or welding area for flat cables, allowing the customer to use reliable, existing systems. Our next-generation FFC and FPC portfolio is for ease of assembly. It is much easier for automated assembly to use one flat foil in the battery rather than a connector where as many as 20 wires are coming out.

***Automotive Engineering:* What does the rapid increase in EV sales mean for the ongoing development of signal and power-connector systems? How rapidly is TE Connectivity's role in electrification evolving?**
Ketscher: TE is an essential player in electrification, driven by the fact that we have long been a major player in automotive signals, with a major share of automotive signal interfaces for 20 or 30 years. We have retained the reliability and performance of our MQS systems while reducing their size. Many OEMs discuss their next steps for new applications and battery systems. The big challenges are to find the right answers for FFC and FPC solutions that replace round wires. We need to find solid-wire termination that avoids crimping. We also see more switching from copper to aluminum in cell connectivity.

***Automotive Engineering:* What are market trends for the future of the EV battery?**
Ketscher: We will have fewer modules and more signal connections per module, because we have the same overall number of cells, or maybe more. Each cell needs a signal connection for temperature and another for voltage-level control. As we get even bigger modules, we need the same number or more connections and higher pin counts. The new standard will be 60 or more pins per connector. The next challenge regards mating forces, which appear when we add the connector on the header side. With the need for 60 or more connectors, we need to find solid solutions with different surface technologies. ■

Watch the full interview with Boris.

SDVs redefine OEM, supplier relationships and deliver new features

LG Display brought new automotive display solutions optimized for SDVs to CES 2024.

CES 2024 offers a busy look at the software-definied-vehicle future.

by Sebastian Blanco

For a technology set to define our automotive future for years to come, it's surprising that not everyone in the industry can agree on what a software-defined vehicle actually is.

It's not controversial to say that SDVs need to be able to adjust — or define — some aspect of a vehicle's performance through software. It's the outer limits of how this works that can prove challenging to define.

In early January 2024, global consulting firm **AlixPartners** released a survey of 180 senior automotive and tech executives regarding SDVs. For the survey, AlixPartners Managing Directors Mark Wakefield and Himanshu Khandelwal defined an SDV as a vehicle "whose features can be controlled and altered by modifiable software rather than hardcoded or mechanical, like safety, security, convenience, and vehicle performance. Can be upgraded over the air and enable new user experiences and personalized features after production/sale during the lifecycle."

Moritz Neukirchner, senior director of strategic product management for software-defined vehicles at **Elektrobit**, said the various SDV definitions all have one thing in common.

"There are many definitions of SDV, but there is really one end goal: to deliver value through software quickly," Neukirchner told SAE Media. This requires three key transformations, he said: decoupling of the software and hardware lifecycles, being able to deliver new value through software, and the ability to capture value.

"All three of these go hand in hand," Neukirchner said. "**Apple** would likely not be able to maintain the ecosystem of iOS apps if each were bound to a specific iPhone generation. A new iPhone today would not achieve market success if it dropped the app store, as the capability for value delivery would be missing. **Google** would have certainly not developed Android if it couldn't monetize the investment via data or the app store."

The industry is also misaligned about when SDVs might arrive. More than 70% of the respondents to the AlixPartners survey said they expect "true SDVs" to be on the market within four years. The details reveal a potential challenge, though. Breaking down the responses by company type reveals that between 60 and 66% of all automotive and tech companies expect SDVs to arrive in 3-4 years. But tech companies think things could move faster, with 31% expecting SDVs to be available for sale in 1-2 years. A quarter (25%) of auto companies expect this to be true, but only 9% of automotive Tier 1 suppliers agree. Notably, 22% of suppliers expect it to take 5-7 years for SDVs to arrive, compared to just 9% for automakers and 8% for tech companies.

In November 2023, a study by **Wind River** product line manager Brenton Murray found that 70% of new vehicles will utilize software-defined architectures by 2030. These "Full SVA" vehicles will offer "complex, continuously updateable features and fail-operational support for higher levels of autonomy," Murray said, and are the precursors to cloud-native vehicles that will arrive after 2030.

CES = SDVs

Whatever the exact definition or timeline, SDVs were front and center at CES 2024. OEMs and suppliers used the show to unveil or update a long list of SDV technologies that touch both consumer-focused features like in-vehicle personalization as well as powertrain and safety components.

Supplier **Marelli** focused on the former with its CES display, specifically the "Software-Defined Interior

LG DISPLAY

Marelli focused on the idea of the "Software-Defined Interior" at CES 2024, including a zonal architecture CCU powered by Qualcomm's Snapdragon Cockpit Platform.

MARELLI

experience." Marelli uses **Qualcomm**'s Snapdragon Cockpit Platform to run a Central Computing Unit (CCU) and up to four Zone Control Units (ZCUs). The zonal architecture replaces fixed analog interfaces with displays and content that can change over time, including with AI.

Marelli brought SDV components to CES, including an updated version of its panorama HUD with a 3D hologram virtual assistant, better driver monitoring and hidden screens. RTI showed off updates to its Connext Drive middleware communication framework that is already used by over two dozen OEMs to run zonal, ADAS and telematics architectures in their SDVs. The platform-independent Connext Drive works with AUTOSAR Classic, AUTOSAR Adaptive and ROS 2 environments and is ISO26262 ASIL-D certified.

Stradvision said its next-generation 3D Perception Network has been improved with increased deep learning and reduced post-processing code complexity. The scalable 3D Perception Network has a 30% decrease in ARM resource usage. This optimization is a boon for the SDV era, Stradvision said, because it decreases CPU usage for broader system operations while increasing the Neural Processing Unit (NPU) utilization for ADAS functions.

