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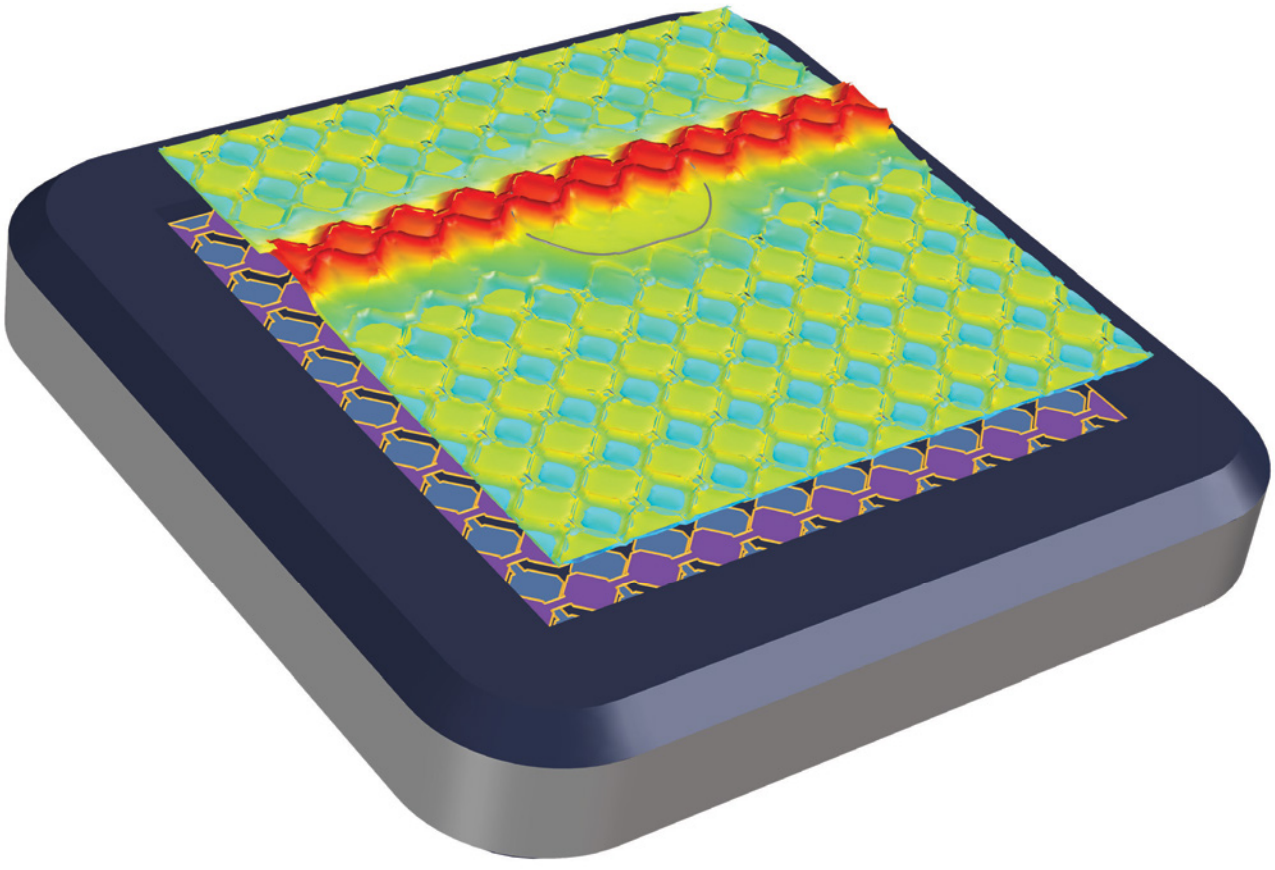

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FEATURES

ON THE COVER

Since its founding in 2010, Alta Motors has proved that electric motorcycles can be fully competitive, on the street and on the racetrack, with combustion-engined bikes. Electric motorcycles have some key advantages, as Senior Editor Paul Seredynski found after visiting the Brisbane, Calif.-based engineering team and riding their quick and quiet products, including the Redshift SM on the cover. Photo by John McInnis.

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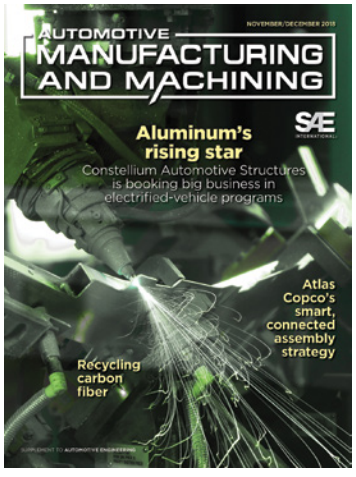

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Automotive Engineering®, November/December 2018, Volume 5, Number 10. *Automotive Engineering* (ISSN 2331-7639) is published in January, February, March, April, May, June, September, October, and with combined issues July/August and November/December by Tech Briefs Media Group, an SAE International Company ®, 261 Fifth Avenue, Suite 1901, New York, NY 10016 and printed in Mechanicsburg, PA.

Annual print subscription for SAE members: first subscription, $15 included in dues; additional single copies, $30 each North America, $35 each overseas. Prices for nonmember subscriptions are $115 North America, $175 overseas. Periodicals postage paid at New York, and additional mailing offices. POSTMASTER: Please send address changes to *Automotive Engineering*, P. O. Box 47857, Plymouth, MN 55447. SAE International is not responsible for the accuracy of information in the editorial, articles, and advertising sections of this publication. Readers should independently evaluate the accuracy of any statement in the editorial, articles, and advertising sections of this publication that are important to him/her and rely on his/her independent evaluation. For permission to reproduce or use content in other media, contact copyright@sae.org. To purchase reprints, contact advertising@sae.org. Claims for missing issues of the magazine must be submitted within a six-month time frame of the claimed issue's publication date. The *Automotive Engineering* title is registered in the U.S. Patent and Trademark Office. Full issues and feature articles are included in the SAE Digital Library. For additional information, free demos are available at www.saedigitallibrary.org.
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EDITORIAL

Electrify the U.S. Postal fleet!

They're hot in the summer and cold in the winter, their drivers complain. Their sub-10-mpg fuel efficiency and emissions profile are stuck in the 1980s. Onboard fires are not uncommon due to poorly routed fluid lines. With rear-drive only, their traction in slippery road conditions is "scary," according to **U.S. Postal Service** carriers who brave rain, snow and gloom of night in the Long Life Vehicle—the familiar residential mail truck that is finally nearing replacement.

The obsolete and "scary" LLV. My neighborhood's mail carrier quips that her truck "is so ugly, dogs run away when they see me coming up the street." The USPS should lead with new EVs.

It's hard to believe that some 140,000 of these rolling boxes, based on 2wd Chevy S-10 chassis and gasoline engines, were assembled by **Grumman**, maker of sleek F-14 Tomcat jet fighters. But the cheap-and-crude LLV was the USPS's baby. Launched in 1986 for a 24-year lifecycle, it was given a six-year service extension in 2009. Then six years later the USPS kicked off its Next Generation Delivery Vehicles (NGDV) program to finally develop a mail truck for the 21st century.

The multi-year contract to deliver up to 180,000 new-gen mail trucks is reportedly worth more than $6 billion.

In 2016, the Postal Service awarded prototype development contracts to six OEMs: **AM General**, **Karsan**, **Mahindra**, **Oshkosh**, **Utilimaster**, and **VT Hackney**. AM General and Oshkosh, of course, are well-versed in the gov-spec space and the latter is collaborating with **Ford** for this program. Turkey-based Karsan is partnering with **Morgan Olsen** in Michigan in the competition. Singapore-affiliated VT Hackney is working with electric van newcomer **Workhorse Group**. The program calls for half the prototypes to be hybrid and alt-fuel vehicles. May the best solution win.

Testing under real-world duty cycles has been ongoing for the past year. Suppliers in the running tell me they'd expected the production contract to be awarded last month. That the officially independent USPS is running late here is not surprising, given Washington politics.

The new mail trucks will be ergonomically improved. They'll also feature active and passive safety systems and telematics for precise delivery tracking. They'll even have heat and A/C! A portion of the fleet is expected to have 4wd for snowbelt operations. All good. But the Postal Service's failure to mandate battery-electric propulsion for the *entire* residential-delivery fleet is a strategic and tactical mistake.

EV mail service nationwide is a huge mobility-leadership opportunity for the U.S. Residential mail delivery is the ideal duty cycle for a battery-electric cargo van that runs the same route daily and returns to a terminal for overnight charging. For the USPS it's a no-brainer. The technology is now sufficiently robust for widespread fleet use.

What better way to promote the reliable, durable, quiet, clean, and low-cost operation of EVs than to have them serving us daily in our neighborhoods?

Note to USPS: Skip hybrids, except for the most remote rural routes. It's time to bring home the mail, electrically.

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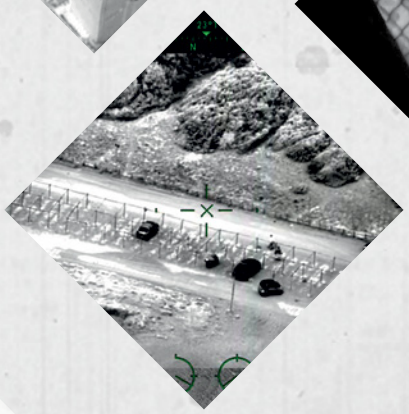

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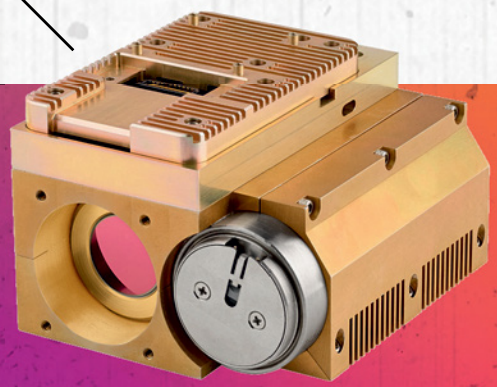

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SAE STANDARDS NEWS

SAE publishes first global standard on shared mobility

As the way people travel is transforming due to demographic shifts, technical advances and environmental concerns, the shared-mobility industry has been challenged with discrepancies in use and definition of terms.

SAE International recognized that the industry was starting to become frustrated by the lack of consensus on shared-mobility terms and definitions—there was immediate need for a standard and the SAE International Shared and Digital Mobility Committee began work on SAE J3163, "Taxonomy and Definitions for Terms Related to Shared Mobility and Enabling Technologies" in December 2017.

