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Building batteries for recycling

The long road from production to beyond end-of-life

What's inside this all-digital issue?

Meet Lincoln's first global SUV

Luminary Cloud brings CAE to the cloud

Kia goes commercial with PBVs

May 2024 mobilityengineeringtech.com

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BATTERIES & RECYCLING

As companies continue to trumpet their next-gen EV battery tech, it seems like new chemistries face more momentum from the established champ, lithium-ion.

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The start-up's 'real-time engineering' service means you can simulate on someone else's GPUs.

ON THE COVER

As the industry continues to crank out batteries, a quest to make them easier to recycle. (Image: Hexagon Manufacturing Intelligence)

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EDITORIAL

What we do is exciting

Walking around the SAE WCX conference in Detroit this April and reading through the topic listings for the hundreds of sessions and thousands of presentations, I remembered why I enjoyed this conference so much. I used to attend as a reporter for other outlets, but I haven't been back to WCX since before the pandemic. It was different to walk the halls as editor of this magazine.

What happens at WCX – and at dozens of mobility and transportation conferences around the world – is fascinating. I would bet big money that our readers agree. Still, sometimes it's difficult to translate the deeply technical work that makes up our days into something that piques the interest of those who don't spend inordinate amounts of time thinking about the "future of mobility."

Educating people about what the automotive future could be is easier when we can explain it in interesting ways.

Take, for example, a session quietly titled "Getting to SAE Level 3: Persistent Challenges and Strategies Necessary for OEMs." That sounds ideal for the WCX crowd, but our family and friends won't understand the issue unless they speak nerd. The panelists tossed around automated driving in technical terms like ODD, human-machine interface and L2—perfectly acceptable at WCX.

As cool as some of these technologies are, or will be, they are opaque today, and tomorrow can't be depended on. Educating people about what the automotive future could be – the possibilities and the challenges – is easier when we can cleverly explain kernels of thought in interesting ways.

After WCX, I met with some non-automotive industry friends and told them about the conference and that session in particular. But they don't know the engineering details, so I realized the best way to explain the exciting things I heard at WCX needed to be translated into theoretical questions that engage the average person rather than focusing on the tech itself.

How would you feel if you got into a car without a steering wheel? How should autonomous vehicles tell their "drivers" that they can be riders for this trip? Would you feel safe if you went to rent a car sometime next decade and were offered an AV? Legally, aside from things like the trolley problem, how can we program ethics into AV software?

That last one has at least been given some time in the public eye after Tesla programmed a "rolling stop" into its self-driving cars in 2022. This feature was quickly shut down when people realized the cars were technically breaking the law. But was that a mistake? AVs need to follow traffic laws … right?

What if your car is programmed to follow the speed limit, but then finds itself surrounded by human-operated vehicles going 80 mph (129 km/h) in a 55-mph (89-km/h) speed zone? Is following the law actually dangerous in that situation? Behaviors and ethics are different spaces, so how do you write software so a car can make the affirmative decision to break the law, but in an ethical way?

WCX is an inherently technical conference, as it should be. But when we're not in these environments, I've found that the bigger and more exciting questions get a response. After days of detailed sessions discussing wind-tunnel aerodynamic standards and improved casting methods for EVs – which, let's admit, can be a bit dry – it was worth remembering that what we do is exciting. We can get others to understand this when we frame things in the right way.

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We've been here before

For a couple of decades, virtually every global original equipment manufacturer spent significant capital and attention raising their sales/production profile in China. It became the world's largest light vehicle market by 2010 and has not looked back. Forming new joint ventures to expand their portfolios through the extension of global offerings, several OEMs even took the opportunity to design China-specific variants. Western OEMs followed these JVs, and scores of European, North American, Japanese and Korean Tier 1 and 2 suppliers followed their OEMs, creating a local supply of global components as China became an integral cog in the machine.

A presence in China is core to success for many industry players. China produced about 28 million light vehicles in 2023, based on S&P Global Mobility's estimates. China is not only key for Western OEM profitability, from a volume perspective it is the largest single market (about 31% of the world in 2023) with the highest growth profile. It also resides between Europe and the U.S. from a content and vehicle segment profile. Additionally, global unibody platforms from virtually every global OEM count on China for significant contributions. As recently as 2019, non-Chinese OEMs accounted for 13 million units (53%) of China's light-vehicle output.

Why the history lesson? While this enviable position was key for Western OEMs and their suppliers, a number of factors have and continue to buffet their position in China. These include extraneous events such as COVID-19, chip supply shortages and port delays. More important has been China's regulatory drive toward new-energy vehicles (NEVs) and the improving technical and scale economic profile of Chinese OEMs. Companies such as BYD, Geely, SAIC and others have moved up the past few years and are positioned for more. Their success is apparent. In 2023, Western OEM share dropped to about 40% of China's volume. At this rate, Western OEMs are losing share at a rate of over 900,000 units per year – equal to the loss of three-and-a-half 250,000-unit assembly plants per year. A startling decline. Despite continued market growth, Western OEMs can no longer count on China as an automatic contributor to their global scale.

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In China, Western OEMs are losing share at a rate of more than 900,000 units per year.

Growth in China, by China

There are other impacts of this decline to heed. As Chinese OEMs raise their profile domestically, they start to look toward export markets to diversify demand. Exports have risen from China to South America, various Southeast Asian locations, Mexico and scores of markets in Central America. As export volumes bolster domestic positions, scale economies and designs for multiple markets improve. Already, several Chinese OEMs are eying plants in Europe or Mexico to better serve these new markets from the inside.

Western OEMs must adjust their perspective. For instance, China accounted for over 16% of Ford's global production volume in 2016. In 2023, this slipped to 8%. Mazda's production volume in China declined from 17% in 2016 to 6% in 2023. Virtually every OEM is grappling with pressure on their China-based volume. This places even greater dependency on success in home markets of North America, Europe and Japan/South Korea. Similarly, their suppliers must adapt to the new reality of lower volume in China and stronger China-based competitors.

Turning this tide will be difficult. Many are seeking to slow the growth of China OEMs and suppliers in core export markets in North America and Europe through trade restrictions. Make no mistake, the problem is extremely complex, although history is a wonderful teacher. Any trade-based measures can distort competition and possibly raise prices for consumers. Over the long term, increased competition will result no matter what barriers are erected.

Chinese industry players have faster cadence, are nimble and are breaking many industry norms. This is the new reality. Western industry players will need to adapt as they have before. ■

The Inside Story on Cleaning Digital Noise with FIR and IIR Filters

Filtering is a "must-have" tool in digital data acquisition and digital signal processing to acquire uncorrupted data. Anti-aliasing filtering mitigates signal corruption from frequencies above the Nyquist frequency, and AC coupling filters remove DC offset values. However, despite the obvious advantages, filtering has some negatives. This brief focuses on these pitfalls so that engineers can better understand how filters can distort their data. There are four basic filter classifications: analog, digital, Infinite Impulse Response (IIR), and Finite Impulse Response (FIR). Analog filters are electronic circuits that typically model IIR filters.

What are some examples of signal distortion caused by filters?
There are four main types of signal distortion: roll-off in the passband, distortion in the passband, signal delay/phase distortion, and distortion at the beginning of the signal. These anomalies are created by filter mathematics. FIR filtering is a convolution process, and IIR uses a difference equation. Roll-off in the passband simply means there is no brick wall filter (or the roll-off in the frequency domain being a vertical line). Mathematically this is not attainable, so filters will have a roll-off in dB/octave attenuating the signal before the specified cut-off frequency, typically -3 dB (aka "3 dB down"). Distortion in the passband is typically a trade-off with the filter roll-off. The sharper the roll-off, the more distortion occurs. Filtering also creates a delay/phase distortion in the signal proportional to the number of coefficients required. As a result, the filtered output signal is shifted in time. The delays from FIR filters are linear and constant across signal frequencies. On the other hand, the delays from IIR filters are non-linear and do change with the signal frequency. Engineers should be aware that distortion at the beginning of the signal is caused by a filter's settling time. This is typically an issue with very low cut-off frequencies or when filtering very short-duration events.

Dewesoft's John Hiatt

How do you mitigate signal distortion?
Signal distortion in the passband can easily be controlled by carefully selecting the filter type. With IIR filtering, for example, a Bessel filter is maximally flat with the lowest roll-off per coefficient and the most roll-off within the passband. Chebyshev would be at the other extreme, presenting the most distortion (ripple), the sharpest roll-off, and the least amount of attenuation within the passband. A Butterworth filter is a great compromise between the two and is the most widely used for that reason. The relationship between roll-off within the passband and distortion can be described as inverse. A steeper roll-off results in less roll-off within the passband, while also potentially increasing distortion. Engineers usually prioritize achieving minimal distortion within the passband. The distortion at the beginning of the signal can be addressed by recording a little more data to allow the filter to settle.

Since FIR filters have a linear delay, the time data can be shifted to correct for the phase distortion. IIR filters have a nonlinear delay so there is no online correction, but the filter can be passed through the data forward and reversed during post-processing to remove these nonlinear delay distortions. This process is called phase correction or "zero-phase filtering" or "zero-phase shift filtering."

Why use an FIR vs an IIR Filter?
FIR filters are much more computationally efficient than IIR filters. This is because they require fewer coefficients to achieve the same roll-off. In applications where many channels must be filtered simultaneously at high sample rates, IIR is the way to go. With IIR Filters, both relative phase and time alignment may be compared between channels if the same filters were used on both signals. If absolute time is required online, I recommend using an FIR filter. If offline filtering is acceptable and if phase correction is available, IIR filters are fine.

What is a practical example of signal distortion and how it can lead to incorrect data interpretation?
Numerical integration that changes a signal from acceleration to velocity can be done with a filter. This process in the frequency domain is simply dividing by ω (omega is the angular frequency in radians per second) and shifting the phase. However, if an IIR filter is used and the phase distortion is not corrected in this process, the resulting sine waves will not have a 90-degree phase difference. When balancing rotating equipment, there is a key-phasor, which is a 1 PPR (pulse per revolution) signal on the rotating shaft that indicates zero phase. The other channel is typically a response signal from an accelerometer. These are typically IEPE accelerometers that are AC coupled with a high-pass filter at around 1 Hz. A "best practice" with filters is to filter all your channels with the same filter scheme and understand the frequency response (magnitude and phase) of the filters in the measurement and analysis chain. ■

More Information on this topic can be found at this link.
https://training.dewesoft.com/online/course/filters

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CONNECTIVITY

Cybersecurity firm enlists AI in battle as threats increase

Upstream founder Yoav Levy says the company's new AI tool was a natural response to hackers leveraging AI to produce more creative attacks, more frequently.

Following its annual report detailing the growing cybersecurity threats to vehicles, fleets, and the networks they rely on, Upstream Security announced the launch of a generative AI tool to enhance its ability to reduce the risk posted by global threats.

Israel-based Upstream, which has a vehicle security operations center (VSOC) in Ann Arbor, Mich., monitors millions of connected vehicles and Internet of Things (IoT) devices and billions of API transactions monthly. Ocean AI is built into the company's detection and response platform, called M-XDR, enabling its analysts, as well as those from OEMs and IoT vendors, to efficiently detect threat patterns and automate investigations before prioritizing a response.

The AI allows users to ask natural-language questions about the vast data sets generated by connected vehicles, various onboard security and infotainment systems, charging networks, individual terminals, and more.

Upstream founder and CEO Yoav Levy said at a media event in Ann Arbor that AI is a response to hackers' increasing use of generative AI. These hackers can identify and exploit vulnerabilities faster than ever and against entire fleets of vehicles. "This calls for a new mindset for the entire automotive and smart mobility ecosystem," he said.

Orit Gross, Upstream's senior director of product, said that its VSOC teams analyze up to thousands of alerts daily across large fleets and from the entire ecosystem, which includes vehicle data, telematics, API traffic, IoT data and more. "Ocean AI helps dramatically reduce the complexity of investigations and time-to-remediation."

The M-XDR's primary responsibilities are:

- Risk analysis: Using live and historical data to identify patterns and anomalies.
- Alert filtering and prioritization: This tracks the severity of alerts, including detecting sudden surges in high-security alerts. That's key for prioritizing responses, such as dealing with an unauthorized over-the-air software update with more urgency than an item affecting a single vehicle, such as an unlock-door request from an unusual IP address.
- Investigation and automation: As more is learned about particular threats, the AI can help build and trigger automated responses, decreasing the time between event detection and reaching secure status.

Responses to detected threats and attacks can come directly from Upstream or be handled by the OEMs or network operators, depending on the contract. "Our work is largely collaborative," Levy said during a previously held tour of the Ann Arbor VSOC. He said that includes sharing intelligence with the security community at large when warranted.

A bracing state-of-cybersecurity report

The announcement follows the release of Upstream's sobering assessment of the state of vehicle cybersecurity, from which the two biggest takeaways were:

- Organized hackers are generally moving from attacking individual vehicles or IoT points (like chargers) to attempting large-scale attacks on fleets and networks.
- The potential cost of cyberattacks to the automotive and smart-mobility ecosystem

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now reaches hundreds of millions of dollars a year, and it's growing.

The hackers are moving to attacks at scale and going for impact: The report asserts that in 2023, 65% of deep- and dark-web cyber activities "had the potential to impact thousands of millions of mobility assets." The targets of these black-hat hackers and fraud operators can be broken down as follows:

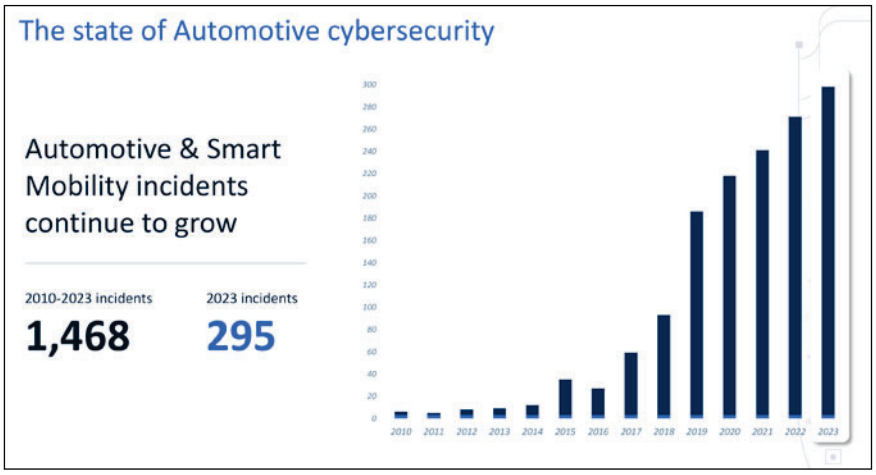
- 49% were vulnerability exploits.
- 19.3% targeted diagnostic software.
- 12.5% took control of vehicle manipulation tools.
- 6.7% spent their time creating instructional guides to hacking vehicles.

