SAE INTERNATIONAL®

AUTOMOTIVE ENGINEERING®

ONE founder and CEO Mujeeb Ijaz

ALSO:
What's next in e-motors?

Cameras and radars for next-gen ADAS

e.org

SAE INTERNATIONAL®

AUTOMOTIVE ENGINEERING®

ONE of a kind

Our Next Energy's new battery tech delivers high energy density with safety

ONE founder and CEO Mujeeb Ijaz

ALSO: What's next in e-motors?

Cameras and radars for next-gen ADAS

March 2022 autoengineering.sae.org

Returning this spring!

Illus_man/Shutterstock.com

BATTERY AND ELECTRIFICATION SUMMIT

April 26-27, 2022

Discover how new developments in battery and electric power are changing standards across the automotive, commercial vehicle, aerospace, and defense industries. During the two-day **Battery and Electrification Summit**, leading manufacturers and researchers will discuss how design teams can prepare to meet evolving power demands and requirements.

Topics include:

- **The State of Solid-State Batteries**
- **Analytics and Controls: Intelligence to Enhance Battery Performance**
- **Commercializing Battery Cell Technology for Heavy Vehicles**
- **Recycling: Closing the Loop**

Hear from these pioneers:

Joshua Buettner-Garrett
CTO, Solid Power

Kunal Phalpher
Chief Strategy Officer, Li-Cycle

Joshua Israel
Market Development Manager, HORIBA Automotive

Tal Sholklapper, Ph.D.
Co-Founder and CEO, Voltaiq

Jean-Christophe Lambert
Business Development Manager, Lithion Recycling Inc.

John Warner
Chief Customer Officer, American Battery Solutions

CoreDESIGN/Shutterstock.com

For a complete list of sessions and presenters, visit www.techbriefs.com/BET-Summit

Presented by

Battery & Electrification Technology

SAE International

Platinum Sponsor

KEYSIGHT

Interested in becoming a sponsor?
Contact: kaitlyn.sommer@saemediagroup.com

CONTENTS

FEATURES

ON THE COVER

Michigan-based EV battery startup Our Next Energy brings innovative cell technologies and battery architectures to meeting OEM and consumer demands for vehicle range and performance. Company founder and CEO Mujeeb Ijaz, shown in ONE's Novi headquarters with an Aries LFP battery pack, is playing to win. (Photo by Lindsay Brooke)

Follow us on social media

@SAEAutoMag @saeaei SAE Magazines

REGULARS

Automotive Engineering®, March 2022, Volume 9, Number 2. *Automotive Engineering* (ISSN 2331-7639) is published in February, March, April, May, June, August, September, October, December by SAE Media Group, 261 Fifth Avenue, Suite 1901, New York, NY 10016 and printed in Mechanicsburg, PA.

Annual print subscription for SAE members: first subscription, $15 included in dues; additional single copies, $30 each North America, $35 each overseas. Prices for nonmember subscriptions are $115.00 North America, $175.00 overseas, $30.00 digital subscription, $30.00 single copies. Periodicals postage paid at New York, and additional mailing offices. POSTMASTER: Please send address changes to *Automotive Engineering*, P. O. Box 3525, Northbrook, IL 60062. SAE International is not responsible for the accuracy of information in the editorial, articles, and advertising sections of this publication. Readers should independently evaluate the accuracy of any statement in the editorial, articles, and advertising sections of this publication that are important to him/her and rely on his/her independent evaluation. For permission to reproduce or use content in other media, contact copyright@sae.org. To purchase reprints, contact advertising@sae.org. Claims for missing issues of the magazine must be submitted within a six-month time frame of the claimed issue's publication date. The *Automotive Engineering* title is registered in the U.S. Patent and Trademark Office. Full issues and feature articles are included in SAE Mobilus®. For additional information, free demos are available at https://saemobilus.sae.org/.
(ISSN 2331-7639 print)
(ISSN 2331-7647 digital)

Audited by BPA WORLDWIDE BUSINESS SIGNET RESEARCH INC

SAE INTERNATIONAL®

ACRYLITE® has the ability to take on any color – while also remaining green. At its basic structure, ACRYLITE® contains no halogens, no aromatic compounds, and no plasticizers. It is nontoxic, noncarcinogenic, and nonmutagenic. Best of all, at the end of its life, it is fully recyclable. ACRYLITE® is the material of choice for your green products. Our team would be delighted to connect, share ideas, and develop solutions together: **www.acrylite-polymers.com** or **1-800-225-0172.**

ACRYLITE® makes even red lights green.

ACRYLITE®

Free Info at http://info.hotims.com/82330-704

EDITORIAL

The other existential threat

As I write this on Valentine's Day, 105 Russian army battalions backed by more than 500 tactical aircraft and 40 warships are poised for a blitzkrieg-style invasion of Ukraine. I don't think it's just a camping jamboree for 150,000 soldiers in the middle of winter. Watching a news clip online, I'm struck by low-altitude drone footage of Russian T90 main battle tanks churning across a frozen field, followed by a dense black cloud of exhaust smoke.

The inky veil appeared excessive, even for unregulated combat vehicles. The big multifuel V12 turbodiesels in those T90s appeared to be running extremely rich, I thought. And while that might help expose them as targets on the battlefield, their unbounded particulate and NOx emissions are no concern to authoritarian-regime defense planners. Neither are the planners moved by the environmental media, which prefers to direct its scolding at U.S. and Western equipment. A recent piece in Earth.org called American military pollution "a significant contributor to climate change." The article said if the U.S. military "were a nation state, it would be the 47th largest emitter in the world."

Hmm. To the crews inside trucks, tanks, ships and planes, the most vital engineering metrics for staying alive are "payload, performance and protection," as Oshkosh Defense states on its website. I wouldn't bet that those serving in front-line units would trade package space allotted for fuel, ammo, sensors, and armor for complex exhaust aftertreatment worthy of a "Certified Clean Idle" sticker.

In broader scope, however, the drama on the Russia-Ukraine border and its potential global implications shows how geopolitics pose at least as much of a challenge to a clean, safe environmental future as does a changing climate. As tensions peaked over Ukraine, the National Oceanic and Atmospheric Administration (NOAA) released a report projecting that sea levels around the U.S. will rise by up to one foot over the next 30 years due to a warming climate. Which danger poses greater existential threat over the long term? In my view, it's the geopolitics. Governments that are pushing for an EVs-only mobility future by 2030 should rethink options.

Rising sea levels are not our only major dilemma.

Consider that major conflict in Europe, likely to include crippling cyberattacks, would cause cascading economic disruption, experts say. That's on top of an already troubled outlook that has oil prices nudging $100/bbl as of mid-February. Germany's ill-advised decision to abandon nuclear power generation leaves citizens vulnerable and raises questions about how quickly a comprehensive electric-vehicle charging grid can be created. The not-yet-complete NordStream2 gas pipeline is not a reliable alternative, considering who controls the gas source.

Automotive leaders and investors are closely watching the Ukraine situation and its threat not only to democratic principles, but to their global manufacturing enterprises. So is China, which currently holds all the cards regarding lithium supply. Some analysts believe that failure to divert a Ukraine invasion may embolden Beijing's communist leadership to realize its long-held ambition to conquest Taiwan. The resulting conflict would be far more likely to pull the U.S. into a major war than an invasion of Ukraine. Aside from catastrophic loss of life, there would be strategic implications for the OEMs that have billions invested in China production, sales and battery deals, not to mention the future of Taiwan's industry-leading semiconductor companies.

I wish it wasn't the case, but climate change is only half the struggle.

Lindsay Brooke, Editor-in-Chief

EDITORIAL

Bill Visnic
Editorial Director
Bill.Visnic@sae.org

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

Paul Seredynski
Senior Editor
Paul.Seredynski@sae.org

Ryan Gehm
Associate Editor
Ryan.Gehm@sae.org

Matthew Wolfe
Assistant Editor
matthew.wolfe@saemediagroup.com

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

Contributors

Kami Buchholz
Detroit Editor

John Kendall
Europe Editor

Bradley Berman
U.S. West Coast Editor

Sebastian Blanco, 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
Ed Marecki
+1.401.351.0274
edmarecki@earthlink.net

CT:
Stan Greenfield
+1.203.938.2418
greenco@optonline.net

Mid-Atlantic/Southeast/TX:
DC, VA, WV, TN, NC, SC, GA, FL, AL, MS, LA, AR, OK, TX
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
Kyle Fiene
+1.310.800.4514
kyle.fiene@saemediagroup.com

International

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

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

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

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

Integrated Media Consultants

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

Scott Williams
+1.973.545.2464
scott.williams@saemediagroup.com

SUBSCRIPTIONS

+1.866.354.1125
AUE@OMEDA.COM

The new EV-driven regional supply focus

The recent flurry of investment announcements focused on the conversion of North America's light-vehicle production to electric-vehicle propulsion has been head spinning. No less than 20 announced battery plants are in the planning stages with a further round of yet-to-be-announced facilities expected to arrive later this decade. While strategies towards electrified propulsion differ between OEMs, virtually everyone is on the EV bandwagon.

This rapidly rising rate of EV commitments has many suppliers re-examining their future strategic plans with an eye on ensuring their organization can catch the wave – or survive a swifter decline in both combustion-engine and planetary-type automatic transmission volumes through this decade. In previous columns I've outlined whether a supplier should consider the sectors they are currently active in as being EV-positive, EV-agnostic or EV-negative. This determination and subsequent actions by each supplier to optimize the overall strategy are critical to future survival.

Along with the massive shift in technologies, the value stream and program cadence, a new supplier/OEM footprint is emerging. It's evident in the proximity of new battery plants to the light vehicle assembly plants they are feeding now and in the next few years. Gone are the days when engine and transmission facilities were not required to be logistically close to the final assembly plant. Due to economies of scale, there are scores of examples where major powertrain components travel between continents.

This will not be the case with the positioning of battery plants. High volume (over ~150k/year) EV final production facilities require propulsion battery assembly within two to three hours' transit time to limit logistics risk and cost. And it's not just battery supply that is being rethought: OEMs see the need to increasingly regionalize a significantly greater slice of future light vehicle sourcing. Major component systems such as seats, door panels, overhead systems, class A (exterior stampings), front/rear fascias and a host of others will continue to require a close logistics connection no matter what type of propulsion.

Michael Robinet
Executive Director, IHS Markit
SAE Foundation Trustee
michael.robinet@ihsmarkit.com

OEMs see the need to increasingly regionalize a greater slice of future light vehicle sourcing.

Add in battery assembly and the ability to build new sourcing structures for drive systems, power electronics and charging systems and it becomes clears that a transformation is emerging: OEMs have the rare opportunity to construct a new supply ecosystem.

The current system is the result of decades of successive sourcing decisions driven by investment incentives, labor contracts, final customer logistics and other factors. By comparison, the new EV-driven regional focus will increasingly compartmentalize major component supply, reduce logistics risk as well as the currency/tariff risk that is ever-present in the industry. North America's major regions of the Great Lakes, U.S. Southeast, Southwest/Northern Mexico and Mid-Mexico will increasingly compete for investment. The dynamic underscores the need for regional collaboration between states and provinces to drive the agenda.

A rise in EV investment and subsequent volume places pressure on traditional ICE-serving supply chains. Especially in powertrain volume, OEMs are already carefully and selectively winding down their current facilities over time, keeping an eye on capacity utilization. Operating a slew of facilities on one shift as volumes decline is not an effective solution. OEMs will increasingly seek regional/local supply where these make sense from a logistics-risk perspective. As such, Tier 1 and 2 suppliers whose businesses thrived within the current IC engine ecosystem will need to accommodate the new EV landscape. ■

PROPULSION

Wheel-hub-motor innovations in 'flux'

Saietta AFT wheel hub drive mounted on a skateboard-type EV chassis.

The packaging and design of electric motors has, not surprisingly, come under scrutiny in recent years as the pace of vehicle electrification has accelerated. Wheel hub motors [https://www.sae.org/news/2021/07/making-the-case-for-in-wheel-motors], once dismissed as too costly and dynamically problematic for most automotive applications, are increasingly back in focus for EV use. Vehicle developers recognize that hub motors offer advantages – particularly in all-wheel-drive applications. And hub motors tend to favor the packaging advantages offered by axial-flux motor designs.

The compact dimensions of axial-flux motors make it far easier to package in a hub-mounted application. In addition, the more-powerful axial-flux designs are larger in diameter than comparable radial-flux motors, offering a packaging advantage in line with wheel dimensions: Small-wheeled vehicles such as scooters need smaller, less-powerful motors, while the larger wheel diameters of trucks and buses parallels the larger diameter and more powerful motors needed for these vehicles.

U.K.-based axial-flux motor designer and producer **Saietta** recently bought the Dutch supplier of electric drivetrains and high-voltage power electronics, **e-Traction**, from the Chinese **Evergrande** New Energy Vehicle Group. "I was in Slovenia and suddenly a lot of Dutch friends started texting, "Electric motor company about to go bankrupt in Holland," noted Saietta CEO Wicher (Vic) Kist. This was shortly after Saietta had been listed on the London Stock Exchange, following earlier investment from the U.K. Enterprise Investment Scheme (**EIS**).

"I thought, 'This is an opportunity,'" Kist told **SAE** Media. "I flew the entire M&A [mergers and acquisitions] team over that delivered the Saietta IPO and four weeks later, we signed", Kist said. "What I found is it's almost like the brother we didn't realize we had. Fifty-five people, very similar to the U.K. team and power electronics, electromagnetics and especially on the power electronics side, an inverter."