Annie Chang, Project Manager for Emerging Mobility, SAE's Global Ground Vehicle Standards, explained: "The problem with the shared-mobility taxonomy is not that terms and definitions don't exist; it's just that there are too many of them," she told *Automotive Engineering*. "So, we tried to fix that issue. It was not a matter of coming up with a new term, but agreeing to a set of terms and definitions. The SAE Shared and Digital Mobility Committee is trying to agree on which terms and definitions make sense and how the Committee Members want to tweak them so they agree completely."

The group quickly grew to more than 100 experts representing the spectrum of the shared-mobility industry. Its roster reflected a different mix than that which SAE is typically accustomed to seeing on a committee.

"You have urban planners and transportation planners and engineers, people from the business side and even people from the law side all looking at shared mobility," Chang observed.

A panel consisting of a dozen global experts delivered the draft of J3163 to the full committee, which then provided feedback on the draft. This process took place a few times until the committee was ready to ballot.

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With J3163, SAE will serve the needs of a multitude of stakeholders within the new mobility ecosystem.

In September 2018, after just a 10-month process, SAE published J3163, the first globally-developed shared-mobility standard. It defines shared mobility as the shared use of a vehicle, motorcycle, scooter, bicycle or other travel mode, to provide users with short-term access to a transportation mode on an as-needed basis.

J3163 organizes taxonomy into six categories:

- Travel modes (e.g. carsharing and bikesharing)
- Mobility applications (e.g. mobility tracker apps)
- Service models (e.g. peer-to-peer service model)
- Operational models (e.g. station-based roundtrip)
- Business models (e.g. business-to-business roundtrip)
- Deprecated terms (e.g. ridesharing)

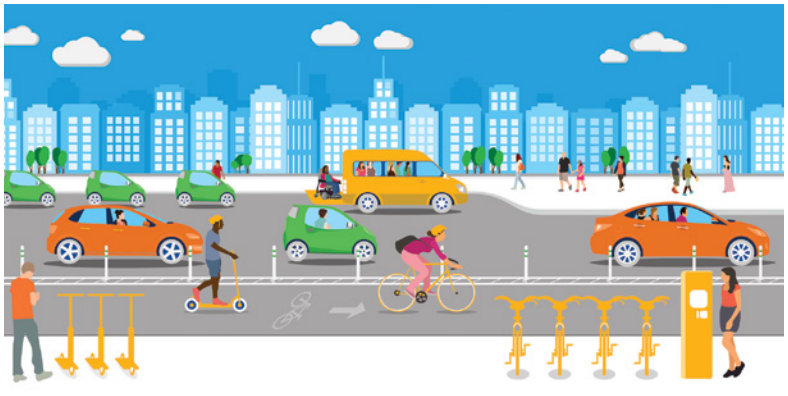
Chang detailed various uses for J3163. The taxonomy presents the much-needed shared-mobility nomenclature that may be used by various stakeholders, including regulators, legislators, insurance/underwriting organizations, media, academia, and consumers. It may be used by shared mobility providers and consumers to set consistent expectations of shared mobility services and technologies; J3163 may also be useful during procurement processes, where references to it may help identify and clarify the desired products or services to be procured and offered.

Standardized nomenclature also facilitates cross-sector collaboration, such as public-private partnerships between transit agencies and shared-mobility providers. Finally, J3163 may be incorporated by reference in policies and regulation for clarity of terms used.

"It was really our initial step to open that door to standardization in shared mobility," Chang said. "A natural next step may include symbols on shared-travel modes now that we have the taxonomy." She added that standardizing shared-mobility data formats is something the committee might also soon tackle.

For more information on SAE's shared mobility portfolio, please visit www.sae.org/shared-mobility. ■

Some information in this article was sourced from the white paper www.sae.org/publications/technical-papers/content/wp-0010/ written by Dr. Susan Shaheen, Adam Cohen and Annie Chang.



The new SAE Shared Mobility illustration.

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SUPPLIER EYE

Moving the goalposts of emission compliance

This industry has worked hard to reduce or at least control several critical risks. The effort has been key for all constituents, impacting strategic direction, the allocation of valuable human and financial capital, and enterprise profitability.

Risk reduction takes many forms. It ranges from aligning fluctuating commodities to an economic/commodity index, and aligning with labor constituents on long-term contracts. It even includes reducing currency risk through co-locating sourcing of a component or system to the same region in which it's sold. Such risk elements, among many, are quantifiable and thus can be controlled and minimized.

Unfortunately, there are several risks which cannot be controlled or even predicted. Case in point is the current Notice of Proposed Rulemaking (NPRM) that's in process (as I write this in mid-October) by the U.S. federal government with respect to light-vehicle emissions. The NPRM is a veritable known-unknown situation. While I am not here to argue for tougher or more lenient regulations—you can choose your side on that subject—what is critical is how OEMs, suppliers and others in the auto ecosphere will react to and accommodate any changes in the current standards set out by the U.S. **EPA** and **NHTSA**.

As football field-goal kickers like to say, "If you are going to move the goalposts, let us know before we snap the ball."

There are nine total options to the NPRM outlined in late August. These range from status quo (maintaining the current standards through 2025) to flattening the standards as of the 2020 model year. The latter is the preferred option as laid out by Washington.

Two major issues arise with the proposed direction for the mid-term review. First, every vehicle OEM active in this market should be designing vehicles and modifying their powertrain mix to comply with the standards on the books, as these are known and part of the current regulatory framework. If the standards do change towards the preferred U.S. option for 2020, there is little OEMs can do other than to modify their powertrain and content mix over the short-term. That cake is already baked.

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OEMs don't want a two-tiered emission-compliance structure because it adds cost, reduces scale and limits their ability to sell vehicles.

The window for truly accommodating any changes in standards from an engineering/design perspective opens at the 3-year point after a final standard is approved and implemented. Again, known versus unknown equals risk.

The second issue with the NPRM is potentially more serious. It has been well publicized that California and the 12 so-called "Section 177" states are not onboard with freezing the standards starting in 2020. They advocate for maintaining the current agreed-upon standards. OEMs don't want a two-tiered emission-compliance structure, either, because it adds cost, reduces scale and limits the ability to sell vehicles between differing compliance markets. The plot thickens.

There is a global twist as well. The current U.S. standards are close in trajectory to those in force in China and Europe. While there are differences in implementation and incentives/stipulations with respect to electrification, the direction is common. Should the U.S. diverge from the current path through 2025, differences in compliance paths between the U.S. and other regions will widen.

Views on the impact of a divergence with China and Europe are varied. In terms of sales and production, both of those regions are larger than North America; we (North America) are the third horse in a three-horse race. We may increasingly become "compliance isolated"—a situation that could impact scale economies and the location of future powertrain/propulsion research hubs as well.

In the end, keeping all constituents happy—legislators, select U.S. states, OEMs, suppliers, consumers and global emissions regulators—is nearly impossible. And uncertainty raises the risk factor.

Placing definitive bets on any one compliance technology is a careful process of balancing several considerations, including cost, consumer acceptance, competitive considerations, and capital. Knowing the future location of the goal posts is the most important consideration. ■

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THE NAVIGATOR

Engineering AVs to 'play nice' with humans

More than a decade after the DARPA Grand Challenge program demonstrated the technical viability of self-driving vehicles, the industry is now preparing its first commercial deployments of the technology at scale. While **Waymo**, **GM Cruise**, **Aptiv** and others begin to ramp-up automated ride-hailing services for paying passengers, unanswered questions remain. Many of them revolve around the "social" aspects of the technology.

Engineering is about taking the principles learned from science and applying them to solving real-world problems. But if the resulting technology requires people to change their behavior for it to work reliably, the engineers are doing it wrong.

The reality of automated driving is that it's going to take many years, decades even, to largely supplant human driving. Even if AVs do take over, these vehicles are going to have to safely coexist with humans on foot, on bicycles or on scooters. If AVs can't play nice with other road users, engineers developing them need to slow down and rethink their approach until the vehicles function properly within the overall mobility ecosystem.

This is where things get complicated. The realities of physics and of human behavior dictate that humans walking or riding a two-wheeler can change direction or intent far more rapidly than another vehicle can. And while AVs can easily communicate with each other via V2V to indicate their intent, machines communicating with humans is much more problematic.

Researchers such as John Shutko at **Ford** and Melissa Cefkin at **Nissan** have been studying how humans and AVs will interact. In 2017, Shutko's team famously ran an experiment with the **Virginia Tech Transportation Institute** using a Transit Connect van equipped with a series of lights. The driver of the van wore a so-called "seat-suit" that made it look as though there was no driver in the vehicle so that the researchers could observe the responses of pedestrians to various signals.

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It's time to develop standard approaches to signaling AV intent and to set policy for micro-mobility services.

Similarly, Cefkin and her team at Nissan have been studying the non-verbal signals given off by humans as they interact in crowded spaces, to understand if similar subtle movements by AVs could be utilized to signal their intent. Other companies, including **Toyota** and **Drive.AI**, have been testing a variety of signage to provide indications from AVs to pedestrians.

All these efforts, however, will only be successful if everyone derives the same meaning from a given signal. More than a century of motorized personal transportation has made us understand what turn signals or brake lights mean when we see them. These non-verbal messages are used globally on road vehicles and are language-agnostic. That's important in a market like India, whose 22 major languages and many more separate dialects make any text-based approach seem unlikely.

At the recent WardsAuto UX conference in Detroit, Shutko called for the industry to come together to develop standard approaches to signaling AV operational intent. Based on the lessons learned from the 2017 experiment, the **Argo AI** test fleet operating in Pittsburgh, Miami and Dearborn, Mich. already has been equipped with lights to signal yield, active driving and start to go. Those involved in AV-experience design should be reaching out to Shutko to get involved in this effort.

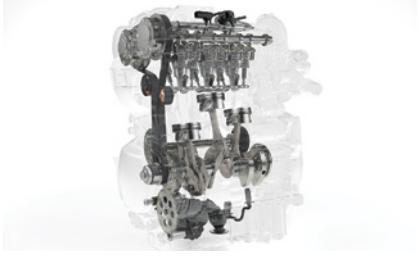
With the explosion of micro-mobility services in 2018, including e-scooters and dockless bike sharing, it's also time for cities to set policy around these vehicles to facilitate safe integration with AVs and pedestrians in the coming years. Consistency in this area is important.

Protected bike lanes that can be used by scooters, getting them off the sidewalks, will improve safety for all. At the same time, the addition of a physical barrier would help to keep AVs a bit more isolated from non-automotive road users. None of this comes free, of course. ■

Volvo XC40 3-cylinder

Can any vehicle with a three-cylinder engine really regard itself as "premium?"