Shira Sarid-Hausirer, Upstream's VP of Marketing, stressed that the mobility cybersecurity industry is at an inflection point due to the increasing frequency and impact of cyber attacks.

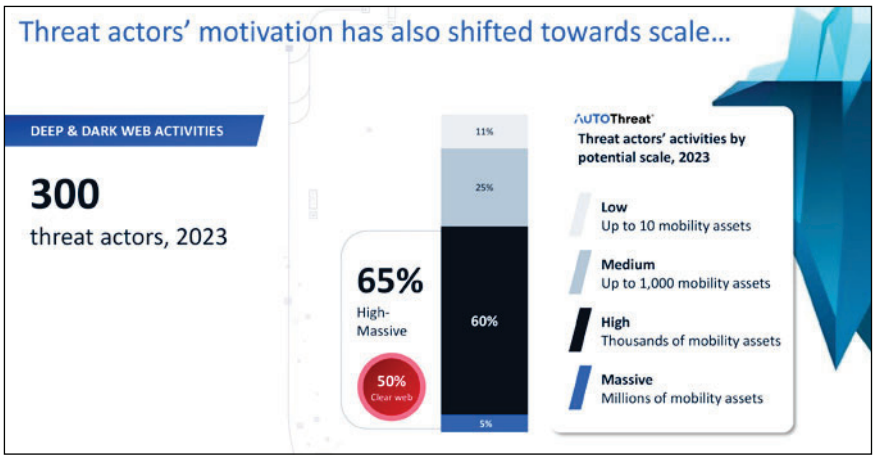
UPSTREAM

As for potential cost, the report mentioned the attack on Taiwan Semiconductor Manufacturing Co., which disclosed that one of its suppliers was hit with a $70 million ransomware attack, the largest such ransom demand in history. TSMC officials said business operations were not affected, but they stopped exchanging data with the supplier.

During a briefing previewing the report, Shira Sarid-Hausirer, Upstream's VP of marketing, laid out the changing threat by focusing not on attack volume but on impact. "It's time to fasten your seatbelt," she said. "This year, the numbers have completely changed. Nearly 50 percent of incidents have the potential to inflict damage on thousands to



Hackers are launching attacks faster than even a few years ago.



In 2023, attacks against large numbers of targets proliferated.

millions of assets. If you just look at the really dramatic incidents, we more than doubled from 2% to 5%. What we consider high impact has doubled from 20-ish to almost 45%."

As an example of impact, she cited a 2023 ransomware attack on a long-haul trucking fleet with more than 1,000 vehicles. The attack struck at the company's business software and shut down everything from driver time-logging — really important for regulatory compliance — to software that managed logistics and employee management. "It took the company three weeks to fully recover once the event was over," she said.

The report also foreshadowed the development of Ocean AI a bit, when it discussed hackers' use of generative AI. "By using GenAI to simulate attack environments, cybersecurity faces an additional challenge, as it leads to more unpredictable and sophisticated attacks, increasing the difficulty of detection," the report said.

Targets aren't only cars

The industry does know and generally understands the looming threats. During a February SAE webinar discussing "Cybersecurity in the Air and on the Ground," the founder of another cybersecurity firm ominously said it's not just wheeled vehicles that are under attack.

Aharon David, cofounder and chief white-hat officer of Afuzion, an Israeli security firm, serves on the SAE G-32 Cyber Physical Systems Committee. He said that when including both ground and aviation vehicles, the target of cyber threats has moved well beyond data and information.

"This is not like the popular perception — the one that you see in movies — that have cyber attacks going for information, and the worst thing you can have is lost information or have your information exposed," David said. "With cyber-physical systems, the odds are much steeper. You may lose your life, you may lose your system, you may lose some critical equipment like an airplane or a power station, like, not just one car in the in the case of ground vehicles, but a whole lot of cars."

Upstream VP for Market Development Giuseppe Serio said heavy trucks and agricultural machinery could also be a target. "If we look at, for instance, agriculture or heavy truck machines, there is (and will be) a lot more automation. So there's probably not so many risks related to safety, but more to business continuity and operation."

David also said the complexity of the problems is growing daily and cited airports as an example. "It's in the complexity of it," he said. "And it's a huge miracle that we have not been hit harder yet. And I hope it's not going to happen anytime soon. And I hope we advance fast enough with our regulations and methodologies."

What's one big thing getting in the way of solutions? David said it's the way many executives perceive risk. "There is a lot of gray, and our cyber adversaries thrive in the shadows." He said executives need to understand that security planning is about planning for the next attack, not necessarily the previous one. "The worst issue is the one that hasn't happened yet," he said. "[The term] 'likelihood' is for executive games. Human factors cannot be reduced to probabilities and statistics," he said. "Where there is a will, there's a way."

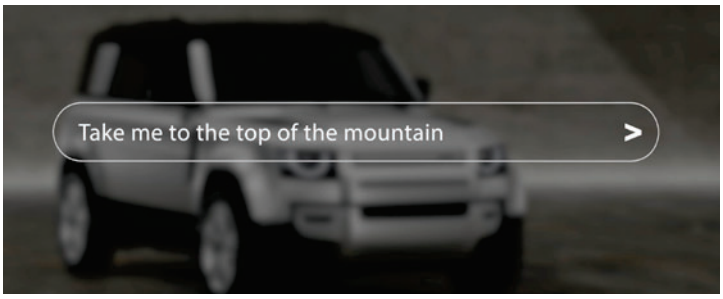
The Upstream cybersecurity report is available online.

Chris Clonts

BOTH IMAGES: UPSTREAM

AI

AI, digital twins reshaping advertising and car creation at JLR



...a user can say, "Take me to the top of the mountain"...

... and the system quickly responds and can then adjust again ...

Better digital twins powered by more powerful AI are going to change not just how car commercials are created in the future, but could open the door to entirely new design and engineering methods.

That was one message delivered at a panel discussion on "Generative AI and Industrial Digitalization in the Automotive Industry" at NVIDIA's GTC 2024 event in San Jose, California, in March. Jaguar Land Rover's chief data and AI officer, Chrissie Kemp, said JLR was able to leverage the digital twin capability in NVIDIA's Omniverse platform, including the Edify and Picasso microservices for generative AI, to render high-fidelity images of a Defender in its appropriate environments just by using conversational prompts. Saying, "take me to the mountains," for example, transforms the background of the photorealistic video, making it look like the car is driving there.

"When you live in a house of brands like we do now, we're just imagining the potential of what this could do for Range Rover, for new Jaguar and beyond," she said. "To be able to just literally say, 'I want to see this Explorer pack,' or 'I want to see in Pangea green,' it blows your mind about what's possible. It makes you think more about digital twins. It makes you think about the creative process, of the beginning.

"Imagine you're conceiving a new vehicle. Imagine you want to see that vehicle throughout its entire life, how it's been driving, if it's been autonomous, what its behaviors have been with client A, but then maybe it's been owned by client B. And you can really imagine this kind of digital copy of every physical asset that we have. And I think that's truly amazing with what's now possible."

Accenture's six-week project

JLR worked with NVIDIA and Accenture on the project, which took just six weeks to come together. JLR provided the digital vehicle model and models of the various parts and Accenture designers added material changes and "eye candy" like the background mountains with an eye towards using the files in future advertisments, said Teemu Nordman, who works on ramping up Omniverse technology at Accenture.

"You can use the Picasso for AI to build this implementation," Nordman told SAE Media. "They are currently building 360-degree API to generate these pictures so that you don't need to bring your car to a specific location to shoot. What we can do here is move the background and car on this specific timescale to demonstrate that it's really there, not just a video. The tool is for the marketing on JLR's side so that they don't need to have the real shooting and a real car anymore."

The technology could one day be used by JLR customers, too.

Despite how easy it will be to make digital advertising assets in the future, Kemp said JLR would keep the digital situations based on what's possible in the real world.

Kemp said it is still early days, but JLR will have a policy about being open with the public when it uses AI, but don't ask her what that is just yet.

"We will absolutely have a policy," she said. "We've only just started, but we absolutely will have one."

Sebastian Blanco

... when the user might say, "I prefer green, with big wheels"...

... opening up the door for what's possible not only with configurators but also as tools for designers and engineers.

ALL IMAGES: ACCENTURE

AI

Volvo EX90 uses AI, NVIDIA SoC to make automated driving safer

Volvo Cars opened its largest software testing center in the world in Sweden in late 2023.

As head of software engineering at Volvo Cars, Alwin Bakkenes is involved not just with all of the software and electronics in Volvo's vehicles but also the automaker's automotive cloud, the data center that trains Volvo's algorithms, the connectivity pipeline and software updates as well as interactions with Volvo's autonomous driving software development subsidiary Zenseact and HaleyTek, a joint venture with ECARX to develop Android-based infotainment systems for Volvo and Polestar. This growing digital footprint gives Volvo an array of tools to improve its future vehicles, something Bakkenes made clear when speaking with SAE Media at the 2024 NVIDIA GTC event in San Jose in March.

Volvo started working with NVIDIA around eight years ago and first used the NVIDIA DRIVE Orin system-on-a-chip (SoC) technology in the updated XC90 SUV, introduced in 2022. In 2023, Volvo built a new 22,000 sq m (236,806 sq ft) software testing center in Sweden at a cost of around SEK 300 million (U.S. $28.4 million).

It's in Volvo's new EX90, though, where the NVIDIA effect can be best seen. The all-electric SUV is equipped with NVIDIA DRIVE technology and a core compute architecture capable of over 280 TOPS. The architecture consists of two core computers that allow Volvo to make the EV "an interface-first, software-defined product where we build and drive a lot of the behaviors of the actual vehicle," Bakkenes said. The architecture also runs the car's ADAS and autonomous driving stack, which Volvo developed in-house "based on our heritage of having done years of safety research and pioneering technology development in terms of active safety."

NVIDIA inside, and also outside

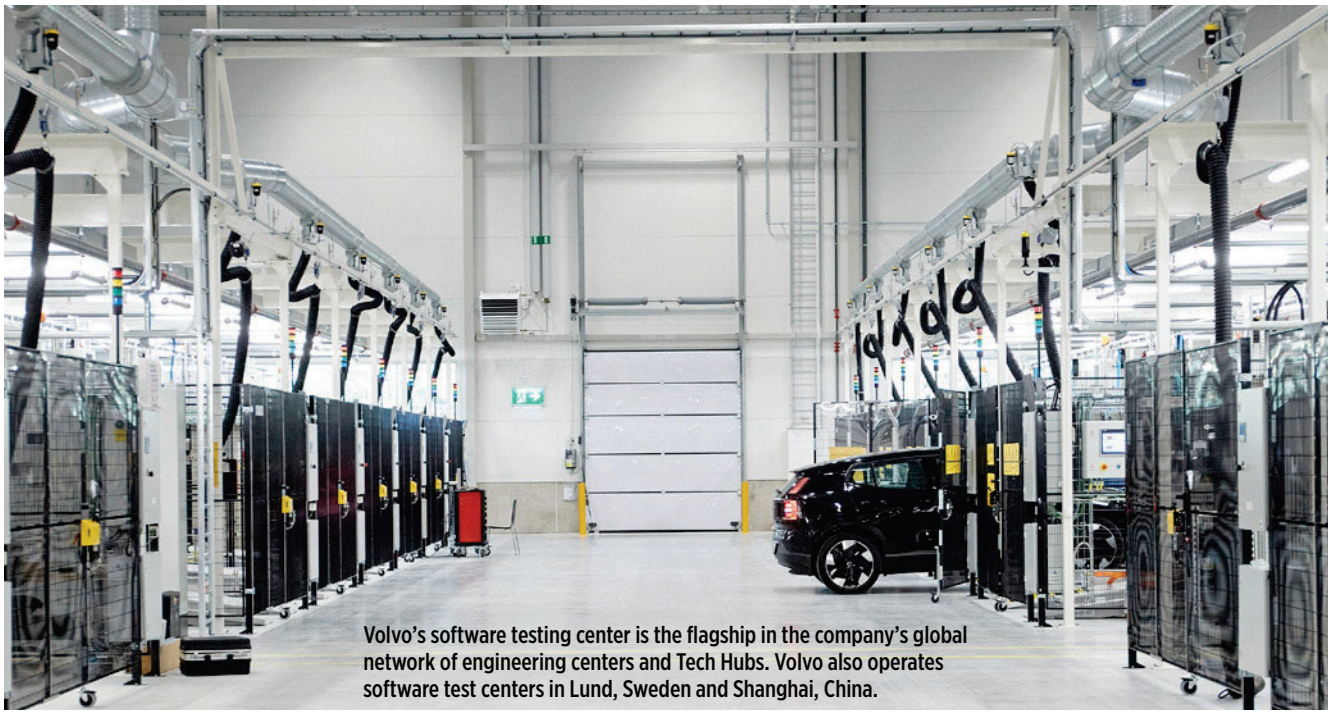
Volvo uses NVIDIA components not just in the car but also in its data center, which is heavily DGX-based, and on desktops. Faster compute speeds, and more sensors in Volvo vehicles allow the developers to work at a pace that would have been impossible before.

"We've always innovated but, typically, these innovations took years to go to market," Bakkenes said. "With the technology that we're introducing [in the EX90], we can actually improve the systems in a matter of weeks. And from a pure developer perspective, we do it in a matter of days. That ability to iterate and learn from a large fleet of cars, in terms of how the systems behave, enables us to be really fast and deliver better cars every day."

The entire auto industry now has access to AI and more powerful computers. Even though everyone can improve their development speeds this way,

The new Volvo EX90 at NVIDIA GTC 2024.

FROM TOP: VOLVO; SEBASTIAN BLANCO



Volvo's software testing center is the flagship in the company's global network of engineering centers and Tech Hubs. Volvo also operates software test centers in Lund, Sweden and Shanghai, China.

Bakkenes said Volvo isn't worried about other OEMs catching up to Volvo's real and perceived lead in automotive safety because Volvo comes at the autonomy problem from a specific perspective.

"If anything, [AI] will enable us to actually leap frog even more," he said. "Our purpose is to build the safest products out there. Collision avoidance is super important and this is where we start. We focus on autonomy, as well, but autonomy for the purpose of creating safer products. We have a slightly different heritage perspective on autonomy than many others, and that gives us an edge."

