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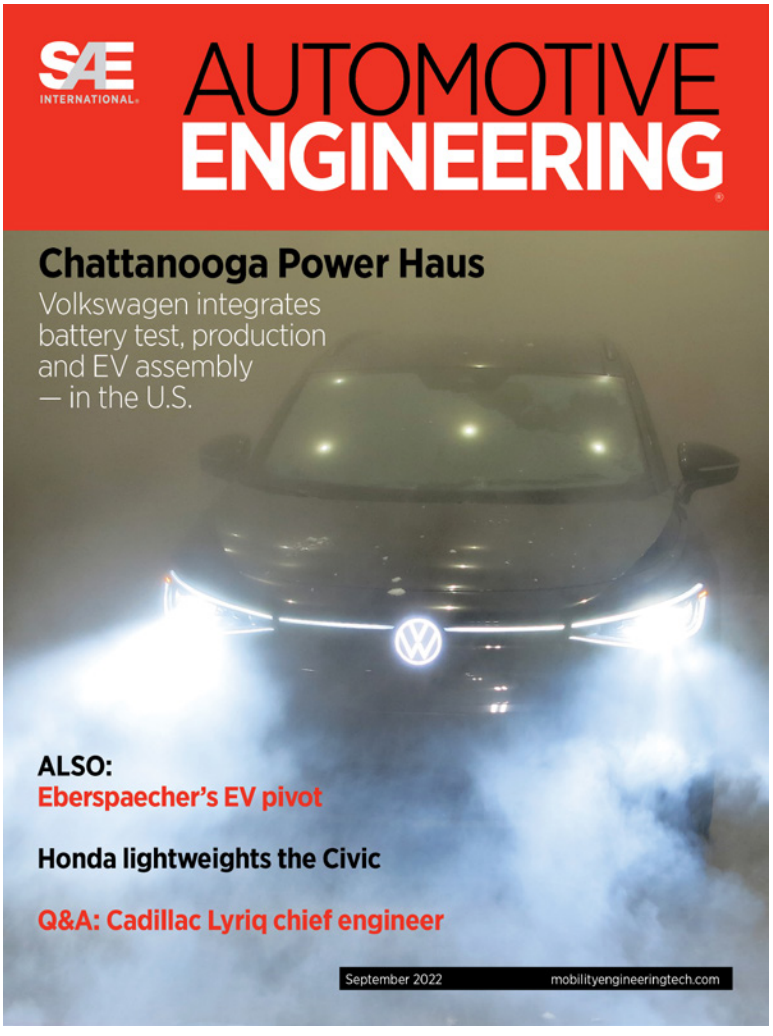

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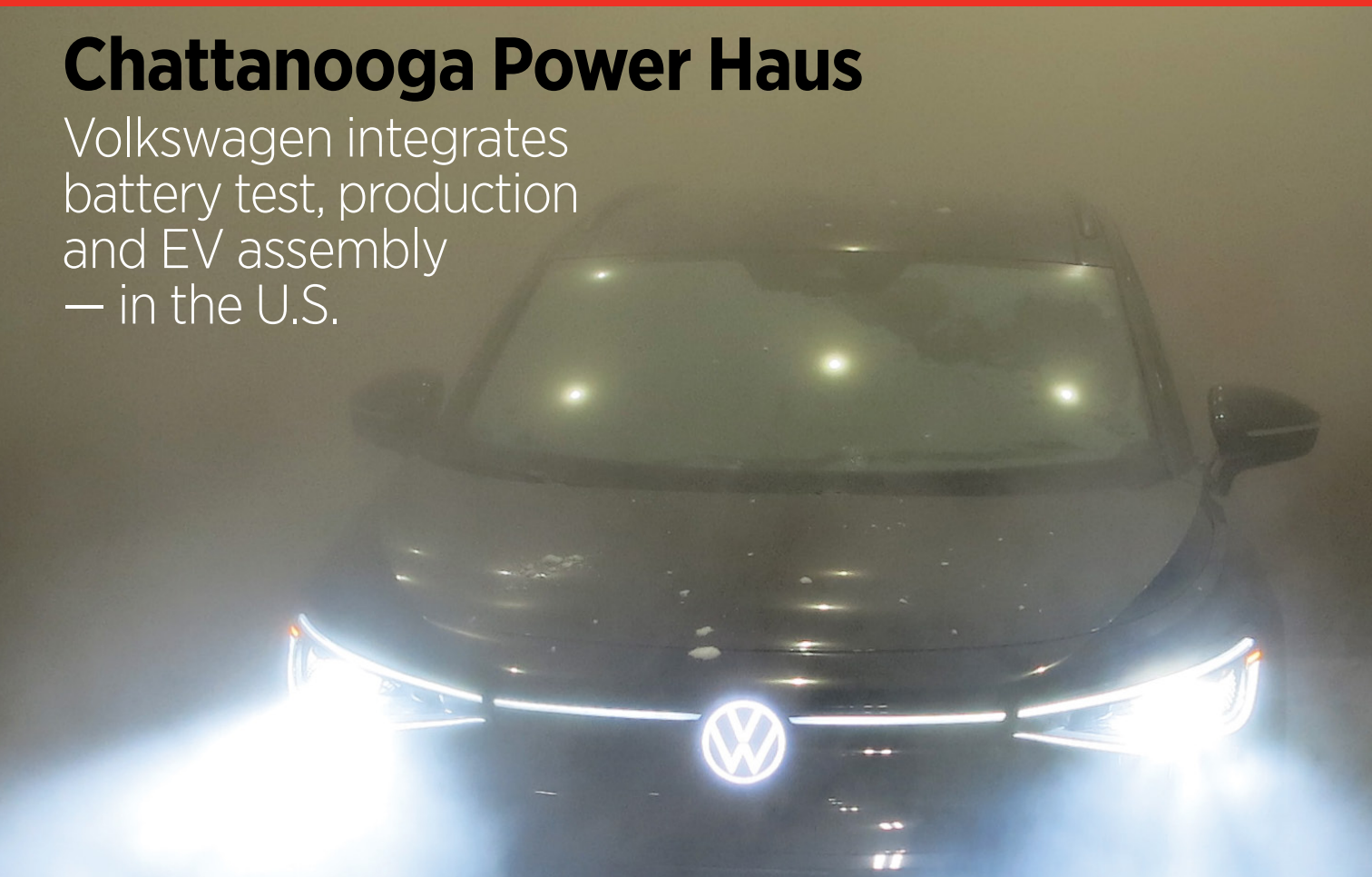

ALSO:

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ON THE COVER

Volkswagen has started output of the new ID.4 electric vehicle at the company's U.S. assembly plant in Chattanooga, Tenn., where the company also has installed an integrated manufacturing and testing footprint for the EV's lithium-ion battery packs. (Volkswagen of America)

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SAE INTERNATIONAL®

EXPERT Insight

3M, Matrix Engineering Consultants Collaborate to Enhance Performance of Chassis Bolted Joints

The vehicle electrification trend means chassis designs are evolving. The increasing number of vehicle variants on a modular architecture can present challenges of how to handle the differences in weight and loading dynamics while utilizing the same or similar carry-over chassis designs. In a new white paper, 3M and Matrix Engineering Consultants demonstrate how the shear capacity of critical bolted connections can be enhanced by using 3M™ Friction Shims. Florian Grimm, Global Technical Lead at 3M Friction Solutions, and Jon Ness, Principal Engineer at Matrix Engineering Consultants, discussed their findings with SAE's Automotive Engineering *magazine.*

***Automotive Engineering:* Why is it important for OEM design engineers to care about bolted joints?**

Jon Ness: Although they appear to be relatively simple structures, bolted joints actually play a critical role in the structural integrity and reliability of an automobile. In the automobile application, weight and costs are both critical constraints, even though the joints are highly loaded dynamically. The key to achieving high reliability in dynamically loaded shear joints is to prevent the joints from slipping under all loading conditions. So, that is why engineers need to pay attention to bolted joints.

Florian Grimm, 3M Global Technical Lead, Friction Solutions.

***Automotive Engineering:* Bolted joints in vehicles aren't uncommon. Why is your new study relevant?**

Florian Grimm: The number of vehicle variants for a model is increasing — and especially in battery electric vehicles, there are multiple models using the same chassis or 'skateboard' design. These variants can present challenges of how to handle differences in weight and loading dynamics while utilizing the same or similar carryover chassis design.

One solution can be to increase the shear capacity of the critical bolted connections. This can either be done by increasing the clamp load in the joint using a stronger bolt or increasing the friction coefficient at the joint interface; 3M™ Friction Shims are an effective way of increasing the friction coefficient with minimal impact to the design as they are very, very thin, nickel-coated steel substrates with partially embedded diamonds. When you place them between two components in a bolted connection, the diamonds bite into each surface to create a microform fit — and that leads to much higher friction within this connection.

Jon Ness, Principal Engineer at Matrix Engineering Consultants

***Automotive Engineering:* Your new white paper takes a deeper dive into the performance of shear loaded bolted joints using finite element analysis?**

Jon Ness: Yes — it is common practice to model these joints using finite element analysis, especially in situations where the load path for the joint is unclear or where perhaps the slip behavior of the joint under the load must be modeled accurately. This paper includes a case study of a typical automotive-chassis strut bolted joint, where we took the CAD model and converted it into the finite element model where the strut was loaded in shear. And we completed multiple iterations of the finite element model, where we varied bolt sizes in one case and we ran it with and without a 3M™ Friction Shim. And as expected, the analysis revealed only an incremental increase in the shear capacity due to changing the bolt size — say from M10 to M12 — but using a 3M™ Friction Shim increased a friction coefficient and order of magnitude.

***Automotive Engineering:* When do you find that that sort of increase in performance is needed — particularly in an existing design?**

Florian Grimm: Shims are proven customizable solution that have been used in a variety of different applications across the vehicle. While they have commonly been used in engine applications for over 20 years, there's even more need with electrified powertrains. As we mentioned before, cars are getting heavier due to additional batteries, and examples are chassis applications in subframe or suspension parts, steering components or e-motor and battery mounts.

The white paper detailing the collaboration between 3M and Matrix Engineering Consultants can be downloaded at 3M.com/connections. ■

Watch the full interview with Florian & Jon.

EDITORIAL

The long-range EV blues

Time waits for no one, and neither do ferry boats. I'm writing this month's column from an island 30 miles out into northern Lake Michigan, and to get my family vehicle here for our annual vacation requires reserving a space on the lake ferry six months in advance. It ain't cheap and missing the boat is not an option. So, our 290-mile (466-km) trek from home to the ferry terminal, with jam-packed minivan, is a single-shot dash at 75 mph. One 5-minute restroom break is the only stop we make.

Having ample range from a single tank of fuel is requisite for my primary-use vehicles, just as it is for the guy who was parking his Volkswagen Passat TDI Wagon at the ferry landing when I pulled in. His rig was outfitted for campin' and fishin', with a rooftop cargo pod and a single-axle trailer carrying a small utility boat and a kayak.

Seeing the TDI badge on the back of his VW, I remarked: "There are still quite a few diesel Volkswagens in use. What made you keep yours rather than turn it in to VW for cash during the Dieselgate mess?"

He gave me an "are you crazy?" look. Despite the recent diesel-fuel price spike, the TDI gets great mileage, can easily pull the fully laden boat trailer at highway speed and is super-reliable, he replied. "It's got 240 thousand miles on it and just keeps chugging along. And our Tesla Model 3 can't do this trip. We'd have to stop to charge even without the weight of our trailer and gear. Electric cars aren't yet multi-mode devices," he asserted.

Now there's an atypical Tesla owner, I thought, as we finished parking. A Model 3, a VW TDI, and an unabashed diesel fan! Of course, EV advertised range is wildly variable depending on load, ambient temperature and driving conditions. High-speed hauling and towing are an EV compromise that will challenge development teams for the foreseeable future. Engineer Dave VanderWerp, a veteran editor at *Car and Driver*, in August published a comprehensive towing test of the three electric pickup trucks currently on the market. The comparison revealed characteristics that will put off many range-focused truck buyers.

The new F-150 Lightning, Rivian R1T, and Hummer all have abundant horsepower, torque, and curb weight to pull 3-ton trailers with confidence. As towing platforms they're excellent — except when it's time to hitch up and go. "You won't want to be going far, as a full battery will take you a mere 100 miles in the Lightning, 110 miles in the R1T, and 140 miles in the Hummer," VanderWerp reported, with the Hummer's immense battery helping the 9640-lb (4372-kg) truck to eke out a few more miles when it's trailering.