Saietta had developed an axial-flux technology (AFT) motor in response to British rival axial-flux motor designer **YASA**, which was acquired by **Mercedes-Benz** in July 2021. Since e-Traction produced an 800-V inverter, it neatly fulfilled Saietta's need for one. The acquisition also added e-Traction's e-axle technology

SAE International Sections
SAE International Sections are local units comprised of 100 or more SAE International Members in a defined technical or geographic area. The purpose of local Sections is to meet the technical, developmental, and personal needs of the SAE Members in a given area. For more information, please visit sae.org/sections or contact SAE Member Relations Specialist Abby Hartman at abby.hartman@sae.org.

SAE International Collegiate Chapters
Collegiate Chapters are a way for SAE International Student Members to get together on their campus and develop skills in a student-run and -elected environment. Student Members are vital to the continued success and future of SAE. While your course work teaches you the engineering knowledge you need, participation in your SAE Collegiate Chapter can develop or enhance other important skills, including leadership, time management, project management, communications, organization, planning, delegation, budgeting, and finance. For more information, please visit students.sae.org/chapters/collegiate/ or contact SAE Member Relations Specialist Abby Hartman at abby.hartman@sae.org.

SAIETTA

to the Saietta portfolio, which will help the company to realize its desire to produce electric drive systems for trucks and buses.

The e-axle designed by e-Traction has the inverter packaged within the drive motors. Kist described it as "a fairly standard outrunner motor" but with direct drive, similar to Saienna's AFT philosophy.

Inside the motor

The first prototypes of the e-Traction-designed e-axle have been built and tested. The principal components of the Saietta AFT motor include a pair of cold-formed, copper hairpin-shaped coils. "That pair is a discrete coil, which you can hold in an assembly line so you can make the entire stator fully automated," Kist explained. The stator ring is extruded and the lamination packs are of grain-oriented steel. The rotor is formed from mild steel and the motor is surrounded by a small cooling jacket. "Torque is r times force and basically because our effective diameter is bigger (compared with a radial-flux motor), we can achieve a higher torque for the same current," he said.

SAIETTA

Saietta CEO Vic Kist with skateboard-type EV chassis.

Acquiring the e-axle technology has accelerated Saietta's plans for powering heavy vehicles. He had been planning to work on similar technology with the aim of introducing the company's own power electronics in three years.

Acquiring e-Traction has accelerated Saietta's development of truck and bus electric axles.

Outboard marine drive

Saietta launched the latest application for its AFT at the Marine Equipment Trade Show (METS) in Amsterdam in November 2021. The company launched a new division devoted to marine propulsion with two new designs under the brand name Propel. The first is an outboard motor and the second a replacement for light marine diesel engines used in leisure craft and work boats, both powered by Saietta AFT motors.

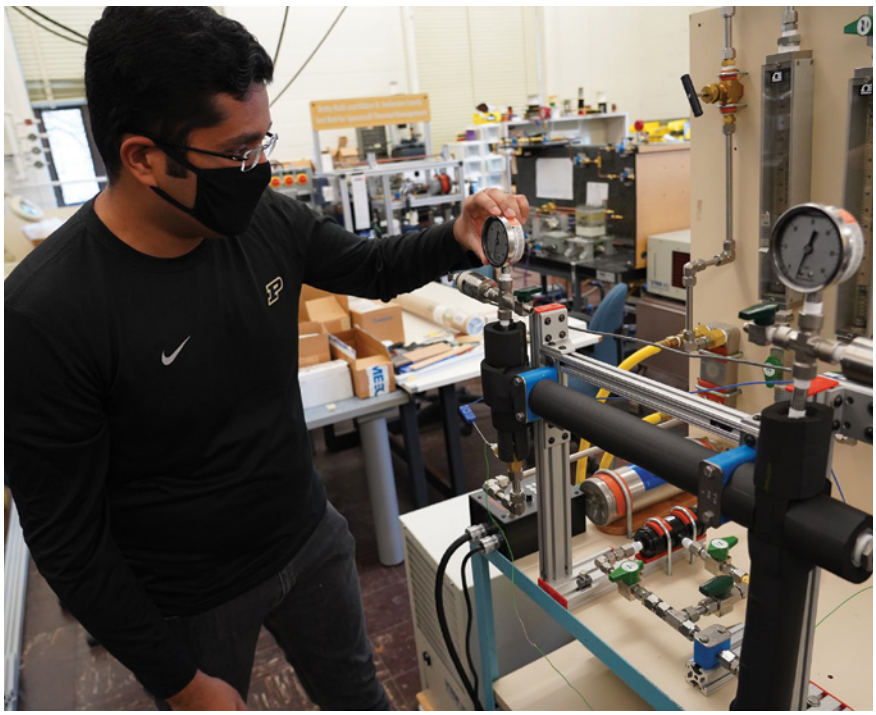
The D1 inboard engine range uses low-voltage motors and does not need a gearbox. Included in the package are a sunlight-readable 5-inch (12.7-cm) display and a side-mounted "throttle" lever, as well as a DC inverter to power onboard 12-V devices. For the Propel S1 outboard motor, Saietta has drawn on existing designs for the shaft leg and also designed and produced a closed-loop cooling system filled with glycol, so the motor could be left in place through the winter. It also removes the need for a cooling-water intake below the waterline.

The motor and control electronics all are housed above the waterline. Saietta claims a 10-kW continuous power output from a 48-V battery. Using Saietta's own four-bladed propeller, this should produce 3.75 kW of propulsive power. "You can optimize your propeller because you don't need an exhaust in the middle of that prop, so that helps a lot," Kist said. "Then, it's just a shaft that goes up with an internal spline in our motor, with integrated inverter and it just goes on top."

John Kendall

ELECTRIFICATION

Purdue prototypes new EV fast-charge cable



Purdue Ph.D. candidate V.S. Devahdhanush monitors system pressure within the charging cable and the flow rate of a dielectric heat transfer fluid via a Rotameter flow meter.

A new charging station cable designed by a **Purdue University** research team could enable an electric vehicle (EV) battery to be recharged in under five minutes, comparable to filling an average passenger vehicle's fuel tank at a gas station. The patent-pending technology "addresses a better thermal management scheme for EV charging cables based on the principles of subcooled flow boiling. This would enable ultra-fast charging of EVs by the safe passage of much higher electrical currents through the cable," said V.S. Devahdhanush, a Purdue University Ph.D. candidate and research project team member.

The Purdue team's prototype charging station cable is designed to dissipate heat as electrical current flows through the cable. In comparison to the cable used by Tesla on its Supercharger V3 – currently considered the fastest charger in the U.S. market – the prototype cable delivers 4.68 times the current, according to Devahdhanush. The Tesla V3 supercharging architecture supports peak charging rates up to 250 kW per car.

To achieve a faster charge rate, a cable needs to enable higher electrical current flow. "We've been able to demonstrate experimentally the safe, steady passage of 2,438-amp current through a 0.25-in wire," Devahdhanush said, noting higher values are theoretically possible. With a 10-foot long (3-m) cable containing two high-direct current wires, equivalent to a single 20-foot wire, 24.22 kW of heat is removed via the cooler cable providing 2,438-A current.

Most of today's charging stations can deliver current up to approximately 520 A. However, DC fast chargers typically deliver less than 150 A. Charging times vary from approximately 20 minutes to several hours, depending on whether a

FROM LEFT: SAIETTA; JARED PIKE

Level 1 (120 V), Level 2 (240 V) or Level 3 (DC fast) charger is used. The main influencers for charging times are the EV battery's power input rating, the power supply's output rating, and the charging cable. A sub-five-minute charge time would require that the power ratings and charging cable be rated at 2,500 A.

Commercially available charging station cables are liquid-cooled, using the principle of forced convection heat transfer, noted Devahdhanush. In this conventional cooling technique, fluid absorbs heat from the cable. After the heat is dissipated to the external surroundings, the fluid temperature falls and the cooling cycle continues.

The Purdue cable design incorporates a liquid-to-vapor cooling process. A dielectric heat transfer fluid flows within the cable conduit that surrounds the wires. When the wires' surface temperature becomes greater than the fluid's boiling point, the liquid starts boiling at the wire surface and small vapor bubbles are produced.

Purdue University's charging station cable R&D team, led by mechanical engineering professor Dr. Issam Mudawar, regularly communicates with a team of **Ford Motor Co.** researchers to review findings and provide feedback on various focus areas. Michael Degner, senior technical leader at Ford Research and Advanced Engineering, noted that this research alliance has the potential to make EV and commercial fleet ownership considerably more appealing and accessible.

JARED PIKE

Professor Issam Mudawar (center) leads a Purdue University team working to develop a new charging station cable inside the Boiling and Two-Phase Flow Laboratory at Purdue's School of Mechanical Engineering.

The next steps in the project include testing the innovative charging station cable on EVs. "We are now negotiating with several cable, coupler, pump, and heat exchanger vendors as part of our just-announced Research Center for Electric Vehicle Charging and Thermal Management to determine how to commence such testing," Devahdhanush said.

Kami Buchholz

ALTERNATIVE FUELS

GM reveals hydrogen-fueled power generator and EV rapid-charger

GM and Renewable Innovations are collaborating on an Empower rapid charger that can help retail fuel stations add DC fast-charging capabilities without significant investment in non-recoverable infrastructure upgrades.

General Motors in January announced the expansion of commercial applications for its Hydrotec hydrogen fuel cells with an integrated DC rapid charger. The company currently is developing units intended for applications such as heavy-duty trucks, aerospace and locomotives, but it now is broadening the intended use to include stationary power generation.

GM's Hydrotec-based power generators will be powered by the company's second-generation fuel cell power cubes. GM is supplying Hydrotec power cubes to **Renewable Innovations** of Lindon, Utah, who will manage the assembly of the mobile power generators.

In addition to mobile EV charging, GM and Renewable Innovations have collaborated to develop the Empower rapid charger. This charger is intended for existing fuel stations seeking the ability to add DC fast charging capability. GM states the Empower rapid charger will help satisfy the growing need for fast charging infrastructure with no additional investment in electrical infrastructure upgrades.

The rapid charger is powered by eight GM Hydrotec power cubes and can supply a DC charge for up to four vehicles simultaneously at a rate of 150 kW. The estimated target for a full charge time of an EV via these units is 20 minutes. GM claims up to 100 or more EVs can be replenished by the rapid charger before the unit would need to be resupplied with hydrogen. Renewable Innovations plans to deploy 500 Empower rapid chargers across the

GM's mobile power generator can fast-charge EVs without having to expand the grid or install permanent charge points in locations where there is only a temporary need for power.

BOTH IMAGES: GM

U.S. by the end of 2025.

"Our vision of an all-electric future is broader than just passenger vehicles or even transportation," said Charlie Freese, GM executive director of the global Hydrotec business. "Our energy platform expertise with Ultium vehicle architectures and propulsion components and Hydrotec fuel cells can expand access to energy across many different industries and users, while helping to reduce emissions often associated with power generation."

According to GM, these hydrogen fuel cell generators could replace gas- and diesel-burning units commonly used at construction sites, data centers and outdoor events. GM also claims they could serve as an emergency power source for residential houses and lower demand commercial needs. The mobile power generator can also be palletized for use in military applications. The power output of these units ranges from 60-600 kW, and they do not generate excessive levels of heat or noise. Pricing details for these units have not yet been announced.

There are currently several validation and development projects planned for the Hydrotec mobile power generator, including a charging station for EVs being funded by the **Michigan Economic Development Corporation** and the **U.S. Army** Combat Capabilities Development Command Ground Vehicle Systems Center. The target launch date for this charging station is mid-2022. The **California Energy Commission** is also funding a demonstration utilizing four mobile power generators to study the use of hydrogen-based mobile power to offset the loss of energy during the planned power shutoffs.

"We've seen that there's a need for EV charging in places where there's no charging equipment," said Robert Mount, CEO and co-founder of Renewable Innovations. "Now we're committed to bringing the best technology and game-changing applications to market with GM to accelerate the company's vision of a zero-emissions future."

Matt Wolfe

PEOPLE

2022 SAE President Sri Srinath: Engineer, leader, mentor

With experiences ranging from being a hands-on engineer to managing multi-billion-dollar businesses to serving as a director in human services, "Sri Srinath is well suited to lead SAE International over the next twelve months amid life-transforming technological innovation in mobility and related fields," Raman Venkatesh, SAE's chief operating officer, noted. "He is sure to be an inspiration for SAE members."

Dr. Srinath, the 116th person to serve as SAE president, has distinguished himself not only at Caterpillar, where he worked in various engineering roles for nearly 30 years, but also at SAE. He became a member in 1988 and has served on the Board of Directors (2014-2016), Finance Committee (2016-2019), Executive Nominating Committee, and COMVEC Executive Council. After retiring from Caterpillar at the end of 2015, he joined the management consulting firm CGN Global, where he currently serves part time as managing director. Srinath is also principal board advisor at Booma Innovative Transport Solutions, an Indian electric vehicle manufacturer.

"I have an engineering background but an executive mindset," he told *Update*, SAE's member publication, in a December 2021 online interview. And so it is with confidence – and "a trace of nervousness" – that Srinath, who describes himself as "easygoing and approachable," starts his one-year term as SAE president. "I can't say enough about how excited I am. It's a great responsibility and I want to make sure I'm a good steward. I intend to leave the organization as least as well as I find it, if not better," he said.

Among Srinath's goals is to support the continued expansion of SAE technical committees in autonomy, electrification and batteries, vehicle connectivity, and other new technology areas. He noted that more than ever the aerospace, automotive and commercial vehicle sectors share a technology focus in these key areas. As engineers learn

Dr. Sri Srinath earned his Ph.D. in aerospace engineering from the University of Michigan.

from each other and collaborate across sectors, Standards is increasingly "a prime area for SAE to demonstrate the integrated approach," Srinath said.

Mentoring, especially for young people, is a personal focus area for SAE's 2022 president, who earned his Ph.D. in aerospace engineering from the University of Michigan. Specifically, he would like to see SAE lead a mentoring process where college students who are already engaged with SAE reach out to high-schoolers before they make their career-choice decisions. "Rather than me or you talking to these kids, college students would have more relevant things to say. They have 'street cred,'" he asserted.