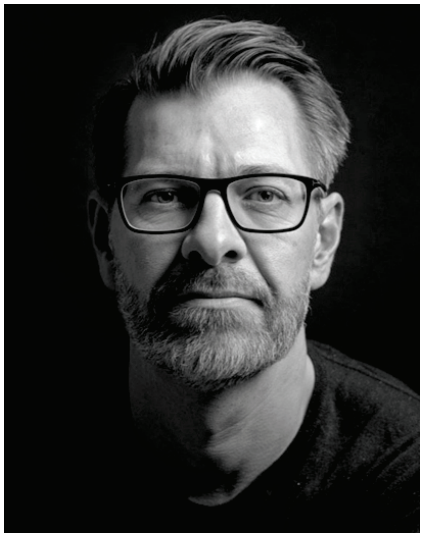
One way Volvo expects to use AI to make its vehicles safer is by harnessing the increased data that the EX90 and future Volvos will provide, including details on actual events and near misses. The EX90, for example, is equipped with exterior radars, exterior cameras, interior cameras, a driver monitoring camera, an interior radar, and lidar on the roof. Some of this information collected can, with user consent, be anonymized and sent to Volvo for further analysis in ways that simply were not possible before. When an incident occurs, Volvo can get information about objects around the car and can see certain things that the sensors saw, which then allows Volvo to recreate the scenario in digital form.

"Instead of understanding what happened, we can actually send the actual sensor data, which we can use for actual retraining of new scenarios, so we can be even better at improving the system over time," Bakkenes said. "We can find corner cases of scenarios that we do not support and we can actually use the technology to build these scenarios out, we can simulate them, we can retrain algorithms to cover them to make the performance of the systems better."

These enhancements can then be deployed back to cars on the road and be used in future vehicles.

"It's a mindset thing," he said. "We're focused on making our products safer. So when we leverage data, we do it with the intent to actually understand how can we make it better, how can we make it safer.

"Starting in the EX90 with our core compute architecture, we can actually start to use some of the data that we get back to recreate the scenarios and actually train algorithms on real-life scenarios. A fleet of actual products can capture reality much better than engineers driving in pre-production vehicles, so it gives us real insights about real-life safety and how to make the products better."



Alwin Bakkenes, head of software engineering at Volvo Cars.

Sebastian Blanco

BOTH IMAGES: VOLVO

CABIN ELECTRONICS

Mapping out future vehicle cockpits

Game-like navigation visuals Conversational-style voice commands. Contactless biometric sensing. A tidal wave of software code and sensing technologies are being prepped to alter in-vehicle activities.

Two supplier companies, TomTom and Mitsubishi Electric Automotive America (MEAA), recently presented their concept cockpit demonstrators to media at TomTom's North American corporate offices in Farmington Hills, Michigan. A few highlights:

TomTom's new Orbis map platform, which relies on open and proprietary data sources, its production-ready Premium Map Renderer, and the gaming engine Unity are the foundation for enhanced navigation maps. Roads, buildings and landscape attributes assume a 3D appearance, making the visuals similar to an immersive gaming product experience, TomTom's senior customer solution manager, Anton van Breemen, told SAE Media.

The driving experience during multi-lane highway travel requires abundant information about other vehicles and the surroundings. TomTom's map technology leverages data from various sources, including Mitsubishi Electric's High-Definition Locator, with precision accuracy of plus-or-minus 25 cm (9.8 in) to provide a comprehensive context of the driving scenario.

Anton van Breemen stands next to TomTom's digital cockpit demonstrator. TomTom's first production application of its digital cockpit is with an American-based EV manufacturer. "You can go into one domain – phone, messaging, media, marketplace, navigation – make a change and that change is immediately applied to the other domains," Breeman said.

MEAA's FlexConnect is an advanced cockpit with a focus on in-cabin and exterior sensing technologies that can be used for autonomous vehicles.

"With lane-level navigation, we can show your vehicle on the map and color the specific lane to be in for a highway exit, or to avoid road construction, or to avoid a traffic accident, or to get the best traffic flow," van Breemen said.

AI-powered conversation is also featured. Using Microsoft's GenAI engine and large language models, TomTom's demonstrator enables talk between the vehicle driver and an AI-powered counterpart. During a demonstration, van Breemen asked where in-vehicle USB ports are located. An AI voice provided the number and exact location of a specific vehicle model's outlets.

MEAA's FlexConnect concept demonstrator integrates vehicle functions

FROM TOP: KAMI BUCHHOLZ; MEAA

In-cabin monitoring on MEAA's FlexConnect includes infrared and thermal cameras, and radar-sensing results fusion, according to MEAA's Grygorii Maistrenko.

MEAA

and applications with Sensory AI. Performing as a smart assistant, the AI-powered communicator enables the driver to talk in a conversational manner with the TomTom navigation system and/or the vehicle's infotainment system. "You don't have to train the system, as it's already advanced enough to understand almost any way you ask it," said Grygorii Maistrenko, product owner with MEAA's advanced engineering Filament Labs team.

FlexConnect also provides contactless biometric monitoring and analysis, including pulse rate based on skin color changes caused by periodic blood flow variations detected by infrared cameras, breathing rate changes detected by radar sensors as well as skin temperature changes detected by thermal camera analysis.

If biometric information analysis indicates a serious health change for the driver is occurring or likely imminent, the system could trigger an autonomous vehicle to go into self-driving mode and maneuver the vehicle to the side of the road while alerting emergency services.

The FlexConnect demonstrator also monitors driver distraction by analyzing data from in-vehicle cameras that track whether the driver's eyes are on the road, on the touchscreen or gazing elsewhere. "For instance, if the system detects drowsiness, it can take action, such as adjusting the cabin temperature or changing the infotainment system to make the driver more alert and focused on driving," Maistrenko said.

Kami Buchholz

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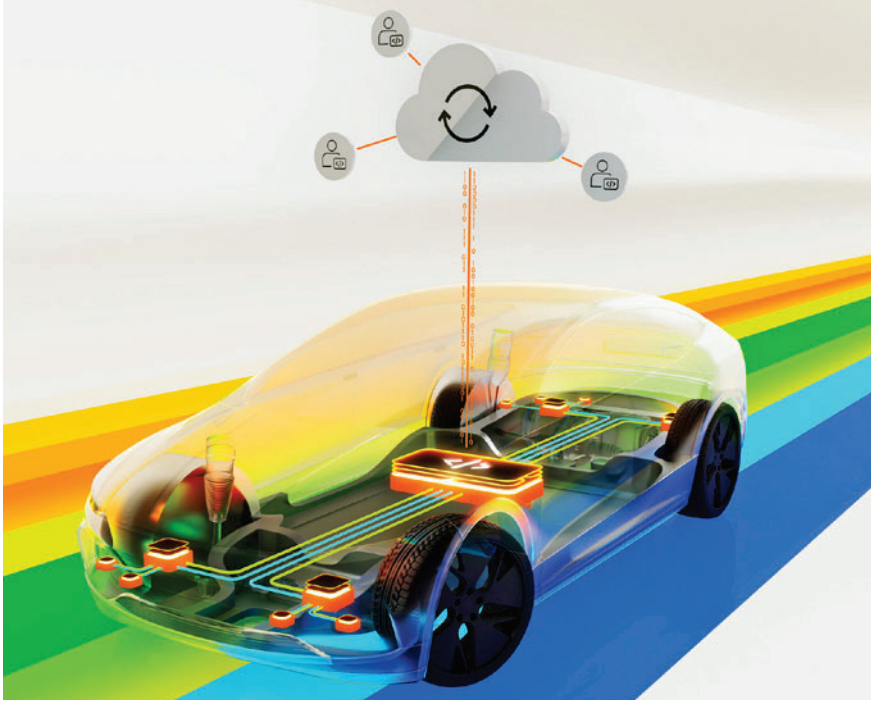
SOFTWARE-DEFINED VEHICLES

NXP S32 CoreRide Platform simplifies development of software-defined vehicles



NXP collaborates with software companies and Tier 1 suppliers to provide the open CoreRide Platform.

A new industry-first open platform for developing the software-defined vehicle (SDV) combines processing, vehicle networking and system power management with integrated software. NXP Semiconductors' new S32 CoreRide Platform was designed to run "multiple time-critical, safety-critical, security-critical applications in parallel," Henri Ardevol, executive vice president and general manager of Automotive Embedded Systems for NXP Semiconductors, told SAE Media.

NXP's new foundation platform for SDVs differs from the traditional approach of using multiple electronic control units (ECUs), each designed to handle specific vehicle system control tasks. Since each unit requires its own integration work, the integration workload exponentially increases with each additional ECU on a vehicle.

Today's entry-level vehicles typically have 25 ECUs, while a luxury vehicle can have as many as 150. The new CoreRide Platform can reduce the number of ECUs required. "But much more importantly, the CoreRide Platform provides a consistent, centralized software development environment," Ardevol said.

The CoreRide Platform includes the new S32N family of super-integration processors to handle scalable real-time and application processing for vehicle control – aspects like the feel and quickness of steering and ride comfort – as well as other vehicle functions. "We are not focusing on the display part of infotainment or on the vision-processing side of ADAS because these are very specific applications that require dedicated hardware accelerators and runtime environments," Ardevol said.

Scalability – as it relates to performance, computing memory, electrical/electronic architecture coverage, system power management, and networking breadth – underpins the platform. Another inherent benefit is design flexibility, which is key to SDVs because every automaker has a different starting point, its own competencies and capabilities, and a distinct product range. "The value chain used to be very rigid and very vertical, and now it's a circle around the OEM," Ardevol said. "We are all trying to work with each other to facilitate the transition to SDVs."

"No one company can do it all," NXP's Henri Ardevol said, noting the relevance of a new foundational platform for software-defined vehicles developed in collaboration with partners. Ardevol and a few partner company representatives talked with media members in Detroit.

BOTH IMAGES: NXP

"When we talk about SDVs, we often forget that there's a hardware part to it," said Valeo's Derek de Bono.

VALEO

Collaborations ahead

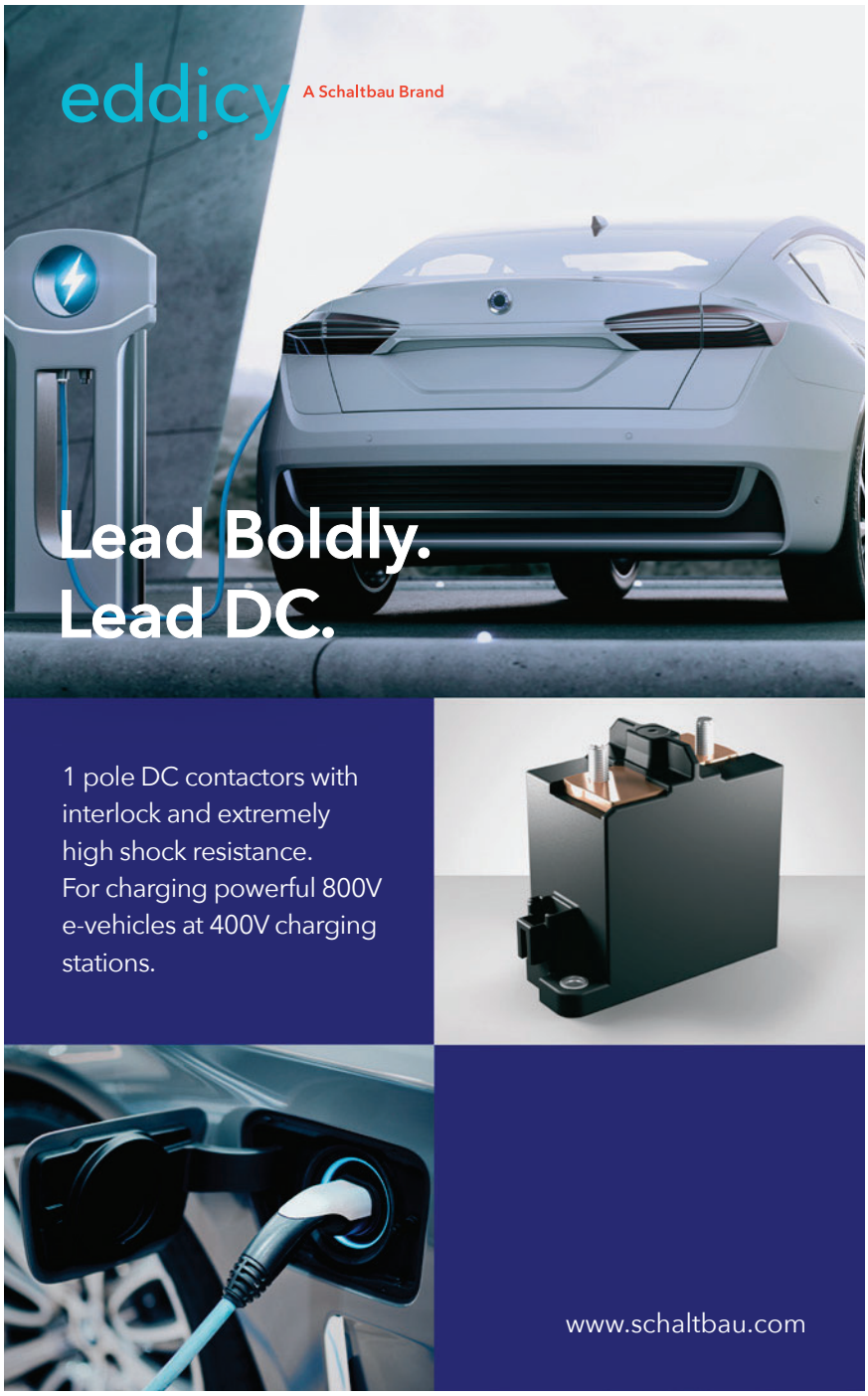
NXP's collaboration-focused approach begins with other suppliers. "We are working with our partners on the fundamental pieces of the platform's software – operating system, middleware services, and in some cases up to the application – to make sure that we deliver an optimized technology stack," Ardevol said.

John Heinlein, chief marketing officer for start-up SDV technology company Sonatus, based in Sunnyvale, California, said that having NXP bring together key providers of complementary software technologies was a smart move. "The software problem that you have to solve to deliver an SDV is becoming more and more complicated," Heinlein said. "It requires collaboration across hardware and software to accelerate time to market and reduce the engineering burden."

Tier 1 supplier Valeo is also among the dozen partner companies involved with the CoreRide Platform. "We look at the CoreRide Platform as a real enabler to be able to scale and adapt to the needs of future processing power in the vehicle," said Derek de Bono, software-defined vehicle product vice president and group product marketing vice president for the Valeo Group.

Vehicles using the new platform could reach the global market around the end of this decade. "We're trying to make it easier, simpler and faster for OEMs by doing a lot of the pre-integration work for software-defined vehicle development," Ardevol said.

Kami Buchholz



EV Accelerator Interview with Nathan Yang of FLO

Range anxiety once was the biggest barrier to electric vehicle acceptance. Lately, it's "where-to-charge" anxiety. Canada's largest charger manufacturer and station provider, FLO, is expanding its U.S. network and is working to ease charge anxiety. SAE's EV Accelerator, sponsored by Keysight, speaks with Nathan Yang, FLO's Chief Product Officer. Yang leads product innovation activities for the company, including hardware and software.

***EV Accelerator:* How did FLO become Canada's largest charging network?**
Yang: Our founder decided in 2004 it was time to do something concrete about climate change. Electric vehicles are the way to go, so in 2019 he founded FLO to drive EV adoption by delivering the best charging experience, which means our chargers must be functional and reliable. A CBC survey rated us ahead of our competitors for uptime and reliability. Such results will help FLO gain market share because our products just work.