Sibros offered demos of its Deep Connected Platform that will power "the future of software-defined mobility," the company said. MotorTrend even hosted an SDV Innovator Awards Gala event during CES 2024.

SDVs: open-source options, new updaters and optimized screens

Open-source software in SDVs was also a topic at CES this year. Elektrobit demonstrated its EB corbos Linux — built on Ubuntu software in its demo of an Interactive framework designed to make Automotive Operating System projects less complex and more secure.

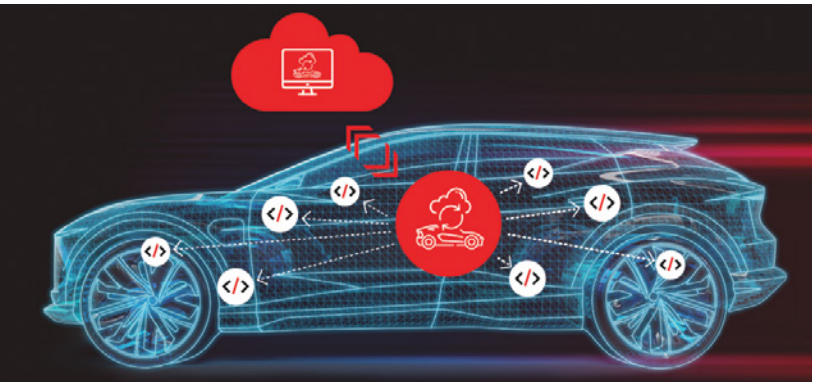
AlixPartners's SDV survey found that more than half of automakers favor using proprietary software for their SDVs for more differentiation and security, even if it costs more than open-source solutions. The survey found that tech firms and automotive Tier-1s prefer a mixed strategy that allows them to use proprietary software for an SDV's core systems.

LG Display brought its next-generation automotive displays optimized for SDVs to CES. These advanced screens were designed to cover a vehicle's dashboard and can be thin and flexible (using P-OLED technology) or more traditionally strong and unbending at a lower cost (Advanced Thin OLED). LG Display also introduced a Switchable Privacy Mode (SPM) for its screens, a technology that automatically adjusts the viewing angle so the driver can't see it when a passenger fires up a movie or video game on a screen.

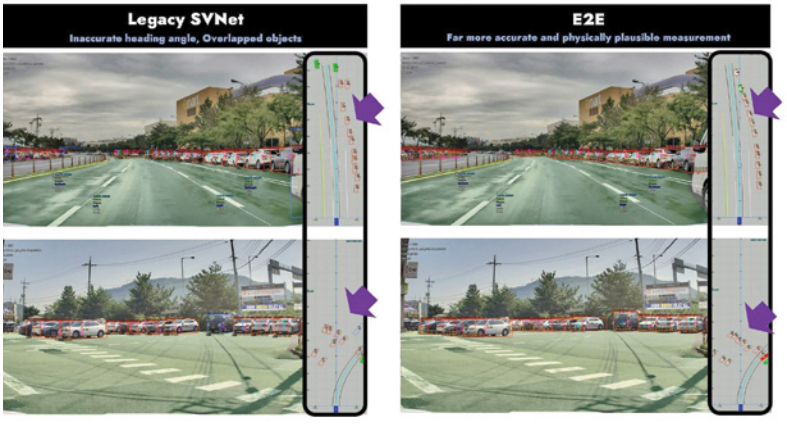
Meanwhile, **LG Electronics** used CES to demonstrate a new cross-domain platform developed in collaboration with Magna. In 2023, LG and Magna introduced a cross-domain cockpit computing system that was integrated into a single System on Chip (SoC). LG said the module supports multiple in-vehicle infotainment systems, and ADAS/AD domain integration provides a benefit to SDVs as more and more of a vehicle's electronic architecture gets consolidated.

Automotive software company **Sonatus** used CES to demonstrate ways that SDVs could change what it's like to move by car by offering

SDVs
redefine OEM, supplier relationships and deliver new features



Sonatus introduced the Sonatus Updater for SDVs at CES 2024. The Updater helps OEMs manage a variety of over-the-air (OTA) update content in one location.



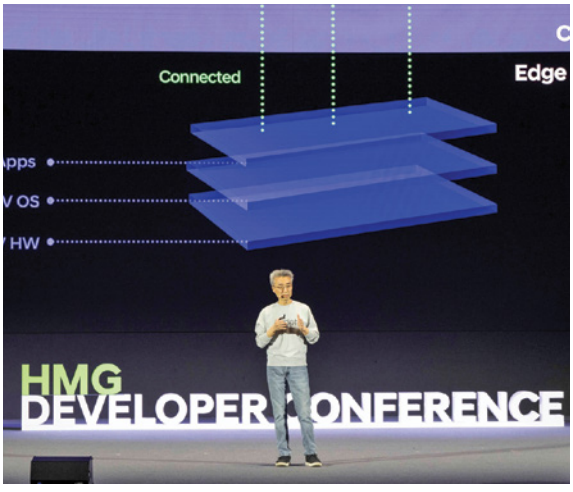
Stradvision's next-generation 3D Perception Network, on hand at CES 2024, uses 30% less ARM resource usage, a "boon for the SDV era."

benefits to individuals (more connections with smart homes) and fleet operators (e.g., automated diagnostics for predictive maintenance). Sonatus also used CES 2024 to announce the Sonatus Updater for SDVs. The Updater is a way for OEMs to manage the variety of over-the-air (OTA) update content from "a single pane of glass, with predictability and end-to-end traceability," the company said.

CES wasn't the only place for recent SDV announcements. **Hyundai Motor Group** held its third annual HMG Developer Conference in November 2023, where the president of HMG's SDV division, Chang Song, led the call for a "transformation" in SDV development. Song called SDV technology one that, "can break down time and space while providing the ultimate freedom of movement to countless people," and that future advances will require "developers with a spirit of challenge."