The new social-media-savvy generation, Srinath said, "is a lot more about giving and doing good and not quite as selfish as my generation was at their age. We should tell them that if you join SAE, 'you can help by advancing the world of science, advancing the world of mobility engineering, and here's how mobility engineering can help the world.'"

Patrick Ponticel

POWERTRAIN

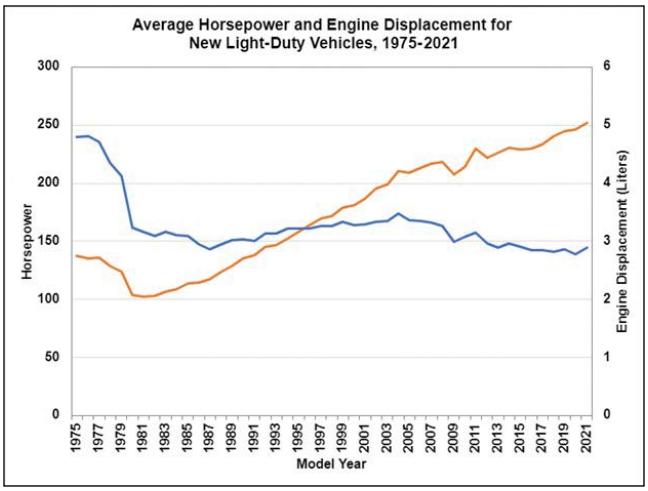
Light-vehicle horsepower hits historic high in 2021

Full-electric propulsion for the U.S.'s light-vehicle market segments is gaining momentum, but developers of the internal-combustion engine aren't throwing in the towel just yet. Figures recently compiled by the **U.S. EPA** to include the 2021 model year indicate average horsepower for light-vehicle engines reached a historic high of 252.2 hp in 2021.

The highest-ever horsepower figure came, said the EPA, despite average engine displacement remaining at a near-historic low. Average light-vehicle engine displacement in 2021 was 2.9L and has been less than 3.0L since 2014. The lowest-ever average displacement is 2.8L, which was recorded in several years since 2014.

The EPA's light-vehicle dataset, dating to 1975, is nearing 50 years of scope. In 1975, average horsepower was 137.3 and the lowest-ever average was 102.1 hp in 1981 – despite an average displacement that year of 3.2L. Average displacement was 3.0L or larger for nearly a quarter-century from 1988 to 2013 and after 2014 has never again exceeded 3.0L. The years 1975 and 1976 had the highest average displacement, 4.8L, in the near half-century of the **U.S. Dept. of Energy** (DOE)/EPA's records.

The DOE's Vehicle Technologies Office noted the marked increase in engine specific output by summarizing, "From 1975 to 2021, horsepower has increased by about 84% while engine displacement has decreased by 40%." The information was derived from the EPA's *2021 Automotive Trends Report*. [https://www.epa.gov/automotive-trends]



Average light-vehicle horsepower hit an all-time high in 2021, despite average engine displacement near a historic low of 2.8L.

Bill Visnic

ELECTRIFICATION

ZF debuts new chip-agnostic EV inverter, ADAS for Vinfast

ZF recently debuted a new scalable and modular e-motor inverter architecture that can be used in powertrain systems ranging from 400V to 800V. But it's the other flexibility built into the system that will likely attract the most attention in the face of the global semiconductor crisis. The new inverter architecture is not dependent on predefined semiconductors, ZF said, and was designed "to support vehicle manufacturers in bridging the silicon-to-silicon-carbide transition while also being prepared for future semiconductor trends."

This next-generation inverter, called the Modular eDrive Kit, "[optimizes] the link between the power semiconductor boundary conditions and control software in order to gain the full potential from the semiconductor configuration," ZF said, especially when used with silicon-carbide (SiC) semiconductors. The Modular eDrive Kit will be ready for production by 2025 but the real benefit might be in the way this set-up helps automakers shorten their product development lead times.

ZF board of management member Martin Fischer said by using different semiconductor chips, whether traditional silicon or silicon carbide, and the different voltage ratings, ZF has created a platform that can be easily shaped and configured for customer applications. "When we started early, we had the comfortable situation of three years between getting the order and shipping the product," he said. "We target cutting that in half."

And the company's long history of working with global automakers now extends to Vietnam. ZF and **VinFast Automotive**, the automotive arm of the VinFast Global conglomerate, announced at CES 2022 that it would bring advanced driver assistance systems (ADAS) to VinFast's electric vehicles. VinFast will use ZF's so-called "Level 2+" ADAS functions (enhanced SAE Level 2) in the new EVs when they launch in mid-2022. The ZF-VinFast partnership will lead into Level 3 technologies "over the next several years," the companies said. VinFast claims that the Eco and Plus trims of its EVs will come equipped with ZF's "L2+" automated driving features, while the Premium trim will feature SAE Level 3 or 4 autonomous technology, but limited to automated parking situations, VinFast claims.

ZF will supply "multiple cameras, radars and lidar sensors" to VinFast, as well as a central control unit that will fuse the information from these sensors in order to offer features like traffic jam pilot, highway driving chauffeur and automated valet parking. VinFast said its EVs will be "among the first systems intended to rely on the vehicle sensor set to operate rather than pre-mapped and instrumented parking structures," when the Level 4 ZF Automated Valet Parking arrives.

Sebastian Blanco

U.S. EPA

ADAS

GM and Qualcomm partner for Ultra Cruise

Ultra Cruise, General Motors' next generation of hands-free 'Super Cruise' ADAS technology, will be powered by a scalable compute architecture featuring a system-on-chip (SoC) design developed by U.S. semiconductor company **Qualcomm Technologies Inc.** As announced by the two companies in January, GM will be the first automotive OEM to use Qualcomm's Snapdragon Ride platform for ADAS use. The new architecture features a 5-nanometer Snapdragon SA8540P SoC and SA9000P artificial-intelligence accelerator, which Qualcomm claims is "industry leading."

Teaser image of a front quarter of the upcoming Cadillac Celestiq; its ADAS will feature the new GM-Qualcomm Snapdragon processor.

SoC technology integrates, on a single microchip, all or most components of a computer, including a CPU (central processing unit), input/output (I/O) ports and secondary storage, with other components including radio modems and a graphics processing unit (GPU). Ultra Cruise's compute, described by GM as approximately the size of two laptops stacked together, will be available in 2023 on vehicles including the Cadillac Celestiq, a super-premium electric sedan using GM's BEV3 platform and expected to enter the market at more than $100,000. In that vehicle, two Snapdragon-based processors, including high-performance sensor interfaces, memory bandwidth and the Ultra Cruise software stack, will provide the necessary bandwidth for vehicle sensing, mapping, localization, and driver monitoring, according to the companies.

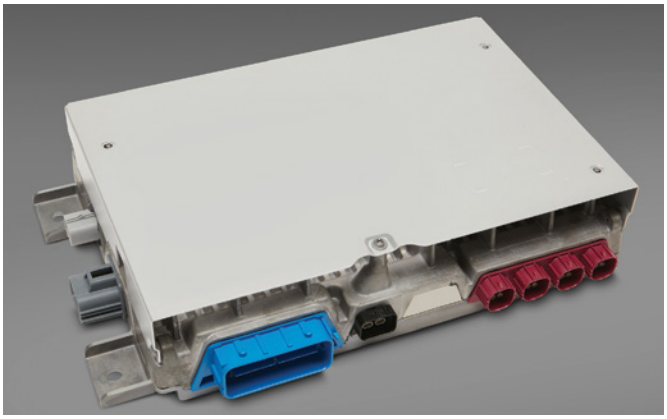
With the Qualcomm technology, Ultra Cruise will have the capability to execute hands-free driving "in 95% of all driving scenarios," GM promises. Noted Ken Morris, GM VP of electric, autonomous and fuel cell vehicle programs, "Despite its relatively small size, Ultra Cruise's compute will have the processing capability of several hundred personal computers. It will take qualities that have distinguished GM's advanced driver-assist systems since 2017 to the next level with door-to-door hands-free driving."

The Ultra Cruise compute is comprised of two Snapdragon SA8540P SoCs and one SA9000P AI accelerator to deliver key low-latency control functions on 16-core CPUs and high-performance AI compute of more than 300 Tera Operations per second for camera, radar and lidar processing. The Snapdragon SoCs are designed with 5nm process technology, enabling "superior performance and power efficiency," Qualcomm said in a release.

The compute, along with Snapdragon Ride SoCs, includes an Infineon Aurix TC397 processor for system safety integrity. The Aurix TC397 is categorized ASIL-D – the highest Automotive Safety Integrity Level (ASIL). To minimize complexity within the compute and reduce mass, GM engineers opted for an air-cooled instead of liquid-cooled thermal-management system. The Ultra Cruise compute also will have the capability to evolve over time by leveraging Snapdragon Ride's SoCs performance and high-speed interfaces for future expansion, the companies said. It will also enable over-the-air (OTA) updates through GM's new Ultifi software platform and Vehicle Intelligence Platform electrical architecture.

The new system will help power GM-developed ADAS software and features going forward. (Ultra Cruise currently is considered an SAE Level 2 ADAS.). GM noted that these capabilities were developed in-house at the automaker's engineering facilities in Israel, the U.S., Ireland and Canada. At CES 2022, Qualcomm also announced that **BMW** and **Renault** will adopt the Snapdragon Ride platform by 2025.

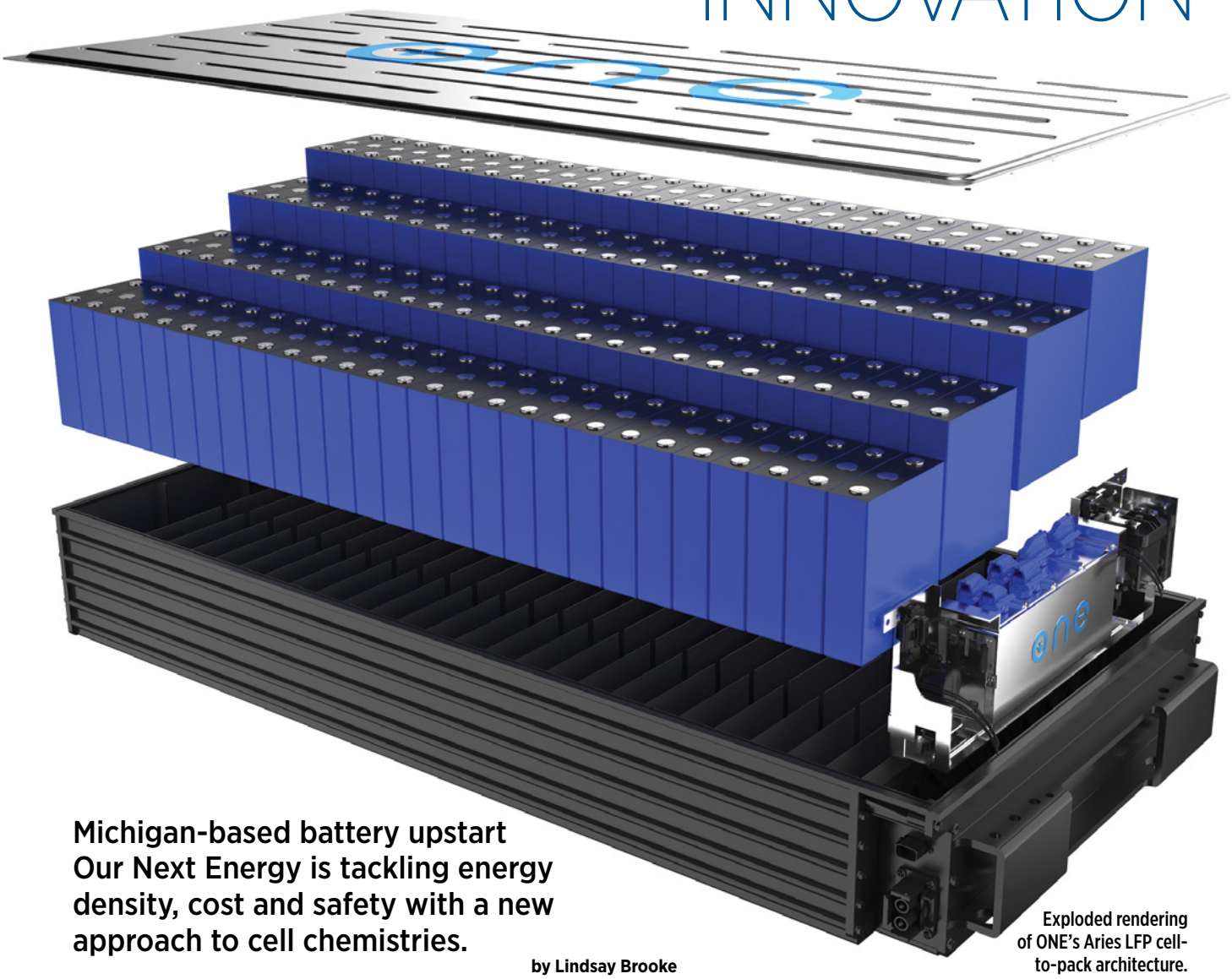
Lindsay Brooke



Snapdragon aluminum housing for the UltraCruise compute is extensively finned inside to aid heat dissipation.

FROM TOP: CADILLAC; GM

The ONE for BATTERY INNOVATION



Michigan-based battery upstart Our Next Energy is tackling energy density, cost and safety with a new approach to cell chemistries.

by Lindsay Brooke

Exploded rendering of ONE's Aries LFP cell-to-pack architecture.