Nathan Yang

***EV Accelerator:* What are FLO's key technical attributes?**
Yang: Our chargers have the right firmware, a cloud to manage sensors, and a mobile app to help EV drivers find the chargers. We ensure reliability from the 10-foot, the two-foot, the one-foot experience. Our app helps you find an EV charger in the parking lot and then makes it easy to pay for. We use quality components made with quality materials and aim for a mean time before failure (MTBF) of eight to 10 years-plus versus three to four years MTBF for most of our competitors. We test connectors at 10,000 cycles. Our FLO Ultra chargers have probably over 250 sensors. By storing sensors in the cloud, we can organize and predict failures, and learn from those failures in the field.

***EV Accelerator:* Describe differences between how FLO tests its various charging systems for different applications.**
Yang: With a residential charger or charging off-site overnight, you plug into an electrical panel. Either requires medium-speed charging, eight hours to fill up your car. Driving between cities, you probably use high-speed charging on the road, taking maybe 30 minutes for a fill-up, and testing is quite different. DC fast charging converts high power to your vehicle, and dissipating that power's heat and ensuring safety requires a lot of testing. We must make sure there is a lot of conversation between the charger and the EV, that the car and the charger speak the same language and hear each other well. Some signals are too low, some are too high. We test all internal components and make sure it's safe. The safety devices must trip when they're supposed to trip. We also take pride in how we test residential chargers. When a family buys a FLO home charger, they're connecting their two most expensive assets. They don't want thermal events to happen to either one of them.

***EV Accelerator:* How will the bipartisan infrastructure bill help FLO's U.S. expansion?**
Yang: You need a lot of EVs on the road to justify a big charging network. But you can't build a big charging network without a lot of EVs on the road. Green tech needs government to come in and jump-start the effort, which can generate local employment, like our manufacturing facility in Auburn Hills, Michigan.

***EV Accelerator:* What else do you need to assure reliability in a coast-to-coast charging system?**
Yang: We use the cloud to detect issues, manage and monitor the system. My domain is hardware and software, and my counterpart in network operations makes sure this works at charging units across the country. We have an operating center with people watching the screens. When there is an alarm, we try to fix it remotely and reboot the charger. If that doesn't work, we send in a field technician. In some instances, we repair our chargers on our own dime to make sure EV drivers aren't left stranded.

***EV Accelerator:* Is FLO adopting the Tesla J3400 connecting standard?**
Yang: Our network's most popular model is Tesla's Model 3. We have already provisioned a lot of our hardware for the FLO Ultra charger to be able to support it. SAE adapted that Tesla connector for all vehicles that may be higher current AC and higher power DC. Our new products will support it natively. We will also continue to support CHAdeMO.

***EV Accelerator:* Where can we go to learn more about FLO?**
Yang: FLO.com. There's also a FLO mobile app. We also have roaming agreements with big networks, so you won't have to pay a roaming charge for using those networks. ■

Watch the full interview with Nathan.

2024 Lincoln Nautilus: The brand's first global SUV

While there is a tendency for new vehicles to have a focus on ride, handling, performance and other dynamic elements, the model year 2024 Lincoln Nautilus team added another element to how the driver will experience the midsize SUV. Not that the ride, handling, etc. were ignored, but the global design and engineering team wanted to do something different with this two-row SUV.

Recognize that this is a vehicle with a sumptuous interior that includes not only first-class seating (24-way adjustable front seats) and materials (Alpine Venetian leather available on the seats; cashmere for the headliner) but also an available high-end Revel Ultima 3D audio system with 28 speakers. What's more, there's "Lincoln Digital Scent," small electronically activated pods containing various aromas (e.g., Mystic Forest, Ozonic Azure, Violet Cashmere). Across the top of the instrument panel there is a 48-inch backlit LCD screen and a 11.1-inch touchscreen in the center stack.

The 2024 Lincoln Nautilus has seating for five and as much as 71.3 cu. ft. of cargo volume and 113.5 cu. ft. of passenger volume.

All of this can be used or experienced while driving.

When in park

But Dante Crockett, features engineer for the Nautilus and an electrical engineer by training, said Lincoln decided to integrate many of these functions so the driver, when the vehicle is parked and the engine running, can, through the touchscreen, select an experience that will help relax then rejuvenate the driver. That is, the screens show an image like the Aurora Borealis, the audio system plays specifically produced music, the scent is delivered through the arm rest, and the driver seat automatically reclines and initiates a massaging feature.

Then, so as not to have to go in the house or office pleasantly groggy, the system goes into a mode where the seat back is powered to a less reclined position and the audio is louder. The driver can select a five- or 10-minute session. Crockett says the functionality, named "Lincoln Rejuvenate," will be an over-the-air update for MY 2024 vehicles and be integrated into MY 2025 vehicles.

Asked what the thinking behind this was, Crockett simply said, "Driveway moments." He said after a long day, the vehicle can serve as an environment to provide a bit of relaxation before going on to the next thing. It isn't just about going from A to B, but about feeling better when you get there.

The 48-inch (1,219-mm) backlit LCD screen is positioned, compared to screens in many vehicles with expansive digital landscapes, back and high. The result is that information about speed and navigation are readily seen with a slight downward look. Other information such as the audio, weather and time can be seen with a glance to the right. While it may appear odd at first, when used during driving it is a highly ergonomic solution.

BOTH IMAGES: LINCOLN

Screen scene

The location of the previously mentioned 48-inch screen is different than the positioning in most vehicles, well forward from where gauge clusters typically are placed. Allen Sun, Nautilus product manager who worked on the

"Lincoln Digital Scent" is based on a small cartridge (about two-thirds the length of a pack of gum with similar width and depth) that has a solid scent pod on the inside and perforations and a chip on the exterior. The cartridges are inserted into a mechanism on the underside of the arm rest. There is a fan that blows air onto the cartridge so that the scent is released through perforations in the arm rest. The amount of scent is controlled via the center touchscreen.

	CORSAIR	NAUTILUS
LENGTH	181.4 in (4607 mm)	193.2 in (4907 mm)
WHEELBASE	106.7 in (2710 mm)	114.2 in (2901 mm)
WIDTH	76.2 in (1935 mm)	79.8 in (2027 mm)
TRACK (front/rear)	62.6/63.4 in (1590/1610 mm)	65.2/65.3 in (1656/1659 mm)

Table 1

electronics and software for the vehicle, explained that the position was chosen to allow the driver's eyes to always look up and out without the need to glance down for operational information or navigation.

The "Lincoln Digital Experience," Sun said, is five times more powerful than the existing SYNC 4 system used in other Lincoln models. The new system is based on a Qualcomm SA8155P SoC specifically engineered for infotainment and instrument cluster applications.

Lincoln's system is Google-centric, with Google Assistant the default voice application, Google Maps for navigation, Google Play for apps, but it permits customers to use their preferred software, such as Apple CarPlay, if desired.

The setup on the screen has the typical gauge information directly in front of the driver with navigation information to its right, well within the driver's field of view. Three other virtual screens – Sun called them" glanceable" – are positioned closer to the front passenger. Information presented here, like what song is playing, may be interesting but is not critical to the operation of the vehicle.

The platform

The third-generation Nautilus is based on a modified version of the Ford C2 platform, which also underpins vehicles like the Ford Escape and Maverick and the Lincoln Corsair. "The C2 platform is used for a lot of vehicles," David Bartholomew, Nautilus Vehicle Engineering Chief, said, but pointed out that there are changes from one model to another (see Table 1).

Bartholomew, who started his career with Ford in the U.K., moved to Australia and then to China, pointed out that this is Lincoln's first global development program. This means there was engineering in Dearborn and China; design by Kemal Curic and his team in Irvine, California; and manufacturing at the Changan Hangzhou Assembly Plant in China.

Thomas Kostrzewski, hybrid systems engineer, notes that much of the development was done during COVID lockdowns, which required extensive digital engineering by a team working around the world.

Propulsion systems

In the previous-generation Nautilus, the step-up powertrain was a twin-turbo, 2.7-L V6 with 335 hp (250 kW). For 2024, the base engine is a 250-hp (186-kW) turbocharged 2.0-L I4 mated to an eight-speed automatic. The optional engine is a 310-hp (231-kW) turbocharged 2.0-L I4 with an eCVT. Yes, a hybrid. This was not some sort of pivot that the company made in reaction to the recent consumer indifference toward battery-electric vehicles. It was in the plan all along.

The Nautilus hybrid system is similar to that used in the current-generation Ford Escape, but given the changes and improvements made for this execution, Kostrzewski said it was really "Generation 4-1/2." Lincoln chose to use an eCVT rather than a P2 hybrid configuration, which has a standard step-gear transmission and a hybrid module between it and the engine, for efficiency's sake.

"What is elegant about an eCVT is that we have both an electrical and mechanical path within the transmission," Kostrzewski said. "We can control the speed and load of the engine independent of the wheel speed. With an eight-speed P2 hybrid, the speed of the system is tied to the wheel speed and whatever gear you're in. The eCVT allows the engine to be at its most efficient speed."

Notably, the Nautilus hybrid provides not only better fuel efficiency than the non-hybrid – 30 mpg city/31 mpg highway/30 mpg combined for the hybrid and 21/29/24 mpg for the standard 2.0-L – but Kostrzewski pointed out that, compared with the previous-generation's step-up powertrain option's fuel efficiency numbers of 19/25/21 mpg, the Nautilus hybrid owner is not likely to notice the 25-hp difference. Plus, the Nautilus hybrid was configured to provide rapid torque response and limited latency.

Gary Vasilash

LINCOLN

Kia's PBV concepts expand commercial possibilities

Kia's entry into the light commercial vehicle market, launched at CES in Las Vegas, provided an overview of the potential range, from last-mile delivery vehicles to medium cargo vans. Kia's Platform Beyond Vehicles (PBVs) will enter production with the PV5 in 2025 at a new PBV-dedicated plant in Hwaseong, Korea. The larger PV7 will follow between 2027 and 2032.

PV5, similar in size to the Ford Transit Connect, was always going to be the first of the range to enter production, according to executive vice president and head of Kia Global Design, Karim Habib. Design plans include a van, a high-roof van and a robot taxi. "The primary purpose was a business-to-business vehicle," says Habib." The business-to-customer side was definitely not very high on the list at the beginning. It came in more and more as the product took shape and as we saw the potential for it, but the business-to-business side was definitely the most important, whether it's ride-hailing or delivery logistics.

"It's a cool, rational kind of thing because we're designing more living spaces now, even when we're doing normal passenger cars, it's about making sure that the time you spend in the vehicle has value, it's not just about the driving. A van is the ultimate execution of that. The great thing about doing it on the EV side is that the overhangs can be much shorter; you don't have a front-wheel-drive layout with the engine in front of the axle. The wheelbase is much longer, the wheels are much bigger, and the vans have a great stance."

Kia's new line of all-electric light commercial vehicles will be built using the Platform Beyond Vehicles system and could include digital screens on the exterior.

The design team didn't just focus on designing the complete vehicle; it also turned its attention to areas that are usually handled by external converters and outfitters, Habib said,

"We designed the bare-bones, base one," he said. We designed what would be an option out of the factory, and we also designed the accessories, but I'm talking here in terms of virtual. We did some mockups, nothing fully production-ready, and we would like to propose that to those third parties, for them to manufacture them, based on those principles."

One of the design's distinctive features is the apparent lack of headlamps. They're there, just positioned in the gap above the front fender, where the air intake for cooling air in an internal combustion engine vehicle would be.

"We wanted to place the headlamps up for two reasons. One is that it gives the vehicle a certain presence, but also because we didn't want them low in the corners for crash damage reasons," Habib said. "They're inset, so they're further in. They're also recessed to protect them. The fenders are in three pieces so that the corners can be replaced, and the center can stay."

Kia plans to sell around 300,000 units a year in 2030. Following the launch in Korea in 2025, the company plans to introduce the vehicles in North and South America, Europe, and other markets.

John Kendall

The Kia PBV concepts feature flexible, open interiors that can be adapted to fit the needs of commercial customers.

BOTH IMAGES: JOHN KENDALL

The Inside Story on Henkel's EV Battery Innovations

Henkel holds a leading market position as an innovation and development partner to OEMs and battery manufacturers in the E-Mobility segment. The company's broad and diversified portfolio of advanced materials are critical to the assembly, sealing and protection of EV components, including battery systems, power conversion and electric motors. Key solutions include thermal interface materials, adhesives, sealants and functional coatings. Pankaj Arora, Vice President Electronics & E-Mobility at Henkel Corporation, North America, discusses the latest advancements in material solutions for EV design and manufacturing.

What is the top challenge facing the electric vehicle market today and how is Henkel addressing that challenge?
There are so many challenges that it's tough to focus on just one. But right now, I think the industry is really grappling with enabling a circular economy for EVs and batteries. Europe has made more headway in this area, but there is increased focus here in the United States as well. At Henkel, we're working on de-bondable adhesives so metals can be recovered and recycled, or in other cases so components can be repaired or repurposed. The key is to do this without causing any damage to the battery. We're looking at different triggers to enable debonding, including mechanical, electrical, temperature, magnetic and chemical.

Pankaj Arora, Vice President Electronics & E-Mobility at Henkel Corporation, North America

How do you feel the EV market has impacted the pace of innovation in the industry?
There's been a huge impact in terms of the pace of innovation. Agility and speed are key and highly sought after. We're focusing a lot of time and attention in the area of modeling and simulation to speed innovation by leapfrogging traditional testing cycles. Through simulation and testing, we can analyze material behavior under various conditions and then test that material on digital twins of our customers batteries. This helps us find material formulations with the best combination of safety, performance, affordability and more in a much faster time and then those results through validation.

What is a recent innovation by Henkel that is particularly important to the future of battery design and engineering?
At the battery cell level, we've introduced Conductive Electrode Coatings, which enable higher energy density due to improved adhesion on the battery cell level. As a result, this helps increase range without increasing the size of the battery pack. The coatings also protect the current collector, prolonging service life of the battery. In addition to performance gains, there's a great sustainability story here as Henkel's process for the technology involves dry mixing, instead of wet mixing. This helps reduce energy demand by removing the need for ovens and in turn, reduces equipment footprint by 70 percent – providing cost savings potential in cell production of greater than 10 percent. This also helps make the manufacturing process more environmentally friendly by reducing the use of organic solvents.

How are battery design changes influencing material solutions?
There's a significant impact. For example, simplified battery designs such as Cell-to-Pack and Cell-to-Vehicle architectures are helping reduce weight, cost and improve energy density. But at the same time, these new architectures require new material innovations. For example, in a Cell-to-Pack configuration, modules are eliminated, and the battery is packed with cells placed directly on the cooling plate/metal case. This configuration simplifies the assembly, but it also brings a new set of requirements in terms of providing both structural integrity and thermal management. Henkel's Thermally Conductive Adhesives (TCA) help manage heat flow, while supporting the structural integrity of the cells through strong adhesion.