Volvo thinks so. The company recently handed over the keys to its "compact premium SUV" XC40—now offered in some markets, including Europe, with a turbocharged 115-kW (154-hp) triple-cylinder variant of its in-house-designed modular "Drive-E" 4-cylinder engine.



The 3-cyl. drives the XC40's front wheels through a pleasant-to-shift 6-speed manual gearbox; an automatic—also 6-speed—is coming soon. The all-aluminum engine is slated for use in other models (not the two-ton XC90, though!) that include hybrids and will play a part in the company's plan to have all models offering electrified drivetrains by next year.

Designated T3, the triple delivers 265 N·m (195 lb·ft) from an impressively low 1850-3850 rpm. Combined fuel economy maxes out at 6.19 l/100 km (approximately 34 mpg) and CO2 output is 144g/km. The 9.4-s 0-100 km/h (0-62 mph) time and top speed of 200 km/h (124 mph) look pretty good for such a small engine in a compact crossover that weighs a minimum of 1497 kg (3300 lb).

First road impressions are excellent. At idle, the engine is near inaudible and the initial few hundred meters immediately show verve. Called on to supply power at 3000 rpm-plus, the not-unpleasant sound of a triple at work is more pronounced.

So, back to the question: can a car be described as "premium" when powered by a 3-cyl. engine? The answer is potentially yes—but for the XC40, probably with the double caveat of having just two pedals and specific gear-ratio subtlety. We'll have to wait and see.

Stuart Birch

2018 Hyundai Kona Ultimate AWD

I've been generally ambivalent about subcompact crossovers such as the **Honda** HR-V, **Ford** EcoSport and **Mazda** CX-3. They're typically cramped and underpowered, leaving you feeling outgunned on the open road and urban freeways, yet there's scant payoff for those deficits at the gas pump, as most of them go to market with surprisingly piddly fuel-economy ratings.

Hyundai's Kona is one of the newest subcompact CUVs and while it's still no overachiever on the EPA rollers (26 mpg city/29 mpg highway), the upper trim levels such as the Ultimate AWD come gunning with the firecracker engine of Hyundai's small-car lineup, the turbocharged, direct-injected Gamma 1.6-L 4-cyl. that spits out an eager 175 hp and 195 lb·ft (264 N·m). The turbocharged Gamma sanguinely propels the top-level Kona's plumpish 3334 lb (1512 kg) in the cut-and-thrust of fast traffic and whips up satisfactory back-road passing muscle, abetted by a 7-speed dual-clutch automated manual transmission that's happy to keep it all simmering and snapping. Provided you press the "sport" button, at least.

I enjoyed the dynamic attributes of this crossover and reckon it would be a clever little foul-weather weapon, but I'm not sure I see "ultimate" value in nearly $30,000 for the Kona Ultimate AWD—even if this top-trim model is crammed with upscale features and ADAS electronics. The thirty-grand price point is where mass-market goodness reigns with the roomier **Toyota** RAV-4, Honda CR-V and even Hyundai's own Tucson and Santa Fe, although those mid-trim models wouldn't be as comprehensively-equipped as the Kona Ultimate.

Bill Visnic

2018 Toyota Prius Four Touring

Toyota's seminal Prius and its twin-motor hybrid-electric drivetrain is largely unchanged this year except for the addition of an 11.6-in (295-mm) touchscreen display for the top Prius Four and Four Touring trims. The monster screen is oriented vertically in tablet-style layout that essentially replicates the gee-whiz effect of Tesla's signature interior focal point. The Prius' screen is a outsized, high-definition indicator of where dashboard design is heading and it's quickly going to become a common sight, I think, in many all-new vehicles—and as a go-to lever to pull in mid-cycle refreshes.

The big screen is a show-stopper for uninitiated passengers and once you are accustomed with the options for portioning its acreage, it's a definite aid in helping to keep eyes on the road. Its vertical orientation doesn't do much for the rearview-camera image, though, which ends up being crunched into the bottom third of the screen.

The Prius remains the case study for why every vehicle needs to have some kind of braking-energy recuperation. In a week almost exclusively dedicated to urban errands and running about—all in the Prius Four's "power" mode—the thing used an eighth of a tank of gasoline, a penny-pinching testimony to its 54-mpg city rating. Even the expected drone from the continuously variable transmission (CVT) is muffled nearly to the point of inaudibility. The only thing I wished for with the drivetrain was a user-selectable option to amp up the regenerative-braking force, a feature common on many battery-electric vehicles.

Bill Visnic

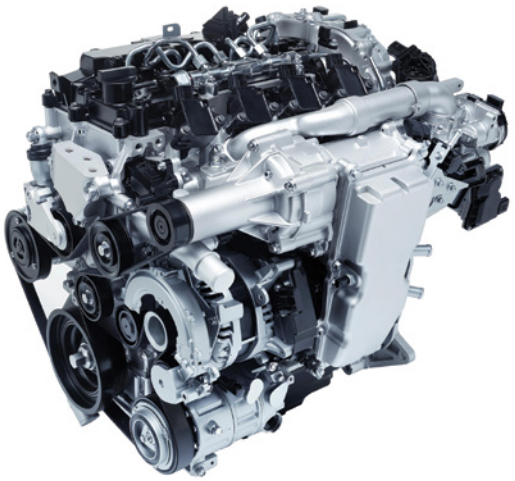
FROM LEFT: VOLVO; BILL VISNIC; TOYOTA

PROPULSION

Mazda details electrification strategy, confirms rotary engine's return

The RX-8 was the last Mazda production vehicle to use a rotary engine.

In an announcement from Japan in October, **Mazda**—one of the few established automakers to articulate a comprehensive longterm commitment to hybridization or all-electric vehicle propulsion—said it intends to incorporate some type of electrification in all its vehicles by 2030. Yet in nearly the same virtual breath, the company affirmed its connection to "soulful" forms of internal combustion, including a confirmation that it will renew its longstanding enthusiasm for the rotary engine.



The Skyactiv-X, billed as the world's first production engine to employ gasoline compression-ignition combustion, is seen by many as symbolic of Mazda's commitment to continuing development of internal-combustion power.

In a carefully-worded statement, Mazda reminded that many credible forecasts call for internal combustion to remain the dominant light-vehicle propulsion source for perhaps decades to come, while discretely laying out its plan for electrification—when and where it makes sense for the environment.

"Mazda will strive to reduce carbon dioxide emissions and enhance the joy of driving by deploying compact, lightweight electrification technologies while further refining the internal combustion engine, which is forecast to be equipped in the majority of new cars for many years to come," the statement said.

"The company will introduce electric vehicles as the optimal solution in regions that generate a high ratio of electricity from clean energy sources or restrict certain vehicle types to reduce air pollution," Mazda stated.

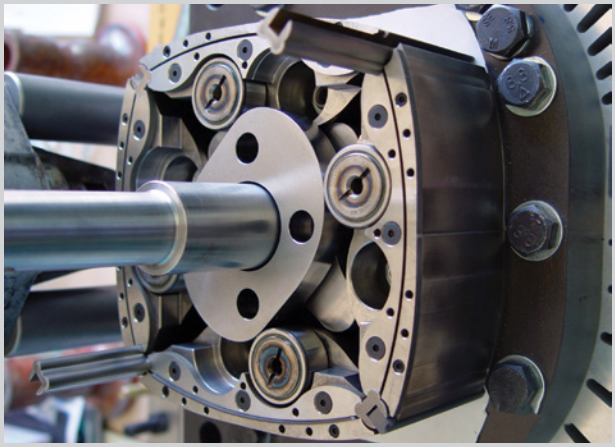
Rotary's new role

Mazda, for decades the auto industry's stalwart—and only—promoter of the smooth and power-dense rotary (Wankel) engine, reignited enthusiast passion with its announcement that it will revive the engine that's so inextricably connected with the brand, even if it will be in the muted role of range-extender for plug-in hybrid-electric (PHEV) vehicles.

Various company executives had hinted in recent years Mazda had not given up on rotary-engine development and even specifically

BOTH IMAGES: MAZDA

New four-chamber rotary engine proposed unique rhombus rotor



Melbourne-based Rotary Engine Development Agency (REDA) has developed a four-stroke rotary engine with a rhombus-shaped rotor.

The Wankel rotary engine has earned a reputation as an ideal choice for many owners and operators of small, propeller-driven aircraft. Compared to conventional piston engines, Wankel rotaries are small and lightweight with a high power-to-weight ratio.

At this point, it's difficult to improve on the Wankel design. Unless one is considering changing the shape of the rotor—into a changing shape.

A new configuration of a rotary engine—the Szorenyi rotary—has been developed by the Melbourne-based **Rotary Engine Development Agency** (REDA). While the stator, or stationary part of the Szorenyi engine is similar to that of a Wankel engine, the geometric shape of the engine rotor is a rhombus, which deforms as it rotates inside the contour of the stator.

This geometry translates to a rotary engine with four combustion chambers as opposed to a traditional Wankel rotary's three. Each revolution of the crankshaft equates to one revolution of the rotor and a complete engine cycle in each of the chambers—resulting in four power strokes per crankshaft revolution.

According to REDA, each four-stroke Szorenyi rotary module is equivalent to an eight-cylinder reciprocating engine.

The Szorenyi engine is also better suited for multi-rotor configuration than a Wankel rotary due to the use of peripheral ports when compared to the Wankel engine's use of complex side ports, REDA claimed.

Higher potential rpm limits mean the Szorenyi engine has a higher power density than the Wankel engine, which could translate into greater aircraft range, endurance and payload capacity. REDA also noted that if a pre-compression phase was introduced, the engine could use diesel fuel—aligning with the U.S. military "one fuel" concept and making the engine a potential consideration for military applications.

Full details concerning the design and testing of REDA's new engine, are available in **SAE** Technical Paper, "The Development of the Szorenyi Four-Chamber Rotary Engine." According to the paper, the Szorenyi engine could run on gasoline, avgas, butane or hydrogen, as the inlet and exhaust ports are well-separated.

William Kucinski

REDA

mentioned its suitability as a range-extender.

The rotary-powered range extender—a concept also demonstrated recently by **FEV** in Europe—aims to leverage the engine's compact size and high power output "to make multiple electrification technology solutions possible via a shared packaging layout," the company affirmed.

The rotary engine's compatibility with gaseous fuels enables it to burn liquefied petroleum gas "and provide a source of electricity in emergencies," the Mazda release added.

Conceding the inevitable?