High-speed hauling and towing are an EV compromise.

"Even if you're accepting of the lengthy recharging stops — which will be even longer due to the need to charge the battery further than when traveling unladen — most highway-adjacent charging doesn't allow pull-through access," VanderWerp wrote. And disconnecting a trailer — especially those with a weight-distributing hitch — every couple of hours "is a major hassle."

When EV drivers do find a charge station, the costs per kWh tend to be significantly higher — around $0.43 per kWh at Electrify America, for example — compared to my residence ($0.17/kWh) in suburban Detroit.

And more troubling news: About 20% of U.S. public charging stations fail to work when EV drivers need them, according to a new report by J.D. Power and EV data firm PlugShare. Merely deploying chargers won't be enough to convince skeptical road-tripping motorists to try an EV. At least not until the last good, pre-owned diesel is finally gone.

Lindsay Brooke, Editor-in-Chief

Almost too beautiful just for the road – lighting design with ACRYLITE®.

What does ACRYLITE® have to do with car design? For over 60 years, ACRYLITE® molding compounds have been a driving force behind the auto industry. Why? Because the multifaceted ways in which ACRYLITE® can be formed open up virtually endless possibilities for design. One shining example is crystal-clear or colored ACRYLITE® whose top light-guiding properties and color stability make for innovative automotive lighting systems. For more inspirational ACRYLITE® products, go to **www.acrylite-polymers.com** or call **1-800-225-0172.**

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SUPPLIER EYE

The battle over EV value-add has begun

As manufacturing shifts to EVs, OEMs are capturing more value for themselves.

A critical industry transition is underway that some already are viewing as an impending battle. At stake is supplier value-add share versus that of OEMs as light-vehicle propulsion formats shift from internal combustion engines to electric motor and battery power. There's nothing like a comprehensive industry transformation to shake the status quo. And OEMs sense opportunity to tip the scales in their favor.

Since the 1980s, OEMs have been working through their bills of material (BoM) to evaluate what components and systems make sense to manufacture in-house versus what is more efficient or profitable to outsource. The establishment of super-suppliers Delphi and Visteon were a direct result of their respective GM and Ford parents deciding that they would be better off on their own.

Establishing greater economies of scale through selling outside the usual OEM family helped reduce costs and advance technology for supplier and automaker. Releasing the need to fund capital requirements for 'non-strategic' sectors enabled OEMs to focus resources elsewhere. S&P Global Mobility's research shows suppliers' share of manufacturing value-add for ICE vehicles to be 60-70% of manufactured cost.

Value-add share from the supply base is a moving target. The current state of business is being driven by new process technology, labor dynamics, more efficient use of capital – and the need to protect intellectual property, mitigate risk and focus product development on what will truly differentiate tomorrow's vehicle experience. As such, over time most OEMs naturally gravitated to manufacturing only what was strategic: vehicle final assembly, Class-A stampings, engines, transmissions (sometimes) and occasionally other driveline components.

The need to establish a technology/cost edge during this BEV shift is forcing OEMs to rethink their approach to entering and navigating the BEV fray. That edge is critical: an OEM that pays $20 more per kWh for the same battery technology could have a $2,000 deficit to close for a 100-kWh battery. The stakes are serious; several OEMs already have spun off their legacy ICE-related businesses or at least significantly descoped them.

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

SAE Foundation Trustee

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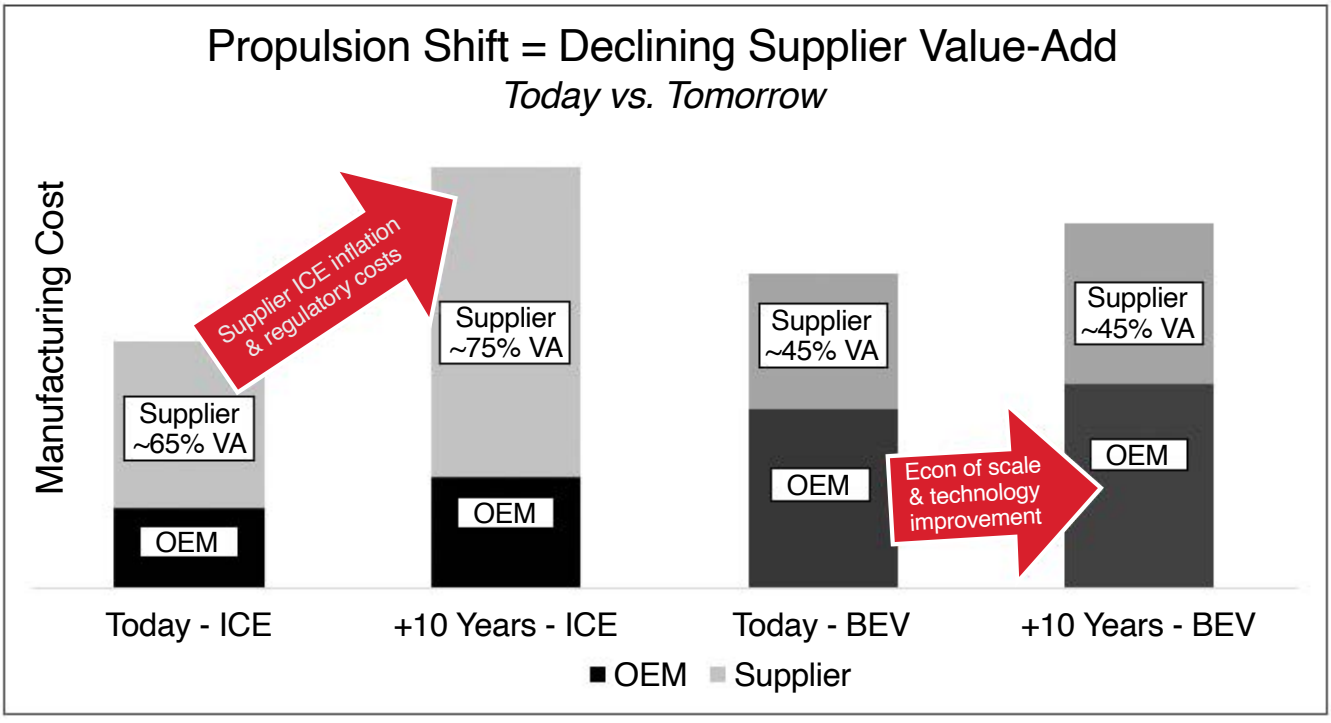
Suppliers' share of manufacturing value-add is falling well below 50% for future vehicle programs.

At the core of this shift is the myriad of joint ventures and alliances in the battery-technology space. Depending upon capacity and format, batteries represent 35-50% of BEV cost. Together with the e-drive systems that many OEMs are or will be building in-house, supplier value-add clearly is shifting into reverse. Rather than commanding up to 70% of the value-add in a current ICE vehicle, suppliers' share is falling to well less than 50% for future vehicle programs.

We have seen this story before — at least from the Detroit Three and select Europe-based OEMs. Over the years, these OEMs have had checkered success with insourcing design and manufacturing of various vehicle systems, including seating, fuel systems, cockpits and suspension modules. Often it lasted a cycle or two (5-10 years) before they would revert to outsourcing non-core activities to capable suppliers with higher scale and better technology. This time, however, the landscape is different. Global regulations are progressively boxing in the ICE, while the scale of investment in vehicle electrification is dwarfing prior efforts. The electric propulsion system, battery, charging hardware and related software are core to EV DNA and to OEM competitiveness. The industry is on a one-way path and it would take many years to change course.

Asia-based OEMs, with strong alliances to their supply bases (Japan keiretsu or Korean chaebol) will utilize those close connections to jointly delve into the BEV market. Similar to their



ICE Value-Add

- Supplier value add assumed at ~65% of total for ICE vehicles
- Lower economies of scale and sector consolidation will drive inflation for ICE-only systems in the future

BEV Value-Add

- OEMs benefit from technology and scale improvements
- OEMs control propulsion battery, software and e-drive value

Rather than commanding up to 70% of the value-add in an ICE vehicle, electrification is causing suppliers' share to fall well below 50% for future vehicle programs.

ICE experience, sharing risk where required with their OEM partners will enable these suppliers to also shift into the electrified world.

Additionally, the BEV insourcing shift allows OEMs to retain more of their employment levels and ameliorate the unions to a degree. But for suppliers, there is a real possibility of lower employment, declining revenue share within the next ecosystem, and increased sourcing risk. OEMs are being careful to avoid vertical integration of key systems which are well outside their sphere of efficient execution. These will continue to be seating, electronics, structures, thermal, chassis systems, interiors, material supply and other systems.

Supplier influence, control, and in some cases survival, are in the crosshairs.

Supplier influence, control — and in some cases, survival — are in the crosshairs during this transformation. Additionally, where a supplier resides within the OEM-supplier tiering structure may shift — forcing many to rethink their market approach and structure. In the end, the ICE-to-EV shift is more than just swapping in a battery and e-drive for an engine/transmission. Suppliers on all tiers must redefine their business strategy within the new dynamic. The OEMs already have a game plan. ■

S&P GLOBAL MOBILITY

The Inside Story on Qualcomm Technologies, Inc.

Moving toward electric and autonomous vehicles, with consumer expectations evolving rapidly — there's little question that the automotive industry is changing. Demand for unique features and new use cases in connected vehicles is prompting many automakers to redesign their electronics and digital architectures, transitioning to a software-defined vehicle that is continuously evolving. This digital transformation will create nearly endless opportunities for automakers to innovate and monetize their fleets in the future.

SAE International's *Automotive Engineering* recently spoke with Anshuman Saxena, Senior Director of Product Management at Qualcomm Technologies, Inc. (QTI) to discuss how automakers can make optimal use of new technologies that are driving change in the automotive industry.

QTI recently announced the Snapdragon® Digital Chassis™. What is it, and how does it help automakers navigate their rapidly changing industry?

A set of open and scalable cloud-connected platforms for automotive telematics and connectivity, the cockpit and advanced driver-assistance and autonomy, the Snapdragon Digital Chassis gives automakers a comprehensive and flexible digital architecture for building future vehicles. When equipped with a digital chassis and connected to the cloud, each vehicle has the potential to become a unique experience on wheels — one that can be customized and upgraded to meet the needs of individuals throughout its lifetime.

Anshuman Saxena, Senior Director of Product Management, Qualcomm Technologies, Inc.

Having a cloud-connected digital chassis sets the stage for the software-defined vehicle that is continuously learning and improving. For example, connected vehicles can have a virtual platform in the cloud simulating multiple driving scenarios simultaneously to determine the best course of action on the ground — allowing the car to learn without risk to the driver. Having the ability to upgrade and improve vehicle software over time gives consumers the flexibility to incorporate driver assistance features and digital services into vehicles at their own pace, while allowing automakers to offer highly differentiated experiences across their lineup.

The Snapdragon Ride™ Vision System was announced at CES 2022 following the three-way agreement between BMW/QTI and Arriver and then Qualcomm Incorporated completed the acquisition of Arriver in April of 2022. How does QTI see the ADAS/AD segment evolving in the next few years in the context of these developments?

While there has been a lot of talk about autonomous vehicles, it has become clear to most that fully automated vehicles are several years away. However, driver-assistance systems are becoming more commonplace and are making significant impacts on safety, comfort, and convenience. The cloud-connected Snapdragon Ride Platform can scale to accommodate various hardware and software configurations, while also supporting ongoing upgrades.

Our acquisition of Arriver furthers our ability to extend the Snapdragon Ride Vision System with their award-winning computer vision (CV) software stack. Its uniquely designed modular architecture gives automakers the flexibility to customize vehicles by incorporating features such as map crowdsourcing, driver-monitoring system (DMS), parking systems, cellular vehicle-to-everything (C-V2X) and localization technologies.

Our recent announcement to jointly develop a Drive Policy software solution with BMW demonstrates how automakers can collaborate with us to design new technology features and functionality for creating their own signature automotive experience for consumers. This comprehensive Drive Policy will cover driving maneuvers that human drivers do routinely such as highway autopilot, surface-street driving, automatic lane changes, parking and passing.

What advice would you give automakers looking to integrate new technologies into their vehicles?

Now is the time to differentiate and own the consumer experience in your vehicles. Consumer demand for next-generation vehicles and transportation solutions continues to grow, creating tremendous opportunity for innovation and monetization.