When evaluating a TCA for structural performance, we take into account bond strength specifications and the type of surface on which the TCA is to be applied. In the case of thermal performance, selection criteria include thermal conductivity specifications, temperature stability rating and UL flammability rating.

Any key, future plans for Henkel's continued growth in the EV market in North America?
We're always growing and changing and that makes it very exciting for our team. Because that growth and change is always focused on how we can better serve the market and our customers, we're currently investing in the launch of a Battery Application Center in our facility in Madison Heights, Michigan. The Center will offer equipment for automated material dispensing on up to full-scale battery systems – replicating a production environment on a small scale. The goal is to use the Center to further our customer collaboration and drive innovation related to material application for battery components. ■

Learn more about Henkel's role in electric vehicle development at **www.henkel-adhesives.com/emobility**.

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BATTERIES & RECYCLING: THE NEXT FRONTIER

There will be no lack of used EV batteries soon. There's no lack of companies working on how to recycle them today.

by Sebastian Blanco

A spent pouch cell can be shredded to yield several products. The black mass powder contains anode carbon and the valuable cathode material.

RECELL

Recycling electric vehicle (EV) batteries has been a goal of the auto industry for many years, but the infrastructure to make that a widespread reality is still in the early stages. As the amount of used lithium-ion batteries and cells coming from EVs increases, the industry is getting ready to turn them into fresh packs.

In the U.S., the federal government's push to recycle more Li-ion batteries isn't just to reduce environmental impact. Salvaged materials can be used in new batteries, and recycling can help get the overall production cost of EV batteries under the national goal of $60/kWh.

In February 2019, the **U.S. Department of Energy**'s (DOE) Vehicle Technologies Office (VTO) launched the **ReCell Center**, bringing together industry, academia and national laboratories to develop battery recycling technologies for current and future battery chemistries. ReCell is a collaboration of four national laboratories — **Argonne**, the **National Renewable Energy Lab** (NREL), **Oak Ridge** and **Idaho National Laboratory** — and four partner universities.

Jeff Spangenberger, ReCell's materials recycling group leader in the Applied Materials Division, told SAE Media that ReCell focuses not just on the science of recycling batteries, but also on the people working on this technology.

"Battery recycling is a great way to reduce the material costs," Spangenberger said. "It's a lot easier to recover the materials from recycled materials or from the feedstock of batteries than from the ground. To do that, we like to connect people. No one person is going to solve this, and so we try and connect the dots."

ReCell hosts industry collaboration meetings for those dots, with the next event happening in mid-May.

Direct recycling at ReCell

ReCell's research is focused on direct recycling. Unlike existing hydro- or pyro-metallurgical recycling methods that use chemicals or heat to break down a battery into feedstock compounds like metal sulfates, direct recycling recovers or reuses components in the battery without breaking down the chemical structure. ReCell's website says it developed an analysis model called EverBatt to "compare impacts of virgin batteries to those with recycled content, to compare processes, and to identify sensitivities to various parameters," and found that direct recycling promises to use less energy and is more sustainable than hydro- or pyro-recycling.

"[Direct recycling is] not really researched, it's not commercial," Spangenberger said. "But the analysis

ReCell's Jeffery Spangenberger.

says that direct recycling is a huge opportunity to really catapult the industry into a cost-effective, profitable endeavor, and that would be over hydro and pyro."

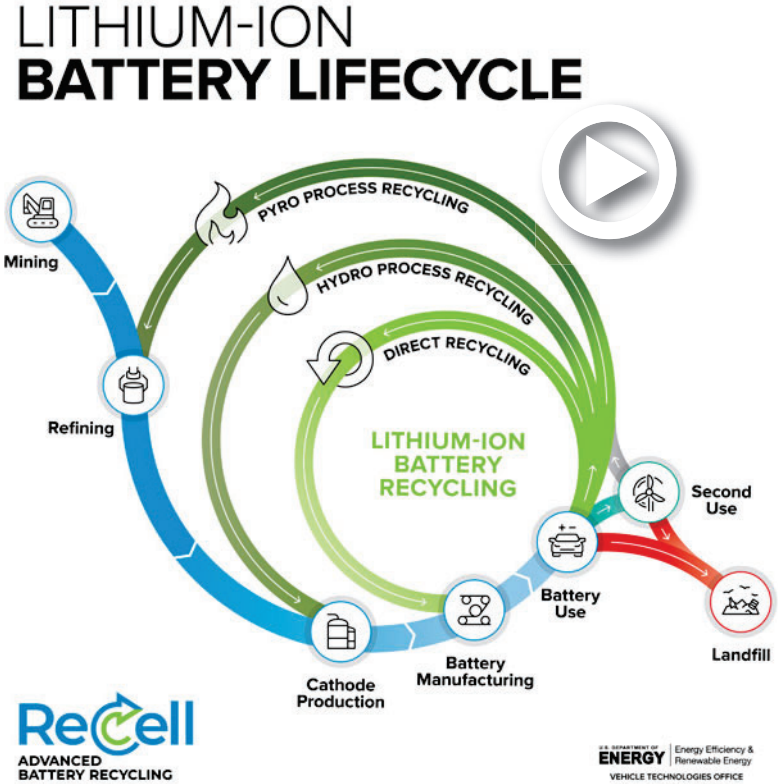
Spangenberger said ReCell has around 50 projects it's working on, with about half of them focused on direct recycling.

"When we started this, there was one company that was working on direct recycling and as we break down the barriers, we want industry to take off," he said. "Now, there's about three companies that are working on this up to the pilot scale. That's showing that we're getting people interested and funding is flowing into direct recycling."

ReCell's other projects focus on advanced resource recovery (finding another home for components, perhaps being upcycled into a new product), design for sustainability (designing batteries so they're easier to recycle or demanufacture) and modeling and analysis (like EverBatt), which Spangenberger said allows ReCell to focus on projects that make big-picture sense. These four aspects obviously interact with each other. Designing something for sustainability means considering if a chemical added to a battery for better performance could obviate its recycling capability, for example.

"You can't have [design for sustainability] as the first metric in the design of a product," Spangenberger said. "If you can't sell a product, you don't need to worry about recycling. So, the cost has to be right, performance has to be right. But I think that one of the metrics that has to be included is end-of-life management. And that's true for any product."

BOTH IMAGES: RECELL



Direct recycling recovers active materials that can go directly back into manufacture of new batteries, avoiding expensive and energy-intensive processing steps.

Hexagon's digital twins to the rescue

Global digital reality solutions company **Hexagon** uses digital twins to help companies manufacture their products better. Hexagon's director of automotive, George Cuff, told SAE Media that digital twin technology can be used with EV batteries to analyze how they function in the real world, like their various thermal characteristics.

"That information can be captured and we can drive that back into product development," he said. "We've got a variety of different tools in the simulation space. As they're trying to optimize the design, they run through a variety of different scenarios, using that real-world information to help drive that."

Cuff said digital twins could also be used to better recycle batteries. Hexagon's software can manage various materials in the digital twin for simulation analysis, for example.

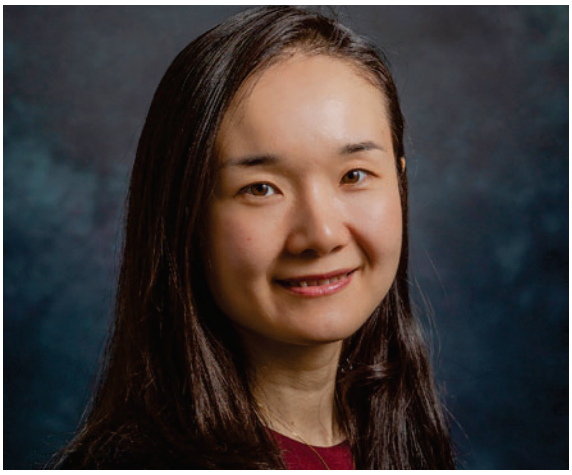
"[That data] can also provide the ability to analyze and say, for this particular battery or this particular vehicle, we have X amount of these raw materials," he said. "This can be recycled, this percentage is hazardous material waste. I can absolutely see a scenario where governments are going to regulate or require an understanding of the types of materials, what can be recycled in these battery packs, what can't be, and what would ultimately be hazardous materials. When these batteries and battery packs really come to end of life there, we're going to need to have a good solid plan to be able to handle them."

BATTERIES & RECYCLING: THE NEXT FRONTIER

Hexagon's digital twin technology can be used to improve a battery pack's recyclability, and to scan other parts of a vehicle.

Factorial's FEST (Factorial Electrolyte System Technology) 100+ Ah quasi-solid-state battery cell.

Officially, the **U.S. EPA** recommends that businesses manage used lithium batteries as hazardous waste, which means the batteries need to be sent to a permitted hazardous waste disposal facility or a hazardous waste recycler as their final destination. If these waste batteries are being shipped internationally, they need to comply with RCRA requirements for the export and import of universal waste. Domestically, the **Department of Transportation** regulations for shipping lithium batteries apply as well to shipping lithium batteries as hazardous waste, even though the EPA says EV batteries that are removed at "a dealership, an auto shop, a scrap yard, or similar type of facility" are not considered household hazardous waste.



Factorial's Siyu Huang.

Solid-state is easier

Woburn, Massachusetts-based **Factorial Energy** is developing quasi-solid-state batteries for future EVs, and is already working on how to recycle them at end-of-life. In June 2023, Factorial announced it would work with the South Korean chaebol (conglomerate) **Young Poong** to build out recycling capabilities.

"There are quite a few recycling companies in the U.S., but most of them have been focused on lithium-ion," Factorial co-founder and CEO Siyu Huang told SAE Media. "At the time, Young Poong was the only one that we knew was working on lithium metal recycling, and the process is quite different from lithium ion. [This] can help us reduce the cost of the cell in the future because we are a cell maker, and there are always cells coming out of the scrap and there are end-of-life cells from our customers, so it's good to have value generated at end of the life."

Huang said solid-state batteries, if they ever gain widespread acceptance in EVs, will be easier to recycle than today's Li-ion packs.

"Solid state is, by nature, safer for disassembly compared to lithium-ion," she said. "It has more solid than liquid. Potentially, it also has better regenerative value, too, because recycling lithium metal as the anode is probably going to be more valuable than recycling carbon or silicon in the anode."

Currently, Factorial needs to ship components to be recycled to Young Poong facilities in South Korea, but is "actively looking for local suppliers that can do recycling in North America," Huang said. "A lot of them are

CLOCKWISE FROM TOP LEFT: HEXAGON MANUFACTURING INTELIGENCE; FACTORIAL; FACTORIAL

"Solid state is, by nature, safer for disassembly compared to lithium-ion."

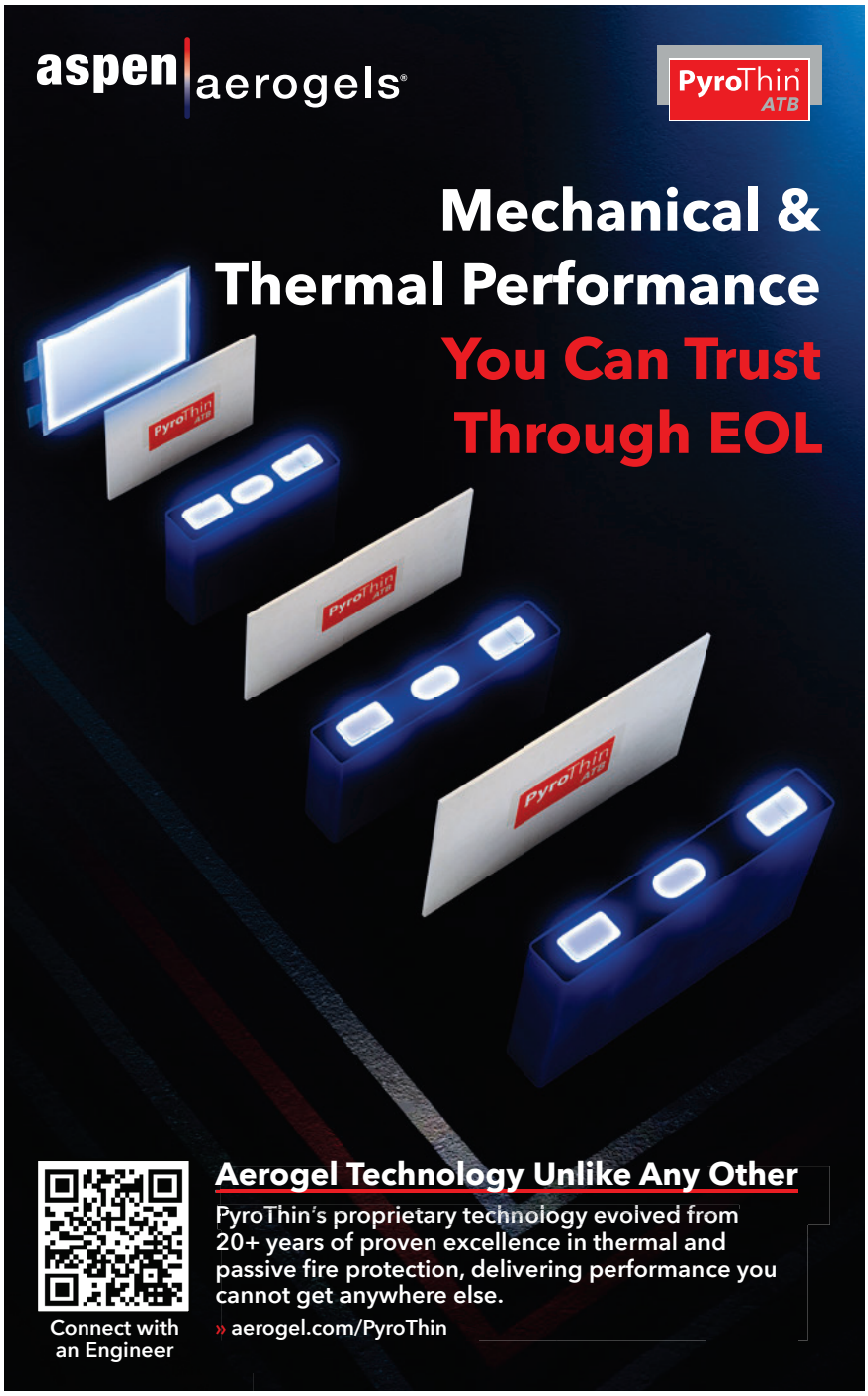
interested. It's just a matter of time and commitment to build a technology that's viable for recycling for lithium metal. Not everyone is as advanced as they are in Korea. But, if there is enough interest and also enough support from the government from various regulatory pathways, I think they'll definitely bring a good tailwind to such industry investment."