Mazda has maintained its dedication to the connectivity between vehicle and driver that comes from internal-combustion (IC) engines, advancing high-tech IC innovations such as its recently-launched SpCCI gasoline-engine that blends the attributes of spark- and compression-ignition engines (https://www.sae.org/news/2017/09/ice-breaker), although the engine's availability in the U.S. market has yet to be detailed.

The company also promoted its intent to further develop the diesel engine, from both environmental and enthusiast perspectives. The company said nearly two years ago it would introduce its newest diesel 4-cylinder for the CX-5 compact crossover in the U.S.—and although the official fuel-economy rating for the diesel-equipped 2018 CX-5 recently appeared at the **U.S. Dept. of Energy**'s fuel-economy website (www.fueleconomy.gov), the figures were mediocre. Moreover, Mazda has yet to indicate in either its press or consumer materials that the diesel engine is available.

With the current announcement regarding electrification, Mazda seems to be yielding to market and other pressures to increase its focus on electrified powertrains.

In addition to its intent to have all production vehicles using some form of electrification by 2030, the company also said that about 5% of vehicles produced will be fully electric. That means two distinct battery-electric models, the company added, with one of them being the electric-drive model employing the rotary engine to recharge its battery pack when the initial charge (from a plug-in source) is depleted.

In 2013, Mazda showed a Mazda2-based concept car that featured an electric drivetrain using a 0.33-L single-rotor engine as a range extender. The Mazda2 RE Range Extender concept's rotary was claimed to provide an additional 100 miles-plus of range from a small gas tank.

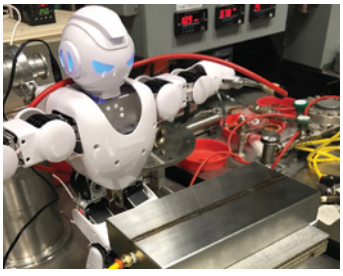
Bill Visnic

ELECTRIFICATION

Detecting battery leaks at production speeds

Inficon has launched what it said is an industry-first, robotic-compatible leak-detection system that can use either helium or hydrogen-forming gas to ferret out minuscule cracks in the batteries of electrified vehicles.

"Customers were asking for an accurate and reliable high-speed leak detector that could use both tracer gases so they could choose the lowest-cost or easiest-to-source test gas available," said Thomas Parker, a mechanical engineer and Inficon's North American automotive sales manager. The leak detector has the same testing sensitivity with either helium or the forming gas (95% nitrogen/5% hydrogen).



This robot quickly and efficiently detects leaks in a lithium-ion battery.

The XL3000flex can detect small leaks up to 20 times faster than conventional systems, the company claims. Inficon's testing unit uses sample gas flows of 300 or 3000 sccm (standard cubic centimeters per minute) vs. the typical sample gas flows of 60 to 150 sccm with existing leak detectors.

"A 60 to 150 sccm detection rate is much too slow to meet typical production cycle times, but a selectable 300 or 3000 sccm is ideal for robotic applications that need a high sample-gas flow for reliable testing, " said Parker. With a gas flow of 3000 sccm, Inficon's system can detect leaks of 10 -3 mbar per liter a second at a distance of 6 mm (0.23-in) during scan speeds of 10 cm (3.93-in) per second, according to Parker. The XL3000flex is a self-contained unit employing a magnetic sector mass spectrometer and patented software algorithms.

One alternative to tracer gas testing is a method in which parts are pressurized and fluctuations in pressure indicate a possible leak. "The problem with today's pressure decay testing is that pressure changes can also be caused by temperature changes. So a pressure drop does not always indicate a leak, and a pressure increase can mask a leak," noted Sandra Seitz, global market manager for Inficon's automotive leak detection tools.

Current production applications of XL3000flex include testing on fully assembled battery packs as well as leak detections on automatic transmissions and high-pressure GDI fuel systems.

Kami Buchholz

INFICON

CHASSIS

Nexteer readies steering technologies for autonomous and mixed-mode driving

Steering-technology engineers continue to consider different solutions to the issue of whether a driver will be prepared to instantly take control from an autonomously-driven vehicle—and in a nod to driver's-training school, drivers assuming steering control from an **SAE** Level 3-5 autonomously driven vehicle might need to pass a hands-on test before the handover.

"We want a safe transition and a driver 'training session' might be a potential way to pre-address that transition," Patrik Ryne, **Nexteer**'s manager for steer-by-wire, said in an *Automotive Engineering* interview.

That training session might unfold with the driver performing various steering tasks such as turning the wheel 90 degrees to the right, then 90 degrees to the left—all while the vehicle is still in the automated-driving mode.

"These steering wheel movements will not affect the road wheels at all," Ryne said, underscoring the de-coupling that's possible with a steer-by-wire system. "It's just a training exercise to prepare and confirm that the driver is ready for the transition."

A Ford Edge retrofitted with Nexteer's Steer by Wire technology. Both the development/demo Edge and VW Golf (in background) vehicles are shown on the company's Saginaw, Michigan test track.

Close attention to human factors

Human-factors studies vary on the predicted time a driver needs to competently take control from an autonomously-driven vehicle. However, industry experts agree that it's imperative the driver's attention is focused on driving tasks before the handover. In-vehicle sensors and cameras for monitoring the driver's head and eye movements—as well as vehicle CAN bus messages to confirm a foot is on the accelerator pedal—already are part of the human-factors solution package, Nexteer said.

"An automated driving system will keep doing what it's doing until there is a handover to the driver. We just want that handover to be a safe and intuitive transition," Ryne stressed. The actual handover could be handled via Nexteer's Steering on Demand, an in-development system that transitions steering control between manual and automated driving.

Nexteer's steer-by-wire system is the key technology enabler to Steering on Demand, as well as the company's Quiet Wheel Steering (QWS), and Stowable Steering Column innovations.

By-wire technology foundation

Nexteer's steer-by-wire system features variable steering ratios and performance settings, according to Michael Hales, the engineering lead for steer-by-wire development.

"Our goal with this technology is to give the driver an emulated feel of the road after the transition from automated to manual driving. That's really important," Hales said, "as most drivers don't realize how many cues they take from how the steering 'feels' on different surfaces, such as the feel of a dry road versus an icy road."

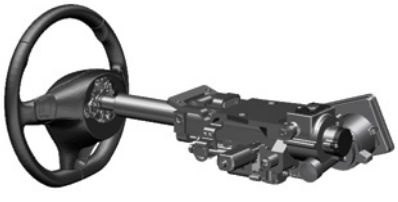
A Nexteer development/demonstration vehicle—retrofitted with steer-by-wire technology to replace an electric power steering system—is being used by engineers in Saginaw, Michigan to develop an evasive-emergency maneuver system. "We want the system to provide an extra steering nudge to the driver's main steering input if that's needed for obstacle avoidance," Hales said.

The trio of Steering on Demand, QWS and Stowable Steering Column technologies are designed to work in unison for a driver handover. QWS holds the steering wheel still via a proportional-integral-derivative (PID) control loop in the steering-column controller that ignores the torque command from the steering gear while the steering column is in its potential retracted position.

"As the driver starts steering the vehicle, the system will verify the driver's intent," said Ryne, noting that intent-confirmation will likely include camera, CAN bus message and algorithms that detect hands on the steering wheel among other inputs. "All of these sensor signals are fused together for an intent decision. If the intent is correct, the steering will be handed over the driver."

Nexteer currently has 12 advanced steering development programs with OEM partners. Those programs are applicable to SAE Level 3-5 automated driving.

Kami Buchholz



Nexteer's Steer by Wire will be vital technology for high-level vehicle automation.

BOTH IMAGES: NEXTEER

Nissan's all-new Altima gets variable-compression engine, AWD

The 2019 Altima works from a revised version of Nissan's D platform and for the first time offers the option of all-wheel drive.

The Altima sedan is an important product for **Nissan**, what it calls its "brand ambassador." Long a solid choice in the mid-size sedan segment, its typically conservative sheetmetal over the nameplate's five generations has set benchmarks for inoffensive design. For MY2019, Nissan has moved the all-new sixth-generation Altima onto an updated, autonomous-capable global platform and is providing two new powertrains, its first all-wheel-drive system for a sedan in this market and styling that is clean, handsome and sharp.

Nissan obviously has invested heavily in its new sedan and as a package, the latest Altima looks and drives the business. Pricing and content also appear set to compete with long-time and recently refreshed competitors including the **Honda** Accord and **Toyota** Camry. All good, save the almost startingly recent industry-wide decline in U.S. sedan sales.

Global-D platform protected for AV driving

The 2019 Nissan Altima rides on an updated version of Nissan's global-D platform, with a longer wheelbase (+1.9 in) and lower/longer/wider (-1.1/+1.0/+0.9 in) sheetmetal. When compared to the previous iteration, body-in-white mass drops 42 lb (19 kg) but stiffness has increased, mostly through the additional use of high-strength steels. The platform warranted so many modifications, Chris Reed, vice president of platform and technology engineering at Nissan's North American technical center in Farmington Hills, Michigan, said Nissan probably should re-label it "D-Prime," with many of the mods aimed at future technologies—including autonomous features.

"It's a commitment, a platform that will last going forward," Reed explains. One example is in the new rack-mounted electric power steering (EPS), "which will need exceptional precision for future autonomous applications. You can't just adapt it to a current model, as it's a packaging issue. It's tens of millions of dollars to make a change as we have to re-certify, so you take advantage of that.

"You're trying to give the customer lots of new features but not change the weight class, so this went back to the basics. You look at all the openings where you have deformation. A lot more 1.2-gigapascal steel. How do you mount the engine? How do you reduce friction? We looked at road inputs and actually changed the kingpin angles in order to change the on-center feel."

Available in the U.S. on all trims with the standard naturally aspirated 2.5-L 4-cylinder powertrain (and standard in Canada) is a new all-wheel-drive (AWD) system—another market first for the traditionally FWD Altima. "That's really feedback from the customer and dealers," Reed explained, "and the system itself is very similar to what we've developed for the Murano." The on-demand AWD setup can vary front/rear torque percentages from 100/0 to 50/50, but tops out at 70/30 under normal dry-road conditions, and uses a brake-based system to vector left/right torque.

VC-T engine goes mainstream

Powering the new Altima chassis are two new engines: a heavily revised standard 2.5-L 4-cylinder and the new 2.0-L 4-cylinder with a variable compression-ratio turbo (VC-T) system, which replaces the previous 3.5-L V6. The standard direct-injected engine sees more than 80% new content (including plasma-coated cylinders replacing iron liners), with a concerted focus on friction and NVH reductions.