ONE

"When I look at our 'toolbox,' we've got one cell chemistry that delivers high energy density, is low cost, but it doesn't have optimum cycle life," veteran battery engineer Mujeeb Ijaz noted. "And we've got another cell that's super-good at cycle life. We realized that given about 99 percent of EV duty cycles, we don't need a single cell chemistry to solve all the problems. We can just use two."

Ijaz, the founder and CEO of Novi, Michigan-based battery upstart **Our Next Energy** (ONE), explained his company's unique approach to the inseparable demands of EV range, cost and safety. ONE has developed two complementary battery architectures. The first, called Aries, is a structural cell-to-pack single-chemistry battery currently in prototype testing at customers. It uses a lithium-iron-phosphate (LFP) cell, in prismatic form factor, that eschews nickel and cobalt. LFP has an outstanding safety reputation but underperforms nickel-cobalt-aluminum (NCA) cells in terms of energy density.

ONE's more-advanced archiecture, Gemini, targets an energy-density level of 450 watt-hours per liter. Its unique dual-chemistry format combines a conventional traction battery with a second chemistry to serve as a range extender. The combination is designed to deliver more than double the 300-miles (483-km) driving range of a typical EV (*see sidebar*).

Ijaz, whose 30-year mobility career began in **Ford**'s fuel-cell EV program followed by stints at battery supplier **A123** and at **Apple**, wouldn't reveal much about Gemini in an interview with SAE Media. "It's not LFP and it doesn't go into thermal runaway," he said. There is "zero cost on the anode side because we deleted all the graphite, which gives us more cathode volume," he confirmed. Manganese is one constituent cathode material that Ijaz and his team believe will help them deliver "a

Cell-to-pack requires three conditions for it to be a rational solution.

high-value range-extender cell that will give an electric vehicle up to 750 miles' range," Ijaz said. Gemini's proprietary technology is supported by more than a dozen patents. ONE plans to demonstrate a production prototype Gemini battery in 2023.

"Metro delivery trucks can probably get away without extended range. But consumer needs are different," he said. "Consumers know that one percent of the time, usually during vacation or holidays, they'll be taking a trip. They'll buy a car or truck for that one percent of their annual driving needs; that's just part of the emotional aspect of a vehicle purchase decision." Ijaz cited study data showing about one-third of vehicle owners will consider an EV for their next vehicle, based on the range of today's EVs. Demand jumps to about 95% if current EV range is doubled, he said.

"We need charging infrastructure, but we also need to extend EV range so that a regional trip — Detroit to Chicago, or San Francisco to L.A., for example — isn't a decision to either drive or fly," he said, because of the time required for en-route charging. Ijaz also explained that ONE aims to establish its batteries before SAE Level 4 vehicle autonomy takes off, a shift that "will disruptively grow our market."

ONE is steering clear of nickel-cobalt for its production batteries because the team believes the chemistry has the potential to thermally run away if an internal short develops. "I'd say we should be worried about the foundation of NCM/NCA," Ijaz asserted. "The industry arrived at nickel-cobalt because it was the only family of cell chemistry to deliver the range numbers." He noted that while he's not uncomfortable in his daily driver, a **Tesla** Model Y which uses NCA cells, if the industry avoids nickel-cobalt altogether as EV adoption rates increase "we'll avoid the risk altogether."

Engineering an EV battery that's twice as capable as today's, in terms of energy density, helps ensure that the battery is not abused or overheated under extreme use as indicated in its C Rating, the measurement of current in which a battery is charged and discharged. With high energy density, the battery is in effect being babied because it has so much available energy in relation to most typical duty cycles.

"Thermal management can be optimized; battery life and overall 'health' are extended by making the energy reserves, the power-to-energy ratio, so much greater." Ijaz equates this to an under-stressed big-block V8 that can loaf along generating high torque at low rpm.

CEO and founder Mujeeb Ijaz, shown with his 1922 Detroit Electric, is retrofitting the car with ONE's LFP batteries.

LINDSAY BROOKE

Making cell-to-pack work

Backed by investors including **BMW i Ventures**, Bill Gates' **Breakthrough Energy Ventures**, and **Volta Energy Technologies**, ONE has grown from two founding employees in late 2020 to 80, mostly engineers, today. That's set to double within the next year as the company launches a pack-assembly plant in Michigan in November 2022, ramps up a new cell R&D facility near San Francisco, continues Gemini development, and finalizes Aries validation and testing prior to late-2022 production "for a customer's delivery vehicle," according to Ijaz.

ONE recently completed a $60 million bridge round of investment aimed at funding manufacturing development in the U.S., noted business manager Nick Twork. It also hired Dr. Steven Kaye as its new CTO. Kaye previously led battery materials R&D in Apple's Special Projects Group. He holds over 60 patents covering battery cathode, anode, electrolyte, cell architecture and pack designs.

A prototype Aries LFP pack prior to delivery for customer testing.

The structural cell-to-pack concept embraced by ONE and other battery suppliers including **BYD** (https://www.sae.org/news/2021/10/byds-blade-runner) does away with modules, integrating the cells themselves into the pack architecture for increased package and mass efficiency. Ijaz explained his team's engineering rationale, noting that cell-to-pack requires three conditions for it to be a rational solution.

"First, the chemistry has to be right," he said, calling LFP "the birth center" of cell-to-pack. "A chemistry that tends to self-oxidize is not feasible; if a failure occurs and the chemistry self-oxidizes, it will rip through the pack because the cells are so intimate," he said. "You can't stop the spread of a thermal runaway."

Secondly, cell form factor is important. Of the four primary types of lithium cell used in EVs, the pouch types are non-starters.

"For cell-to-pack to work, you need to create a load path that's load carrying; a pouch cell needs to be surrounded by a module," he explained. Metal cans and the "blade" type cell (used by BYD) function as stressed members and so are acceptable. And cell-to-pack structures present a challenge in terms of serviceability; Ijaz argues that serviceability has to be given up.

Proving technology in a 752-mile run

To demonstrate their battery-tech prowess and increase the company's visibility, ONE engineers in December 2021 removed the stock 104-kWh battery pack from a Tesla Model S Long Range Plus sedan and replaced it with their own 207-kWh prototype pack, which fit nicely within the Model S's confines. They then set out from ONE's suburban Detroit headquarters into the Michigan heartland. After fourteen battery-draining hours of flogging the Tesla at an average speed of 55 mph (88 km/h), the team had covered 752.2 miles on a single charge.

In stock form, the longest-range Model S was rated by the U.S. EPA at 402 e-mpg. In 2020, *Car and Driver* magazine testers traveled 320 miles (515 km) at a sustained 75 mph (120 km/h) in the same Tesla-S model, a record distance for any vehicle tested by the publication at the time. The standard Model S has a drag coefficient of 0.24, according to Tesla.

Following the real-roads exercise, the team put the ONE-fortified Tesla on a chassis dynamometer at a sustained 55 mph, stretching its legs for 882 miles on a single charge. The prototype battery exercises (which used special cobalt-nickel chemistry) showed encouraging potential for the future of lithium batteries and EV range.

LB

The Tesla S fortified with a ONE high-energy prototype battery, being prepped for its 752-mile test run.

"An EV battery is large and expensive, representing about 40 percent of the vehicle's cost," he said. "To make the battery serviceable is not logical.

"Years ago, we believed that the OEM must be able to service the battery pack. Now, with a decade of EV experience behind us, the industry is learning that battery cells aren't failing.

"Electronics fail," he conceded, "but typically not the cells. You and the customer have to agree that you're not going to replace cells, which then becomes a warranty and validation topic."

FROM LEFT: LINDSAY BROOKE; ONE

Assembling a prototype Genesis pack in ONE's Mich. tech center.

ONE

Data-driven transparency

As a nascent battery developer in a crowded, competitive field dominated by incumbent giants CATL, LG, Panasonic and others, Ijaz is under no delusions about what it will take for ONE to survive over the long term. "I came into being a battery supplier with an appreciation for product-development and process discipline," he noted. "I got my process education twice: once for being around it and not fully valuing it, and again in a start-up needing it. This made me value and embrace it in a whole new light."

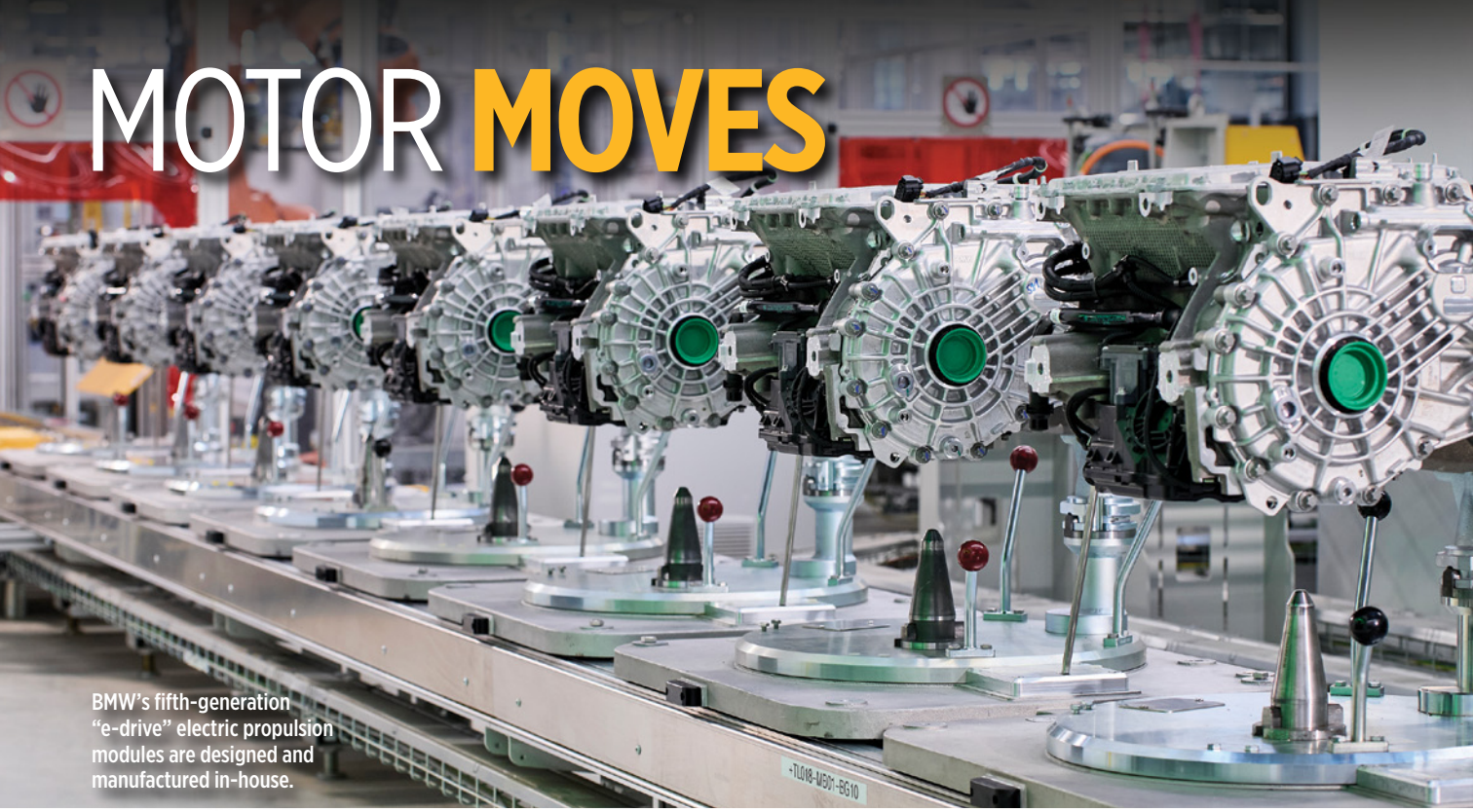
He's acutely aware of battery suppliers' infamous reputation for exaggeration, and chuckles as he reiterates the old saying about "liars, damned liars, and battery suppliers." When he made the jump from Ford to A123, Ijaz staunchly decided that he would not be part of that ongoing joke.

"I would not embody any of the aspects I'd seen in some battery suppliers that I didn't like when I was a Ford engineer. Things like a lack of transparency and thinking they could work their way through a problem without disclosing it. That's the clearest way to create mistrust."

He believes in robust, repeatable data and complete transparency as the only means to build a lasting and stout relationship with industry customers.

"When we went to The Battery Show in 2021, we came with data showing we had a 287-watt-hours-per-liter LFP pack that exceeds Tesla's LFP and their NCA packs as well as other products that we've benchmarked. We said, 'Let's show them' and we actually hung our battery pack on the wall for all to see, and we presented the data behind it," he said. "I learned not to talk about subjects for which I have no data, and to share problems and find solutions together. The customer appreciates that when they're involved and they understand both our progress and where we have risks." ■

MOTOR MOVES



BMW's fifth-generation "e-drive" electric propulsion modules are designed and manufactured in-house.

BMW

With EVs on the path to high-volume market penetration, automaker and supplier drive-motor production strategies come into focus.

by Bill Visnic

It's happening – the transition to EVs is undeniably underway. Recent launches such as **Ford**'s Mustang Mach-E, versatile-body-style EVs from mainstream brands **Hyundai** and **Kia** and forthcoming electric pickups from Ford and **GM** are positioning EVs on the high-volume trajectory widely forecasted as inevitable. Scores of new EV models from all automakers are promised to launch by 2025. Vivid evidence of the sudden EV and electrification groundswell came in early February when the short list of candidates for the European Car of the Year award was announced: every one had a plug.

Aside from batteries, the most significant component of the EV value and supply chain is the traction motor that – often integrated with an inverter and associated power electronics – is applied in single, dual, triple, or even at-each-wheel configurations to provide propulsion. Electric motors are vaunted for their comparative simplicity and efficiency. As such, the design hasn't substantively varied in the past half-century. But as EV market penetration hits its stride, automakers, suppliers and specialist e-motor developers are flowing massive resources to motor design, manufacturing and deployment.