Watch your waste stream

There's no lack of federal money headed toward domestic battery production and use. President Biden's Inflation Reduction Act (IRA), passed in August 2022, included money for 2,300 grid-scale battery plants along with the better-known electric vehicle tax credits worth up to $7,500. But the IRA's emphasis on domestic production is also reshaping where EV batteries will be made and where the materials will come from.

Aqua Metals has been running a pilot of its closed-loop metal recycling process for a little over a year. David Regan, vice president of commercial at Aqua Metals, told SAE Media that work is progressing on its Sierra ARC (AquaRefining Campus) processing center in the Tahoe-Reno Industrial Center. Aqua Metals said the ARC "will be the first sustainable lithium battery recycling center in North America and the first commercial-scale deployment of our Li AquaRefining technology." Regan said the equipment was being installed this spring, and he expects black mass to be going in over the summer. The ARC should be in full production by the end of the year, he said, and Aqua Metals has a target of processing 3,000 tons of black mass in the first phase, with 10,000 tons as the target for the next phase.

"We don't see any issues getting feedstock for ourselves at up to 10,000 tons, at all," he said. "We're talking to a lot of black mass creators. It's just really a matter of pricing. We're also engaged with OEMs and cell manufacturers. Between now and 2030, they're going to scale to a terawatt of cell manufacturing. That's going to produce a significant amount of manufacturing scrap. They don't want that to go to waste. The OEMs have spent money on that



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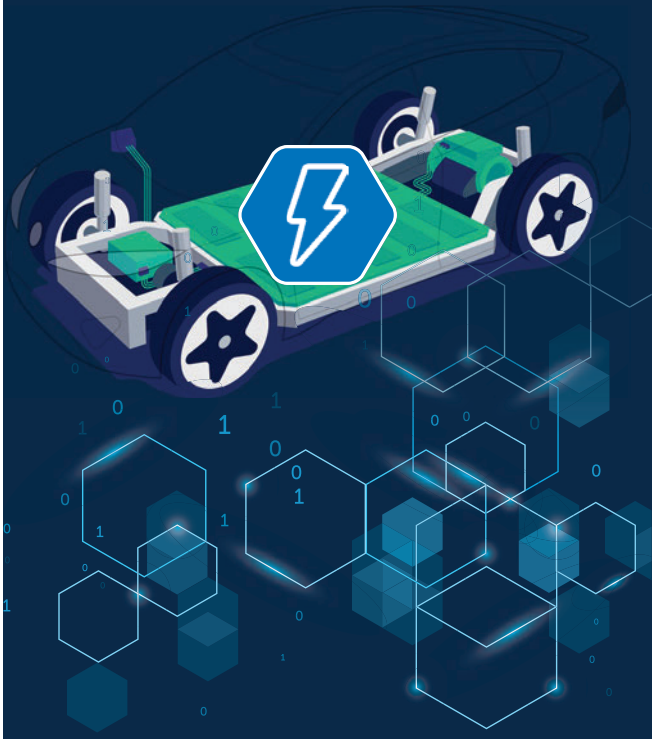

ELECTRICAL AND END-OF-LINE TESTING OF MODULES AND PACKS

Marposs provides complete solutions for battery cells inspection. The cells can be measured to check dimensional characteristic, safety conditions, and electrical functional parameters. Tailored solutions are available depending on the type of cells (prismatic, cylindrical, or pouch) and integration requirements within the manufacturing line.

A rendering of Aqua Metals' future Sierra ARC campus. The phased development strategy will let Aqua Metals "rapidly expand our commercial lithium battery recycling capacity while maintaining a higher level of flexibility and resilience," the company said.

The interior of Aqua Metals' Lithium AquaRefining Pilot facility.

material, and they want to get it back into circulation."

In March 2024, Aqua Metals and **6K Energy** announced they would jointly develop a sustainable lithium battery circular supply chain in North America. Regan said 6K's process uses nitrates instead of sulfates as a feedstock. 6K doesn't produce any sodium sulfate waste stream as part of its process, whereas traditional cathode active material (CAM) manufacturing produces around 26 tons of sodium sulfate for every ton of CAM, Regan said. Traditional hydro-recycling also produces about one-and-a-half to two tonnes of sodium sulfate for every ton of black mass, he said.

"Traditional processes are extremely dirty when it comes to waste streams, and also have a high carbon impact," Regan said. "We don't produce any sodium sulfate. Using renewable electricity, we have an extremely low carbon footprint compared to other technologies. If we're producing two tons of sodium sulfate for every ton of black mass recycled, that has to go into landfill or go into the ocean. When we're recycling millions of lithium-ion batteries, EV batteries, millions of tons eventually over the decades, that amount of waste stream is just not viable." ■

BOTH IMAGES: AQUA METALS

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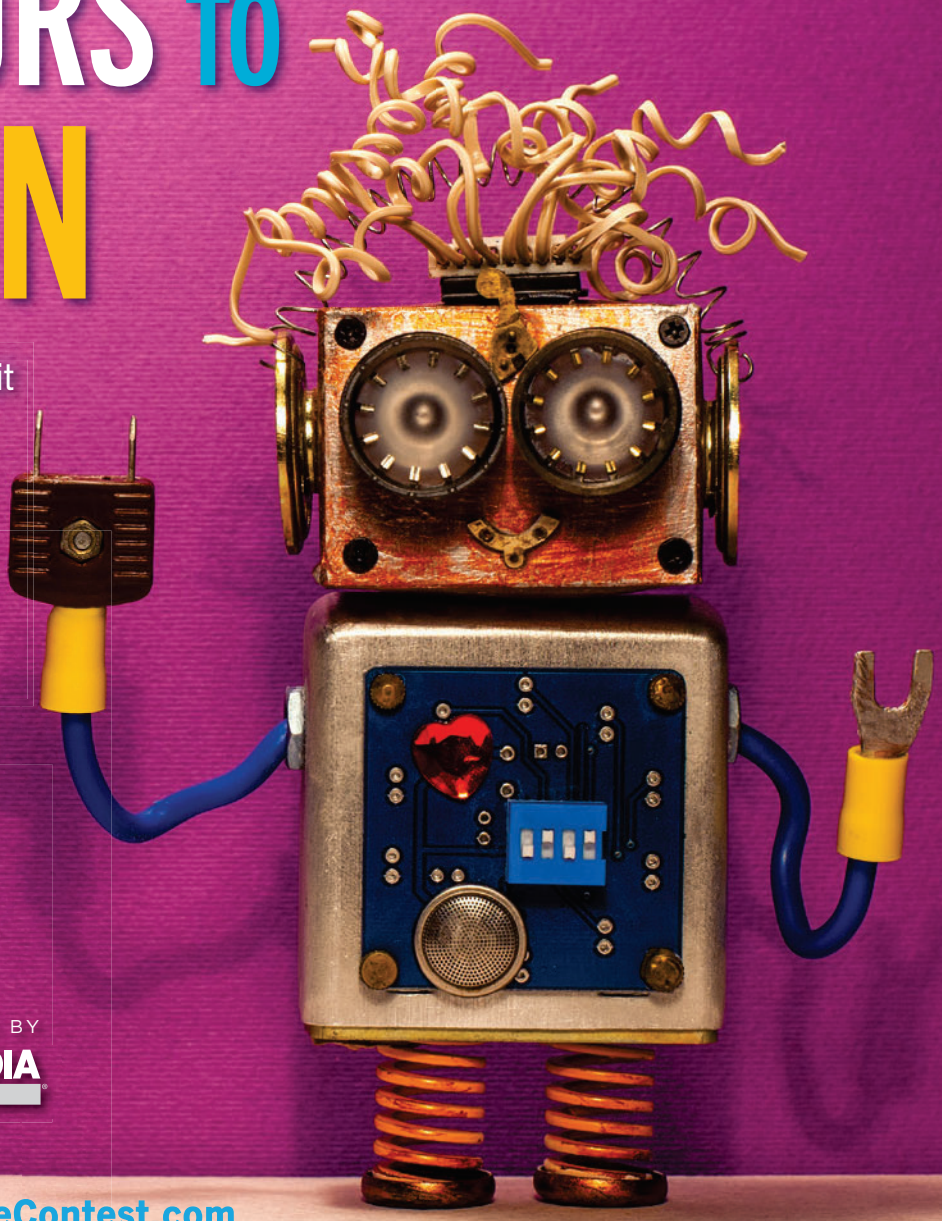

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Are we stuck with LITHIUM-ION?

As companies continue to trumpet their next-gen EV battery tech, it seems like new chemistries face more momentum from the established champ, lithium-ion.

by Chris Clonts

There's no shortage of alternatives to lithium-ion EV batteries in development. From lithium-iron phosphate to sodium-ion to multiple solid-state chemistries, companies are racing to perfect these technologies and figure out how to manufacture them at scale.

But to an outside observer, it can feel like breathless coverage of future battery technology is much ado about not much. Lithium-ion batteries seem to have all the momentum, seeing as they're the power supply of choice for most EV manufacturers. And if there's anything that's true in the automotive industry, it's how hard it is to buck momentum. Here are just a few of the big issues lithium-ion batteries have in their favor:

- Already built factories that manufacture batteries and face tremendous costs to retool for a different technology.
- An economy of scale that has driven down the cost per kilowatt-hour from $732 in 2013 to $139 in 2023.
- The vehicle development curve can be seven or more years before hitting production. That means betting on a technology and a mining and manufacturing ecosystem that hasn't been fully tested.
- Some companies are slowing EV launches and reconsidering investment in new technologies given the recent slowdown in the growth of EV sales.

At the same time, it's strategically important to the industry to diversify its power sources, as China effectively controls the lithium-ion battery market.

Keith Norman, chief sustainability officer for battery maker **Lyten**, said that the same lithium-ion momentum in the mobility industry is also being experienced by the home and industrial-energy-storage industry (such as **Tesla**'s Powerwall). Norman said lithium-ion chemistry is probably not the ideal solution for either, but it's the easiest for now.

"When you get a solution like lithium-ion that meets the market demands for tolerances that you have to show to play in the space, you can grow very, very rapidly," Norman said. "Our view is that you're going to see something a little bit similar [in alternate chemistries]. There probably won't be tens of chemistries. It's going to be a small number that will find their place and grow very rapidly."

Lyten's Li-S ramp

While Lyten is all-in on lithium-sulfur chemistry due in large part to the fact that sulfur is one of the most widely available and lowest-cost minerals available, it is another material that sets the company's batteries apart. "The real innovation is a new material, a three-dimensional graphene material that is ultra-high-strength and high conductivity that allows us to tune structural and permeability properties...to go deliver performance gains in industrial products," Norman said. Like some companies in the e-motor business, Lyten is focusing on other applications, such as drones, satellites and other defense applications before homing in on mobility.

The biggest challenge on the table is increasing the rechargeability of the cells, which the company is already producing in San Jose, California.

Compared to today's most common lithium-ion chemistries, Norman said Lyten, with its Li-S battery, is targeting an energy density of 20% to 25% above NMC batteries and two times that of LFP batteries. The other calling card of Lyten's batteries: a lack of weight, which, in addition to energy density, is another way to

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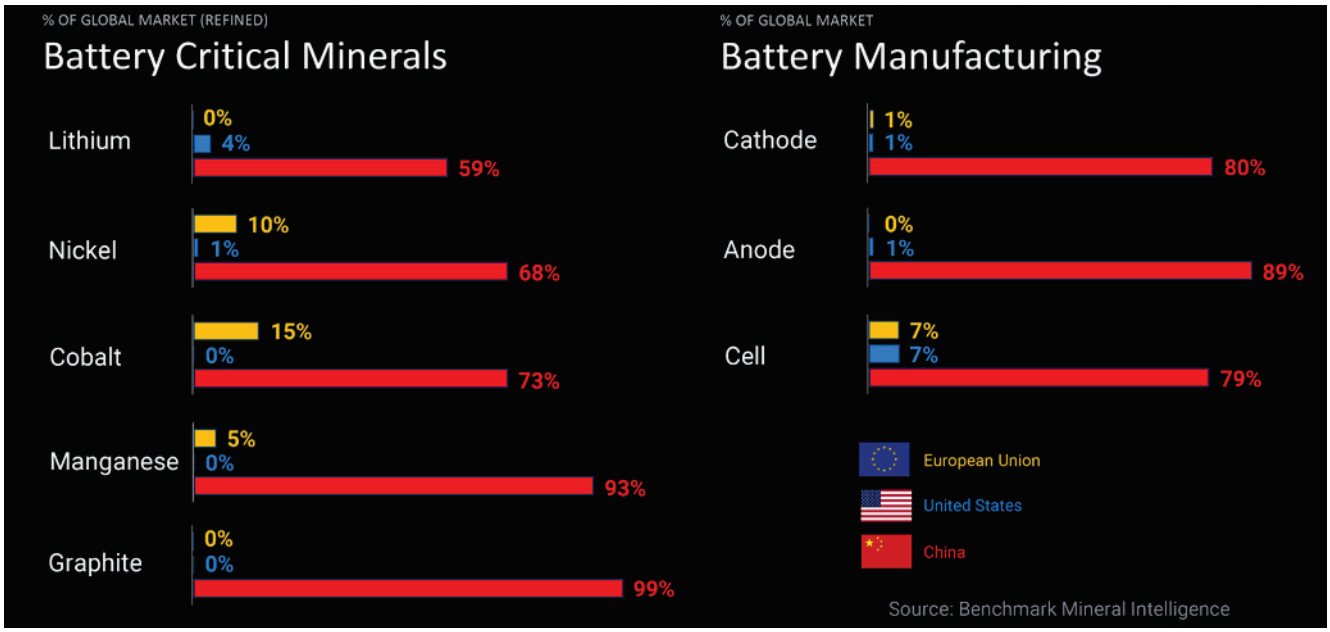


Currently, China dominates the market for EV battery cells.

Lyten's Keith Norman said he has long been a fan of sulfur due to its ubiquity and low cost.

Lyten is already producing cells in San Jose, Calif. The first applications are drones and satellites. The company will then move to the mobility market.

ALL IMAGES: LYTEN

extend an EV's range. And what may attract attention is a claimed 50% reduction in cost versus lithium-ion batteries.