We are engaging in long-term working relationships with automakers to help drive the digital transformation of the automotive industry, empowering automakers and related companies to completely change their business models and take advantage of new opportunities and better compete in the future. Using the Snapdragon Digital Chassis and our broad technology expertise can help to ease the transition for automakers. ■

Learn more at **qualcomm.com/automotive.**

Snapdragon Digital Chassis, Snapdragon Ride, and Qualcomm AI Stack are products of Qualcomm Technologies, Inc. and/or its subsidiaries.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LIGHTWEIGHTING

Altair honors innovations in sustainability and lightweighting

Sustainable Product: 2022 Ford F-150 Lightning has an extended battery range of up to 320 miles.

Ford follows up its top prize in last year's Sustainable Product category — for the Mustang Mach-E — with another electric-vehicle winner, the 2022 F-150 Lightning. The battery-electric variant of Ford's top-selling vehicle is one of six category winners to be honored at the 10th annual **Altair** Enlighten Awards conducted in partnership with the Center for Automotive Research (CAR).

"The caliber of nominees for this year's Enlighten Award was unparalleled and is a true testament to the investments the automotive industry is making to reach — and even exceed — global sustainability targets," Richard Yen, Altair's senior VP, product and strategy, said during the awards presentation at **CAR**'s Management Briefing Seminars (MBS) in August. "As we celebrate our tenth year and have evaluated hundreds of worthy entries over the years, we have seen this award evolve from showcasing vehicle lightweighting initiatives to companies now fully embracing sustainability and the commitment to building a net-zero environment and circular economy."

Media partners for the 2022 Altair Enlighten Awards include SAE International and its *Automotive Engineering* and *Tech Briefs* publications, as well as *Automobil Industrie*. While the awards acknowledge the automotive industry's best initiatives to reduce vehicle weight and meet emissions targets, they also consider other parameters such as cost reduction, improved performance, part count reduction and applicability to other vehicle programs. The three Sustainability categories also consider progress toward a reduced carbon footprint and factors such as water/energy consumption and material reuse and recycling.

Sustainable Product

The 2022 Ford F-150 Lightning with a 131-kWh extended-range battery can travel up to 320 miles (515 km) and deliver a maximum 580 hp and 775 lb-ft (1051 Nm) — the most torque of any F-150 ever. The ability to power a home, if needed, is a bonus. The F-150 Lightning is powered by dual in-board motors and is built on an all-new high-strength steel frame that supports a maximum 2235-lb (1014-kg) payload and towing up to 10,000 lb (4536 kg).

Runner-up: **Lacks Enterprises**' weight-saving composite wheel technology is recognized in a joint **Environmental Protection Agency** (EPA) and the National Highway Traffic Safety Administration (NHTSA) report titled *Midterm Evaluation of Light-duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy (CAFE) standards for Model Years 2022-2025*. The patented wheel design allows for multiple finishes and designs on the

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FORD

same wheel "backbone," offering increased trim-level differentiation while saving costs and optimizing aerodynamics and fuel efficiency.

Sustainable Process

Nemak's Melting Center in Monterrey, Mexico, specializes in the production of aluminum-silicon alloys for the automotive industry. Nemak contributes to more sustainable manufacturing by recycling 2.5 billion aluminum cans per year. With a recycling capacity of more than 400,000 tons per year, the process decreases the amount of energy needed to extract primary aluminum by 95%, the company claims, thus eliminating 4.8 million tons of CO2 per year.

Runner-up: **ArcelorMittal** has launched the first large-scale green trial of hydrogen-based injection in a direct reduced iron (DRI) plant. Through a $10 billion investment plan, ArcelorMittal expects this milestone will propel the future large-scale supply of green steel to automotive OEMs.

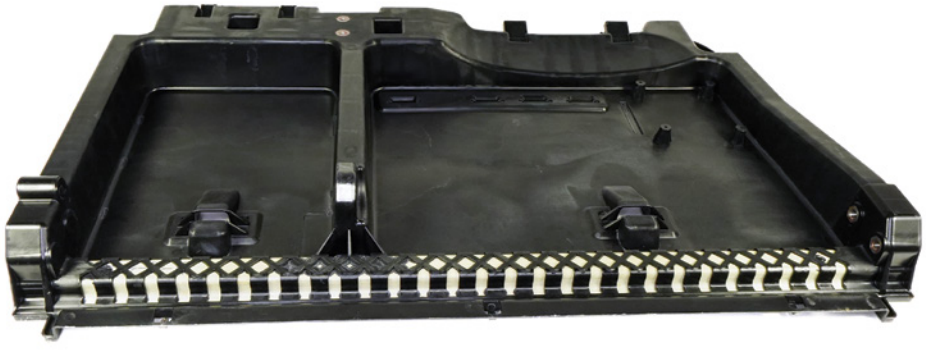
FORD

Sustainable Material: This Ford wiring harness clip is made of 100% post-consumer-recycled ocean plastic.

Sustainable Material

Ford has implemented an "industry-first application" of 100% post-consumer recycled (PCR) ocean plastic (PA6) into vehicle parts, specifically for wiring harness clips. The material for these clips is collected by workers from plastic waste in the Indian Ocean and the Arabian Sea, promoting a healthier marine environment, reducing landfill waste and energy use, and providing jobs.

Lightweighting Enabling Technology: Shiloh Industries provides Acoustic Patch Laminate for targeted noise control on General Motors vehicles.



Module Lightweighting: 2022 Toyota Tundra's second-row seat structure replaced more than 60 stamped and welded steel pieces with four composite parts.

Runner-up: **Nucor Corp**. has introduced what it claims is the world's first net-zero carbon steel produced at scale, called Econiq. Nucor says it is pioneering the reduction of a vehicle's carbon footprint without changing the design or grade selection. Currently available to automotive companies, Econiq has a "very high percentage" of recycled content.

Lightweighting Enabling Technology

Shiloh Industries provides Acoustic Patch Laminate (APL) components using targeted noise control for certain General Motors vehicles. Called ShilohCore, the patented laminate provides comparable NVH performance as a fully laminated vehicle material but can reduce the mass of damping treatments by 45% — by up to 2 kg (4.4 lb) per vehicle — lower interior noise by over 2 dB and cut total cost by 15-20%, according to Steve Lin, director of engineering for Shiloh.

"With a patch laminate, for some of the high frequencies we can go up over 10 dB noise reductions," Lin said during an MBS session. He noted that BEV transmission gear noise and electric whine noise are prevalent from 1,000 to 5,000 Hz, a range in which ShilohCore "shows excellent STL [sound transmission loss] values." APL treatment requires early design involvement, Lin added, and is not as flexible for last-minute coverage changes.

Runner-up: **Bionic Mesh Design GmbH** uses tools from the entertainment industry to redefine lightweight design for mass casting and forging through the direct transformation of topology in CAD models and an emphasis on production processes. By requiring 90% less design time than standard solid modeling processes, Bionic Mesh Design can help compress the product development cycle for automotive OEMs and suppliers.

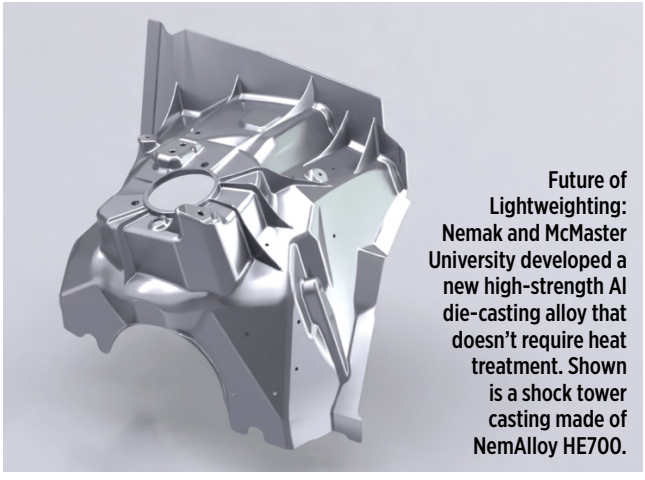
Runner-up: **Human Horizons** has incorporated high pressure die casting (HPDC) and heat-free treatment material into the manufacturing of a rear cabin, resulting in up to 20% weight reduction. The HPDC rear cabin has integrated 40 parts of the rear floor into a single part, reducing manufacturing and mold development time by one-third.

Module Lightweighting

Toyota engineers, with help from **BASF Corp**. and **L&L Products**, replaced more than 60 stamped and welded steel pieces with only four composite parts in the 2022 Toyota Tundra's second-row seat structure. This achievement results from the industry's first use of combining polyurethane pultrusion to add localized stiffness and strength where needed, in conjunction with an injection-molded engineered plastic. These changes in production resulted in 20% mass reductions and 20% cost savings compared to previous generations' steel seat structure, Vik Bhatia, group manager, engineering design chassis at Toyota Motor NA, said at MBS.

Runner-up: **Bocar Group** and Toyota co-developed a "first of its kind" visual class-A exterior structural die-cast application, for the 2022 Tundra's rear end post. Integrating multiple steel components into a single aluminum casting results in mass savings of 4.4 kg (9.7 lb) per vehicle — the equivalent to saving 78.9 kg (173.9 lb) of CO2 emissions per vehicle per year.

FROM TOP: SHILOH INDUSTRIES; TOYOTA



Future of Lightweighting: Nemak and McMaster University developed a new high-strength Al die-casting alloy that doesn't require heat treatment. Shown is a shock tower casting made of NemAlloy HE700.

NEMAK

Future of Lightweighting

Nemak and **McMaster University** partnered to develop a new high-strength aluminum die-casting alloy that doesn't require heat treatment, specifically for use in automotive body-in-white and chassis components. NemAlloy belongs to the 7000 series Al-Zn-Mg alloy family more common to aerospace than automotive, Dr. Glenn Byczynski, R&D manager, Nemak USA/Canada, said at MBS. "We needed to go back to base metallurgy and understand casting alloys more fundamentally and how we can bring new value propositions to our customers," he said.

The F-temper, or as-cast, product develops yield strength in the range of 160-170 MPa, 315 MPa ultimate strength, and elongation above 11%, "which is quite good for an as-cast component," Byczynski said. "With tweaking the chemistry slightly and adding a heat treatment, if desired, we can really push this to nearly 400-MPa ultimate tensile strength, which is quite good for aluminum alloys."

Runner-up: **Adient** has constructed ultra-thin, reinforced automotive seats made of thermoplastic elastomer panels. UltraThin seating can result in 30% overall seat-trim-outline volume reduction, 14% overall mass reduction and 10% reduction in overall seat part count compared to standard foam, trim and comfort systems.

Runner-up: **Yanfeng**'s instrument panel and passenger air bag (IP PAB) integration combines the chute and airbag module housing into one part to lower costs and create synergies in the development process. Through material substitution and weight savings of 23%, the system reduces the product's carbon footprint by 50%.

Honorable mention: **AMC**, **csi entwicklungstechnik**, **DITF** and **BMW M** collaborated to develop a biobased automotive center console. The NaMiKo-Project team combined methodical lifecycle analysis and lightweight design to develop a center console using the "NFK in 3D" filament winding process covered with circular "smart textiles" and bio-based natural fiber composites.

Ryan Gehm

ELECTRIFICATION

New chemistry aims to slash fuel-cell PGM costs by 50%

Hydrogen fuel cells are steadily proving to be a competitive zero-emissions solution for powering heavy trucks, railway locomotives and ships, as well as for and various stationary-energy applications. The cost of hydrogen fuel is coming down, with production of "green" hydrogen at parity with the price of diesel in some regions, according to recent industry reports. And production scale is playing a major role: studies by **McKinsey & Co**. and Deloitte have shown the cost delta of fuel-cell systems for trucks versus equivalent diesel powertrains to be narrowing, based on annual production volumes of 150,000 vehicles.

The cost reductions are being driven mainly by industrialization of the fuel-cell system. "Everything except the catalyst in a typical system — the bi-polar plates, the membrane material and related components — has potential for economies of scale," explained Tom Stephenson, CEO and co-founder of **Pajarito Powder**, an Albuquerque, New Mexico-based manufacturer of catalysts for use with proton-exchange membrane (PEM) and alkaline fuel cells and electrolyzers. "It's the catalyst that is 40 percent of the overall cost, because of its PGM (platinum group metals) content," he said, noting the most recent U.S. DoE projection for fuel-cell cost based on 500,000-unit volume.