Software-defined relationships

One thing these SDV announcements prove is that this new technology is forcing the different cultures of Silicon Valley and the automotive industry to find ways to work together once again. AlixPartners asked about this culture clash as it relates to testing in its SDV survey and found a clear line between the two worlds.



Chang Song, president and head of Hyundai Motor Group's SDV division, speaks at HMG's developer conference in Seoul, South Korea.

"When we asked the participants, 'how do you tackle the software and hardware challenges,' the automotive folks clearly responded with, 'we are going to do sort of incremental changes the way we have been doing it,'" for safety and cost reasons, Khandelwal told SAE Media. "Technology players, on the other hand, said, 'you know, we're going to use AI and high-end tech stacks to drive the testing and integration aspects.'"

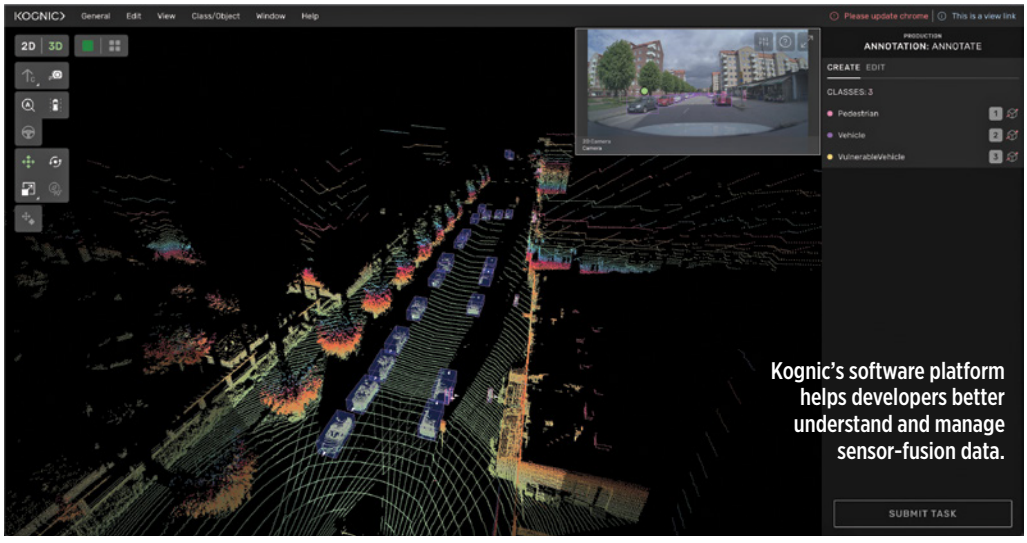
Developing SDV technologies could re-arrange these dividing lines, but in an unusual way, AlixPartners found. Almost half (46%) of the tech executives surveyed said they expect strengthening their company's SDV capabilities to be done through partnerships with tech companies. Only 38% of automotive OEM executives said they expect these partnerships to lead the way, and another large segment (29%) said collaboration with suppliers is the business model that will push SDV technology. When AlixPartners asked those Tier 1 suppliers directly how they expect to strengthen their SDV capabilities, a full 65% said it would be in partnership with the tech companies. In other words, if this survey accurately predicts the future, OEMs will indeed be working more than expected with tech companies, they'll just be doing it with Tier 1 suppliers as well.

Marelli CTO Joachim Fetzer said we can see how SDVs are already changing the automotive industry.

"Before SDVs, there was a Tier 1 system supplier, the big animals like **Bosch** or **Denso**, **Leer**, **ZF**, **TRW** and all these, and then the OEM," he told SAE Media. "This world is changing as the OEMs tell us 'we don't like the word Tier 1, we like co-creation partner.' So, the change with the software-defined vehicle is that both the former Tier 1 and the OEM now create the product by working together instead of having predefined sets of systems or component kits, which you can arrange in a certain way." ■

CLOCKWISE FROM TOP LEFT: SONATUS; HYUNDAI; STRADVISION

Tuning-up AI's 'understanding' to make safer ADAS, AVs



Kognic's software platform helps developers better understand and manage sensor-fusion data.

Kognic's advanced interpretation of sensor data helps artificial intelligence and machine learning recognize the human thing to do.

by Bill Visnic

In December 2023, **Kognic**, the Gothenburg, Sweden-based developer of a software platform to analyze and optimize the massively complex datasets behind ADAS and automated-driving systems, was in Dearborn, Michigan to accept the **Tech.AD USA** award for Sensor Perception solution of the year. The company doesn't make sensors, but one might say it makes sense of the data that comes from sensors.

Kognic, established in 2018, is well-known in the ADAS/AV software sector for its work to help developers extract better performance from and enhance the robustness of safety-critical "ground-truth" information gleaned from petabytes-upon-petabytes of sensor-fusion datasets. Kognic CEO and co-founder Daniel Langkilde espoused a path for improving artificial intelligence-reliant systems based on "programming with data instead of programming with code."

There's a broad term that is probably unfamiliar to anyone not intimate with software or artificial-intelligence development: AI alignment. It's the part of AI safety research attempting to assure that AI systems are aligned with human intent and values. Langkilde asserted in a Forbes article in fall 2023 that, "In its capacity to power self-driving cars, AI has not lived up to consumer expectations. The problem is not one of intent. The problem is there is no single way to drive."

SAE Media spoke with Langkilde about what AI alignment really means and what will be required from software to improve the safety and performance of ADAS and high-level driving automation.

What exactly is AI alignment — and is it a new thing?