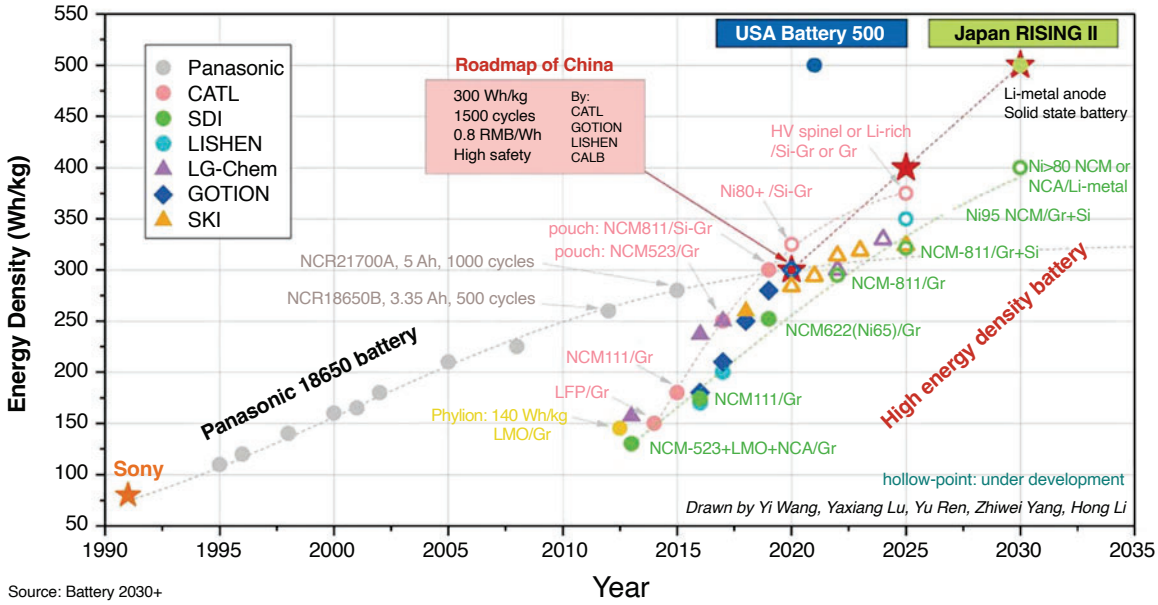
So far, Norman said, Lyten can manufacture cells using the same equipment currently on most lithium-ion manufacturing lines. That's important. Dan Lee, a senior manager at **Plante Moran** in Michigan, said the investment in today's gigafactories is just too big to be easily written off. "When you look at OEMs investing, you know, $2 billion or $3 billion, at least, on gigafactories, that's a big ask that five years down the line, all your capital equipment is worthless," Lee said.

He also said that some OEMs and suppliers still believe there's efficiency to be wrung out of lithium-ion technology, adding another incentive to stick with current technology. "Tesla's still dialing it in. It has been able to alter the cathode process where they're using a dry cathode process in the Austin gigafactory," he said. They've removed some of the curing time. It's all about how you simplify the manufacturing process" to take time out of it, he said.

Wide range of predictions on "when"

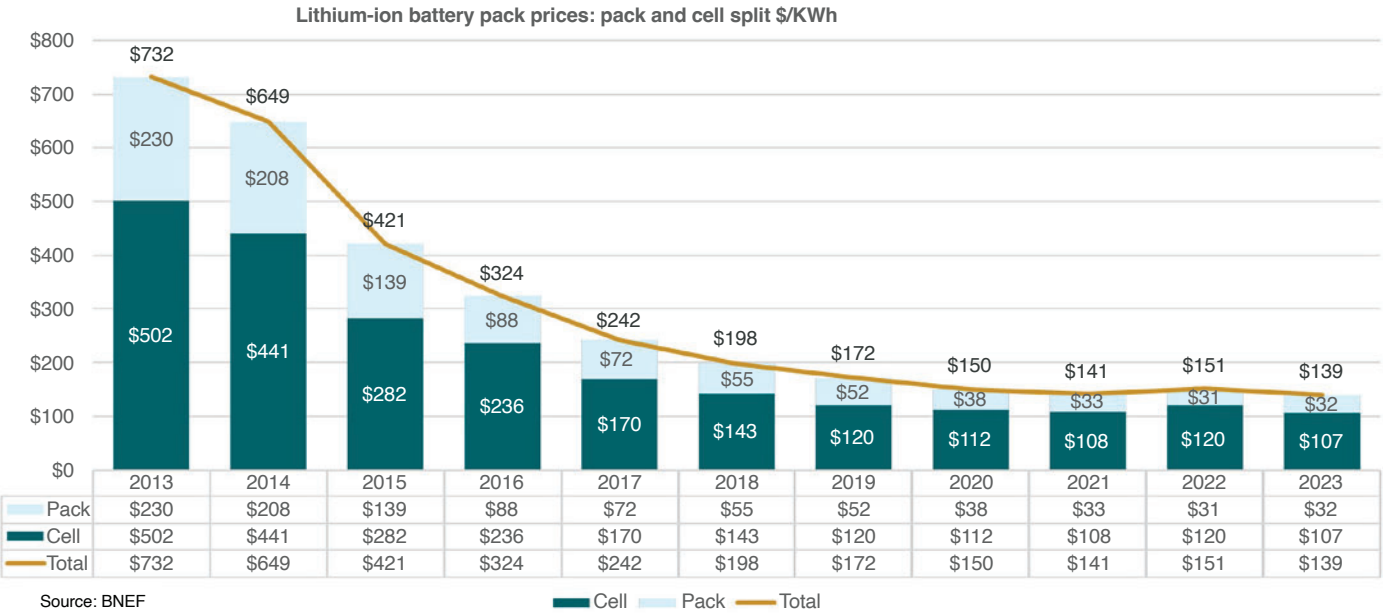
Despite the clear hurdles, most independent analysts agree that new battery technology will come to the market. The question is when.

Are we stuck with **LITHIUM-ION**?



Source: Battery 2030+

One overview of the development of different battery companies and their technologies suggests solid-state batteries would not hit the market until close to 2030.



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Pack	$230	$208	$139	$88	$72	$55	$52	$38	$33	$31	$32
Cell	$502	$441	$282	$236	$170	$143	$120	$112	$108	$120	$107
Total	$732	$649	$421	$324	$242	$198	$172	$150	$141	$151	$139

Source: BNEF

New technologies are competing with lithium-ion batteries' cost, which has been driven down as the market has scaled.

Most estimates range anywhere from five to 15 years. As for who is most likely to step forward first, Plante Moran's Lee suspects it will come from a non-OEM startup or supplier. "It could be Tesla or **BYD**, companies with a strong core competency in battery manufacturing. [The OEMs'] internal capabilities to develop a new chemistry in the lab and bring it to production, I think, are lacking," he said. "That's why you see OEMs, via their venture capital arms, making investments into some of these technologies."

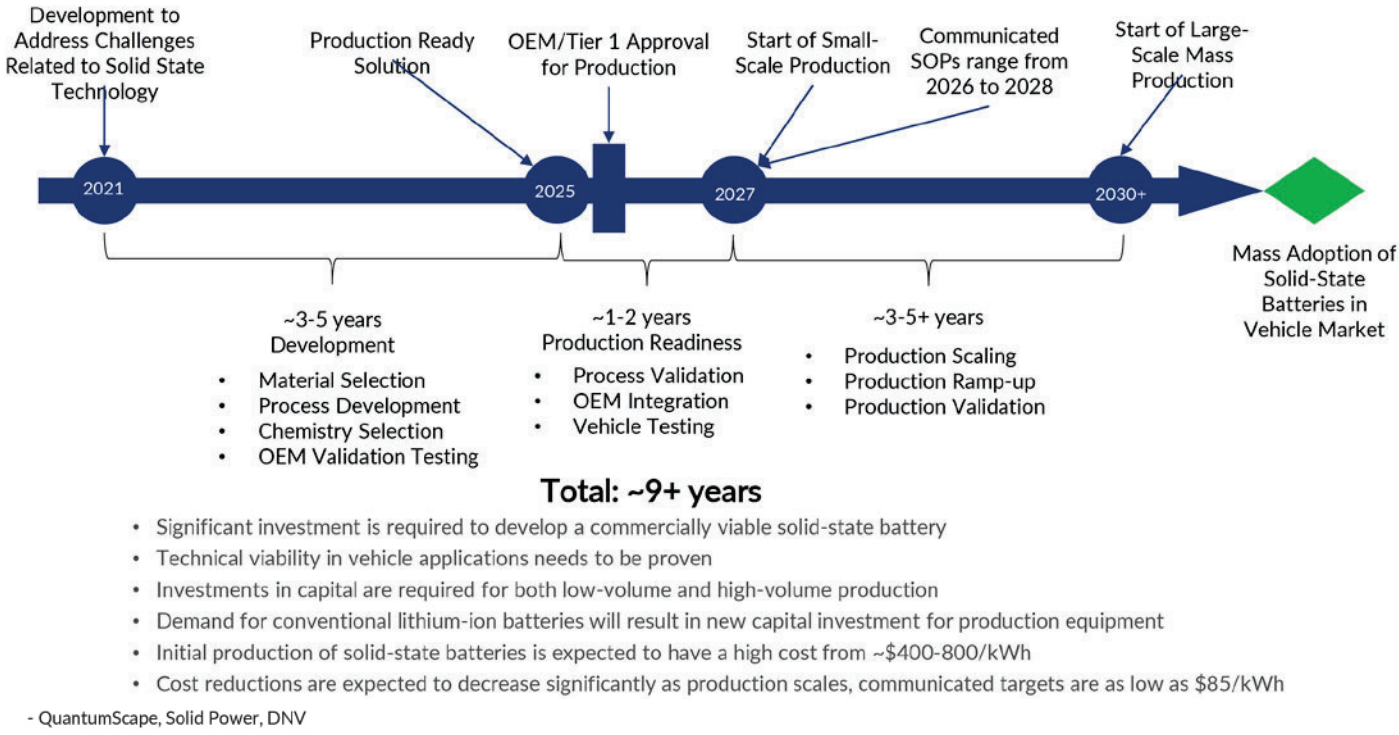
Siyu Huang, founder and CEO of **Factorial Energy**, which is betting on its quasi solid-state technology, said the race to get to market is fierce.

"Everybody's looking at a timeline from '26, '27, '28 or '29, around that time frame," she said. "We are very committed to bringing the technology to the market the soonest among all of the players."

Factorial's solid-state tech

Factorial Energy uses a polymer-based solid-state electrolyte system. The use of a polymer either results in low energy density or no improvement in

BOTH IMAGES: PLANTE MORAN



Plante Moran's overview of the solid-state battery market.

PLANTE MORAN

weight, both of which affect range. "We developed a polymer-based solid-state technology that also uses some liquid in the system," Huang said. "By having a liquid there, we'll be able to utilize more than 80% of the manufacturing process for today's lithium-ion manufacturing."

She also said they are targeting up to 50% higher energy density and 50% weight reduction. "Traditional lithium-ion battery EVs are about 1,000 to 3,000 pounds heavier than traditional combustion-engine vehicles. If we're able to produce a battery that's even 30% lighter than today's lithium-ion battery, that's about 100 kg or 200 pounds."

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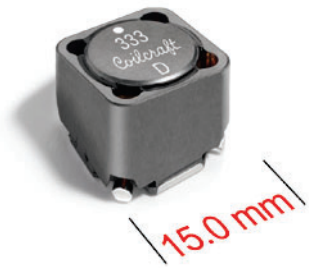

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> "If there's anything that's true in the automotive industry, it's how hard it is to buck momentum."

Solid-state technologies tend to be more thermally stable, so more weight reduction could come with the deletion of thermal-management equipment, Huang said.

Managing investment, managing expectations

Plante Moran's Lee and Lyten's Norman said it would take continued government investment in the industry to bring new technologies such as these to the automotive market. Lee said the Inflation Reduction Act and the bipartisan infrastructure law have $7 billion earmarked for battery materials and manufacturing research. But it will still take plenty of private investment to spool up future battery tech.

George Cuff, director of automotive for the manufacturing intelligence company **Hexagon**, said that despite the headwinds, he sees battery production in the United States growing year after year. "Some of that expansion is being tempered because of the overall market with electric vehicles, but I do expect long-term that the overall battery production in North America will continue to rise year over year," he said. "It just may be later than what was originally announced by the OEMs and their battery manufacturing suppliers like **LG Chem** and the other battery suppliers out there."

Norman had a word of caution for the many companies clamoring to get the attention of media and investors as they explore the innovations that experts insist will make their way into vehicles. "The battery industry has not done itself a lot of favors by getting giddy about technologies that can't yet be scaled," he said. ■

Sebastian Blanco contributed to this report.

LUMINARY CLOUD takes CAE to THE CLOUD

The start-up's 'real-time engineering' service means you can simulate on someone else's GPUs.

by Sebastian Blanco

Luminary Cloud co-founders Jason Lango (left) and Juan Alonso.

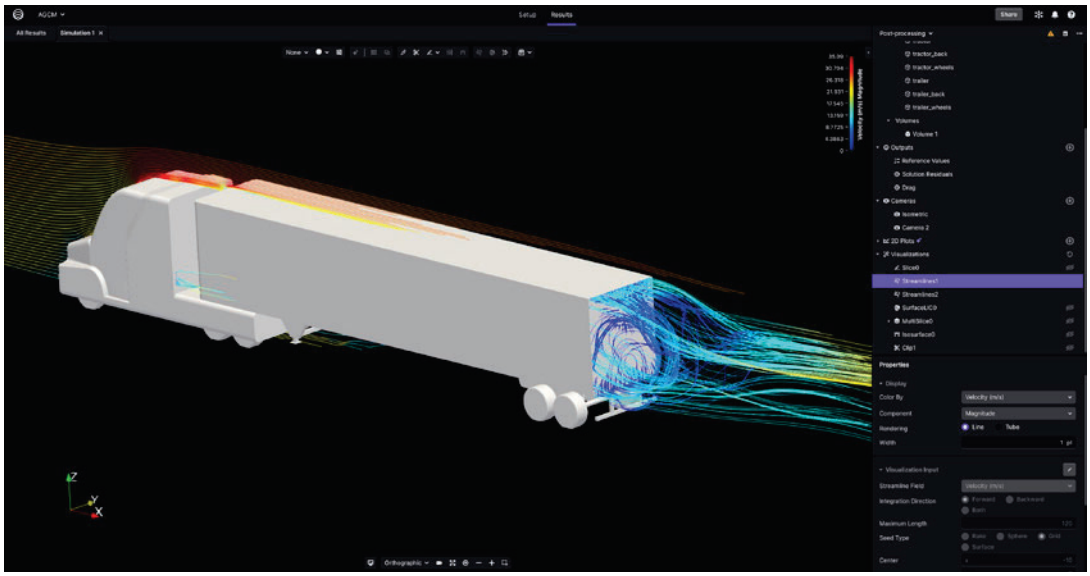
LUMINARY CLOUD

The cloud is many things to many people, but it's really just a new way to talk about using other people's computers instead of your own. When it comes to expensive GPUs that run intensive simulations, using someone else's computers—theirs—is exactly what Luminary Cloud wants the automotive industry to do.