The revised 2.5-L unit is assembled in Decherd, Tennessee, and features a new composite intake that inserts directly into the cylinder head via insulated ports. An integrated exhaust manifold faces rearward, as the engine has been flopped 180 degrees in the bay to help lower the cowl. A variable-displacement oil pump and cooled external EGR are aimed at efficiency/emission improvements. Power is up 9 hp to 188 hp (140 kW), while torque jumps 3 lb·ft to 180 (244 N·m), along with a 1 mpg-gain across the EPA cycle.

Automotive Engineering has previously detailed Nissan's innovative new VC-T system (https://www.sae.org/news/2018/05/2019-infiniti-qx-50-w-vc-turbo-review) that debuted in the Infiniti QX50. The VC-T setup on the Yokohama-assembled KR20DDET can alter the compression ratio anywhere from 8:1 to 14:1 with maximum boost of 23 psi (1.6 bar).

The 2019 Altima is the second application of Nissan's innovative variable compression ratio turbocharged (VC-T) 2.0-L 4-cylinder engine, after it debuted in the Infiniti QX50.

BOTH IMAGES: NISSAN

The all-new interior on the 2019 Nissan Altima features a lower cowl, and a brighter, more spacious feel.

For its second application in the new Altima, it receives a unique calibration to complement new intake plumbing. So installed, the port- and direct-injected 2.0L VC-T produces 248 hp (185 kW) and 280 lb·ft (380 N·m) at 1,600 rpm on premium fuel, which is not required (likely a crucial distinction for Nissan customers). On regular fuel, Nissan claims a 15% fuel-economy improvement compared to the outgoing V6.

Both engines are paired with **JATCO**-supplied Xtronic CVT transmissions, which maintain their ratio spreads (2.5L - 6.96:1; 2.0L - 6.3:1) but get new tuning to accommodate the new engines' torque characteristics, with a new, tighter torque converter designed for a swifter and more linear engagement feel. The CVT will automatically move to a "stepped" ratio map somewhere around the 50% throttle mark to provide the perception of swifter acceleration, and paddle shifters to access eight specific ratios are available on the SR trim.

Additional standard safety and tech

A new, more responsive infotainment system features a standard 8-inch display, and **Apple** CarPlay and **Android** Auto are standard on all Altima trims. Nissan is also expanding its Safety Shield 360/ProPilot Assist (safety/adaptive driving) suite, and this includes all-speed adaptive cruise with lane-centering tech, and a new rear-automatic-braking feature.

The full safety suite is standard equipment on SV trims and above, and includes high-beam assist, automatic emergency braking with pedestrian detection, forward collision warning, and lane-departure/blind-spot/rear-cross-traffic alerts. A new Traffic Sign Recognition system can provide drivers with the most recent speed-limit information.

The 2019 Nissan Altima went on sale this fall and will be assembled at Nissan's Smyrna, Tennessee and Canton, Mississippi plants.

Paul Seredynski

NISSAN

Lexus soups-up seventh-generation ES sedan

Sedans and any configuration of a "car" might be a tough sell at the moment, but **Toyota**'s Lexus division certainly wasn't going to let that stop it from launching a new, seventh generation of the ES midsize sedan, which by a large margin just happens to be the brand's best-selling car (51,398 last year in a shrinking U.S. market for sedan bodystyles). The ES typically accounts for nearly half of Lexus' total car sales.

Considering that kind of sales critical mass, it's tough to say the ES has been injured by its reputation as being the softer "cruiser" of the Lexus car lineup, but the company seems to continually strive to inject more sporting character into the midsize sedan. Such is the case with the new 2019 ES—there are two variants, the ES350 with a 3.5-L V6 and the ES300h hybrid that went on sale in the U.S. in September—although refinement and isolation remain at the expected high levels.

New platform, more size

The seventh-generation 2019 ES is built on Toyota's GA-K (global architecture – K) platform, which itself is a derivation of the wide-ranging TNGA architecture. So the new ES remains front-wheel-drive, directly related to the current-generation Toyota Camry and Avalon and tangentially connected to other TNGA-underpinned models such as the Prius. Strangely, Toyota continues to resist an all-wheel-drive variant.

Chief engineer Yasuhiro Sakakibara summed the differences between the new ES and its GA-K platform partners by saying "there are a lot of custom parts," adding that its not about the number of changes, but the sum of the alterations that help fashion a different character for the ES.

"Take the same piece of steak, but give it to two different chefs," is his analogy.

Chief among the changes for the 2019 ES is a new "V-brace" behind the rear seats that enhances torsional stiffness, with the intent of imparting sportier chassis response—and make the ES feel more like a rear-drive car. And new, Dynamic Control Shocks for the front strut, rear independent trailing-arm suspension have a special auxiliary-valve design to deliver improved response without unwanted stiffness.

The 2019 Lexus ES is longer, wider, lower and is available with two powertrain choices.

LEXUS

For the 2019 ES350, the 3.5-L V6 is enhanced with the D4S fueling system, which helps to extract an additional 34 horsepower.

Interior of the F-Sport variant of the 2019 ES350.

For F-Sport and Ultra Luxury trim levels, there's a new horizontally-located damper at the front to enhance torsional stiffness in the quest to provide better cornering, while the electric power-steering motor now is rack-mounted instead of on the steering column. For the F Sport, there is the standard Adaptive Variable Suspension and its 650 discreet automatic adjustment settings; all ES models have driver-adjustable drive-mode settings.

And in a now-common chassis-stiffening measure, the 2019 Lexus ES increases the use of structural adhesives by 142%—engineers say the car uses some 65 ft (19.8 m) of the stuff.

All this combines to good effect, as the ES does seem to be palpably more composed in hard corners, although *Automotive Engineering* can't vouch for much improvement in steering feedback, which remains practically non-existent.

Meanwhile, the new ES is 2.6 in (66 mm) longer and 1.8 in (46 mm) wider, plus there's a 2 in (51 mm) hike in wheelbase. As a result, Lexus is claiming best-in-class rear-seat legroom of 39.2 in (996 mm); a visit to the rear seats will have few disputing the assertion. But all the newfound size (does any established model ever get smaller?) and added refinement measures—25% more sound-deadening material coverage for the floorpan, for one example—mean the 2019 ES 350 is no lightweight at 3649 lb (1655 kg), despite an aluminum hood and front fenders.

Two drive options

Internal-combustion powertrain development may be funnelling itself inexorably towards 2.0-L turbocharged 4-cylinder engines, but Lexus didn't get that message for the ES: standard power remains Toyota's 3.5-L V6 with the D4S port- and direct-injection fueling setup that helps summon an additional 34 hp—for a total of 302 hp (225 kW)—compared with the non-D4S-equipped 2GR-FKS V6 used in the previous ES.

The engine's sophisticated variable valve-timing on the intake side helps enable high-expansion Atkinson-cycle operation when possible. Torque output now is 267 lb·ft (362 N·m), up 19 lb·ft (26 N·m) and thanks to strategic lightweighting to many of the engine's reciprocating components, redline is increased from 6,200 rpm to a tastier 6,600 rpm.

Backing the V6 is Toyota's 8-speed "Direct Shift" **Aisin** automatic transmission that uses a nifty, ultra-thin torque converter and a multi-plate lock up clutch to essentially eliminate slippage in most driving situations.

The ES300h's hybrid system—now in its fourth generation—is substantially revised and might make the ES300h the thinking-person's choice for most versatile of the ES model range. Lexus said the electric 29-kW (39-hp) drive motor now is smaller and more power-dense; combined with the revised 2.5-L 4-cylinder engine, total output increases by 20 hp to 215 hp (160 kW).

Lexus continues with nickel-metal-hydride chemistry for the ES300h's 1.6-kWh battery pack, although its smaller footprint enabled placement under the back seat, freeing an additional 4.5 ft^3 of trunk space (although the new V-brace means the rear seats cannot be folded). A new multi-axle design for the hybrid system's complex transaxle and close attention to matching engine speed with road speed is claimed to curtail the rubber-band sensation of the continuously variable transmission (CVT).

At 44 mpg combined, Lexus claims the 2019 ES300h is the most fuel-efficient luxury vehicle of any kind that doesn't feature plug-in capability. The figure is 4 mpg better than the previous-generation ES hybrid's combined fuel economy.

Stuffed with safety

Standard for all 2019 Lexus ES models is the Lexus Safety System+ 2.0 suite of driver-assistance features, including pedestrian and cyclist detection, automated emergency braking, lane-departure warning and assist, automatic control for high beams and adaptive cruise control.

Lexus may be discreetly backing away from Toyota's "native" app system in the driver interface, offering for the first time **Apple** CarPlay smartphone integration, while **Android** users now can use the **Amazon** Alexa voice interface for some functions. An excellent, high-resolution head-up display is optional and choosing the navigation system brings a large 12.3-in central control interface, commanded by the still-controversial Remote Touch Interface mouse-like controller.

Bill Visnic

BOTH IMAGES: LEXUS

SEARCH WITH A PURPOSE

IN SAE'S MOBILITY TECHNOLOGY SOLUTIONS GUIDE

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Electrifying the two-wheeler

Alta Motors, one of the newest electric motorcycle OEMs, is fueling zero-emission excitement with a passion for product.

by Paul Seredynski

EDITOR'S NOTE: *As this issue of* Automotive Engineering *went to print, Alta Motors reportedly halted production of its battery-electric motorcycles, but had yet to issue any public or media-directed statement regarding its status and future plans.*

Readers who have faced the challenges of creating a sustainable vehicle OEM, from scratch, know the risks involved are enormous. Alta Motors was well along in establishing itself as a maker of well-regarded, consumer-saleable (and podium-worthy) e-motorcycles. Regardless of the company's abrupt turn of fate, we believe its story is emblematic of many start-ups in the electrified-mobility space and remains relevant. The cover feature appears in original form below.

AE will report on any business developments that involve Alta Motors, its engineers and technologies. Watch the SAE website (https://www.sae.org/news/) for further information.

Alta Motors did not set out to create a zero-emission vehicle or invent a vital cog in the new landscape of electrified mobility. It wanted to build the best motorcycle it could regardless of powertrain, with products to satisfy the most serious motorcyclists. The fact that Alta's electrified two-wheelers are pushing the envelope in terms of power density and control algorithms is secondary, as the company seems mostly fueled by a genuine passion for its products.