Langkilde: It's a rather new term. It's a new concept for most people. In the AI community, I guess people interchangeably use 'AI safety' and 'AI alignment.' There are a few different interpretations, I suppose, because it's an emerging field, but typically AI alignment is about ensuring that the behavior of an AI system is consistent with either the preferences or goals of humans.

So as these systems become more capable, it becomes more opaque what is in fact the 'policy' by which the system operates, and that increases the importance of being able to probe that and ensure that it actually does what you intended to do. I'm an engineer. I'd love to think the world is well-behaved and easily quantified and so forth. You realize that it's not. It's ambiguous and it's subject to a lot of interpretation.

[Driving] still is a very subjective task. There are many types of negotiations between drivers and judgment calls about the viability of a path, the intention of other objects and so forth. So I think under ideal circumstances, self-driving vehicles are actually already here. I mean, Waymo works really well.

As 'outsiders,' if we look at what you're trying to do now with AI alignment, is it teaching machine learning how to learn?

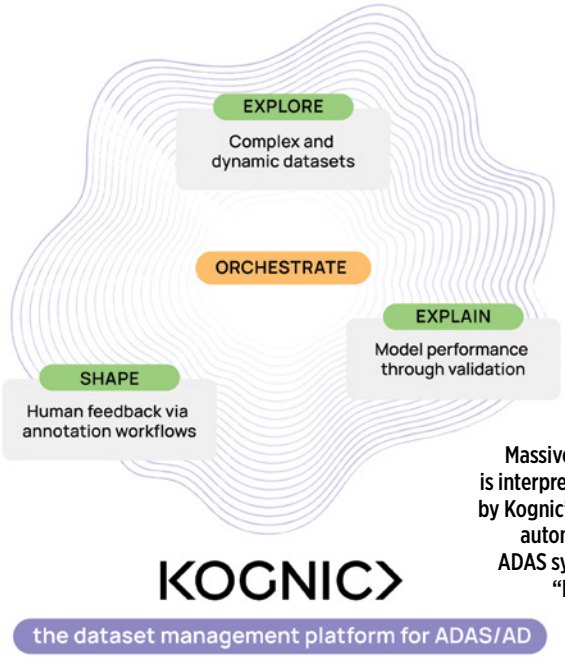
Langkilde: It needs to understand human preference. I guess I prefer to be very precise here. Typically, with today's machine learning, you put together a dataset, you select a type of neural network or something, and you train that on the entire dataset. It takes days or weeks. It uses huge amounts of GPU.

For most self-driving-car companies, and certainly almost all ADAS products, scenario interpretation is typically not based on machine learning, or at least not neural networks. It's actually because the tech stack is typically divided into three pieces. You have first a perception system that you train to understand the world around you. That is 100% machine learning today, pretty much, because that's where modern deep learning turns out to be very powerful — to understand the camera images and lidar point clouds and radar reflections, deep learning works really well.

So you put together a large dataset, you label it very carefully, and then you train a machine learning model using supervised learning. That's step number one. Step number two is that you try to predict where everything will be going; your perception system gives you a snapshot of the world, and then you try to immediately make a prediction of where everything is going to go.

KOGNIC

Kodiak Robotics commercial-truck "SensorPod" side-mirror module includes front-facing Luminar-developed lidar and a wide field-of-view camera; Kognic's software evaluates and manages massive amounts of data from such sensor-fusion systems.



Massive data information is interpreted and evaluated by Kognic's platform to help automated-driving and ADAS systems make more "human" decisions.

This has to happen very, very fast because you don't have a lot of time — you have 10 milliseconds or something to make a prediction. That's also a task that machine learning is actually pretty well-suited for, is to predict where all the trajectories are going.

The third step is the planning. You then need to figure out, based on your goals, how do you plan to navigate the scene as an agent, which is the preferred trajectory for yourself? That's the part that, as of right now, is actually fairly rule-based, or at least more traditional in its design.

As of right now, I'm fairly sure an end-to-end trained neural network that does perception prediction and planning as one big chunk wouldn't be good enough. And it appears that the leading robotaxi companies agree to that. But it's possible that a solution will overtake other options very quickly.

Either way, the designer of the system needs to carefully consider what sort of data they base their product on, because it doesn't really matter if it's end-to-end trained or if it's the three P's: perception, prediction, planning.

The 2023 Cruise robotaxi incident in San Francisco — in which a pedestrian struck by another vehicle was subsequently dragged by a Cruise robotaxi — seems like an example of lack of AI alignment, because it appears the vehicle's intelligence did not understand how to react to that situation.

Langkilde: It's fair to assume that that is not something they had ever really seen in their training and testing data. I'm pretty sure that was what you would call an edge case that they were not prepared to handle.

There's nothing magical going on inside a machine-learning system. It's a set of parameters that are fine-tuned based on a dataset to the best of the computer's ability to replicate known things. If you can't crisply define what your expected behavior is, you will suffer from unwanted events.

When we started six years ago with Kognic and we talked to the German OEMs, they basically said what is now becoming the big problem for the robotaxi companies, that they have tried on these kinds of technologies for many years, but building a working safety case has always been very difficult.

Does Kognic have competitors?

Langkilde: So, it depends a little bit. It's a big world, so it's hard to definitively claim you're unique, I guess, because there's always someone who's intersecting a little bit here and there. The things that we believe make us stand out in the global market is, first of all, the combination of safety-critical applications, mobility and shaping datasets. We are the only company that is exclusively focused on what we call 'embodied AI' and the tools required to shape such datasets.

We focus on products that have a physical manifestation and that require sensor fusion, so camera, lidar, radar, with the intention of navigating the work. So if it's a niche, we are the global leader for sure — and possibly we're maybe even the only one, actually. It makes it easier to be the leader, I guess.

FROM LEFT: KODIAK; KOGNIC

Kognic co-founder and CEO expects robotaxi specialist Waymo to expand operations.