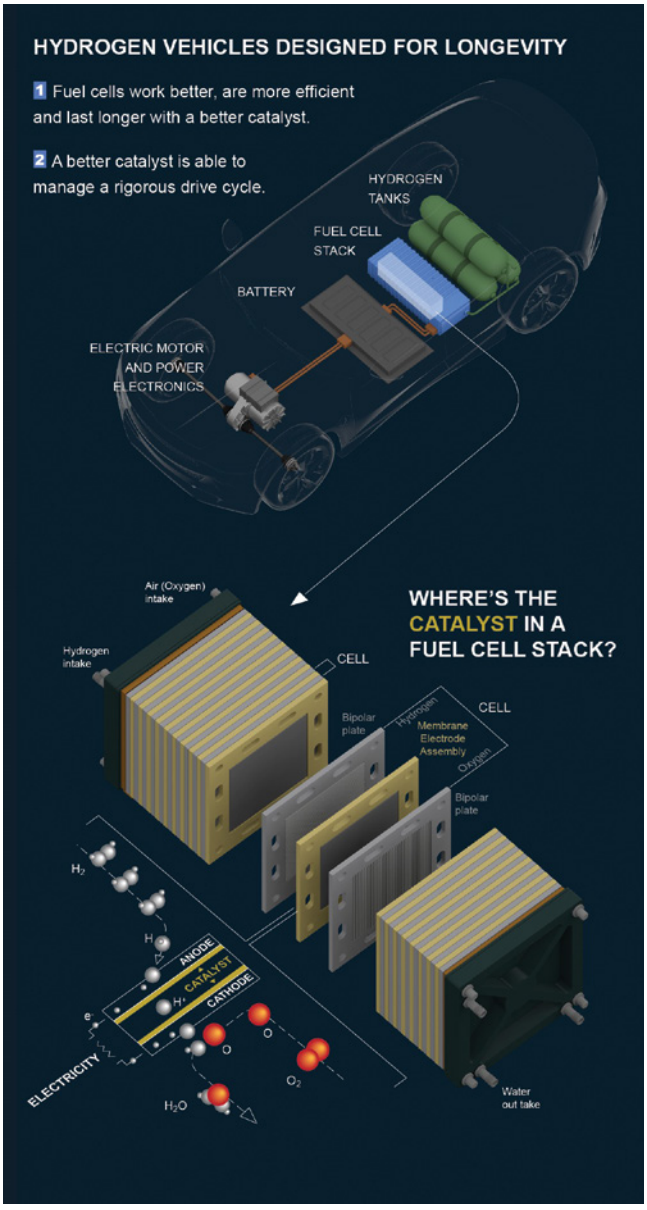
Stephenson cited the hydrogen-fueled **Hyundai** Nexo SUV, the only production fuel-cell vehicle to have published data on platinum content. The Nexo's catalyst has 56 grams of platinum; as of mid-August 2022, platinum was trading at $31 per gram, leaving the platinum content alone at a cost of $1736. "Do the math; it's clear that catalyst costs must be reduced," he said. "But the challenge is, in large part, not about eliminating the platinum, but making it more effective. That equates to less platinum loading per fuel cell. We're able to deliver a catalyst that can cut the amount of platinum per fuel cell in half."

During an interview with SAE Media, Stephenson showed a market sample of the black powder catalyst material Pajarito plans to manufacture that promises to be a game-changer for automotive hydrogen-propulsion economics. He explained that the powder is the result of research on platinum-free catalyst formulations done at **Los Alamos National Laboratory** (LANL) and the **University of New Mexico**, which license the technology to Pajarito Powder for commercialization. Both institutions serve as ongoing R&D partners. The Pajarito name comes from the area in New Mexico where LANL is located.

Pajarito Powder CEO and co-founder Tom Stephenson.

Hyundai Motor Co., long active in hydrogen fuel-cell development, is among Pajarito Powder's investors. Pajarito also has done a DoE grant project as a subcontractor to General Motors, Stephenson noted. Hyundai is helping to fund Pajarito's next big project: a new manufacturing facility to expand operations. Pajarito Powder's patented-and-trademarked VariPore process is readily scaled for high-volume manufacturing, Stephenson said.

Lindsay Brooke



The catalyst is 40% of a fuel cell's overall cost due to its PGM content.

FROM LEFT: LINDSAY BROOKE; PAJARITO POWDER

SAFETY

Hyundai breaks ground for Safety Test and Investigation Lab

Hyundai Motor America is creating an industry-unique testing zone to address root cause crash investigations and electric vehicle/future product analysis activities at its Michigan R&D campus west of Detroit. "The Safety Test and Investigation Laboratory (STIL) will put a focus on speed, speed, speed in understanding what happened," in a crash or component failure, said John Robb, president of Hyundai America Technical Center Inc. (HATCI). STIL is targeted to be operational in the fall of 2023.

SAE Media interviewed Robb and other Hyundai officials at the groundbreaking for STIL, a $51.6 million facility being constructed at the automaker's southeast Michigan technical hub. Hyundai officials said 160 engineers, including those in electrical, mechanical, materials and safety, will be hired to work at the new facility. STIL will feature vehicle inspection bays, a field-crash investigation lab, a 1,640-ft (500-m) asphalt test track, a vehicle-dynamics area and a high-voltage battery lab with test pad.

"We're going to get in front of issues and apply the learnings to future products," said Brian Latouf, global chief safety officer for Hyundai Motor Co. When operational, the STIL will enable technology specialists to use various investigative tools, such as a high-tech CT (computed tomography) scanner. "Instead of pulling apart and destroying an electrical-mechanical component system, we can scan the internal components to see if there is a circuit fault or other failure," Latouf said, noting the scanner could be used to evaluate system components after a crash. Such testing also could be used to investigate reported issues from dealership service departments.

A loss of power steering, unintended acceleration, loss of braking and other vehicle operational failures are extremely critical. "So we want to investigate hazardous or recurring issues and get that diagnostic and data acquisition in place, then do a full root-cause analysis to apply that robustness back into the product design for the future," Latouf explained. Automaker crash-test labs typically are focused on activities for production verification and government-mandated certification. "The STIL lab will be studying product in the field. And, we'll be focusing on electrified vehicles," said Latouf.

Electrified-vehicle testing at STIL will occur indoors via an EV battery lab and via an outdoor test pad. "With EVs, you have to isolate away from offices and buildings to study and push things to the limit as it relates to battery overcharging, thermal events and other conditions. Although we have EV evaluation capabilities at our R&D center in Namyang, South Korea, having EV testing capabilities in North America will enable our regional engineers to figure out the appropriate responses or remedies," Latouf said.

NHTSA supports the STIL's development. A 2020 NHTSA

A rendering of Hyundai's STIL, which is slated to be operational in the fall of 2023.

consent-order agreement with Hyundai — relating to hesitant recalls for more than 1.6 million Hyundai and Kia vehicles equipped with Theta II 4-cylinder engines that demonstrated propensity to catch fire — dictated a $25-million investment in a safety facility. Hyundai is doubling the investment to more than $50 million for the STIL. Robb noted that the facility will represent another step forward for Hyundai's mobility vision. "We want to look at not only making it easier for customers to go from point A to point B, but we want to make that journey safer," he said.

Kami Buchholz

MANUFACTURING

Ford starts the hard work of EV battery, raw-materials security

As it accelerates its shift to vehicle electrification, **Ford** confirmed in July that it has sourced the bulk of battery manufacturing capacity the company needs to meet its 2-million-plus global EV production target for 2026. It also confirmed "direct-sourcing" some crucial battery raw materials in strategically amendable locations that include the U.S., Australia and Indonesia.

In a significant supporting play to its materials-sourcing actions, Ford also announced it will begin offering lithium-iron phosphate (LFP) batteries in addition to their standard lithium-ion, nickel-cobalt-manganese (NCM) chemistry for the Mustang Mach-E and new F-150 Lightning (which is slated to make a big jump to production of 150,000 units for 2023). The Mach-E reportedly will offer LFP batteries by sometime in 2023 and the F-150 Lightning by early 2024.

Ford's LFP battery cells — which are less energy-dense that the NCM chemistry and thus are projected to offer a reduction in driving range that Ford describes it as "minimal" — will be manufactured by **Contemporary Amperex Technology** (CATL). Ford said CATL will install 40 GWh of LFP production

HYUNDAI

Ford confirms the F-150 Lightning will have the option of new lithium-iron-phosphate batteries.

capacity in North America, although it will not be available until 2026. The company also indicated that some LFP battery capacity will be sourced in China.

The strategy to introduce LFP seems to indicate that Ford and other manufacturers are grappling to manage the delicate balance of EV cost versus American consumers' driving-range expectations. Underscoring the extreme cost sensitivity of batteries in the current EV environment, Ford said in a release that LFP, "at current costs, brings a 10 to 15% bill-of-material savings for Ford versus NCM batteries." EV-only **Tesla** already uses LFP batteries is some base versions of its Model 3 and electric pickup-truck startup **Rivian** confirmed that it also plans to leverage the less-costly LFP chemistry.

600,000 EVs in 2023

Ford detailed the EV production rates intended to be in place by 2023: 270,000 Mustang Mach-E; 150,000 F-150 Lightning; 150,000 Transit EVs for North America and Europe and 30,000 units of an unspecified SUV for Europe, totaling 600,000 units globally on the way to 2 million-plus by the end of 2026.

To that end, the company said it now has secured 100% of the 60 GWh cell-manufacturing capacity to support the production target of 600,000 EVs in 2023 and 70% of the battery capacity needed for 2026. Ford said its established relationship with **LG Energy Solution** (LGES) for lithium-ion batteries and a relationship with **SK On** are central to meeting the required battery capacity for late 2023.

Meanwhile, against a backdrop of heightening attention to raw-materials sourcing from politically and socially sensitive regions, Ford said it is "working with major mining collaborators and has sourced most of the nickel needed through 2026 and beyond." That includes non-binding MOUs with **Vale Canada Ltd** for wide-ranging opportunities; **PT Vale Indonesia** and **Huayou Cobalt** for nickel processing project and the rights to the equivalent of an annual 84 kilotons (ktpa) of nickel; and **BHP** for nickel sourced from Australia.

Bill Visnic

FORD

Hornet, first electrified Dodge, arrives for 2023 MY

The industry's red-hot and crowded compact-utility vehicle market gets a newcomer for the 2023 model year with an electrified, top-of-the-line version of the **Dodge** Hornet. "It's intentional to enter a segment that's growing fast with a younger demographic that's more predisposed to early adoption of electrification," said Tim Kuniskis, CEO of **Stellantis**' Dodge brand. The vehicle made its global debut on August 16 during Dodge Speed Week at the M1 Concourse in Pontiac, Michigan.

SAE Media interviewed Kuniskis and others about the new Hornet. The base-model Hornet GT will be ICE-powered, while the Hornet R/T will reign as the Dodge brand's first electrified nameplate. "R/T models have always been the performance step-up," Kuniskis said, noting the plug-in hybrid electric R/T will be the faster, more-powerful variant of the Hornet.

Hornet GT's Hurricane 2.0-L turbocharged inline 4-cylinder is projected to produce more than 265 hp and 295 lb-ft (499 Nm). The Jeep Wrangler and Jeep Cherokee SUVs use the engine, and it is the foundation ICE component of the 4xe PHEV propulsion system. The Hurricane has an aluminum block and head, and the Hornet GT's version is paired with a 9-speed automatic transmission. The Hurricane I-4 shares some traits — such as common bore and stroke and cylinder spacing — with its sibling, the Hurricane twin-turbo I-6. The I-6 is available in the Jeep Wagoneer and Grand Wagoneer SUVs.

The 2023 Hornet GT shown is propelled by a turbocharged 2.0-L 4-cyl., while the R/T variant has a PHEV drivetrain that generates in excess of 285 hp

Dodge claims the entry-level Hornet GT will have the quickest 0-60 mph (0-97 km/h) time in the compact-utility vehicle segment that includes the **Ford** Escape, **Chevrolet** Trax, **Nissan** Rogue and the **Toyota** RAV4, the perennial bestseller in the U.S. Hornet will be a differentiator in its market segment, said Dodge officials. "Hornet GT is a no-kidding, high-performance vehicle at a price point under $30,000," said Micky Bly, senior VP, head of global propulsion systems at Stellantis.

Plug-in performance

The electrified Hornet R/T sports a 1.3-L twin-turbo 4-cylinder with third-generation Multiair technology to adjust valve lift and timing; it's coupled with a 6-speed Aisin automatic transmission and a 121-hp (90-kW) electric motor powered by a 15.5-kWh, 306-volt lithium-ion battery pack. The Hornet R/T's combined power output is projected to exceed 285 hp and 383 lb-ft (519 Nm); the ICE powering the front axle provides 199 lb-ft (270 Nm), while the rear e-motor provides 184 lb-ft (249 Nm). Bly noted that the vehicle will have an electric driving range of approximately 30 miles (48 km). "Pending EPA certification, that's a 70-plus mpg equivalent when driving as an EV and ICE together," said Bly.