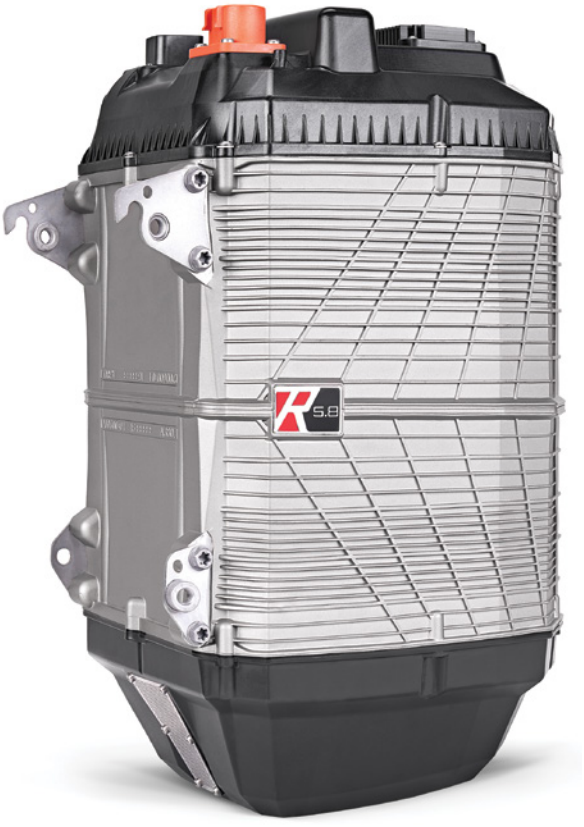
They'll need that zeal, because they've entered a rough market, irrespective of propulsion source (see "Making It..." sidebar). Alta also has taken more of a racing-focused and proprietary-component route, accepting fewer compromises from a supply base that is still struggling with automotive-scale electrified products, never mind those of a motorcycle startup.

This is a tougher route to ride, and such tenacity may bring more pains as the company grows, but it's quickly won Alta's products many fans in a niche field. *Automotive Engineering* spent a day with company co-founder and CTO Derek Dorresteyn discussing Alta's genesis, technology and products. Our visit also included ripping up the nearby streets of San Francisco on several Alta offerings to see if the hype around one of the newest OEMs was warranted.

Competition-focused product line

Alta does not build touring bikes. It instead applies research and engineering resources towards motorcycle products that best leverage the strengths of an electric powertrain (instant torque) and minimize the drawbacks (range). The result is Alta's lineup of competition-grade off-road motocross, street-legal enduro/dual-sport and street-legal supermoto models. The week we visited, Alta earned its first AMA Pro

JOHN McINNIS



The Alta-designed, -engineered and -assembled 5.8kWh Li-Ion 350v battery pack weighs 67.9 lb (30.8 kg), is IP67 rated and can be fully recharged in 1.5 hours with a 240v charger.

Alta CTO and Co-founder Derek Dorresteyn points out aspects of the chassis' aluminum construction.

BOTH IMAGES: ALTA MOTORS

EnduroCross podium, competing on equal footing with gasoline powered machines.

A tour of Alta's corporate offices and manufacturing line in Brisbane, Calif.—housed under one roof in a nondescript industrial park just south of San Francisco—was led by Dorresteyn, who along with Jeff Sand (chief design officer) and Marc Fenigstein (chief product officer), founded Alta in 2010 and moved Alta to the Brisbane location in 2015.

"Jeff Sand and I had gotten together over the idea of an electric motorcycle and we were working on it nights and weekends. That was 2008 and '09, and in 2009, we also brought on the third co-founder, Mark Fenigstein," Dorresteyn explained. "At the time, I owned a CNC machine shop in San Francisco and ended up staffing out a little bit, hiring additional engineers to work on this and we got to a concept point where we thought it was worth trying to form a company and raise some capital."

The nascent OEM quickly outgrew the machine shop, noted Dorresteyn, a fourth-generation Californian who studied industrial design at San Francisco State University. The team proceeded to build out the Brisbane space from an empty shell in 2015, and by the time of our tour in 2018, were already looking for additional facility space.

Dorresteyn impresses as sort of a Conan O'Brien/Tony Stark mash-up, providing the sense that if ever held captive in a cave by terrorists and you had him, a welder and a lathe, you'd likely *Iron Man* your way out. This comes to mind as we're walking the low-key production line laced with networked Raspberry Pi modules tracking assembly metrics. Dorresteyn is calmly explaining that thanks to the battery pack's IP67 waterproof rating and automotive-grade connectors, theoretically, you could ride an Alta motorcycle underwater. "Not that I can recommend it," he said, while also noting the pressure-relief capability for high-altitude riding.

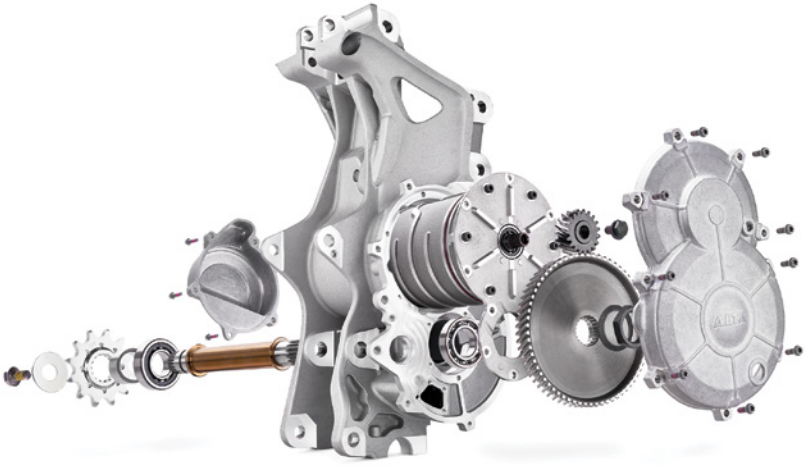
Low volume derived from high volume

That Alta-engineered, -designed and -built 5.8-kW·h Li-Ion 350v battery pack is the heart of its products. Currently on what Dorresteyn claims is "version 1.5," the 67.9-lb (30.8-kg) pack uses the same cylindrical 18650 cells that Tesla has applied, a keen counter to low volumes.

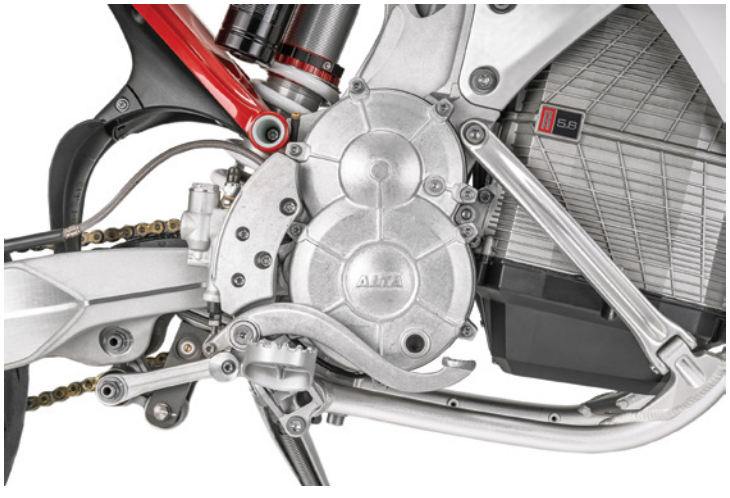
"This is something that **Tesla** founder Martin Eberhard realized some years ago, that cylindrical cells are currently produced in the highest volume of any format of lithium-ion batteries," Dorresteyn said. "Because the volume is there, we've got very high quality, the latest technology and because it's a standardized format, we have some amount of competition between different manufacturers. All that adds up to a better business case and a better product case."

Alta's battery technology is focused on the integration of cylindrical cells and is easily extensible into the 21700 or other cylindrical formats, Dorresteyn explained. "We've worked hard to develop relationships with some of the biggest and best battery technology companies in the world," he said. "That was a heavy lift, because we had to convince these companies that we could safely integrate their technology into a high-voltage automotive battery pack."

Electrifying the two-wheeler



The frame's stressed "bulkhead" core functions as the motor's outer casing, coolant circuit and gear-reduction case while also connecting to the rear suspension, forged chassis and trellis skidframe.



Roughly equivalent to a modern 350-cc four-stroke engine, the newest "Redshift" version of the Alta motor weighs 15 lb (6.8 kg) and delivers 50 hp at the countershaft, routing power through a 3.5:1 reduction gear to deliver 42 lb·ft (57 N·m) at the wheel from 0 rpm.

Power density with safety

Alta claims one of the industry's highest system-level power densities at 185 watt-hours per kilogram. "A lot of the work we've done is how do you take mass, cost and volume out of the system and still safely integrate a high-voltage pack to the cell?" Dorresteyn asked. "We've developed the full stack of the EV drivetrain from cell-to-output and everything in between—all the electronics, all the firmware—and we think it's absolutely critical to producing class-leading products."

The approach has allowed Alta's engineers to work quickly to improve and advance these systems, but also not to be beholden to other partners' concepts or priorities. They've also focused great attention on propagation resistance, an aspect of battery-pack design that Dorresteyn believes does not receive as much as attention as it should.

"If you have a battery cell that, for a myriad of reasons—it could be a manufacturing defect, a mechanical intrusion—goes into thermal runaway, that heat doesn't bring other cells in the pack also into thermal runaway," he asserted. "This is one of the foundations of our safety approach to lithium-ion batteries and we've developed patents around that."

Past the power source

Alta assembles its components into complete motorcycles via a snaking, on-site assembly line, with the battery pack powering a 14,000-rpm permanent-magnet AC motor located at the motorcycle's roll center. The placement and low counter-rotational mass permits what Alta claims is "the lowest polar moment of inertia in motorcycling" to reduce gyroscopic effects on handling.

Roughly equivalent to a modern 350-cc engine, the newest "Redshift" version of the motor weighs 15 lb (6.8 kg) and delivers 50 hp at the countershaft, routing power through a 3.5:1 reduction gear to deliver 42 lb·ft (57 N·m) at the wheel from 0 rpm.

The frame's stressed chassis core (what Alta labels the "bulkhead") functions as the motor's outer casing and a coolant circuit for the liquid-cooled motor and inverter, as well as the transmission case for the gear reduction. It's also the main structural hub connecting to the rear suspension, the forged chassis and the trellis skidframe.

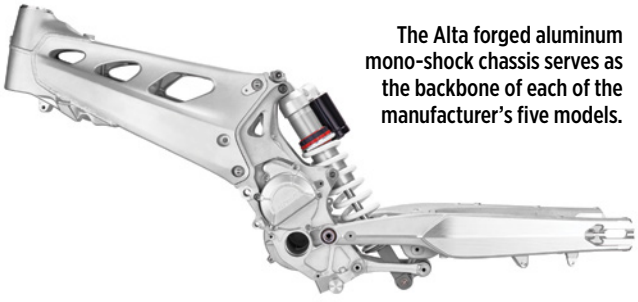
Aside from the electrified powertrain, the bodywork, suspension, brakes, wheels and tires on all Alta models are entirely conventional, and therefore compatible with a host of aftermarket suppliers.