Who are your customers?

Langkilde: Full-line customers we can publicly talk about: we are the global software platform of choice for **Bosch**, which obviously is a major tier one in the automotive community. So all of the [SAE] L2, L3 and L4 systems development that Bosch is engaged in is based on our dataset-management platform. Another example is **Qualcomm**, which actually has become a rather aggressive player in the ADAS game.

In the background of our Bosch deal [are OEMs such as] Ford and Volkswagen, who are major customers of the Bosch-developed perception systems. With Qualcomm, it's **BMW**. With **Volvo** cars, we are a direct supplier or vendor or partner or whatever they prefer we call it. We also have **Continental** and **Kodiak**. So we work with a mixture — it can either be an OEM, a tier one, or a sensor maker or an L4 player.

Where do you see the larger picture of AV development in 36 months? Is it going to be in a better place?

Langkilde: If we talk about the automation of driving as a whole — as opposed to only robotaxis — starting from the top, **Waymo** will carry on Waymo-ing and they will be just fine. They will gradually increase their operational design domain, including [Los Angeles] and maybe a few more cities. The challenge Waymo has is lowering the cost of expanding the operational design domain to a point where it's actually profitable to drive someplace. Right now, it's massively unprofitable.

Then there's **Aurora** and Kodiak. I think both will successfully do [commercial] deliveries in the next 36 months. **Cruise**, I think, will survive because they are dependent, so they can't fold. They are betting it will improve GM's access to great ADAS, which it's probably doing.

Kognic co-founder and CEO Daniel Langkilde.

I think **Ford** is going to emerge as a much stronger ADAS player than previously — because of its Latitude organization and the bet they are making to vertically integrate a lot of things. I also believe **Mercedes** is doing really well.

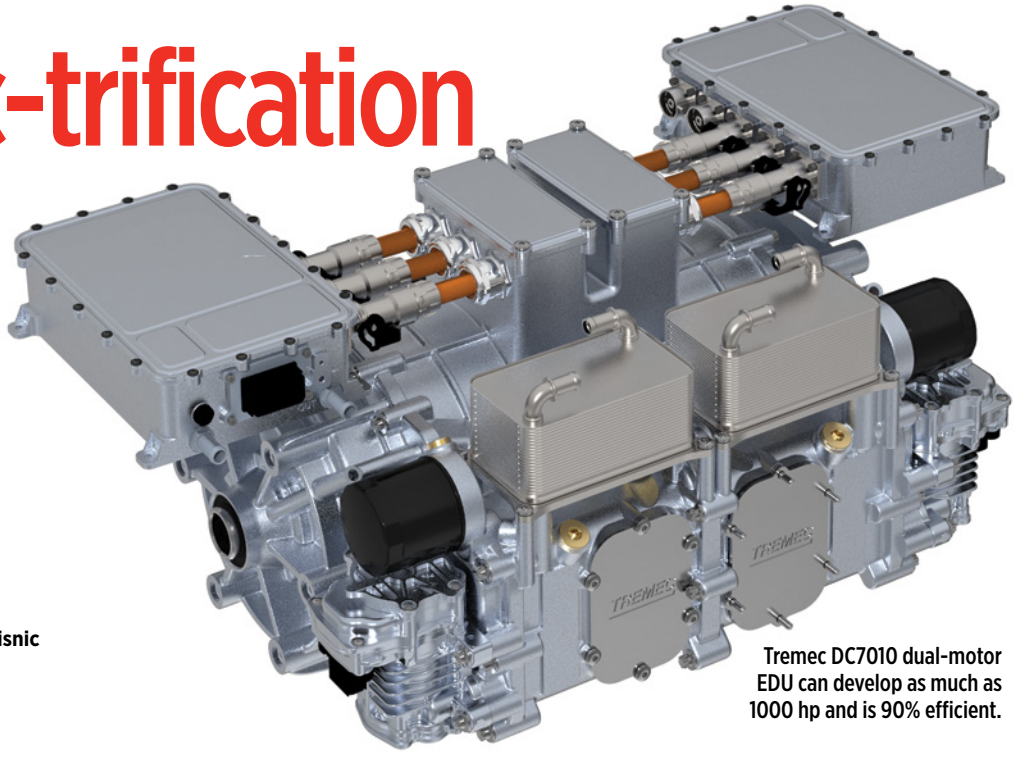
When it comes to consumer experience, I think, first of all, penetration of L2 ADAS is like 4.5% on new-vehicle sales. So for the most part, the industry will just increase penetration and hope the take rate is enough to fund further development. ■

FROM LEFT: WAYMO; KOGNIC

Tremec-trification

Tremec cranks up electric-drive innovation as the logical extension of its transmission-making expertise.

by Bill Visnic



Tremec DC7010 dual-motor EDU can develop as much as 1000 hp and is 90% efficient.

Tremec is charting a future in vehicle electrification that leverages the company's gear-manufacturing history while clearly departing from its intrinsic connection to internal combustion engine. Tremec, a transmission developer and manufacturer, was created in 1964 to build transmissions in Mexico for **Ford**, **GM** and then-**Chrysler**. Like many longstanding auto-sector suppliers, Tremec is now remaking itself to be successful in the inevitable EV transition, and the company is shaping that transformation with a strategy that reflects its unique market presence.

Industry insiders and performance enthusiasts know Tremec by its decades-long reputation in manual-transmission development and, most recently, as the supplier of the brilliant automated-manual transmissions that flavor the high-performance character of the current eighth-generation **Chevrolet** Corvette and the thundering Ford Mustang Shelby GT500, among other high-profile applications. The company produces about 300,000 light-vehicle transmissions and upwards of 80,000 commercial-vehicles transmissions a year, said Matt Memmer, Tremec's director, engineering and program management, in an interview with SAE Media in the first half of 2023. Memmer emphasized how Tremec's internal combustion-related transmission expertise is fueling its expansion into electric propulsion.