The Hornet R/T gets the first application of the Dodge-exclusive PowerShot technology; according to Bly, the effect is similar to the Challenger Hellcat's launch mode. The PowerShot activation process starts with a button push and pulling the steering wheel paddles. After a system check of the battery's temperature and state of charge, a gauge cluster indicator shows that the PowerShot is ready. Depressing the accelerator then unleashes a 25-hp battery-power boost. The process can be repeated after a 15-second cool-down. PowerShot improves the 0-60 mph time by a second, Bly said. The Hornet GT in sport mode accelerates from 0-60 mph in 6.5 seconds and the R/T accelerates 0-60 mph in 6.1 seconds.

The 2023 Hornet GT reaches dealerships in late 2022. The Hornet R/T is slated to arrive in dealerships in spring 2023.

Kami Buchholz

The Hornet's cabin includes a standard TFT gauge cluster and a 10.25-inch center display.

BOTH IMAGES: STELLANTIS

Charger Daytona SRT previews Stellantis' musclecar future

If it looks like a **Dodge**, sounds like a Dodge, and drives like a Dodge, it must be a Dodge. That "must-be" vision has been the perpetual mantra behind the development of a future electrified Dodge musclecar. "This concept is true to what a Dodge musclecar is, but with an alternative propulsion system," Tim Kuniskis CEO of Dodge brand, said about the battery electric Dodge Charger Daytona SRT Concept.

The target date for a production version of an all-electric Dodge musclecar is 2024, providing ample talk-time for the brand's electrified future. "We want enough soak time that by the time we get to production, it's not 'new' news that people have to get used to," Kuniskis said in an SAE Media interview.

Certain design and technology elements on the concept Dodge Charger Daytona SRT are in invention-protection mode. The concept musclecar's throaty sound source is addressed via a pending patent technology, as is the all-electric car's transmission and the two-door hatchback's aerodynamic front end. The patents-pursuit also underscores the scramble to stand out from competitors as the industry begins to transition from ICE-power to EVs. "It's the next space race," said Kuniskis in the same week that the company confirmed it is ending production of its Dodge Challenger and Charger internal-combustion icons after the 2023 model year.

An 800-volt propulsion system, dubbed Banshee, delivers the power to all four wheels of the all-electric Dodge Charger Daytona SRT Concept musclecar.

NASCAR visuals

The concept Daytona's front end features an aerodynamic device referred to as an R-wing (a tribute to Gary Romberg's enormous rear wing on NASCAR's 1970 Plymouth Superbird racecar). The concept car's front aero component is functional: air flows through this front opening to enhance downforce. The exterior design also tucks carbon fiber intakes into both sides of the front and rear lower fascias.

Meanwhile, the Fratzonic Chambered Exhaust is an acoustic design that involves actual pipes, chambers and ducting. "We're not achieving the sound artificially. We're taking the road, vehicle speed, throttle position, shift points and movement of air and running that through our proprietary exhaust system," said Kuniskis.

The Charger Daytona Concept's bold R-Wing front spoiler design pays homage to Dodge's NASCAR heritage.

BOTH IMAGES: STELLANTIS

eRupt-ing performance

While most light-duty EVs use a single-speed transmission, the Daytona concept features a multi-speed electro-mechanical transmission. Micky Bly, Stellantis senior VP – head of global propulsion systems, said the transmission befits an electrified musclecar. "The eRupt system launches the car really, really hard by getting a lot of torque multiplication, then it can be slowed down to get the EDM (electric drive module) in a more efficient spot to get a longer driving range. So it's a high-performance launch and good range," Bly told SAE Media. The company executives weren't pinned down about horsepower and torque figures, but media material said the 800V "Banshee" electric propulsion system makes "Dodge's first electric vehicle faster than a Hellcat [V8] in all key performance measures."

Power levels for the electrified production musclecar will tally nine, with three of the levels available through Dodge and six available through Direct Connection, Dodge's factory-backed performance-parts operation. "This car, we believe, will redefine muscle," Kuniskis said.

Kami Buchholz

Chattanooga POWER HAUS

The eMAST shaker table is key to pack development.

Volkswagen sprints forward in the EV race by integrating battery test, production and EV assembly in the U.S.

by Lindsay Brooke

Volkswagen is rapidly gaining on General Motors, Ford and Tesla in terms of overall EV development and production assets in North America, according to industry analysts. With the recent launch of its $22 million Battery Engineering Lab (BEL) near Chattanooga, Tennessee, VW becomes the first non-domestic OEM to fully integrate battery test and validation, pack assembly and EV manufacturing in the U.S. The 32,000-sq.ft BEL is adjacent to VW's vehicle and pack assembly complex and includes in-house test capabilities that in some metrics surpass those of the top three domestic EV makers, battery R&D experts indicate to SAE Media.

"We are transforming this region into a powerhouse for EV production, including suppliers," asserted Johan de Nysschen, Volkswagen Group of America's COO, during a tour of the BEL in June 2022. De Nysschen said VW is moving to full vertical integration of EV batteries in the U.S., including prismatic-cell manufacture and recycling. The plan is being implemented by **PowerCo**, VW's new wholly owned €20-billion battery organization. A new U.S. cell plant, expected for the Chattanooga area, will be based on a standardized factory design, the first of which is now under construction in Salzgitter, Germany. Salzgitter is designed for 40-GWh annual capacity and will start production in 2025. Six factories built on the Salzgitter "blueprint" currently are in the works for Europe. Each cell plant will be 100% powered by electricity from renewable sources.

VW's strategic electrification goal is to "unite our operations in the U.S., Mexico and Canada," de Nysschen said.

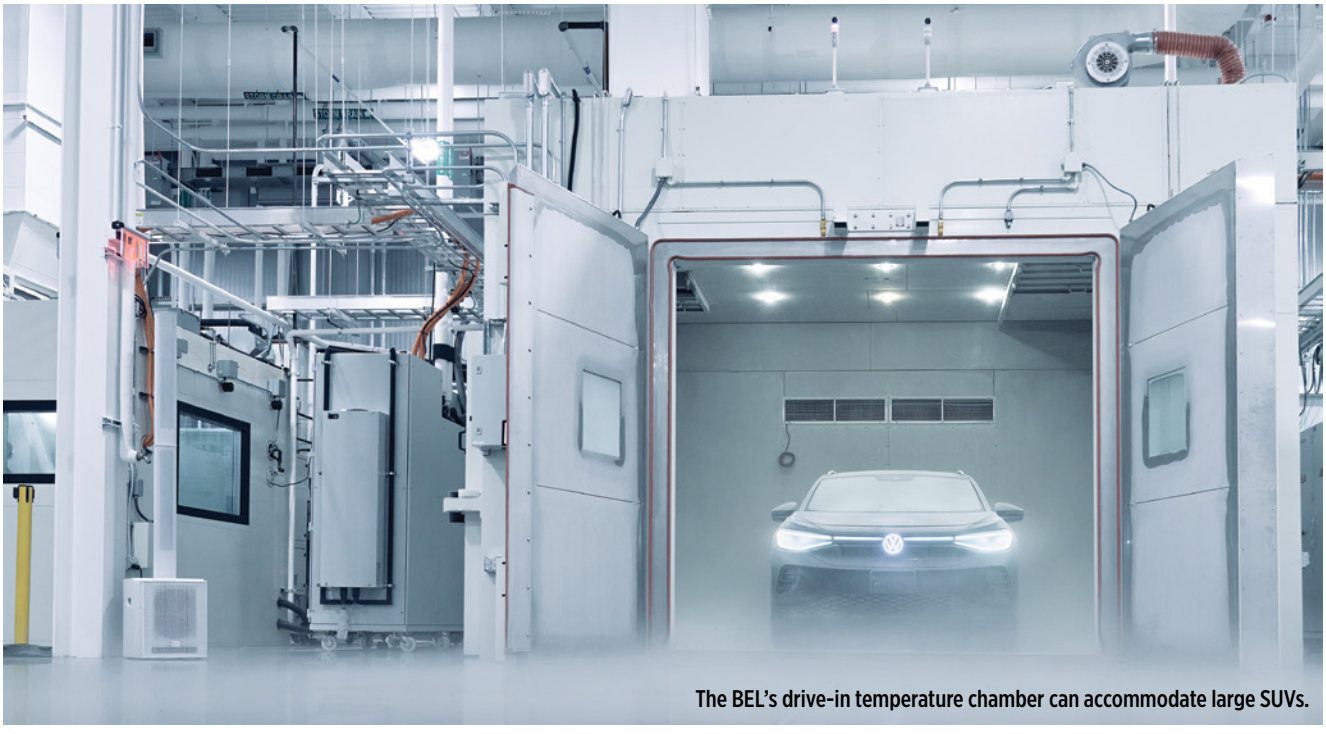
In the near term, VW will source its U.S. EV battery cells from **SK Innovation** at the new $2.6 billion factory SKI is building in Georgia. VW expects production scale generated by PowerCo's standardized cell and production scheme will reduce battery costs by up to 50% and ensure high quality, Dr. Wolfgang Demmelbauer-Ebner, VW America's chief engineering officer, told SAE Media.

The new BEL also is likely to be used to test and validate batteries for **Navistar** commercial trucks (part of VW-owned **Traton Group**) as well as a new generation of **Scout** SUVs, according to Scout CEO Scott Keough, who spoke with SAE Media at Chattanooga. Demmelbauer-Ebner said "now that we're brothers and sisters with Navistar, it makes sense to share the 'center of gravity' and big investment we have here in Chattanooga with them."

Shock, dust and immersion

A comprehensive tour of the BEL led by Wolfgang Maluche, VP engineering, revealed the majority of test cells to be WW-series equipment sourced from **Weiss Technik North America**, based in Grand Rapids, Michigan.

VW



The BEL's drive-in temperature chamber can accommodate large SUVs.

Electrical Multi-Axis Shaker Table (eMAST): With an array of six actuators each capable of generating 16,000 lb (71,171 N) of force, under the control of an MTS digital computer, the BEL's eMAST performs extreme vibration tests to simulate more than 9,000 miles (14,484 km) of driving in seven days — in varying climate conditions. The rig can administer acceleration shock up to 16-g to a 2,200-lb. (998-kg) battery-pack payload, in a thermal range of -40 deg. to 158 deg. F (-40 deg to 70 deg C). The eMAST closely monitors all cell parameters via the pack's CAN bus and is capable of rapid load cycles, charging at 1,000V/900kW at 800A, and discharging at 350A. "The eMAST will influence our future pack structure design and engineering," Maluche said.

Thermal shock chamber: This Weiss Technik unit engineered for extreme durability testing "is vital for speeding battery development and validation," Maluche noted. By running 40 thermal-shock cycles in just three days, the chamber reduces the typical thermal-shock testing cycle by 17 days, he said. Capable of generating temperature deltas from -40 deg to 158 deg. F, it's the best equipment with which to fully simulate EV battery cell and pack life (including welds, seals and fasteners) through a Michigan winter, which VW engineers deem to be the most extreme cold-weather use case. VW is currently sharing this test chamber with battery partner SKI.

Drive-in temperature chamber: Measuring 20 x 16 x 11.5 ft, this space is more than large enough to accommodate the largest SUV (Atlas) currently in VW's lineup, or two ID.4s. This Weiss Technik WW-series chamber was immediately in big demand for evaluating batteries across the wide spectrum of North American climatic/stress scenarios, Maluche said. Thermal capabilities range from -112 deg. to 356 deg. F (-80 deg. to 280 deg. C), with

The Thermal Shock chamber has enabled engineers to reduce testing time by more than two weeks.

FROM TOP: VW; LINDSAY BROOKE

Battery standardization 'not quite yet'

Q&A with Dr. Wolfgang Demmelbauer-Ebner, VW chief engineering officer

EV battery technology still is in a state of flux, with competing chemistries, form factors, etc. Does VW see a standardization coming?
Not quite yet. There is more to come in the chemistries, including solid-state batteries within the next 5-10 years. And the form factors will continue to be fluid, as OEMs change them to meet different vehicle applications — high-floor cars, low-floor cars, wide and narrow battery packs depending on the vehicle architecture. We are a global manufacturer and have to build vehicles for different customers and regions, so there will not be a single form factor perhaps for quite a while.


Dr. Wolfgang Demmelbaur-Ebner.