On the road

Alta's motorcycles, particularly the latest Redshift models that added power and range, have received overwhelmingly positive reviews. After chasing ex-pro-level motocrosser Dorresteyn around the wildly entertaining San Francisco streets on dual-sport and supermoto models, *AE* believes the praise is warranted. The seamlessness and intuitive linearity of the controls belie Alta's limited time in the industry.

"One of the things that's different from the car world is that you use wheel slip as a control vector, especially in off-road motorcycles," Dorresteyn explained. "And there's an expectation by the rider for that to happen in a very intuitive way, so they feel confident in the way the machine is behaving. We've done a tremendous amount of development and testing around those characteristics."

ALL IMAGES: ALTA MOTORS



The Alta forged aluminum mono-shock chassis serves as the backbone of each of the manufacturer's five models.

That work paid dividends, as Alta's products are serious motorcycles that welcome aggressive riding and easily live up to the performance expectations of seasoned pilots. The biggest adjustment from a conventional motorcycle is about all the things you don't have to do (warm up the engine, shift gears, clutch, etc.), leaving a safer chunk of attention for piloting duties. A ride selector with four distinct modes provides a machine with personalities from docile to hooligan, making it simultaneously suitable for novice or expert, or a machine to grow with.

The other big adjustment is an e-moto's lack of noise. Silent save wind noise and chain whir, the rider feels almost unnaturally aware and plugged into the surroundings. "The lack of noise is a huge benefit across the entire spectrum of motorcycling," Dorresteyn said. "When you look at the loss of riding areas in the world, the move out of the urban areas, the loss of race tracks, it's almost 100% driven by noise compliance."

Best leveraging the advantages of an electrified drivetrain, Alta Motors builds some serious, competition-grade motocross, dual-sport/enduro and supermoto motorcycles.

Engineering in the e-mobility space

So how does Alta view itself in a rapidly shifting mobility landscape? "We're currently a motorcycle manufacturer, but we're also an electric drivetrain developer and manufacturer," Dorresteyn explained. "In the process of building an electric motorcycle, we've built a deep team and level of expertise around all the components of an electric drivetrain."

Making it in e-motorcycles

Motorcycle sales in the U.S. have not rebounded since the Great Recession, hovering around the 500,000 units/year-mark since 2009, when the recession more than halved sales. Global markets—where motorcycles purchases are less discretionary and smaller displacement machines often dominate the urban landscape—have rebounded far better since the recession, while the U.S. has seen additional casualties.

The U.S. motorcycle market has been a rough business since its inception. After its founding in 1903, **Harley-Davidson** (H-D) outlasted dozens of competitors to become the sole volume American manufacturer for decades. **Polaris Industries** launched **Victory Motorcycles** in 1998, and though it ended the brand in 2017, it continues in-essence as **Indian Motorcycle**.

For electrified drivetrains, none of the global motorcycle OEMs have yet to commit, save **KTM** with a single off-road model, the Freeride E-XC. The **Lightning** brand has demonstrated stunning performances at places like Pikes Peak and Bonneville with its LS-218 superbike, but seems to be in perpetual prototyping mode since launching in 2006.

Mission Motors (which was involved in H-D's LiveWire project—see sidebar) ceased operation in 2015, the same year Polaris Industries acquired **Brammo**'s e-moto division which it then nixed in 2017 along with the Victory brand under which it was marketed. This e-moto pair join gasoline-powered makes **Motus** and **Buell** in the recent "former" column of motorcycle manufacturers.

On the electrified front—with **Alta Motors** recently going into a non-producing "low-power" mode at presstime, presumably in hopes of securing new financing—the current major domestic player is **Zero Motorcycles**. Another NorCal operation begun as **Electricross** in 2006, Zero now builds 2,000 bikes a year in Scotts Valley just north of Santa Cruz. It is the only manufacturer to provide a full-range electric motorcycle via its 13 kWh Zero S model (shown at left), claiming a 223-mile (359-km) urban capability. Zero offers six street and soft-roading models, with export distribution in Europe and Australia.

Italy's **Energica Motor Company**, a Modena-based subsidiary of **CRP Group**, builds three trellis-framed electric sportbike models (Eva, Ego and EsseEsse9) around an 11.7kW·h lithium-polymer battery pack and oil-cooled, permanent-magnet motor. Featuring four riding modes with four regenerative maps, depending on the model, Energica's powertrain delivers 148 lb·ft (201 N·m), 145 hp and a 150-mph (241-km/h) top speed.

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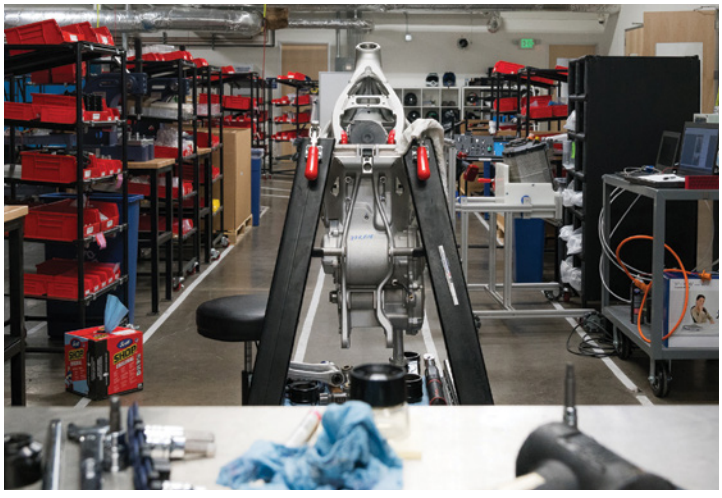
Electrifying the two-wheeler



Alta's assembly line at its Brisbane, Calif., location is lined with Raspberry Pi modules to gather and track assembly metrics.

That expertise is not always easy to come by. Dorresteyn noted that much like aerospace did in L.A. starting in the late 1950s, the e-mobility craze in the Bay Area is a double-edged sword: There's talent available but you'll pay for it. On its 40-strong engineering staff, Alta counts a number of ex-Tesla employees, plus Formula **SAE** alumni.

"We have industrial design, mechanical, electrical, firmware, software and test engineers and some specialists in things like thermal and simulation. We also have, separate from all of that, manufacturing engineering, which is constantly trying to increase our quality by improving traceability and control of everything we manufacture."

Challenges and the last mile

Particularly for racing and off-road applications, riding range may not be the non-starter for motorcyclists it is

ALL IMAGES: ALTA MOTORS

Harley-Davidson amps up (literally)

In July 2018, American motorcycle maker **Harley-Davidson** made a nearly unprecedented announcement about its future products. Part of a global investment strategy to help create a new generation of motorcyclists, the plans from H-D promised not only a novel and global mix of products in new segments (including adventure, street-fighter and small-displacement machines), but also a commitment to electrified motorcycles.

This includes the 2019 launch of its stunning LiveWire (which first debuted in concept form in 2014; bottom photo), followed by two new middleweight e-models with "accessible power and price points," and three new lightweight (think urban, scooter or e-bicycle-like) models by 2022.

Then in September, H-D announced it is establishing an R&D center in Silicon Valley to help engineer this new electrified lineup, with the facility serving as a satellite of its Milwaukee-area product development center in Wauwatosa, Wisc. H-D claimed it planned to hire 25 people from the Bay Area with electrical, mechanical and software engineering skills and will open the new center in the fourth quarter of 2018.

H-D remains mum about its previous equity investment in **Alta Motors**—which in mid-October reportedly ceased production of Alta-brand electric motorcycles—and the work it had done with the now-defunct **Mission Motors** on the LiveWire concept. But with its July announcement and creation of the Silicon Valley center, H-D apparently has committed to its own e-moto engineering.

"This new facility will serve as a satellite for the Willie C. Davidson Product Development center in Wauwatosa, which is where I'm located," explained Sean Stanley, H-D's chief engineer for EV platforms. "It will initially focus on EV research and development and it includes battery power electronics, e-machine design, development and advanced manufacturing.

"I will be working directly with the EV-systems team there, establishing an EV architecture and building blocks that can support many of the vehicles that we plan to bring to market," Stanley told *AE*. "At the PDC in Wauwatosa, we'll take those building blocks—that the Silicon Valley center develops—through the product development cycle to prepare for commercially available vehicles."

So far, H-D is the only major motorcycle OEM to announce specific plans for an electrified addition to its traditional lineup. Next year's LiveWire is being positioned as a "premium, high-performance motorcycle with streetfighter style and attitude."

As to what's prompted the first major OEM—one legendary for its V-twin engine architecture and characteristic exhaust note—to add electric offerings, Stanley noted that, "EV technology has a lot to offer in the area of new experiences and connections to the motorcycle and environment around you. Simplistic, twist and go riding [as] there's no shifting. Reducing the noise to focus more on the experience of riding. The instant torque, reduced maintenance. A bike that's easy to control for novice riders, all the way up to performance that intrigues experienced riders."

And what about that sound? "A Harley-Davidson wouldn't be a Harley without a signature sound," Stanley said. "We have and will continue to focus efforts in this area and deliver an authentic and unique sound."

-PS

for consumers in the automotive space. "It's still a hurdle for us, but we're trying to select markets and segments of markets that satisfies most consumers' use cases," Dorresteyn admitted. "We're focusing on urban transportation and off-road, where the total energy required is less."

As far as being part of the larger electrified landscape, unlike e-bicycles and scooters, Dorresteyn says he would not position e-motos and Alta in the same "last-mile" scenarios as those lower-speed solutions. "When we think of last mile now, we think of literally going a mile or two at relatively low speeds with a conveniently placed public transportation vehicle that you can pick off a rack and ride to work and ride back.

"Motorcycles are personal transportation and they're a lot of things that scooters and e-bicycles aren't," he opined. "They're exciting, quick, very capable. You can crisscross a city. It's a much more personalized form of transportation and also expressive of the owner and rider, something they take as part of their image to the world."

As for being part of the larger-scale e-mobility landscape, Dorresteyn says Alta is all in, and few who have experienced it would argue when he says: "The supermoto bike that we have, in an urban environment... I have not ridden anything that is more fun than that."

The 2019 Alta EX-R is a street-legal, race-ready dual-sport enduro machine.