Engineers and experts who spoke with **SAE** Media largely agree that two of the most crucial aspects of the transition from internal-combustion engines to electrified propulsion are how quickly it happens and whether automakers or suppliers will assume the development and manufacturing lead. Even if OEMs desire to emulate their tradition as the chief architects and builders of IC engines, the new paradigm of electrification may deliver different results. It is likely there will be markedly more traction motors designed and manufactured by suppliers than has ever been the case for IC engines.

"It seems there will be a mix of in-house, purchased, and in-house assembly with purchased components," said Jeff Hemphill, chief technical officer at **Schaeffler**, in response to emailed questions from SAE Media. "Our goal is to develop technical advantages that make us a preferred supplier," he added. It's a tack many Tier 1 suppliers are likely to take.

In-house or supplied

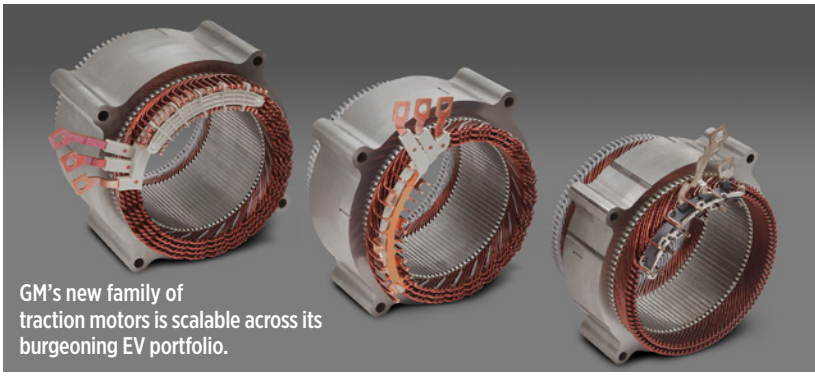
Currently, several global full-line automakers have indicated they intend to retain design and manufacture of traction motors as an in-house competency. General Motors plans to have some 1 million units of EV manufacturing capacity in North America by the end of 2025. Last fall GM revealed a "family" of electric motors – a pair of permanent-magnet (PM) synchronous units outputting 180 kW and 220 kW (241 hp and 295 hp) and an AC induction motor rated at 62 kW (83 hp) – designed to work as a system with the company's Ultium lithium-ion batteries. GM has yet to provide specifics about manufacturing, but in January announced it is spending $154 million to refit its components plant in Lockport, New York to produce motor stator modules. It is widely believed the company will produce most, if not all, of the new EV motor portfolio in North America.

Ford has not made any wide-ranging announcements about its electric-motor manufacturing strategy but has said the PM motors for Mustang Mach-E and the F-150 Lightning pickup coming in mid-2022 were developed in-house and are or will be built at the company's Van Dyke transmission plant near Detroit. The company said the F-150 Lightning's two traction motors – one per axle

– will generate a combined 318 kW (426 hp) with the pickup's standard-range battery pack and 420 kW (563 hp) with the extended-range battery. Torque in either configuration is 775 lb-ft (1051 Nm).

BMW, a brand with much to lose if the transition to electrification falls short of its powertrain heritage, recently announced a half-billion-euro expansion of its Dingolfing, Germany, plant for its "e-drive" motor modules (traction motor, power electronics and transmission in a single housing). Production at the site and others in Germany will facilitate manufacturing of e-drive (now in its fifth generation) for upwards of 500,000 electrified vehicles in 2022. "We expect at least 50 percent of the vehicles we deliver to our customers worldwide to be electrified by 2030. To achieve this, we are relying on our extensive in-house drivetrain expertise," said Michael Nikolaides, senior VP, Production Engines and E-Drives, BMW Group, in a release.

The "in-house advantage" might be most intense at startup **Lucid Motors**. In an interview with SAE Media, chief engineer Eric Bach stressed that Lucid's electric-drive module – a PM motor, inverter and gearbox the company dubs "impossibly compact," is an entirely in-house effort.

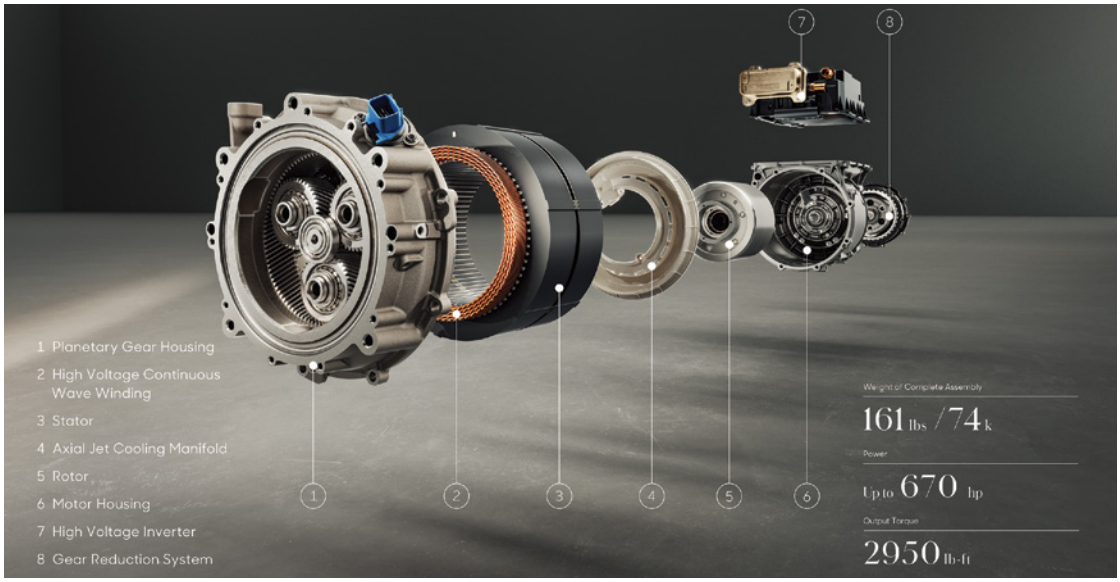


GM's new family of traction motors is scalable across its burgeoning EV portfolio.

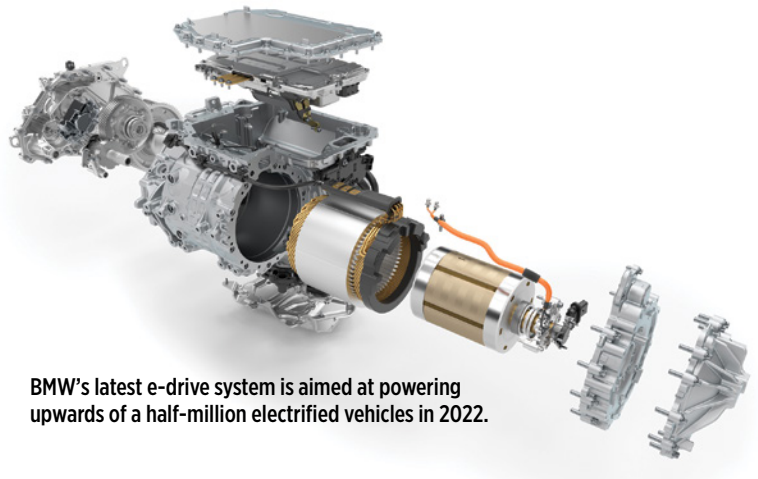
GM

"We purchase components, obviously, like a casting, we purchase gears, we purchase bolts, we purchase copper wire, we purchase the lamination stacks, but they've all been designed and engineered in-house," Bach asserted. "And we wind our copper in house. We do it really from single parts to the complete end-of-line-tested drive unit."

Countering the current slant toward in-house design in manufacturing for traction motors is the opening that several suppliers see in e-axle design and manufacturing, supplying a motor-integral axle module to easily impart propulsion for an axle not typically powered in the standard vehicle configuration. Tier 1s including **Bosch**, **ZF**,



Premium-EV startup Lucid Motors lavished ingenuity from several engineering disciplines to derive thunderous performance and efficiency for its traction-motor design.



BMW's latest e-drive system is aimed at powering upwards of a half-million electrified vehicles in 2022.

Lucid Motors chief engineer Eric Bach.

Magna, **GKN**, **Schaeffler**, **BorgWarner**, and **American Axle** see e-axles as expanding business for many years, particularly for hybrids. E-axles also are considered a method to simply and cheaply impart AWD capability for typically front-drive vehicle architectures.

Design and materials in 'flux'

As the light- and commercial-vehicle EV markets expand into volume, it seems certain that long-established PM motor designs will be the prevalent choice – particularly for high-volume or highly price-competitive vehicle segments. Such was the thinking for GM with its new three-motor lineup, said Patrick Curran, assistant chief engineer - drive units.

"When we designed the family of motors, we designed it such that in pretty much any combination, we can do anything in our fleet today. A lot of [vehicles] that we're not even talking about yet, we're going to be able to do with these. Think about how many engines and transmissions we have in the corporation," he continued. "It's an embarrassingly large number. We're going to be able to do all that with three motor combinations. There are different gear ratios, so you can get different output torques. But that's how we can really fine-tune the performance for each of those."

Schaeffler's Hemphill confirmed that "Permanent-magnet synchronous [motors] have the momentum right now, with induction machines sometimes used on a second driven axle. This seems likely to continue but could be modified by market forces like magnet prices."

Curran noted advancing technology will enable "conventional" permanent-magnet motors to do even more. "As technology advances, we'll probably be able to bump up (motor speeds). That's what we've seen in the industry over the years. We can play with those [gear] ratios. If your ratio goes up, you get more torque, your ratio goes down, you get more speed to the wheel. We can do a lot of things. As technology goes up, the speed is increasing."

He said each of GM's motors has a different peak rpm, broadly connected to the mass of the unit. But

CLOCKWISE FROM TOP: LUCID MOTORS; LUCID MOTORS; BMW

developing motors capable of higher rpm typically enables more power output. "If you can go for more rpm, you basically can get more output from the motor," Curran explained. "You have a constant torque phase, and then you get a constant power phase. That power phase comes in after you're through that constant torque speed. As the speed keeps going – obviously power is speed-based – you can get more and more power as you go along."

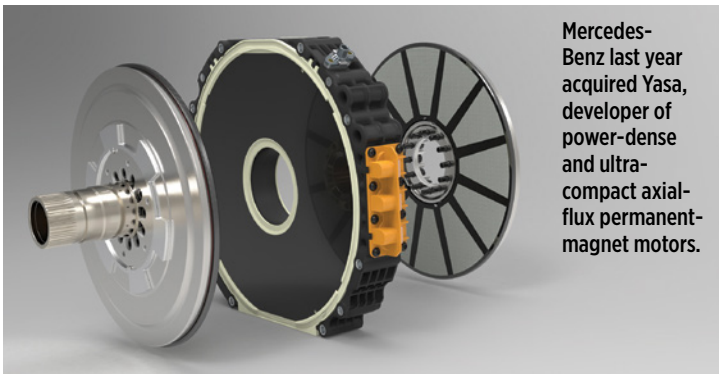
Lucid already has won acclaim for its Air motors' combination of monstrous power – ranging from 480 hp to 670 hp, depending on trim and battery-pack configuration – and industry-leading driving range. To get there, chief engineer Bach said the company's engineering teams focused on efficiencies – chiefly windings and thermal management, but even gear-tooth design – for its highly power-dense yet ultra-compact PM motor. (The company claims the entire drive module can fit in an airline roller bag and weighs just 163 lb [74 kg]). The Air platform's system architecture also operates at 900V, which also has a significant impact on power potential.

The Lucid drive motor has carefully calculated windings the company dubs "continuous-wave" because of the way in which the rectangular copper is precision laser-welded, rather than the typical "hairpin" copper windings pressed into slots. "The winding pattern has been developed in house to achieve a fundamentally efficient and torque-dense electromagnetic layout," explained Bach. "The electromagnetic simulations, the flux simulations, the thermal simulations – that's all done in house. And then we've developed the winding not just to be great from a performance perspective, but so that it's really easy to manufacture." Bach also claims the Lucid design uses "about half as much copper as the competition."

He added that a clever augmentation to the motor's powerful cooling of its windings comes easily – and at almost zero cost. As the stator stack's laminated layers are stamped, the dies are indexed to punch a portion of the winding cooling channels into each layer. "We punch that entire lamination stack with the cooling channels included for free."

As scrutiny mounts about electrification's impact on scarce and expensive minerals, engineers are focused on reducing rare-earth content in motors. **Renault** and **Valeo** are developing rare-earth-free motors, in which windings replace the permanent magnets. Production is aimed at 2027.

"There are lots of reasons not to want to put a bunch of rare earth in there," asserted GM's Curran. "It's not just from where it comes from, but it's



Mercedes-Benz last year acquired Yasa, developer of power-dense and ultra-compact axial-flux permanent-magnet motors.

MERCEDES-BENZ

super expensive. You want to make sure you get as little as possible, and then eventually maybe you get out of it altogether. That's where the science is – how do you get the same efficiency and same torque with less and less, and ultimately zero rare earth?"

In October 2021, GM and **GE** Renewable Energy announced a non-binding Memorandum of Understanding (MoU) "to evaluate opportunities" to improve supplies of heavy and light rare-earth materials and magnets, copper and electrical steel used for manufacturing of electric vehicles and renewable energy equipment. The companies said the initial focus is on creating a North American and European-based supply chain for vertically integrated magnet manufacturing.

Lucid's Bach said his company also is endeavoring to manage rare-earth consumption. "We are using neodymium magnets, obviously, because that's where you need to go. But we are using very, very little compared to the competition, again, for the power that we are pulling out." He added Lucid is not using "heavy" rare earths infused into neodymium to impart extra heat-resistance characteristics crucial to consistent traction-motor performance.