Do you see the 12V lead-acid battery being designed out of EVs to save weight and complexity?
No, not any time soon. The 12V battery is inexpensive, reliable, recyclable and has high energy density for a number of use cases.

What role will your R&D partners from Oak Ridge National Labs and University of Tennessee be playing in VW's EV developments in Chattanooga?
Many roles. They have huge expertise not only in batteries but also in other areas of propulsion technology. We have a super-strong relationship with them. They're a huge asset for us in identifying new technologies, and also a good pool for new talent.

Lindsay Brooke

An example of the current ID.4 battery pack on display in the Chattanooga pack-assembly plant. This 82 kWh pack uses LG-supplied NCM712 cells and weighs 493 lb. A new pack using SKI-supplied NCM811 cells recently entered production.


The BEL's water immersion test is a Polar Bear Club for batteries.

a ramp rate of 3 deg. C per minute. **Keysight** supplied its pack-level Scienlab Battery Test System and its Energy Storage Discovery software for this important lab, which has 1,000V/900A/360kW battery-charging capability.

Dust chamber: Supplied by Italy-based **ACS Angelantoni Test Systems**, the BEL's sophisticated dust chamber uses ISO-standardized dust particles, fed at flow rates up to 2,600 cfm to replicate 70 mph (113 km/h) road speed, to attack the test pack's seals. The ISO-certified "Arizona" dust particulate measuring 1/70th of a human hair in diameter often is blended with abrasive material. A typical dust test at BEL is 20 cycles at 20 minutes per cycle, over approximately seven hours. This would be part of a sequence of battery-pack tests that begin with a thermal cycle, then the dust test, water-jet test at garden-hose pressures, followed by a high-pressure steam test. The pack then is completely disassembled and analyzed.

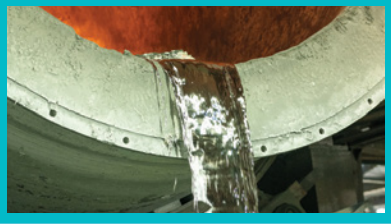
Water immersion and sodium chloride: Salt-bath tests that simulate up to one year of EV life in a hostile winter environment (such as southeastern Michigan) and a water-immersion test that simulates water ingress after shocking the aluminum case structure, are keystones in VW's pack development. The 2,100-gal. (8 sq-m) water-immersion tank, supplied by Florida-based **Equilam NA**, heats the pack structure to 140 deg. F (60 deg C) before dunking it into 40 deg. F water (dyed a color, for easier leak identification) for five minutes. Each immersion test cycle includes 20 tests that are like a Polar Bear Club outing, but for battery cases. ■

ALL IMAGES: LINDSAY BROOKE

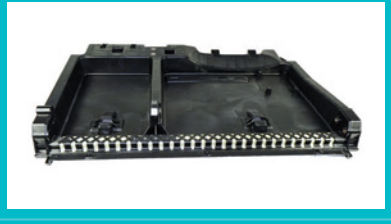
CONGRATULATIONS TO THE WINNERS OF THE 2022 ALTAIR ENLIGHTEN AWARD

Sustainable Product (Vehicle)
Ford Motor Company

Sustainable Product (Material)
Ford Motor Company

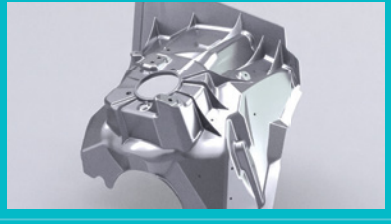


Sustainable Process
Nemak



Module Lightweighting
BASF Corp., Toyota, and L&L Products

Enabling Technology
Shiloh Industries and General Motors



Future of Lightweighting
McMaster University and Nemak

Great Minds Think Light.

Sustainability and emissions reduction are critical challenges for the automotive sector and society as a whole. The Enlighten Award shines a light on the inspiring work of automotive engineers worldwide.

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#ONLYFORWARD

A materials lesson in Civics

Honda's Indiana-based manufacturing project leader shares insights on meeting all-new product challenges with the launch clock ticking…during COVID.

by Lindsay Brooke

The new Civic replaces the previous model's all-steel rear liftgate with a weight-saving steel-and-resin 'sandwich,' shown here being fitted in the Indiana assembly plant.

As a veteran manufacturing engineer, Jill Fuel was an ideal choice as project leader for the production launch of **Honda**'s 2022 Civic Hatchback at Honda's Indiana assembly plant. In eleven generations of Civic, it's the first hatchback variant to be built in the U.S., sharing 85% of its underbody and 99% of its chassis with the sedan. And being an all-new model with many significant design changes, Fuel expected the usual challenges when the program kicked off in 2018.

"This was my first full-model project," she told SAE Media during the 2022 Great Designs in Steel conference. "It was a big step up for me and for our 100-person team — and then came COVID." The subsequent temporary suspension of production at the Greensburg, Indiana, facility for several weeks hit the Civic project hard, as it did vehicle programs across the industry.

"We faced a lot of curveballs during that time," Fuel said. "Our skeleton crew of associates was all working from home. Then when Indiana started opening up, some suppliers who weren't located in our state weren't ready to go. Our equipment-install timing was severely affected. 'Plan B' became Plans C, D, or whatever happened to work. And once we got going again, we had to compress and re-compress our schedules to launch on time."

She said the experience taught the team plenty about flexibility. Over the first three years of the project, Fuel made seven trips to Japan to attend in-person drawing reviews with the vehicle's designers, in addition to many videoconferences and virtual meetings.

The result, delivered on schedule, earned 2022 North American Car of the Year honors, a Top Safety Pick+ rating from the Insurance Institute for Highway Safety (IIHS) and praise as the best Civic yet, thanks to design, engineering, materials and process changes.

Program priorities

Honda's '22 Civic program investment included $50.2 million in upgrades and tooling for the Greensburg plant. Most of that went to a building expansion to accommodate a four-step laser brazing line for attaching the vehicle's steel roof panel — the first application of a laser-brazed (actually a copper weld bead) roof on a lower-priced Honda model. Typically reserved for premium vehicles, Honda first used laser welding on the 2018 Clarity, later migrating it to Accord and Acura TLX models.

"The move to a laser-welded roof is a short-term cost but a long-term gain," Fuel noted, "because it eliminates the ditch joint, the 'mohican' molding, the fastener equipment for the molding, and the install cost." New **Yaskawa** laser-weld robots lay down 1.5 meters (about 5 feet) of copper bead per body side in 44.5 seconds. The robots are precisely guided by a high-speed, compact 3D laser-vision

HONDA

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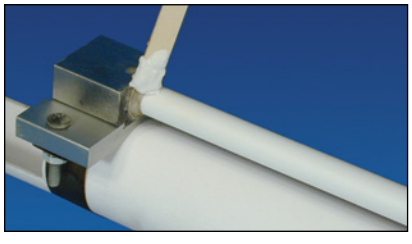

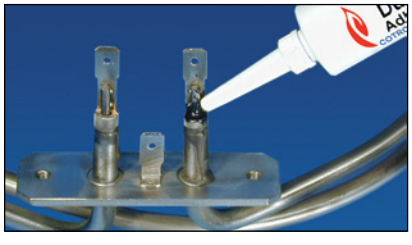

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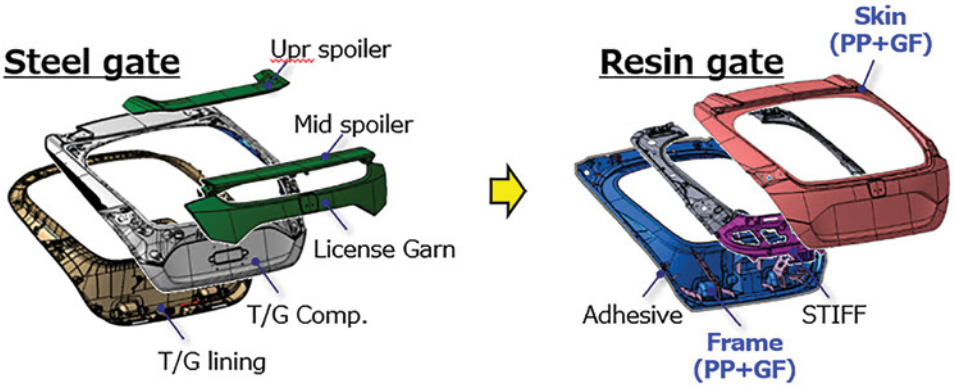
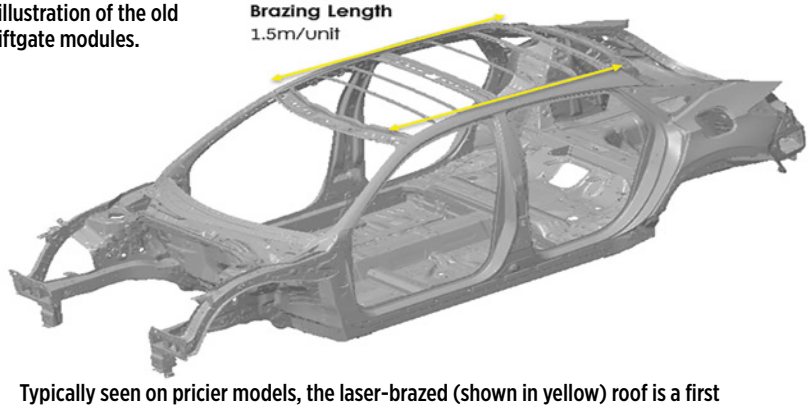
A materials lesson in Civics

Project leader Jill Fuel's manufacturing engineering experience was vital in executing the 2022 Civic Hatchback project on target.



Exploded CAD illustration of the old and new Civic liftgate modules.



Typically seen on pricier models, the laser-brazed (shown in yellow) roof is a first for Civic and required significant plant and process alterations.

seam-tracking system supplied by Montreal-based **Servo Robot**.

The Civic design team prioritized crash safety, driving dynamics, mass reduction and cost reduction/ease of manufacture as the car's target attributes. The foundation of these is a new generation of Honda's longstanding 'ACE' (Advanced Compatibility Engineering) body structure that is 19% stiffer in torsion and 13% stiffer in bending than the previous generation, with rear-suspension mounting points that are 17% stiffer.

"Ease of manufacture and weight reduction really complement one another, and were a big piece of our early conversation," Fuel said. In keeping with Honda's overall materials strategy, the '22 Civic maintains a steel-intensive materials mix in the body-in-white, with aluminum hood inner and outer panels (stamped by Honda and the first AL hood on a Civic) to reduce mass and meet pedestrian protection (ped-pro) targets. High-strength steel (HSS) content is up versus the previous-gen vehicle, comprising 38% of the body structure. "Our focus was to improve our IIHS crash rating, which meant high-strength steel in the engine compartment, side sills and door-ring stampings," she noted.

In her presentation at GDIS22, Fuel revealed the following high-strength steel alloys content: Hot-rolled tensile strength dual-phase, 19%; cold-rolled advanced HSS, 16%; hot-rolled high strength with excellent formability, 9%; hot-rolled ultra-high-strength, 7%, and cold-rolled very high strength, 6%. The remainder of the steel in the Civic hatchback's body structure is 29% galvannealed commercial grade and 14% high-carbon alloy.

A sticky situation

Stiffer structures typically are more difficult to manufacture, Fuel explained. "We increased our use of structural adhesives and sealants on this project, but those materials came with a list of criteria that were a struggle. How to weld through it? How do you apply it to the same spot each time, at line rate? We had to make the technology work in our existing facilities. The learning curve with the adhesives took some time to master,."

Honda's use of **Dow** sealers throughout the BIW now includes high-performance structural adhesives in the underbody. The '22 Civic body uses 10 times as much adhesive as was used on the outgoing model. It is applied in both continuous and stitch patterns, depending on location and adjacent welds. In conjunction with spot welds and new lateral steel reinforcements in the floor structure, the adhesives significantly improve overall rigidity.

Fuel noted the challenges in adopting weld-through sealers in the body shop. In some areas the sealant has to be applied before the weld; this creates expulsion issues with the weld robot's electrode. And the new super-high-performance adhesives have different flow and set-up characteristics compared to the products with which Honda Indiana was familiar, she said. "We had to develop new checkpoints for the robots in this process, including new vision systems on the line to ensure precise and repeatable location of the sealer with the welds," she explained.