The company's palette of next-generation products includes a family of electric drive units (EDUs) that feature traction motors in single and dual configurations that operate on a single drive axle. The EDU integrates the traction motors with silicon-carbide (SiC) power electronics and the company's own gearsets.

Memmer said the initial market focus is on comparatively low-volume performance applications that could provide an easy path for an OEM to add a high-performance variant to a more workaday EV. Tremec's engineers have ensured that capability isn't an issue. Tremec displayed a dual-motor EDU featuring internal permanent-magnet (IPM) design in a 736-kW (986-hp) specification at the 2023 Specialty Equipment Market Association (SEMA) show. The 800-volt capability and SiC electronics help optimize efficiency, which in turn enhances driving range, while oil cooling enables consistent delivery of maximum power even under demanding racetrack conditions, Tremec said.

The DC 7010 dual-motor EDU weighs just 243 lb. (110 kg) and is 90% efficient on the WLTP test cycle. It produces what the company claims is a class-leading 5.25 kW per kilogram – while peak torque can be as much as 4000 Nm (2950 lb-ft) at each wheel. Maximum motor speed is 16,000 rpm and can generate vehicle speed of up to 186 mph (300 km/h) with its single-ratio epicyclic gearset.

Specialty focus

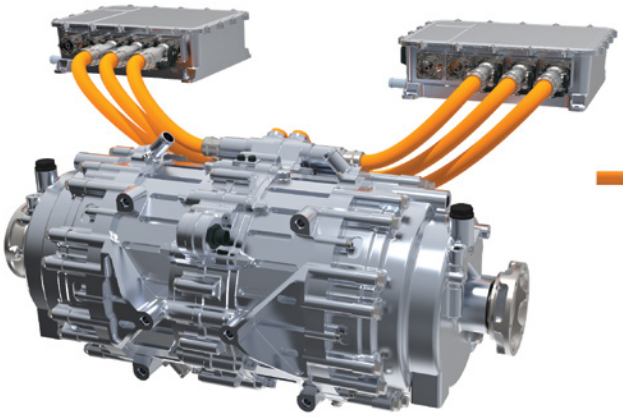
Tremec sees its EDUs and other electric-drive components as options for OEMs to augment their volume traction-motor offerings. There are also interesting aftermarket possibilities.

"Our goal is to not compete with the vertical integration of the OEMs or with the high-volume [suppliers]," Memmer asserted. "It's to participate in the more specialty segments and offer a solution that has a high level of performance in a very dense package space. One of the objectives at the OE level is to be able to offer them a solution that is a higher performance level than their vertically-integrated standard products."

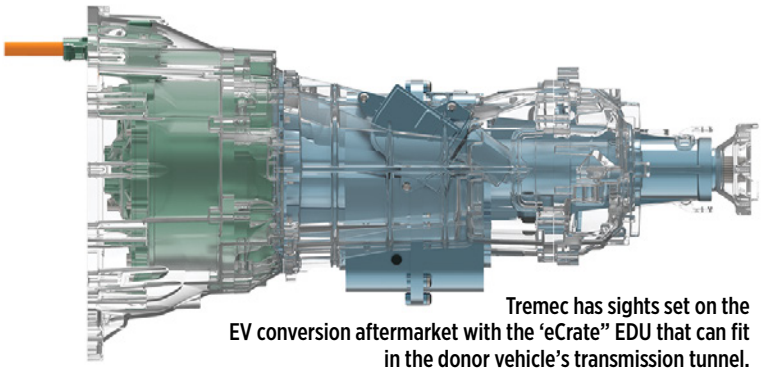
Crucially, Tremec engineers concentrated on keeping its EDUs' footprint and weight to a minimum. Memmer said its aim is to offer exceptional motor power density that packages in the same space as a "production" EV drivetrain. "They don't have to redesign the vehicle architecture, they don't have to come up with a new frame. They don't have to do much other than put [our EDU] in," Memmer explained. "Now there's more to it than now you got to make the battery and everything else. But we would like that space – that's kind of our core space as it is."

But there's more. "There's an aftermarket space that's growing very quickly with battery electric conversions," he added. "And that's a space we're already very heavily entrenched in, in the aftermarket side

TREMEC



Tremec has sights set on the EV conversion aftermarket with the 'eCrate" EDU that can fit in the donor vehicle's transmission tunnel



Tremec has sights set on the EV conversion aftermarket with the 'eCrate" EDU that can fit in the donor vehicle's transmission tunnel.

with our [existing] manual transmissions. We see a lot of opportunity to bring the same product from an OEM level into the aftermarket just like we've done on the transmission side."

Apart from its EDUs for EVs, Tremec also developed a single-motor "drop-in" EDU for conversions. The unit incorporates a permanent-magnet traction motor, SiC inverter and helical gearset that are cleverly packaged as an "eCrate" system to fit in an existing IC vehicle's transmission tunnel.

To boost the profile of its EDUs' aftermarket potential, in August 2023 Tremec acquired **Electric GT**, a developer of plug-and-play ICE-to-EV conversions. In a media release about the acquisition, Tremec said it can now, "[provide] the customer with all the components necessary for the conversion, including batteries, cabling, drive motors, inverters, gearboxes and the control systems necessary to install and operate the system safely and effectively."

Memmer said the company's aftermarket strategy offers a high-value system perspective that has significant potential. "If you're doing a classic car, if you're a builder who specializes in classic cars, you don't necessarily know how to go out and piece all these [EV conversion components] together. But if we give you a whole system – here's the batteries, here's the cabling, here's the drive unit, here's everything you need – and you do what you do well, which is fabricate and fit it into the vehicle, we'll give you all the rest. That's where I think where the market goes."