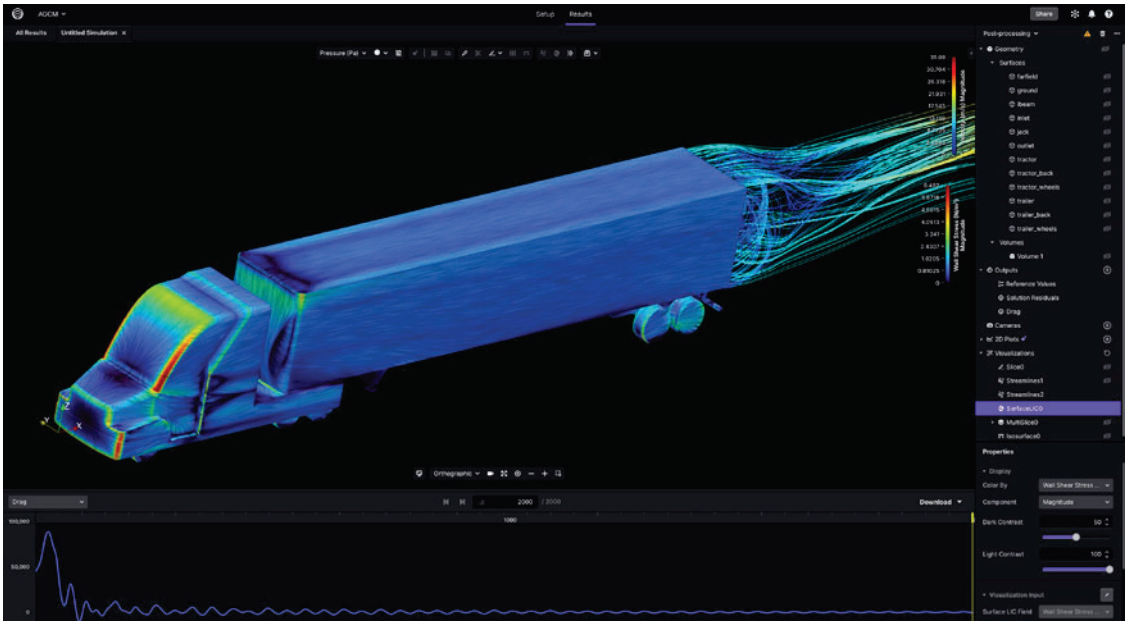
Luminary Cloud came out of stealth mode in early March, just in time to make a splash at NVIDIA's GTC 2024 event. With the support of $115 million in funding from Sutter Hill Ventures, Luminary Cloud now wants to offer the "world's first modern computer-aided engineering (CAE) software as a service (SaaS)."

Luminary Cloud provides CAE simulation solutions of various physics, with all the physics solvers being based on GPU computing. The SaaS portion of the equation uses NVIDIA's GPUs. It can "share massive amounts of data, large simulations with terabytes of data, with just a share button, like a Google Doc," Luminary Cloud, Inc. CTO and co-founder Juan Alonso told SAE Media. "I can distribute it across my entire team. That comes from the fact that all your data is stored, and it's always available anytime, anywhere, in a secure way." Alonso said customers can also write their own Python scripts to use with the service and create new models to infuse into their workflows. Customers do not need to install any software or maintain a cluster to use Luminary Cloud's "real-time engineering" services.

LUMINARY CLOUD takes CAE to THE CLOUD



Luminary Cloud uses NVIDIA GPUs to offer 'real-time engineering' to companies in the automotive space.



Luminary Cloud's physics solvers can track airflow around large vehicles as well as small things like golf balls.

The computer-aided engineering (CAE) part comes from Luminary Cloud's physics software, which can ingest CAD files, generate meshes, run solutions and extract solutions for visualization.

"One of the things that we've done is, by leveraging the GPUs in the cloud, we give you elasticity," Alonso said. "We can run one simulation, but 100 times faster than the competition, so instead of taking four to six hours to do a RAN simulation on a hundred million cells, we can actually do it in a couple of minutes. If you're in a crunch to run, let's say, 1,000 simulations in a day, you don't have to have a cluster that has 30,000 GPUs to do that, which would be a waste for your company. Rather, you can utilize them for one day and then move on."

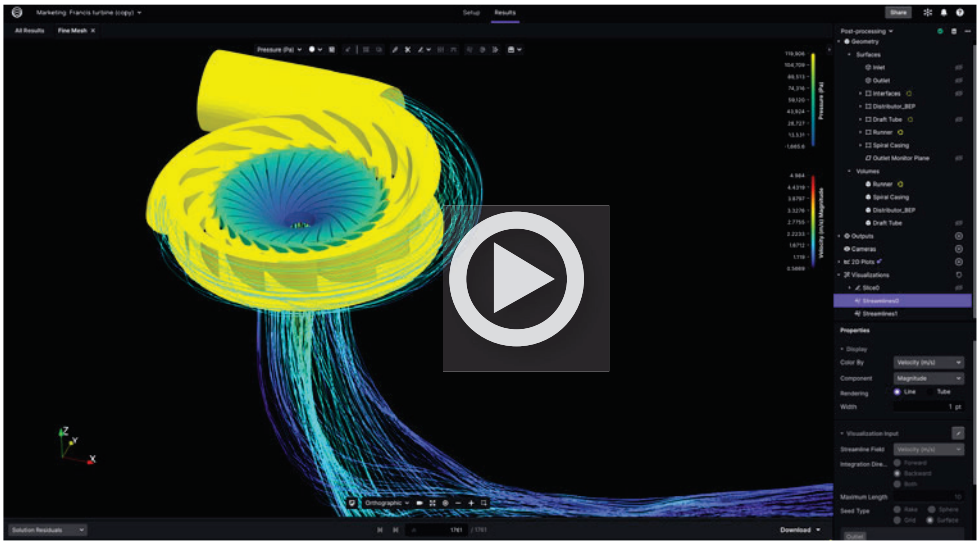
24 hours in 60 minutes

Ian Lockley, Luminary Cloud's principal solutions engineer, told SAE Media that the company's physics simulations impressed a potential automotive customer who asked them to run a blind test analyzing a transient aeronautics simulation. The customer's previous effort to run the simulation took them 24 hours.

"Now, in my job, you never want a blind test," Lockley said. "You always want the test data before you run the simulation. But they said, 'Run a simulation of this vehicle, and we're not gonna tell the answer.' So we ran that simulation in less than an hour, and we were within 3% of the results of that test data. So that was pretty cool."

Alonso said Luminary Cloud offers another advantage over other cloud-based CAE companies. The company knew it wanted to deliver

BOTH IMAGES: LUMINARY CLOUD



Luminary Cloud's SaaS can model water physics in a Francis turbine without requiring users to download any solver software.

LUMINARY CLOUD

speed but soon realized that running simulations in less time requires more than just better processors.

"Speed's not just speed of the solver," he said. "It's the end-to-end process, importing the CAD, actually cleaning up the CAD and making the meshes, possibly adapting the meshes, so you don't have to have a high degree of expertise in order to get accurate calculations and then interpreting the data.

"The initial premise of the company was to bring the solution time from hours to minutes. And early on in the company, we realized we could do that. Then we saw that setting up the visualization takes a long time, interpreting the results takes a long time, bringing in the CAD, setting up the mash, and realizing the mesh is not refined enough in various places. So we've been automating all of the steps in that process so that, eventually, people with less expertise can actually run Luminary and have confident and very quick results."

Beyond flow physics

Luminary Cloud will announce some of its automotive industry partners later this year, and Alonso said he expects case studies to be published as well.

"We are quite interested in expanding beyond flow physics or aerodynamics," he said, adding that porous media and conjugate heat transfer simulation capabilities will be announced soon. "As you can see, we are trying to work on the complete solution for automotive," he said.

Alonso said Luminary Cloud grew from one pre-paid customer at the start of 2023 to 33 at the end of the year, along with "a number" of pay-as-you-go customers. The company also grew from about 45 people to almost 100 in 2023.

Alonso said Luminary Cloud is taking a page from its sister company, Snowflake, when it comes to operating entirely as a pay-as-you-go, cloud-based data SaaS. Mike Speiser, Sutter Hill Ventures MD and the founding CEO of Snowflake and Pure Storage, serves on Luminary Cloud's board. Alonso founded Stanford's Aerospace Design Laboratory and was formerly the director of NASA's Aeronautics research program. Luminary Cloud's other co-founder, CEO Jason Lango, was an Entrepreneur in Residence at Sutter Hill Ventures and cofounded Bracket Computing. ■

UPCOMING WEBINARS

THE ROAD TO ZERO PROTOTYPES: LIVE FROM VI-GRADE'S ZERO PROTOTYPES SUMMIT 2024

Wednesday, May 15, 2024 at 8:00 am U.S. EDT

Developing a human-centered approach while utilizing state-of-the-art simulation software and driving simulators is essential to address the "Zero Prototypes Challenge" for today's automotive industry. This 40-minute Webinar – livestreamed from VI-grade's ZERO PROTOTYPES Summit – will highlight the "Road to Zero Prototypes" concept, the importance of vehicle attributes in enhancing the driving experience, and how simulators enable automotive development to be redefined in anticipation of emerging technologies and regulatory frameworks.

Speakers:

Guido Bairati
Managing Director, VI-grade (part of HBK Virtual Test Division)

Ben Bryson
President, HBK

Jonas Grötzinger
Senior Expert - Vehicle Motion, EDAG Engineering GmbH

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

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TRANSFORMING TRANSPORTATION MANUFACTURING: UNLOCKING GROWTH WITH SUSTAINABLE ENERGY SOLUTIONS

Tuesday, May 21, 2024 at 2:00 pm U.S. EDT

Traditional manufacturing processes are being disrupted by new technologies, incentives to onshore production, and carbon emissions reduction goals. Companies in the transportation industry are making big investments in production lines and plants when interest rates are high and competition for qualified staff is fierce. This 60-minute Webinar will focus on how an onsite utilities-as-a-service model can help companies better fund, design, and deploy the systems that heat, cool, and power manufacturing operations.

Speakers:

Maribel Adydan
Director, ENGIE North America

Wendell Wakeham
Business Development Senior Advisor, ENGIE North America

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UPCOMING WEBINARS

ACCELERATING THE SOFTWARE DEVELOPMENT LIFE CYCLE FOR THE SOFTWARE-DEFINED VEHICLES

Wednesday, May 29, 2024 at 11:00 am U.S. EDT

In the rapidly evolving landscape of automotive technology, the paradigm shift towards software-defined vehicles heralds a new era of innovation, connectivity, and efficiency. To keep up with these changes, customers need state-of-the-art development environments that enable them to create high-quality software in the shortest possible time while maintaining lower costs. This 60-minute Webinar will present the key aspects of creating and working on an electronic control unit integration project.

Speakers:

Robert Bitel
Expert Software Engineer, Elektrobit

Brandyn Ureel
Senior Software Engineer, Elektrobit

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APPLYING MODEL-BASED DESIGN TO SDV DEVELOPMENT: A PRACTICAL EXAMPLE

Thursday, May 30, 2024 at 10:00 am U.S. EDT

The shift towards software-defined vehicles is driving a significant change in how we design, build, and validate software. Model-Based Design (MBD) stands as a key strategy to navigate these software challenges, now enhanced to better align with DevOps methodologies. This 30-minute Webinar will explain how MBD can be integrated with DevOps and cloud technologies to enable continuous, scalable software releases and meet the evolving needs of modern automotive engineering.

Speaker:

Sameer Kariappa Muckatira
Senior Automotive Application Engineer, MathWorks

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Q&A

Kia takes aim at commercial vans with PBV concepts

Kia is positioning itself to make waves in the commercial vehicle sector. At CES 2024 in Las Vegas, the company pulled back the curtains on its electrified commercial van lineup. Though the designs are still at the concept stage, Kia has made it clear that it intends to enter the global commercial van space in short order.

SAE Media interviewed Tim Walker, director of fleet and remarketing, at **NTEA**'s Work Truck Week 2024 in Indianapolis to discuss some design details of the PV vans, Kia's overall strategy for entering the commercial vehicle sector, and the challenges of bringing the vans to market.

What is Kia's main goal in entering the commercial vehicle sector in North America?

The genesis for this idea was to move our fleet to zero carbon emissions by 2045. Obviously, that starts with the retail side, but at the same time our chairman changed the general edict of our corporate strategy to be more focused on mobility solutions. Mobility is not just selling a customer a car. It's about moving people and goods in a new and different way. E-commerce was also a big factor. There is a lot of desire to deliver products to customers and other entities by using electricity instead of fossil fuels. We're mainly focused on big fleets, but we're also looking to serve small businesses. We see a lot of need in the near future to move this direction, so we're introducing these concepts to indicate that we're coming to this space.

How many different models are currently planned?

The lineup that we are currently planning is four distinct models. The PV7 is the largest model in the family. The PV5 is our mid-level offering, and we will have three different versions including a chassis cab, a tall box and a rideshare vehicle that can carry up to five people. The smaller vans like the PV5 will have a 400-volt architecture, while the PV7 will have an 800-volt system. The 800V system will have a design similar to our EV6 and EV9. Both the PV5 and PV7 will have a single motor with a range of 50 to 70 kWh. The 70-kilowatt version will be what we use for North America because it gives us more range which better fits the U.S. driving style. The PV9 will have a 103-kWh motor for the U.S. market, which will provide a 209-mile (336-km) range. The bigger vans will have a payload of 2,866 lbs. (1,300 kg) and the smaller van will have 1,730 lbs. (785 kg).

What are some details about the driveline and packaging that you can share?

These vans are all front-wheel drive. The front module is similar to what we use in some of our other vehicles. There's a reduction gear motor and the power electronics sit on top of the battery. The powertrain itself is entirely housed in the front of the chassis, which is a unibody design. The batteries are centrally located between the wheels but biased towards the rear to open up space for various ergonomic options. On the cargo versions, there is an option to fold the passenger seat into the floor and the console will be a different configuration so that the driver can easily move from their seat into the cargo area.

Kia plans to launch the PBV lineup globally by 2026.

> **"Mobility is not just selling a customer a car. It's about moving people and goods in a new and different way."**
> **- Tim Walker, Kia's director of fleet and remarketing**

How modular is the basic platform?

One of the big ideas behind this platform is that it's all interchangeable. Our goal is to be able to switch out the 'life modules' between cargo, rideshare and other configurations. If you look at the cab portion which is from the door forward, the design is fixed at this point. From here back you can change the body to different configurations. We also announced at CES that customers will be able to purchase a kit and make body changes themselves. It's a tubular design and some of the panels are attached with mechanical fasteners and electromagnets. So, modularity is built in from the basic design. The front bumpers on these are three pieces. One of the most common places for vans like this to get hit is on the front. So, if you do happen to hit something, you can just replace one piece of the fascia and not the whole thing. The front charge point has also been moved out of the impact zone to avoid damage.

Do you have any details on production?

All of these vehicles will be produced at our plant in Hwaseong, South Korea. We have an additional plant that is dedicated just to producing these vehicles. Our total volume will be roughly 150,000 units annually. This is a global program, so we intend to sell these vans in markets all over the world. Our target time to market for the rideshare van is Q1 of 2026. The cadence after that is still to be determined.

Matt Wolfe

KIA