The new Civic hatchback features an all-new rear liftgate construction that reduces mass by 20% compared with the previous model's all-steel liftgate. It uses a steel inner stamping surrounded by durable impact-resistant, resin-based inner and outer skins. The new "hatch" also is perhaps the 2022 car's most recognizable change. The liftgate is shipped to Greensburg as a complete assembly from a supplier. ■

CLOCKWISE FROM TOP LEFT: LINDSAY BROOKE; HONDA; HONDA

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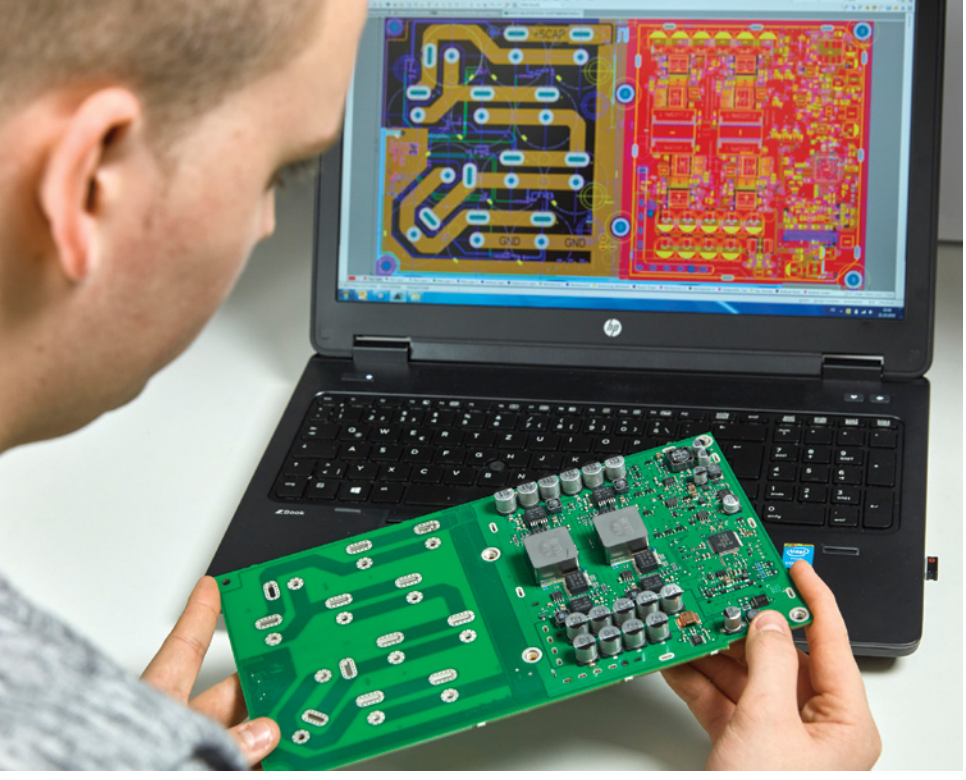


Eberspaecher's Electronics unit is driving the company's future growth.

From emissions tech to EV electronics

Eberspaecher's Electronics unit is enabling big growth in EV and AV business.

by Lindsey Brooke

A recent visit to **Eberspaecher**'s North American engineering and manufacturing complex reveals how a global Tier-1 rooted in combustion-engine technology is profitably navigating the transition to the electrified future.

In the Brighton, Michigan, plant, which produces 40% of U.S. Class-8 diesel exhaust systems, catalyst bricks are being canned and prepared for shipment to OEMs. Meantime in the facility's engineering offices, work is progressing on next-generation heating systems for passenger and commercial EVs, power electronics, automated-driving systems, and high-voltage switching solutions. Best known for 90 years as an exhaust-systems and climate-controls supplier, the Germany-based company now is a parallel force in electric power switching and distribution. Since establishing its Electronics business unit in the early 2000s, Eberspaecher has produced 30 million electronic control modules, more than 17 million high-performance switches and six million DC/DC converters, among other power-net components.

"We are in development with a customer right now on an SAE Level 5 fully-autonomous vehicle that will launch within a year," reported Joe Vollmer, the veteran engineer who heads North American business for Eberspaecher's Automotive Controls and Climate Controls divisions. For the past five years his team has been busy with multiple AV projects. "A particular Detroit-3 automaker needed to have its AV programs moved forward and urgently needed a supplier to step up to 'move the electrons' to the critical devices, under the ASIL-D regimen. And we were chosen," Vollmer noted.

ASIL-D is among the most stringent Automotive Safety Integrity Levels, a risk classification system defined by the ISO 26262 standard for road vehicle functional safety. Vollmer's team developed the customer's first-generation AV power electronics and will soon deliver the second generation, he said.

EV, give me heat!

With its fuel-operated heaters popular in marine applications since the 1950s, Eberspaecher added electric heaters in 1999, beginning as a JV with **DBK**. The core technology is the PTC (positive temperature coefficient) thermistor. Vollmer and applications engineer Robert Tate see significant growth potential for new EV (and advanced ICE) heating technologies. Both recognize the industry's need for more efficient HVAC without the range-robbing parasitics of current systems.

"I joined Eberspaecher in 2011 as we were launching on the Chevrolet Volt," Tate said. "Our first-gen heaters were on most of the first wave of EVs. Many of the early electronic and electrical components used then weren't automotive-qualified. The only thing then available in the voltage range the OEMs were moving to were 1,000-volt IGBTs made for fighter aircraft! Today's MOSFETs are on the move and are better for reverse-polarity. We had to do a lot of R&D work in high-voltage switching to make it happen."

Tate noted some OEMs' interest in geothermic heat pumps as an EV cabin heat solution. "But [heat pumps] aren't terribly efficient in cold temperatures," he explained. "That's where Eberspaecher fits; we specifically use PTC heating elements that perform best in cold temperatures. As the element gets hotter, it acts as a variable resistor letting less electricity through. In PTCs, the heating element will never raise above a certain temperature; that dramatically reduces any risk of fire." Originally, Eberspaecher purchased PTCs on the market, then invested in its supplier **Rauschert** and in 2016 took over its PTC development and production.

The challenge with EV cabin heat is "balancing heat when it's needed with vehicle range, which is directly related to battery capacity and size. That's the bottleneck in EV development," Tate asserted. "You don't want to consume more energy than is necessary, but need to keep comfort and safety in mind. In California, for

EBERSPAECHER

Industry veteran Joe Vollmer spent years at GM, Bosch and Sturman Industries before joining Eberspaecher.

Eberspaecher's new 4th-generation heater technology generates more heat performance with fewer components, explained applications engineer Robert Tate.

example, you might be able to get away with a 2kW-3kW heater. But automotive designs for the 100-percent use case, not 20- or 50-percent." Roughly 10% of an EV battery is scaled for cabin heat and cooling.

Tate's team sees various EV heater strategies emerging. Some OEMs are focusing on larger heaters they plan to run for shorter periods, with the goal of maintaining temperature in the coolant and in the cabin. Others are adopting a "localized approach" including electric seat heaters incorporating blowers that vector warm air on the occupant's neck. "They're called an 'air scarf' and we're involved with that technology," he said. "It's very popular in Europe on convertibles." Another more costly strategy is decentralized heating that fits mini heaters in the vents, closer to the seats, to warm customers more efficiently.

Eberspaecher's latest heater is designed to be located on the coolant loop. According to Tate, engineers debate whether a coolant loop heater is the right choice for an EV versus an air heater, the output of which feels more direct. "One thing that gets overlooked is these systems are putting out 5kW to 8kW of heat — that's equivalent to house heating," he noted.

48V supercapacitors are among the company's expanding product portfolio.

"That may be a bit overpowering, but it's necessary to warm the occupants and clear the windshield."

The company's fourth-generation heater technology is entering production. Its design boasts a reduced number of heating elements. "We're generating more heat performance with fewer components," Tate explained. "In relation to the battery it's not that impressive, but in terms of design cost and overall size, we've made year-over-year improvements."

Latency and liquid cooling

Looking ahead in electronics technology to meet industry trends, Vollmer and Tate note the move to higher system voltage levels. "There's a lot of talk about 800 volts, and we have definite development plans in that realm," Vollmer said. He added that OEM development cycles "are wild right now — faster, with changing component requirements — because of all the improvements that are coming." The automakers also are "learning quickly about high-voltage component requirements and how they need to interact with one another. This has led to communication-network changes, from CAN to LIN, for mixed-signal vehicles. We've had to be quick at adapting to the different vehicle networks," he explained.

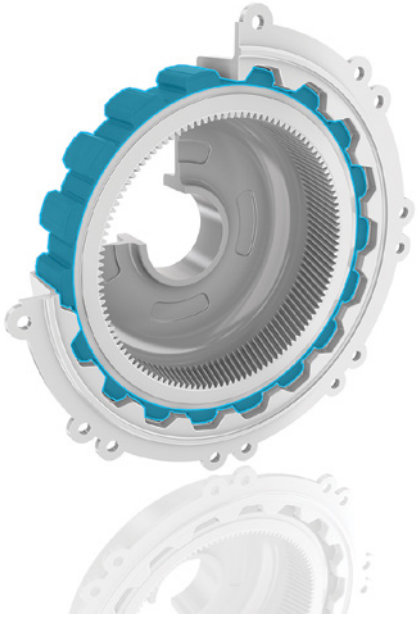
In the automated-driving space, in-vehicle data-processing speed with decreasing latency is another challenge. "The AV world is going after 100-microsecond latency," Vollmer said. "The first question the vehicle topology people ask us is, 'How fast can we switch?' That determines how to build up the hardware set. Does it need to be an ASIL-D microprocessor? All the components we select must be able to meet the specified switching times." There also are discussions on cooling strategies. Liquid cooling is a current topic with Eberspaecher's commercial vehicle customers, he noted. ■

CLOCKWISE FROM TOP LEFT: LINDSAY BROOKE; EBERSPAECHER; LINDSAY BROOKE

PRODUCT BRIEFS

SPOTLIGHT: PLASTICS AND COMPOSITES

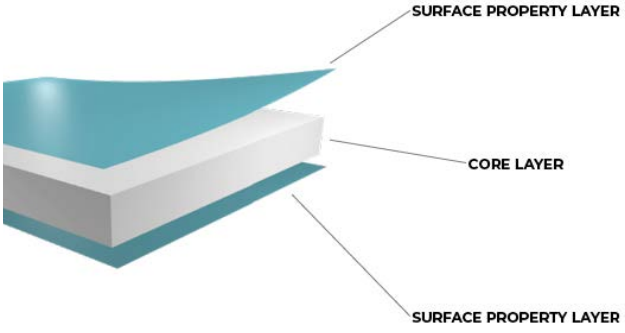
Rubber ring gear



Vibracoustic (Darmstadt, Germany) has developed a tunable rubber ring gear for use in EV powertrain planetary gearboxes. The company states that the elastic ring gear provides superior vibration isolation between the housing and the ring gear. Vibracoustic also claims that its ring gear mitigates high-frequency excitations such as torque ripple that often are caused by electric motors and vibrations that are transmitted into the gearbox housing. The gear also offers multi-directional decoupling (radial, axial and torsional) to significantly reduce the transmission of vibrations. In some applications, this ring gear reportedly can render additional acoustic encapsulations obsolete thanks to its wide-frequency working range.

For more information, visit http://info.hotims.com/82335-400

Polypropylene and polyethylene foam



Toray Plastics (North Kingstown, Rhode Island) introduced its polypropylene and polyethylene foam technologies for automotive applications. The company's offerings include ToraSoft, TorayPEF, ToraPRO, and XLPE. The ToraSoft and ToraPEF foams are intended for luxury haptics in automotive applications such as instrument panels, consoles, armrests, glove boxes, seatbacks and knee bolsters. The ToraPRO foams are specified for flooring applications. Toray states that these polypropylene-based foams deliver excellent sound dampening and higher compression resistance at lower density than traditional polyethylene-based underlayments. The XLPE foams are used for gasket, tape and composites applications. These foams reportedly provide end users with the consistent density, thickness, and uniformity and are available in a range of densities and thicknesses.

For more information, visit http://info.hotims.com/82335-401

PP Compounds

SABIC (Riyadh, Saudi Arabia) introduced new PP compounds for foam injection molding. New mineral reinforced SABIC PPc F9005, PPc F9007 and PPc F9015 grades reportedly can help deliver excellent aesthetics for visible automotive interior parts with complex geometries, such as door panels and trim, seat and trunk cladding, A/B/C/D pillar covers and center consoles. The company claims that total weight loss for these parts could be as high as 10%. SABIC states that the new PP compound features uniformly high surface quality similar to solid injection-molded parts and that foamed parts made with this compound offer significant weight savings.