Whether for OEM fitment or the aftermarket, the company's volume targets for its EDUs are in line with its current performance-market presence. "Our targets right now are low-volume production in 2026, volume production in 2028," Memmer said. "And I think there's plenty of opportunities that align those. 'Low-volume' for us would be in the hundreds – 500 a year to a couple thousand, 2,500 a year. 'High volume' or 'volume' for us would be any individual program over 10,000 a year. Somewhere in that 10,000 to 50,000 range. When we say 'high-volume,' we're talking about tens of thousands, but not hundreds of thousands. Not that we would turn that down," he laughs.

In 2023, Tremec acquired EV conversion specialist Electric GT, maker of this EV version of the Fiat 124 Spider, among other conversion efforts.

Value-adding with technology

Memmer said Tremec has developed both IPM and surface permanent-magnet (SPM) motors, settling on PM as "the only real option for us in terms of performance level that we need and package space." He said IPM and SPM designs have tradeoffs in power density, packaging size and cost.

"On the IPM side, you have to get a little bit bigger, although they're starting to become pretty close. And they have some advantages in cost. There's a lot of technology going into how you wind the copper, to try to increase the density there. As we work with suppliers on both sides, we see there isn't a one-motor solution that works for everybody. One of the things we've tried to do is understand the options and then pick the right motor for the application. There's always cost and packaging and performance and thermals [considerations]. All of those things are trade-offs.

"So rather than just saying we're only going to do this kind of motor and that's the only thing we're going to offer," Memmer continued, "we're going to try to keep that relatively open to pick the right motor for the application. And that's something else we try to offer to the customers – we'll work with them to understand their requirements."

Tremec also takes seriously its in-house software and mechatronic-controls competency – be it for ICE-supporting dual-clutch automated-manual transmissions or EDUs. "Most of our software development is in Belgium," Memmer said. "We have calibration engineering here locally in the U.S. and we have a little bit of software in Mexico, but limited. But almost all of it is in Belgium. That's where we do all the DCT software where we're doing all the EDU development." ■

CLOCKWISE FROM TOP LEFT: TREMEC; TREMEC; TREMEC ELECTRIC GT

UPCOMING WEBINARS

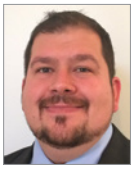
NOISE, VIBRATION, AND HARSHNESS PRIORITIES FOR EVs

Tuesday, February 20, 2024 at 12:00 pm U.S. EST

With EVs accounting for an increasing proportion of supplier and OEM product-development investment, what are the new vistas in NVH abatement? This 60-minute Webinar from the editors of *Automotive Engineering* will present evolving methods for addressing various aspects of EV NVH — and examine how ever-advancing simulation methods promise new possibilities for assessing and countering NVH issues in EVs.

Speakers:

Dave Bogema
Senior Director, VI-Grade



Rich Byczek
Global Technical Director, Intertek

Jeffrey Pruetz
NVH and Vehicle Integration Manager, FEV North America

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REVOLUTIONIZING ELECTRIC MOBILITY: ADVANCEMENTS IN PHYSICS SIMULATIONS AND CAE METHODS

Wednesday, February 21, 2024 at 2:00 pm U.S. EST

The transition to electric vehicles demands a paradigm shift, challenging manufacturers to surpass the performance of traditional combustion engine vehicles. In the aerospace sector, the rise of electric vertical take-off and landing (eVTOL) vehicles introduces a new frontier. The challenges of eVTOL design necessitate physics simulations for optimal performance. This 60-minute Webinar will explore how enhancements in physics-based simulations can bolster productivity and achieve sustainability goals.

Speaker:

Alexis Talbot
Global Head of Acoustic Business Development, Hexagon

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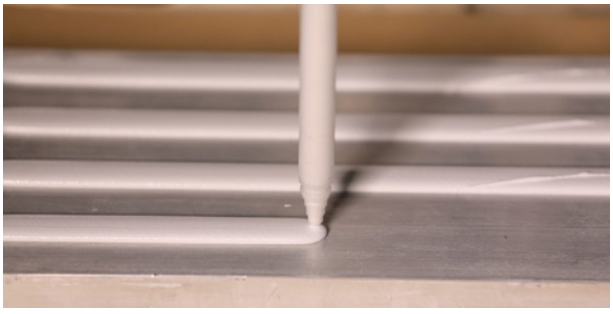
SPOTLIGHT: THERMAL MANAGEMENT

Conductive gap fillers



Parker Hannifin (Cary, North Carolina) launched three new thermally conductive gap fillers designed for EV battery systems. The CoolTherm SC-2000 RW reworkable gap filler is a soft-curing, low-density and low-abrasion silicone gap filler that reportedly offers excellent thermal conductivity. Parker Hannifin states that the CoolTherm SC-2000 RW was designed with rework in mind and maintains flexibility during battery manufacturing and end-of-life disassembly. Also announced was the CoolTherm SC-3000 LD, a low-density, two-component silicone that provides high thermal and shock resistance, and the CoolTherm UR-2000, a two-component thermally conductive urethane system that cures at room temperature and adheres to powder-coated and e-coated aluminum surfaces, such as battery boxes and cooling plates.