Honda and **Toyota** also have been developing drive motors without heavy rare-earth composition. Their designs substitute more abundant and lower cost rare earths that engineers believe can lead to magnets that retain exceptional heat resistance.

Hemphill said Schaeffler is studying design improvements such as improved cooling concepts to "reduce magnet content and/or cost." The company also is developing new supply-chain partners to assure sustainable supply, as well as studying vertical integration to control costs.

"At the moment," he said, "it seems these measures and the developing market will be sufficient to stay with PM motors." ■

SAE INTERNATIONAL®

WCX™ RETURNS TO THE MOTOR CITY IN 2022

APRIL 5-7, 2022

WCX™

DETROIT, MICHIGAN OR ONLINE

WCX™ World Congress Experience

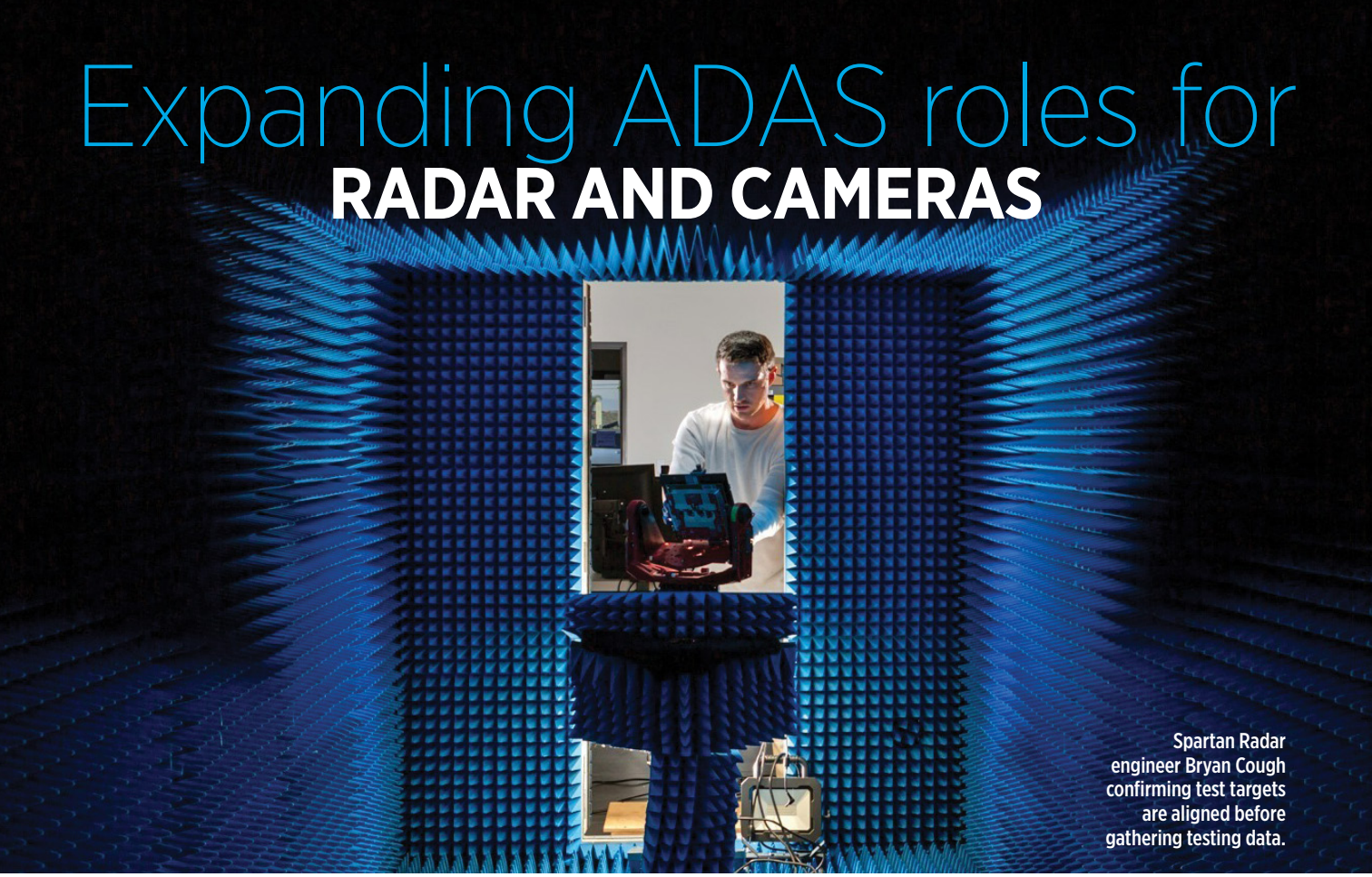
is where the engineering community convenes on mobility's biggest hurdles from mass deployment of electric vehicles to developmental timelines for autonomous vehicles to understanding global supply chain constraints impacting the automotive industry.

Join us April 5-7, live in Detroit, Michigan — or from wherever you are in the world — to discover the latest innovations and emerging technology as we move towards sustainable solutions for the next generation of passengers.

Register Now at sae.org/wcx

P22872306

Expanding ADAS roles for RADAR AND CAMERAS



Spartan Radar engineer Bryan Cough confirming test targets are aligned before gathering testing data.

SPARTAN RADAR

Evolving into lidar alternatives, the bread-and-butter sensors of ADAS are seeing potential far beyond commodity status.

by Paul Seredynski

Cameras and radar have become so widely used in advanced driver assist systems (ADAS) that it'd be easy to label them as commodities. The well-known technologies, in use in the automotive space now for decades, are often considered only placeholders for lower-level autonomy while the industry waits for significant lidar price reductions. But cameras and radar systems continue to evolve rapidly and may even supplant the need for lidar.

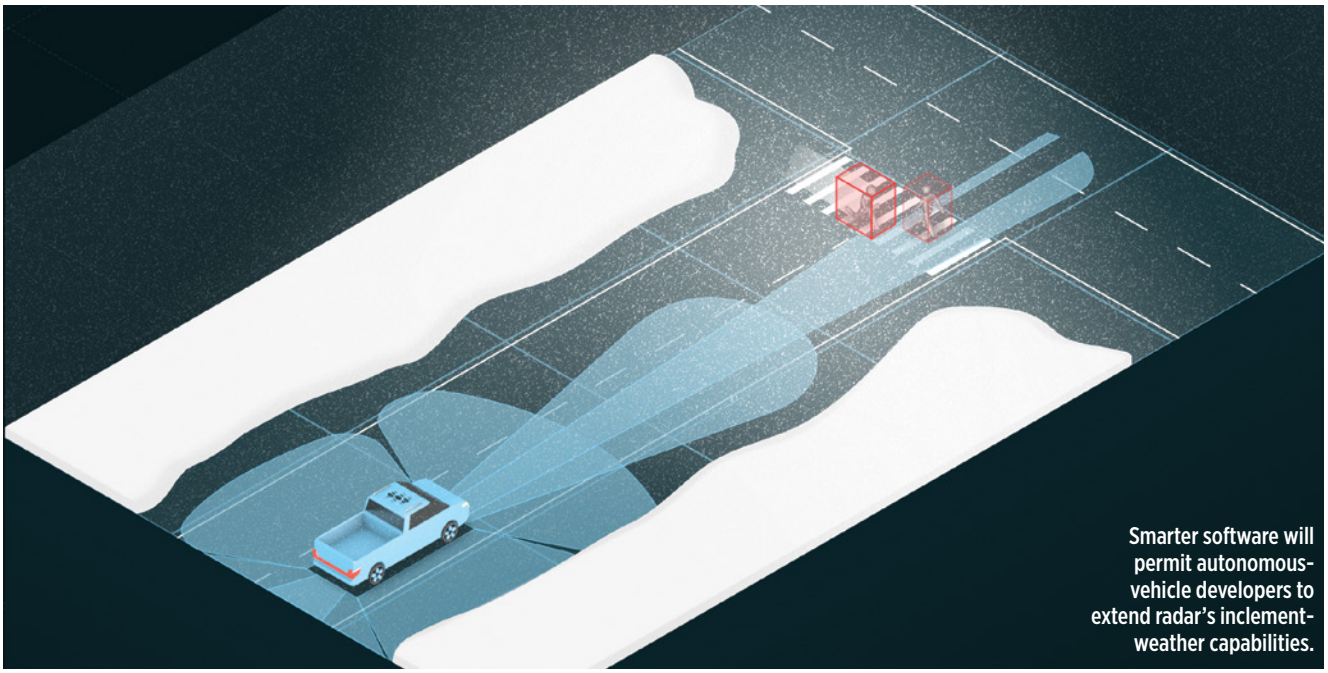
"Backup cameras and blind-spot detection are two applications for cameras and radar, respectively, that are the most likely to just be commoditized. It's going to be the 'lowest man wins,]" explained Phil Amsrud, senior principal analyst, **IHS Markit**. He and other industry experts note that regardless of lidar progress, advances in camera and radar tech means their roles in autonomy are far from complete.

"There certainly are people that look at lidar as fools' gold. I won't say who he is, but he's got a car company, and he goes into space periodically," Amsrud quipped. "I think the majority of the industry is looking at lidar as it brings something to the party that's unique, but we're now seeing sensors that are starting to compete with each other for the same space. When we had standard-resolution radar and lower-resolution cameras, then lidar was the high-resolution solution everybody saw on the horizon. Those three sensors were seen to work cooperatively."

"But now that you're starting to look at higher resolution on cameras and radar, I think there's going to be a little pressure on lidar in terms of, 'How much of your value proposition can I get with it, or can I cover it with high-resolution imaging radar and higher-resolution cameras?'" Amsrud noted. "Whereas there used to be white spaces between them, do cameras and radars cover enough of that white space? Maybe you don't eliminate lidar, but maybe you use lidar more strategically than saying, 'I'm going to put an entire halo of lidar around the car.'"

Cameras inside and out

A key aspect of autonomy involves not just what is happening outside the vehicle, but ensuring vehicle "drivers" are paying enough attention to resume control when needed. "It's really all about seeing farther outside or inside the car," Amsrud said. "As driver monitoring evolves from head tilt to pupil dilation, you've got to have a lot more resolution to be able to see those smaller geometries. You've also got continuing performance improvement in terms of high dynamic range so that you can better differentiate very broad contrast, so coming out of a tunnel into a well-lit area," he noted of continued camera evolution.



Smarter software will permit autonomous-vehicle developers to extend radar's inclement-weather capabilities.

SPARTAN RADAR

"Now that you're starting to look at higher resolution on cameras and radar, I think there's going to be a little pressure on lidar."

"At the same time you're doing that, you're going from two megapixels' worth of data to four- to six-times that. Something's got to process all that," Amsrud cautioned. "I think there may come a point at which you start looking at cost and performance and say, 'Well, what if I put a little more of that compute out at the edge? What if I let the cameras do some processing before they send the raw data to the central computer?' That's going to be the next step that will keep cameras from becoming just a base commodity."

Radar gets smarter

Until recently, a common notion in autonomy has been that across all conditions, a combination of sensors will be required to provide adequate situational overviews, leading to assumptions that without lidar, cameras or radar alone will not suffice. But even as lidar goes solid state and prices continue to drop, smarter radar technology, much of it software driven, is coming to market.

"We've spent most of our time talking about radar like short range, medium range, long range that had to do more with a broad- or a narrow-field of view," Amsrud explaned. "But we didn't really talk a lot about resolution. Imaging radar is now the thing that's putting resolution on the table for radar. By today's standards, all the secret sauces are in software."

Los Angeles-based **Spartan Radar** is one such company that is using software to elevate and expand radar's role. "A 'better chip' is the story we hear a lot," suggested Nathan Mintz, Spartan Radar co-founder and CEO, of the traditionally hardware-focused industry. "They're trying to fit more IP cores into the same chip and not really looking at radar from the standpoint of capability. The modes and algorithms are really the power of what makes a radar tick. It's like a cell phone without apps. We're adding the killer apps."

"That's a lesson we learned in aerospace about 30 years ago," Mintz explained, "when we transitioned from mechanically scanned arrays that scanned the sky very slowly and have a limited field of view, to electronically scanned arrays, where suddenly you could put energy anywhere in the sky instantaneously. It became possible to do more than one thing, sometimes two or three or five things at a time," Mintz said of the quantum leap of simultaneity.

"Radar really became this multifunction sensor that's able to search, track, identify and find unique kinematics of many objects of interest in the sky at once," Mintz noted. "In automotive, to a large extent, the radars are still mostly single-function. That's why you see such a proliferation of sensors coming out on the bumper of newer vehicles where you have very short-range, medium-range and long-range radars all cohabitating on the same car with different applications in mind."

According to Mintz, lidar is not yet an ideal solution, citing cost, complexity, robustness and reliability issues that radar doesn't have. "And if you can make radar that can reliably produce imagery below one degree in resolution, then it's competitive and the lidar might not be necessary," he said. "I think where lidar had the advantage is that the imagery that it produces looks much more similar to what you see from cameras."

Though the industry already is well-acquainted with integrating radar hardware, getting AI engineers to familiarize themselves with radar imagery will steepen the learning curve. "They know how to put this in a bumper,

Spartan Radar's Nathan Mintz noted that the industry is beginning to leverage the power of software in automated-vehicle radar applications.

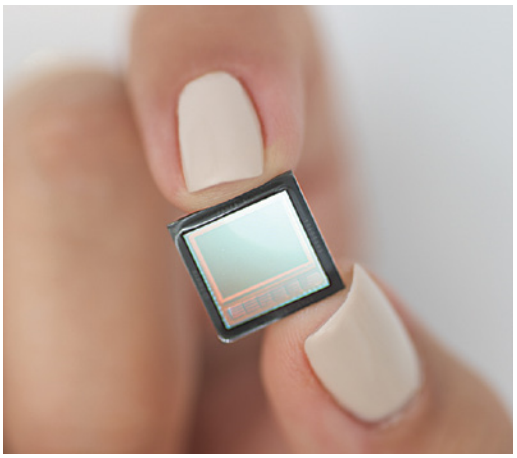
TriEye's Avi Bakal notes that the SEDAR system could help more advanced ADAS functionalities reach a broader market.