For more information, visit http://info.hotims.com/82335-402

Bluetooth TMPS

Sensata Technologies (Swindon, United Kingdom) announced a new Bluetooth low energy (BLE) tire-pressure monitoring system. Sensata states that the new BLE TPMS replaces the ultra-high frequency (UHF) radio with BLE radio to enable two-way communication. The system is available in both clamp-in and snap-in configurations and reportedly features long battery life while delivering the same pressure, temperature and auto-location capabilities as Sensata's existing UHF TPMS solutions. Sensata said it will be launching production of the system in the first half of 2023.

For more information, visit http://info.hotims.com/82335-403

The notorious Prince of Darkness

Another great Editorial in the August issue! Reflecting back on dealing with Lucas in the 1960s, the major impression I got was one of arrogance born of monopoly. We had no choice in the U.K. other than Lucas, and when we pleaded with them to consider ventilated breaker points, or replacing the fiber distributor cam follower with nylon, as was typical in the USA to improve ignition system life, their attitude was typically "no one else is complaining, what's wrong with you?"

When trying to complete 50,000-mile emissions endurance tests for compliance with HEW (EPA predecessor) regulations, with only prescribed permitted maintenance, we typically had to push-start the test vehicles due to deterioration of the ignition system, and then appeal to HEW for permission to perform exceptional unscheduled maintenance just to complete the process. Lucas' reaction was to simply ridicule a country (the USA) which expected vehicles to run almost indefinitely, or at least 12,000 miles, with minimal maintenance.

Bernard Robertson

Mr. Robertson is the former senior VP of Engineering at DaimlerChrysler and General Manager of Jeep and Truck Operations. He joined Chrysler in the U.K. after graduating from Cambridge University in 1965, and worked as a powertrain engineer on Sunbeam Tigers, Alpines, and other Rootes Group vehicles. He was hired into Chrysler USA in 1970 and retired from the company in 2003 after a 38-year career.

I worked in engineering at Lucas Varity after the company was founded in 1996 from the amalgamation of the old Lucas and Varity Corp. Despite our marketing efforts and a serious push to improve electronics quality (which I believe we achieved), we were never able to shake the notorious "Prince of Darkness" stigma. Why do the English drink warm beer...?

Richard Whitley

My favorite Lucas story: I sold my MGB to an editor I worked for (bad mistake), so naturally if I wanted to keep the client, I also owned the car forever. Shortly after the bride and I moved into our first house, he called, asking if I could help with some electrical issues he was having. Well, the first issue was simple: he had crossed the plug wires after changing the spark plugs, and naturally the engine was misfiring. The second: virtually all the electricals were operating intermittently. I checked the fuse box and all the fuses were okay. So, I lifted the fuse box, which was under hood on the sheetmetal. There was the issue: a layer of corrosion on the underside. A generous wire-brushing and a coating of anti-corrosion protectant, and he was good to go... at least for at least another few months.

Paul Weissler

Mr. Weissler is a longtime SAE Media contributor, a veteran freelance technical journalist, and a member of the SAE HVAC Standards committee.

RE: The poor reliability record of Lucas electrical components: The editorial is correct in stating much of the bad reputation was due to bad systems design by the British OEMs.

Armand Zeller

The old Lucas stuff was, in my experience, no worse in its reliability than the electrical hardware from Delco-Remy, Packard Electric, FoMoCo, and even Bosch in the late 20th century. I share the editor's concerns that the industry has entered a new period of electronics issues.

L.P. Kenyon

Damping vs. dampening

RE: August 2022 issue, page 18: From an engineering perspective, damping is to reduce vibration, whereas dampening is to make moist. Would you ever call shock absorbers 'dampeners?' No, they are called dampers. It is a ubiquitous error ... even by many engineers, unfortunately.

Bill Draper

Bill, thanks for your correction and for reading Automotive Engineering. *– Ed.*

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 and clarity.

UPCOMING WEBINARS

HOW TO INCREASE PRODUCTIVITY IN EV DESIGN BY LEVERAGING THERMAL SIMULATION

Wednesday, September 7, 2022 at 9:00 am U.S. EDT

In the electrification era, thermal-management system design requires a complex approach to ensure vehicle performance and customer satisfaction. Studies of fast-running, system-level models to detailed thermal analysis of subsystems are enabled by virtual analysis.
This 60-minute Webinar showcases how thermal analysis can be utilized for critical systems, such as battery packs and integrated motors, that require proper cooling to meet performance and range requirements.

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

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BUILDING THE AI/ML DATA AUTOBAHN FOR ADAS/AV DEVELOPMENT

Wednesday, September 14, 2022 at 11:00 am U.S. EDT

ADAS/AV data systems face three important challenges: movement and management of terabytes to exabytes of data; massively parallel, complex data streams, including images, videos, LiDAR, radar, and vehicle data; and data silos created by data globally dispersed across hybrid infrastructure and geopolitical barriers. This 30-minute Webinar discusses how adopting AI/ML methodologies can help automotive ADAS/AV engineers and managers overcome these challenges.

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STREAMLINE YOUR FUNCTIONAL SAFETY SYSTEMS TO SAVE TIME, IMPROVE PERFORMANCE AND ENHANCE SAFETY

Monday, September 19, 2022 at 11:00 am U.S. EDT

As off-road and highway vehicles become smarter and aspire to reduce environmental impact, the complexity of on-board systems continues to increase. This added complexity is driving the need for companies to comply with industry safety standards, such as ISO26262 and others. This 30-minute Webinar will present a model-based approach to help attendees create safer and more reliable functional safety systems.

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

UPCOMING WEBINARS

IN-MOTION AUTOMATIC PAINT DEFECT REPAIR

Tuesday, September 20, 2022 at 11:00 am U.S. EDT

With today's new high-performance coatings, obtaining a high-quality finish is even more important. Modern high-performance, inline, car body surface-inspection technology can bring users closer to achieving a near 100% defect-free coating within a current factory floor space. This 30-minute Webinar examines new paint-scan technology that scans up to 40,000 images, using up to 40 high-resolution cameras, on a moving line with short cycle times (less than 10 seconds).

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EXPANDABLE EPOXY ADHESIVES IMPROVE TRADITIONAL BONDS AND ENABLE COMPOSITE DESIGN PERFORMANCE

Thursday, September 22, 2022 at 9:00 am U.S. EDT

Highly toughened, expandable structural adhesives reliably join gaps while adding strength and rigidity to body-in-white structures, chassis, and closures. When used in vehicle body construction between sheet metal cavities, these hybrid epoxy adhesives enhance the structural performance of the vehicle with minimal weight penalty as compared to alternative solutions. This 60-minute technical Webinar will discuss how these new solutions can provide benefits beyond non-expandable adhesives, including a look at real-world case studies.

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HOW ADAPTIVE AUTOSAR SOLVES COMPLEXITY IN AUTOMOTIVE

Available On Demand

Advancements in automotive architecture with high-performance computing and its associated complexity are driving the adoption of Adaptive AUTOSAR. Centralized and zonal architectures need new standardized middleware to perform the functions required for advanced and autonomous driving capabilities. This evolution brings new system requirements. In this 60-minute Webinar, experts share the benefits and best approaches for implementing standardized Adaptive AUTOSAR.

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Q&A

2023 Cadillac Lyriq executive chief engineer: New EV is her 'North Star'

At the Cadillac Lyriq's media drive program in Utah, SAE Media spoke one-on-one with Jamie Brewer, Lyriq executive chief engineer, about developing the first-ever Cadillac EV, its purpose-designed Ultium vehicle architecture and the uniquely styled SUV-wagon's positioning in the market.

The Lyriq is just the second production vehicle (the first being GMC's Hummer EV) to use the dedicated Ultium platform. I'm curious about the overall strategy for materials, because the Lyriq has a fairly conventional steel body. Did you consider aluminum bodywork or closure panels?
Yeah, we did look in aluminum — we looked at it a lot. We have a lot of mixed metals, but it [the bodyshell] is steel. Once we got the structure to the point where it met all requirements, then we put it through what's called MCO, our Mass Component Optimization study; it's more rounds of CAE iterations to then say, 'Okay, where can we do lightweighting, where can we take section out, where can we change material? And it iterates on all of the different opportunities from a mass-optimization perspective until we find that sort of perfect balance between mass, performance and costs.

Because the Lyriq is based on GM's first wide-ranging EV architecture, how did you decide on a mass target — or did you have a mass target?
Yes, we did have a mass target. Before I answer that question, I've got to go back to the intent and purpose of the vehicle – the sort of the "North Star" for the team working in the vehicle. And that North Star was for it to be the best Cadillac SUV we've ever made.

So, did we have a mass target? Yes. Did we run into some issues during development where decisions would've had to have been made on the content or the design or the styling to enable the mass target that was originally styled? 'Best Cadillac SUV ever.' So, we did modify our mass targets to make sure that the vehicle that we were delivering was the Cadillac that we wanted to deliver. We're at 5,600 pounds [2540 kg]. It is a heavy vehicle. It's not the heaviest out there.

You've already heard some criticism: the Lyriq has no 'frunk.' Is that something that when this Ultium architecture was first being conceived, maybe nobody thought a frunk was going to become a big deal?
The number of meetings I had on this! First of all, this vehicle has a 19.2-kilowatt onboard charger. That had to go somewhere. Once we put in the onboard charger, there absolutely was still room for a frunk. You could have put a laptop or something in it. It's either a small frunk and a medium size-cargo area, or no frunk and a large cargo area. I would challenge that a real customer, once they get over the hype of a frunk, would prefer to have the biggest rear cargo area possible. I knew I was going to get hit in the media. But that wasn't my priority. My priority was the customer.


Jamie Brewer, executive chief engineer for the 2023 Cadillac Lyriq.

My goal was for this to be the best luxury midsize SUV in the industry — irrespective of drive type or powertrain.

Where do you see the Lyriq in terms of segmentation? What are you calling it? I see the profile and see a little more wagon, maybe, than some SUVs.
My goal was for this to be the best luxury midsize SUV in the industry — irrespective of drive type or powertrain. From a segment perspective, we're really going after the heart of the midsize, luxury SUV segment.

Yeah, I can see [wagon] too. Especially with that really low roof angle. But when you look at the chair height and the command view of the road, that really is what puts it in that SUV category. From our confirmation clinic, where we show sort of the final-design interior and exterior of the vehicle, this vehicle scored higher than any other vehicle in General Motors history. I think the public is ready for this vehicle. ■

This is an edited version; the entire interview can be found here: ***https://www.sae.org/news/2022/08/cadillac-chief-engineer-qa***

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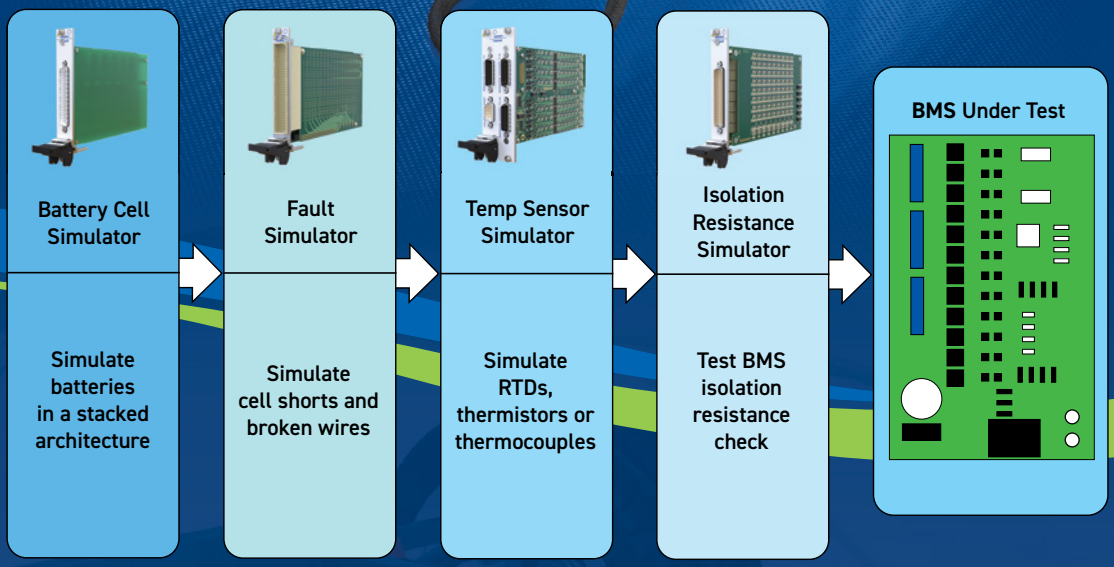

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