https://www.parker.com

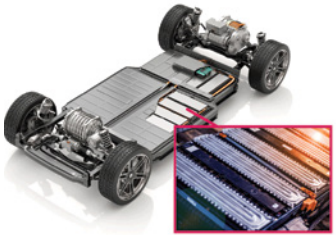
SPOTLIGHT: HVAC ELECTRONICS

High-voltage connectors

TE Connectivity (Schaffhausen, Switzerland) released its HVA HD400 high-voltage connectors that are IP68 and IP6K9K rated and have been designed to withstand transmission-level vibrations. The company states that its contact position assurance (CPA) ensures a secured contact between the female and male connector during the mating process. The HVA HD400 high-voltage connectors are rated for up to 1,000 VDC, and 60 A (at 80 deg C/176 deg F) and have an operating temperature of -40 to +140 deg C (-40 to +284 deg F). Their design reportedly allows for either 2 or 3 conductors in the same interface, handling 2.5, 4 and 6 mm^2 LV216 conductor cross-sections single-core cabling (multi-core and ISO cabling on the way).

https://www.te.com

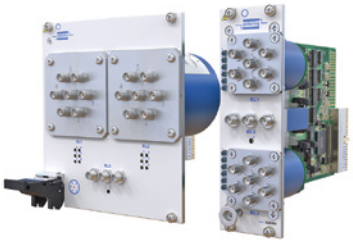
Heat-resistant plastics



Polyplastics Group (Tokyo, Japan) announced a new heat-resistant plastic for EV cooling components. Polyplastics states that general-purpose engineering plastics like polyoxymethylene (POM) or polypropylene (PP) can be used instead of metals or high-performance EV plastics. The company utilizes PP-LGF (long-glass fiber) instead of short glass fibers to increase strength, dimensional accuracy and overall performance. Polyplastics also offers DURACON bG-POM made with biomass as an eco-friendly option. The company claims that replacing high heat-resistant plastics such as PPS with POM and PP not only reduces material costs but also helps with efforts to reduce CO2 by reducing the carbon footprint of materials and energy consumption during molding.

https://www.polyplastics.com

Microwave switches



Pickering Interfaces (Essex, United Kingdom) announced a new 40/42-890 family of modular, flexible PXI/PXIe microwave switches. Pickering states that they are suitable for test environments requiring high-frequency microwave switching such as from radar, satellite and short-range land-based secure communications to consumer electronics and 5G infrastructure. The new 40/42-890 microwave switch family reportedly provides a configurable RF switching solution up to 110 GHz via the PXI platform, delivering flexibility, versatility and test system optimization. A full range of SPDT, SPnT, and transfer switch types are offered in PXI/PXIe, with terminated or unterminated ports at frequencies up to 110 GHz with options available in 50Ω or 75Ω impedance.

https://www.pickeringtest.com

H_2 direct injection

Marelli announced its hydrogen ICE direct-injection fuel system. Marelli states that the system's injectors offer reliable performance and low-noise operation with the same packaging dimensions as those used for traditional fuels. The injectors feature double actuation, a magnetic circuit to control the speed of the needle and a high static flow that can meet the requirements of a variety of different vehicles. The design also mitigates uncontrolled hits between the injector's dynamic components to reduce performance drifts. The fuel system also includes a pressure reducer with an integrated regulator to reduce hydrogen pressure to the injection's working pressure and an H2-specific manifold tested for severe-duty applications.

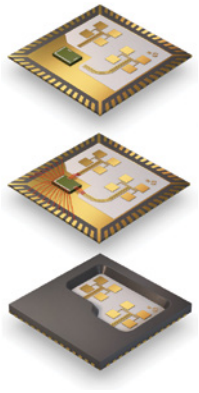
https://www.marelli.com/

AI cameras

Brigade Electronics (Portland, Indiana) launched its AI detection camera for the U.S. market. The company claims that its AI cameras have a range of improved features and offer enhanced visibility at both the front and rear of a vehicle. The cameras are compatible with all of Brigade's HD monitors and MDR digital video recorders and include Brigade's full range of connectors. The cameras recognize and alert drivers to pedestrians in a vehicle's front and rear blind spots. Detected pedestrians are shown in a colored box overlayed on the HD camera image on the driver's monitor. Image processing and detected person overlay are built into the camera.

https://brigade-electronics.com

Silicon transceivers



indie Semiconductor (Aliso Viejo, California) launched a fully integrated 240 GHz radar front-end (RFE) silicon transceiver. The TRA240091 is a cascade-able radar front-end with an operating bandwidth of up to 45 GHz at 240 GHz. These unique features enable extremely high resolution suitable for applications within the license-free 244-246 GHz ISM band and beyond. According to indie, recent safety initiatives such as European New Car Assessment Program (Euro NCAP) are driving the use of 120 GHz terahertz frequency radar for in-cabin driver and occupant monitoring due to its higher resolution. The higher frequency-enabled precision of 240 GHz radar is being leveraged for new and emerging vehicle dynamics and monitoring applications.

https://indiesemi.com/

Current sensing resistors

Littelfuse Inc. (Chicago, Illinois) announced a new current sensing resistor (CSR) family. Littelfuse states that these new CSRs offer a more cost-effective solution for measuring current within circuits, enabling voltage monitoring, control and power management of functions such as battery charging and motor speed, while also providing overcurrent protection and control of critical electronics. Each of the eight CSRs is either a metal foil, metal strip or metal plate resistor used for measuring currents in circuits due to its high precision and low resistance rating. They are available in tape-and-reel quantities of 5,000.

https://www.littelfuse.com/

Charging computers

Deutronic (Spartanburg, South Carolina) developed a new line of charging computers to supply reliable power to the 12V board net for EV or ICE vehicles. Deutronic states that the DBL 1903-14 has a 120-amp power supply and is a single-phase device with touchscreen controls. The unit is intended for original equipment production line charging applications, assembly rework areas and aftermarket dealer environments. An automatic detection feature for OEM customers determines the connection to both lead-acid and lithium-ion batteries to deliver smart and safe charging to all vehicles.

https://www.deutronic.com/

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