[or] into the side of a mirror. It's a known, understood variable," Mintz noted. "Radar imagery does look different than lidar and camera imagery, and there's some training that's going to have to occur across the full radar waterfront to get the perception guys to appreciate that."

Power of processing

The real power of Spartan's work, Mintz claimed, is the recognition of the modes and algorithms that makes radar work. "Our unique value proposition is we have a family of what's called compressive sensing and super resolution techniques, where we can take the exact same radar someone else has part-wise, and lay the antenna out differently and add additional signal processing on the back end to increase the resolution by a factor of five in each dimension, and decrease the number of antenna elements you need by a factor of two or even four."

The other key aspect of Spartan's IP is an ability to interleave different modes of operation. "You aren't always necessarily interested in having crystal-clear imagery of everything in the field of view, all at the same time, all the time," Mintz said. "Sometimes it's more important for you to have a higher revisit rate on the guy that's braking right in front of you than on taking exquisite imagery of some tree on the edge of the road that's moving out of your field of view."



Developed over a decade, TriEye's CMOS-based Raven SWIR sensor brings down proven defense technology to a competitive cost level.

"We want to be the **Microsoft** of automotive radar," Mintz responded when asked where Spartan Radar sees itself in the autonomous-stack supply chain. "We want to be where we're basically providing both the foundational layer of the software — the operating system — and then the applications and the modes that allow it to really reach up to the next level. We see our magic being in the software modes and algorithms that we provide."

An all-conditions camera

Camera-based sensors currently lead in object-recognition development, but require a light source. A key lidar advantage is it requires no environmental lighting since it's self-illuminating. Radar has significant advantages over both cameras and lidar in inclement conditions. But what if you could combine the best traits of each in a single sensor, forming a self-illuminating camera that works in a wide range of conditions? Billing itself as a fabless semiconductor company developing mass-market, short-wave infrared (SWIR) sensing solutions, Tel Aviv-based **TriEye** has genuine claim that it's already developed such a sensor.

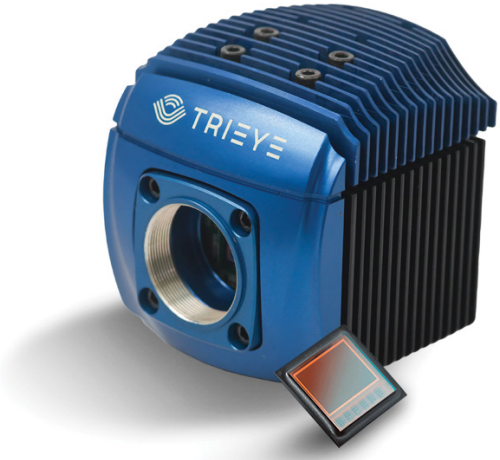
Most common in aerospace and defense, SWIR technology is well-known as an effective all-environment imaging sensor, its only major drawback being dizzying cost. TriEye claims it has created a CMOS-based SWIR sensor at a fraction of the cost of current SWIR solutions, and it is currently working with Tier 1s and OEMs to apply the technology as part of autonomous-sensor suites.

"The TriEye solution for automotive provides not only vision, we also provide depth perception under any condition — day, night, fog, dust," claimed Avi Bakal, TriEye CEO and co-founder. "And in terms of pricing, it's ten-times lower cost than the lidar solution. So not only that the product brings much better performances, but it's also highly cost-effective."

SEDAR as lidar alternative

The company grew out of an academic tract as a solution to what it considers a huge technology gap facing the industry. That is, ADAS systems function well in ideal conditions, but in poor conditions — fog, low light, pedestrians walking in dark roads, etc. — when their safety benefits are most needed, they fall short. The other challenge is cost, which prevents higher-function ADAS devices or sensor suites

TriEye's SEDAR (spectrum-enhanced detection and ranging) solution combines a SWIR camera with a proprietary illumination source that operates (like lidar) outside the visible spectrum.



TriEye's SWIR technology could bring enough requisite data to AV sensor stacks to eliminate the need for lidar.

from reaching mass-market volumes to prevent more accidents.

TriEye's solution is what it calls SEDAR (spectrum-enhanced detection and ranging), which it claims outperforms any lidar system on the market in terms of cost and performance. Bakal explained that the TriEye innovation is its proprietary CMOS sensor, which it developed after nearly a decade of research, which it combines with its proprietary illumination source that operates (like lidar) outside the visible spectrum. Both components were designed to meet high-volume manufacturing requirements from day one.

"The way we operate and build depth is by illuminating the scene in very short pulses, a kind of code that we know," Bakal explained. "Based on the code and how it interacts with the surroundings, we can extract the depth in a deterministic way — like per-pixel depth." Operating in the SWIR portion of the spectrum is a huge advantage, Bakal noted, "because we are shooting a very high peak-power pulse that's illuminating the scene for a very long range, over 200 meters... really 200 meters, not marketing.

With this kind of system, you don't need lidar. You have image in any weather and lighting condition, you have depth capability in any weather and lighting condition, and all that in a product that is very low cost compared to any lidar.

"Once you provide a system that is not using just your own vehicle lighting, that's where the real breakthrough comes," Bakal said, adding also the advantage of being "camera"-based for object recognition.

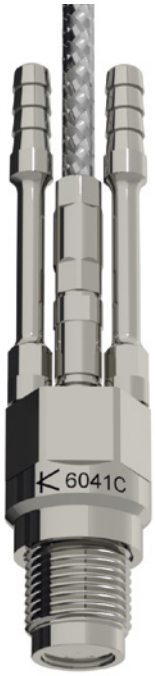
"We are leveraging the existing and the proven, the pre-trained algorithms that reduce dramatically the time and cost of the development cycle that leads to easy integration to the existing ADAS and AV system. If you want to add radar or not, this will be the question."

When will this breakthrough SWIR tech appear on production vehicles? TriEye announced a collaboration with Tier 1 Hitachi Astemo in January 2022, and Bakal claimed they are already embedded in current development cycles. "I can say that we are in a few integration paths as of today, [and] as you are aware, the integration cycle into a vehicle is a few years' path," he disclosed.

"In the next couple of years, you will see vehicles equipped with the TriEye solution. We expect this to happen, I would say, three years from now." ■

SPOTLIGHT: THERMAL MANAGEMENT

Water-cooled cylinder pressure sensor



Kistler (Winterthur, Germany) has introduced its latest M8 miniature cylinder-pressure sensor. The 6041C sensor incorporates PiezoStar crystals for more improved temperature measurement accuracy as well as improved thermodynamic behavior with minimal sensor-to-sensor deviation. Kistler states these advances provide the sensor with a higher natural frequency and excellent thermal stability within the application temperature range of 50°±30°C. The sensor can be installed in a sleeve or directly into an M8x0.75 bore and can be either flush-mounted or recess-mounted. Like its predecessors, the 6041C cylinder pressure sensor is very compact and can be mounted in bores as small as 12 mm (0.47 inches) in diameter. The sensor is compatible for mounting with its predecessors as well as the uncooled variants.

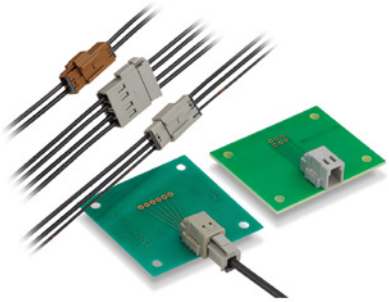
For more information, visit http://info.hotims.com/82330-400

Thermal measurement system

Advanced Thermal Solutions, Inc. (Norwood, Massachusetts) has introduced the iQx instrument system for measurement of air temperature and velocity, surface temperature, air-pressure drop and humidity. The iQx is equipped with input ports for up to eight air temperature/velocity sensors, four J type thermocouples, two pressure sensors and one humidity sensor. These can be positioned in different locations within a system under test, such as an electronic enclosure. The system is supplied with all necessary components except temperature and velocity sensors. The company offers several different sensors for use in the eight available ports. Temperatures tracked range from -10 to +120°C (+14 to +248°F) and air velocity ranges from 0 to 50 m/s (10,000 ft/min). Most of these sensors can be intermingled, depending on testing needs.

For more information, visit http://info.hotims.com/82330-401

Upgraded antenna connector



Hirose (Yokohama, Japan) has reduced the size of its 2.5 GHz high-frequency antenna connector to offer significant space-savings in automotive antenna systems. Its latest connector, the GT21 Series, features a one-step crimp termination system that provides consistent assembly in a shorter timeframe. The connector's design also ensures that cable assembly can be completed without touching the center conductor, which enables better positioning. The connector's locking mechanism is constructed to handle NVH conditions found in automotive applications and can operate in temperatures from -40 to +105°C (-40 to +221°F). The GT21 Series is available in three termination variations, and the antenna connector supports single coaxial, 2-port, 3-port and 4-port cable terminations.

For more information, visit http://info.hotims.com/82330-402

Precise analyzer for electrical components

Marposs (Auburn Hills, Michigan) has announced its LT400 system, a laboratory windings quality analyzer designed to perform partial-discharge (PD) measurements on electrical components such as coils, motors and generators. The analyzer can perform standard high voltage tests (AC and Pulse) with PD measurements to detect defects standard tests cannot. The LT400 utilizes E.D.C. partial discharge to measure component performance, which is less sensitive to external noise compared to antenna-type measurement. The LT400 also utilizes the same software as production line testing, which streamlines the correlation of the laboratory results to production testing. It can also combine and configure several tests within the same inspection cycle, accomplishing a task that would normally require several different instruments.

For more information, visit http://info.hotims.com/82330-403

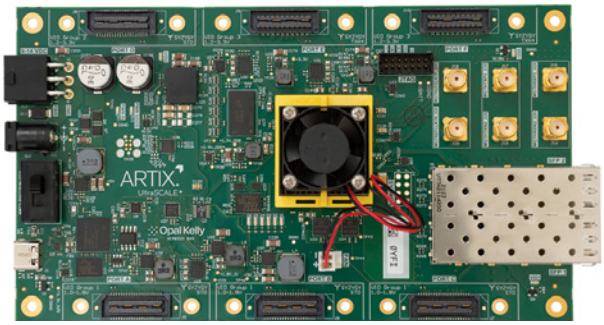
SPOTLIGHT: HARDWARE & SOFTWARE

Resolution cloud streaming

Varjo (Helsinki, Finland) announced the addition of cloud streaming to its Reality Cloud platform. The new service enables users to deploy virtual and mixed reality applications from the cloud and include human-eye resolution VR/XR content when using Varjo headsets. Varjo's Reality Cloud is powered by Amazon Web Services and NVIDIA GPUs. The company states that by streaming content directly from the cloud, local computing requirements are significantly reduced and the need for supported software applications is diminished. Varjo's proprietary foveated transport algorithm can stream content directly from their cloud to VR/XR devices with a bandwidth of 35 megabits per second. Additionally, all the traffic between the local PC and the servers, including the stream itself, is encrypted.

For more information, visit http://info.hotims.com/82330-404

New development platform



Opal Kelly (Portland, Oregon) announced the XEM8320-AU25P development platform for the Xilinx Artix UltraScale+ FPGA. The new platform features Opal Kelly's FrontPanel SDK for building high-performance, software-connected FPGA applications. It leverages the versatile SYZYGY modular connectivity for rapid prototyping and expansion as well as USB 3.0 Type C SuperSpeed interface. The platform also includes 11 highspeed gigabit transceiver lanes via Artix UltraScale+ transceivers that support serial standards such as 10 GbE, JESD-204B, DisplayPort, PCI Express, SATA, HD-SDI, XAUI, and Aurora. Opal Kelly states that the platform is fitted with several SYZYGY connectors plus four standard ports and two transceiver ports for expansion and system development.

For more information, visit http://info.hotims.com/82330-405

Plastic gears

Evonik (Essen, Germany) VESTAKEEP PEEK plastic gears are now in series production for a mass-balance transmission. The gears feature sufficient tribological properties and durability for applications which ordinarily required metal gears. The company states that this is the first use of plastic in this application and that these gears can withstand oil temperatures of 130°C (266°F). The gears are manufactured by **IMS Gear** SE & Co KGaA and currently are utilized by **Mercedes-Benz** AG in various models. According to Evonik, plastic gears suffer lower friction losses than metal counterparts, with significantly quieter operation. Their lower-mass moment of inertia also saves energy and the injection molding manufacturing process is very cost-effective compared to metal gear production.

For more information, visit http://info.hotims.com/82330-406

Graphics output boards

Abaco Systems (Huntsville, Alabama) announced the release of its NPN244 and NPN244S graphics output boards for defense, aerospace and industrial applications. The 6U VPX high-performance computers (HPC) offer improvements to minimize latency for real-time video and data streaming. Both boards are aimed at data-intensive digital signal processing for military and civil applications, including ISR, high-performance airborne radar, synthetic aperture radar and ground moving target indicators. They are supported by Abaco's AXIS ImageFlex, which enables rapid development of high-performance image processing for visualization and autonomy applications with unique size, weight and power (SWaP) requirements.

For more information, visit http://info.hotims.com/82330-407

UPCOMING WEBINARS

WEBINAR SERIES: NEXT-GENERATION SMART MANUFACTURING

Begins March 2, 2022 at 1:00 pm U.S. EST

The many challenges in EV manufacturing initiatives are explored in this Webinar series, which consists of six 60-minute sessions on topics that examine manufacturing trends in electrification, additive manufacturing, intelligent supply chain and operational excellence. Each session has a technical focus and a live Q&A with subject matter experts sharing their insights on challenges that you may be facing.

Sponsored by: SIEMENS

Hosted by: SAE INTERNATIONAL

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

---

USING ST STELLAR MCU VIRTUAL PROTOTYPES TO DELIVER NEXT-GENERATION SOFTWARE-DEFINED VEHICLES

Wednesday, March 16, 2022 at 11:00 am U.S. EST

Automotive microcontrollers for next-generation software-defined vehicles need to deliver higher software capabilities. ST Stellar Integration MCUs offer safe, secure and deterministic solutions for new vehicle architectures. The use of virtual prototypes is a key enabler to solving the emerging, complex software development challenges throughout the automotive design and test supply chain, such as feature integration, functional safety, and secure communications.

This 30-minute Webinar provides an overview of ST Stellar Integration MCU architectures and application domains, explores how virtual prototypes enable the supply chain, and includes a discussion on their benefits. Real case studies based on the ST Stellar virtual platform are examined to show how it's integrated with the automotive tool ecosystem.

An audience Q&A follows the technical presentation.

Sponsored by: SYNOPSYS®

Hosted by: SAE INTERNATIONAL

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

---

ADVANCED MOTOR AND DRIVE ANALYSIS

Thursday, March 17, 2022 at 11:00 am U.S. EDT

You know the basics of electrical power measurements, have set up your dyno and made key measurements — which is great. But as your motor and drive projects progress, the complexities of system drive requirements can change frequently. Control algorithms, networked communications and mechanical systems form a complex web of interactions that need sorting. This 60-minute Webinar explains how to get past ground-level measurements and delve into comprehensive solutions that leverage test and measurement instruments including power analyzers, high-speed data acquisition and real-time software.

The technical presentation includes an audience Q&A.

Sponsored by: YOKOGAWA Test&Measurement

Hosted by: SAE INTERNATIONAL

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

UPCOMING WEBINARS

HOW ADAPTIVE AUTOSAR SOLVES COMPLEXITY IN AUTOMOTIVE WITH HIGH-PERFORMANCE COMPUTING

Wednesday, March 23, 2022 at 2:00 pm U.S. EDT

Advances 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.

In this 60-minute Webinar, experts share the benefits and best approaches for implementing standardized Adaptive AUTOSAR.

Sponsored by: Elektrobit

Hosted by: SAE INTERNATIONAL

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

---

FROM OPTIMIZATION TO UNCERTAINTY QUANTIFICATION THROUGH MACHINE LEARNING

Thursday, March 24, 2022 at 2:00 pm EDT

Advances in machine learning have led to the ability to build highly accurate emulators, also known as predictive models. These emulators have a key role in Uncertainty Quantification (UQ) because many techniques that make up UQ can be computationally costly to implement directly on the simulation. As a result, a cheaper-to-evaluate emulator of the simulation is required. By using emulators and ideas from UQ, engineers and data scientists can get more value out of their simulations and achieve faster, more reliable optimization results.

This 60-minute Webinar provides an introduction to machine-learning-based UQ and emulation and their benefits to optimization.

Sponsored by: SMARTUQ® Quantify Every Uncertainty.

Hosted by: SAE INTERNATIONAL

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

---

SHORTENED ELECTRIC VEHICLE DEVELOPMENT CYCLE USING NI AND AVL VIRTUAL TESTING SOLUTION

Tuesday, March 29, 2022 at 11:00 am U.S. EDT

As electric vehicle (EV) powertrains grow more complex, model-based design and testing promises true insight, detailed communication, and engineering and operational process efficiency. Automotive test engineers who are focused on electric powertrain development want to shift as much testing as possible to simulation earlier in the development process, decreasing dependence on costly dynamometer and field testing. They need to validate and optimize their system design and software control algorithms with model-based simulation to decouple from other team schedules, increase test coverage and lower the cost of finding and fixing bugs early.

This 45-minute webinar examines how model-based FPGA simulation and an integrated systems approach combine flexibility with off-the-shelf delivery.

Sponsored by: NI

Hosted by: SAE INTERNATIONAL

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

READER FEEDBACK

The bi-directional EV charging oxymoron

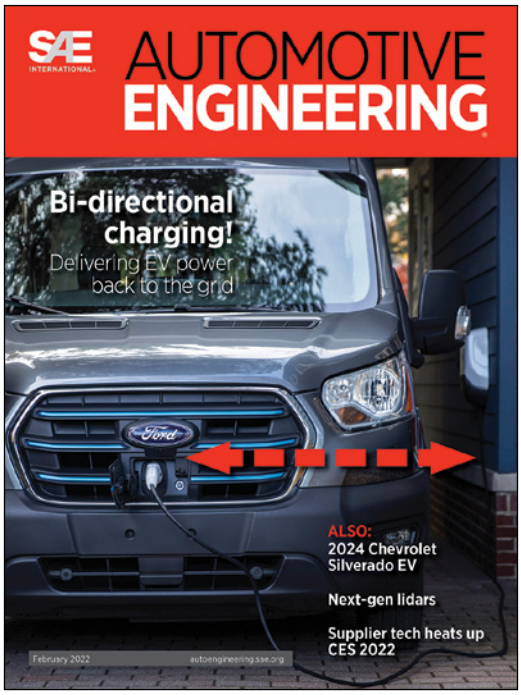
The article on bi-directional charging in the last issue [Feb. 2022] caught my eye, and not all of it was in a positive way. The need of a "bi-directional charging technology" to battle "grid failure" is just quite an oxymoron. To me, the apparent reason for the Texas grid failure was not that people cannot use their pickups to power their home. Rather, it was due to the longtime failure of the electrical infrastructure, to residential single-home zoning laws propelled forward by the automotive industry, together with the fossil-fuel industry that makes reliable power delivery not possible (cable to reach a household is way more than that of European countries.)

And taking a step back, if I want to protect my family from power outages, wouldn't a generator in the garage be a better option than driving around extra equipment that I don't need?

The quote in the article from Ryan O'Gorman, "It is going to be cool to see how our customers use it," is not a phrase resembling a brilliant thought process. 'Let's invent a problem for my solution to exist' is more like it.

Thank you for taking the time to read my rant and much appreciated.

Xing Yun



V2L capability is being dramatically oversold by automakers. It's not a chicken-and-egg scenario because electrical grid reliability and capacity is needed before a large fleet of EVs 1) plugs in to be charged regularly and 2) attempts to supply battery power back into the grid. Does anyone believe that U.S. power utilities will be ready for the EV volume that the industry claims is coming this decade?

Manuel Ramirez

Bi-directional charging has been the OEMs' promise ever since electric vehicles entered production in the modern era. It fits nicely into the dream of many homeowners, that they can somehow escape or at least mitigate their reliance on their local utilities which often are monopolies. "You can even power your house with this truck," is what advertisements claim, right? Well, take your pick on how much of your daily electrical load your light truck's battery can cover. The fridge? Perhaps. Maybe one air conditioner on a July day? How about your internet server and the interior lights, and for how long?

RogersCv76

Thank you for reading SAE's Automotive Engineering *and taking the time to share your thoughts with us. Your points regarding bi-directional charging/V2L are well taken. Author Bill Visnic and I agree with you that a primary challenge for widespread vehicle electrification is the lack of a robust and/or flexible charging grid. It's one reason that home auxiliary generators are increasingly popular. — Lindsay Brooke*

EV pickup architecture war

It appears that Ford and GM are headed in different directions regarding the architectures of their electric pickup trucks [AE March Editorial]. I don't believe this situation will be permanent. Ford's decision to keep the F-150 Lightning on a separate chassis frame is a logical strategy for the short-to-mid term. Planners do not yet know at what point in the future when electric truck volume will exceed production of the IC trucks that are driving revenues. So Ford hedged its bet and engineered the Lightning battery pack to fit a modified version of the frame. Smart move, but the future for electric trucks is probably Chevy's direction for the Silverado EV: a flexible structure dedicated to and optimized for electric drives and large batteries. I think the auto companies want to get rid of outsourced heavy steel truck frames from suppliers and EV construction is one way to achieve that.

Kevin Barton
Cincinnati, OH

Pragmatic Bosch

The interview in the February issue with Uwe Gackstatter was revealing. He was frank about the industry being steered by regulators and politicians into the costly electric unknown, while Bosch and other suppliers must continue to invest in existing ICE technologies. It is impossible to predict when the world will no longer need to support IC engines, but Bosch is clearly not yet ready to give up on them.

Neil Tredwinski

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.

COMPANIES MENTIONED

AD INDEX

Q&A

Establishing closed-loop EV battery recycling

Last spring, Clarios, formerly known as Johnson Controls and now the world's largest automotive battery maker, emerged a winner in the second phase of the Lithium-Ion Battery Recycling Prize competition. The three-phase program, sponsored by the U.S. Dept. of Energy, aims to develop and demonstrate processes that, when scaled, have the potential to profitably capture 90% of all discarded or spent lithium-based batteries in the U.S., and re-introduce key recycled materials into the U.S. supply chain.

Clarios' winning concept for the DoE prize (worth a total of $5.5 million) focuses on developing and applying technologies to identify and separate lithium-ion batteries from lead-acid types, ensuring proper and safe recycling methods for each chemistry. In Phase III of the competition, Clarios aims to validate its concept in pilot programs.

Adam Muellerweiss is Clarios' chief sustainability officer and also serves as president of the Responsible Battery Coalition, a group of automotive OEMs, large fleet owners, auto-parts stores and other retailers working to build a closed-loop recycling network for lithium batteries. He spoke with editor Lindsay Brooke about the challenges and opportunities for recycling hybrid and EV batteries (read the full interview on SAE.org).

Clarios has over 100 years of experience in recycling lead-acid batteries, at a rate of 99%. Are there learnings you are applying to hybrid and EV batteries?

Yes. Our experience began before Daimler and Benz built their first motorcycle [1885]. Today, we're at about the same point in the process with recycling advanced lithium batteries as we were back then. Currently, our process can separate that wide spectrum of materials, but the technology isn't yet at the 'holy grail' stage: the ability to harvest battery-grade materials and turn them right back into same-grade materials for new batteries.

The circular or closed-loop supply chain for lead-acid relies on the ability of people to return their used batteries. Over 80 percent of the materials that we use for new batteries are recycled lead and polypropylene. Future recycling demand will require all types of batteries and chemistries. At Clarios we're really focused on ensuring the right chemistry for the right application across its lifecycle.

To what degree are the nickel metal-hydride batteries used in millions of Priuses in the recycling stream?

Hybrids' battery pack value is proven. Prius batteries don't sit in junkyards. They're being collected and rebuilt for taxicab use in many of the early Priuses out there, and for aftermarket service batteries.

We're seeing a lot of second life in the batteries' original application because those packs were designed, validated, and tested to automotive grade, and proven to be safe in use. So, while the discussions about using the packs for another energy-storage source, perhaps stationary applications, might be an interesting topic, the batteries were really designed for use in vehicles. What we're seeing as the most likely trend to emerge is batteries being used to extend the life of the vehicle. It's the same industry experience as remanufactured transmissions, engines and other components.

So, the ball is rolling?

Yes, that's where the DoE Lithium competition is so exciting. They have very smart people with some incredible tools looking at those 'holy grail' opportunities. Argonne National Laboratory's ReCell Center is focused on taking those 'used' materials and turning them into battery-grade materials. We're not quite there yet but we know we're on the evolutionary path. And once you have used batteries in hand, you need to aggregate them across major markets, across the country. That requires transporting them, in some cases storing them to wait for available capacity or just to manage material flow.

There has to be an underlying infrastructure, long-term, to handle a large magnitude of batteries. The scale that's required currently isn't there. ■


Adam Muellerweiss

CLARIOS

The technology isn't yet at the 'holy grail' stage: the ability to harvest battery-grade materials and turn them right back into same-grade materials for new batteries.

CALL FOR PAPERS

The automotive and transportation industries are advancing with composites playing a key role in the development of electric vehicles and sustainability initiatives worldwide. Lightweight composites are ideal materials for improving vehicle performance, reducing mass, extending range and compensating for battery weight. Polymer composites are enabling lower emission vehicles, reducing the carbon footprint and saving energy to benefit the environment now and in the future. Thermoset and thermoplastic composites are the **THE KEY TO EV MOBILITY AND SUSTAINABILITY.**

In addition to the new category on Composites in Electric Vehicles, the presentations are organized into the following categories: Thermoplastic Composites; Thermoset Composites; Modeling; Additive Manufacturing & 3D Printing; Enabling Technologies; Sustainable Composites; Bonding, Joining & Finishing; Carbon Composites; and Business Trends/ Technology Solutions. Paper abstracts are requested as soon as possible and are due by **April 15th, 2022.** Final papers or non-commercial presentations are due **June 17th, 2022.** Authors who submit full papers (not presentations) in the proper format will be considered for the conference's Best Paper Awards, which are presented during the event's opening ceremony. A template for papers can be downloaded from the SPE ACCE website online via **http://speautomotive.com/acce-forms**. Inquiries about submitting papers can be sent to **ACCEpapers@speautomotive.com.**

SPONSORSHIP OPPORTUNITIES

SPONSORSHIP AND EXHIBIT OPTIONS offer companies the opportunity to support the event and promote their products and services to a very targeted and interested audience. All sponsorships include passes to the event including access to all keynotes, panel discussions, technical sessions and daily networking opportunities. Sponsorship also includes corporate exposure on SPE ACCE websites, advertising, publicity, social media, signage throughout the event venue and more. Companies interested in sponsorship should contact Teri Chouinard at **teri@intuitgroup.com** and go to **https://speautomotive.com/acce-conference/** for more info.

2022 SPONSORS

MEDIA SPONSORS