"Passion is a pretty important thing for us," Dorresteyn said. "We have people that are passionate for building better motorcycles, and for building better EVs. We have people that are passionate about the electrification of transportation as a whole and about their specialties in design engineering. That's what drives this place, completely." ■

A classic 1960 magazine ad from U.S. electric power utilities predicted an autonomous-driving future but with wire-guided vehicles. The ad copy read: "Highways will be made safe—by electricity! No traffic jam…no collisions…no driver fatigue." And, no provision for out-of-position passenger restraint.

AV testing is for DUMMIES

Rapid development of automated vehicles is driving ATD innovations, as Humanetics' CEO explains.

by Lindsay Brooke

A few years ago, Chris O'Connor started to notice a common talking point emerging from within the many autonomous vehicle conferences and meetings he was attending.

"It seemed that many people in the industry, and those in Congress, were saying: 'With autonomous cars, we won't have traffic accidents anymore,'" noted O'Connor, the CEO of **Humanetics Innovative Solutions**, the leading developer of anthropomorphic test devices (ATDs), commonly known as crash-test dummies. "And since there won't be crashes, we will no longer have to worry about occupant safety," he recalled many pronouncing.

At the time, AVs were just emerging as The Next Revolution in mobility. Industry leaders and policymakers alike were being seduced by the growing hype—that self-driving vehicles will eliminate virtually all road accidents.

"Since then, of course, we've all come to realize such statements are ridiculous," O'Connor said. "There will be crashes involving autonomous vehicles. They will have electronic systems that will fail, and software problems. These are realities we'll have to face."

O'Connor is not a critic of AV technology and its potential to significantly reduce road crashes, injuries and fatalities. In fact, he's a vocal advocate whose deep knowledge of and experience in the vehicle crash-testing sector and the analysis tools used in the industry is helping to bring the emerging challenges around AV occupant safety into practical focus. Speaking with *Automotive Engineering*, he is quick to point out that much of the industry's scenario planning is being done based on an occurrence of approximately 37,000 annual fatalities—while six million accidents of all types occur every year in the U.S. alone.

"We cannot stop thinking about occupant safety as autonomous vehicles become more common on our roads," O'Connor asserted. "We've all seen some of the seating layouts for AVs, particularly within the concept cars at shows. They feature passengers sitting facing one another, because no one needs to drive or focus attention on the road. That's challenge number one."

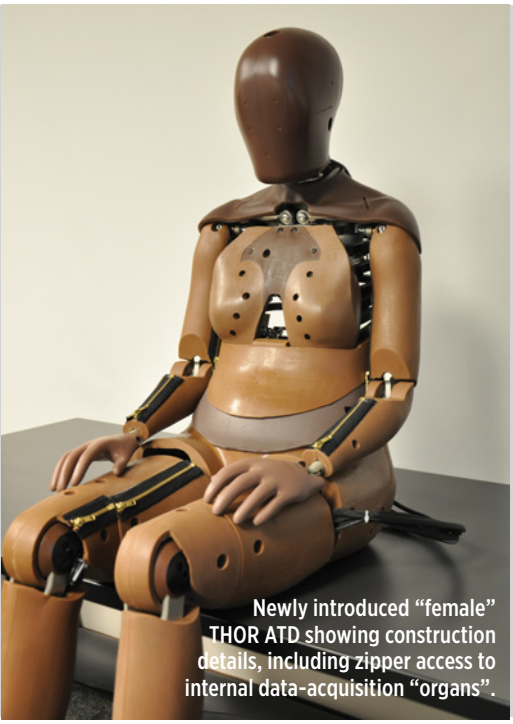
Future visions

The passenger compartment to which he refers is not new. It's been capturing the public's imagination since the "jet age" 1950s and the "space age" 1960s, when **General Motors** showed its Motorama and Futurama concept cars gliding driverless along electromagnetic wires embedded in the highway. The occupants of these futuristic cars sat playing cards, dining, or chatting. Such images became indelible in the public's mind.

But the truly hassle-free and nearly accident-free reality will require years' more engineering, science, and safety systems testing, O'Connor notes. In the meantime, many technical hurdles must be solved.

What will an autonomous shuttle, for example, or **SAE** Level 4 vehicle with their occupants riding facing each other, present to vehicle safety testing, the standards behind the testing, and the development of even more specialized ATDs?

FROM LEFT: ARCHIVE IMAGE/AMERICA'S ELECTRIC LIGHT AND POWER COMPANIES; HUMANETICS INNOVATIVE SOLUTIONS



Newly introduced "female" THOR ATD showing construction details, including zipper access to internal data-acquisition "organs".

Meet the THORs

The industry's newest state-of-the-art frontal crash ATD is Humanetics' THOR-50M. The acronym stands for Test device for Human Occupant Restraints; the suffix indicates 50th percentile male. It's one of an extensive family of increasingly sophisticated human replicants engineered to endure severe impacts and deliver vital data. THOR replaces the previous Hybrid-3 dummy, developed by Humanetics in the 1980s.

Although the latest iteration of Hybrid-3 has been updated with up to 20 sensors, "it's really primitive compared with the technologies available today," CEO Chris O'Connor explained.

The primary design objectives for the more human-like THOR included greater biofidelity, dynamic response, repeatability and durability. Its internal data-acquisition systems, capable of delivering up to 150 channels of information, are specific to injury assessment.

The latest Humanetics' THOR model (shown) is a female version, designed to ensure better protection for women who are physiologically more prone to crash-related injuries and fatalities than men. The female THOR joins other specially tailored Humanetics ATDs, including models for elderly and obese people, who also experience automobile accidents differently than the 50th-percentile male.

"We made the elderly dummy proportionally correct based on data for a 70-year-old woman," O'Connor explained. "'She' looks a little obese, but it's exactly average. This is very important for restraint systems."

He said data show more elderly fatalities result from a liver or spleen being ruptured. And not only are injury and fatality rates higher for the elderly, but the deaths typically don't happen at the time of the accident but rather days later as a result of internal organ ruptures.

"We instrumented not only the abdomen [in the new elderly THOR] but also the organs," O'Connor noted. "This is important for determining whether a restraint device or part of the car is causing an organ injury and ultimately the death of a senior person." **–L.B.**

AV testing is for DUMMIES

Humanetics' CEO Chris O'Connor with his company's latest "obese" ATD (in red vest) and "elderly" ATD. The THOR family of crash-test dummies incorporates enhanced biofidelic features and significantly expanded data acquisition capability, compared to the standard Hybrid-III 50th percentile adult male ATD.

The moment of truth during the 2018 Global NCAP crash test of Tata Motors' new Nexon. The compact SUV achieved a four-star adult occupant rating and a three-star child occupant rating.

"Let's say you're sitting in a car seat that has its backrest position set at 23 degrees. There is currently a standard test for that seating position. Recline the seat to 33 degrees or 43 degrees; this is not an extreme difference, yet your rate of injury could go up dramatically under each of these circumstances," he said.

Then spin the seat around so it's facing in the opposite direction. Or angle it sideways. These positions are being portrayed as common and acceptable in the new world of autonomous driving.

O'Connor suggests another likely scenario in the not-too-distant future: traveling in an autonomous shuttle heading to the airport. You're seated in a middle row seat that's facing the rear of the vehicle, like riding in a train. In this position, your head is directly facing the frontal crash zone. At the same time, one of your co-riders sharing the shuttle has rotated her seat, as it was designed to do, around to the side so she can watch the scenery pass by.

With such a vehicle, the entire structure will have to be re-envisioned completely—to cope with worst-case impact scenarios.

"It's not a simple thing," O'Connor continued. "Look at the [robot taxi maker] **Zoox** model. Their car has a quad seating configuration where the two rows of seats are facing each other. The car can travel forward or backward, it doesn't matter. Reclining the seat alone, in such a configuration, has the potential to be more dangerous.

"You're more apt to recline the seat in an AV because you don't have to pay attention to the road; you're watching a movie or want to take a nap," he noted. "These vehicle concepts have to be studied, and now is the time to consider the overall safety, in the early design phase."

Rethinking crash testing

Based in Farmington Hills, Mich., Humanetics manufactures about 250 ATDs per year, O'Connor said. Each model can take 10-15 years of development, followed by extensive approval processes at **NHTSA**, **NCAP**, and various government agencies, and can cost up to $800,000 each, depending on equipment. About 75% of the company's sales are outside the U.S.

O'Connor's engineers have been working with the OEMs to create test procedures for the unconventional, often out-of-position seating configurations of AVs. "We're being very proactive about this. We're

FROM TOP: HUMANETICS INNOVATION SOLUTIONS; GLOBAL NCAP

taking our latest and most advanced THOR dummy [see sidebar] and modifying it for autonomous vehicle testing," he said. "Because in these altered seating configurations, the traditional safety belts and airbag restraints will not work effectively.

"The OEMs all know they are going to have to modify and rethink these systems and they need a proper test device to evaluate them," he said.

O'Connor predicts that the new THOR series will be used in the next-generation NCAP (New Car Assessment Program), as well as in NHTSA's new oblique testing protocol. Under these new guidelines, a stationary vehicle will be struck by a crash sled at 56 mph (90 km/h) with a 35% overlap, and the test vehicles positioned at a 15-degree angle relative to each other. In this scenario, vehicle occupants are easily tossed out of position from the restraint system—offering valuable insights for the design of future AV structures, cabin, and safety systems.

With AV development moving rapidly at a growing list of vehicle OEMs, O'Connor and his team are also working on developments to prepare for European NCAP's 2020 program. The new protocols include a comprehensive revamp of safety ratings, with numerous new tests and assessments added, and the scores associated with the current tests modified. Euro NCAP 2020 is similar to NHTSA's proposed NCAP program.

"In the past, the U.S. led the way in automotive safety. However, in the last 10 years we've lost that lead to other regions, as other markets continued to add pedestrian protection and other critical tests and higher standards," O'Connor asserted. "The proposed new U.S. NCAP is the chance for the U.S. not only to catch up, but to move ahead."

For this reason, Humanetics is currently leading a consortium of private enterprises to address safety issues specific to autonomous vehicles, such as non-traditional seating positions within these cars. This is notable for Humanetics and other consortium members, as it shows private industry is voluntarily taking a proactive lead in addressing issues which have traditionally been government's domain.

"We have to move at a high rate of speed," O'Connor stated. "We're a big proponent of virtual testing and we make all virtual-dummy computer models available to the OEMs, to help them run simulations in advance of actual crash tests. However, only by testing the physical product can we be sure the test is being done correctly and the expected results are achieved." ■

2019 Yamaha Niken steers a radical path

The world's first leaning three-wheel motorcycle is an expression not only of engineering prowess, but of a real passion for riding.

by Paul Seredynski

When **Yamaha** debuted the MWT-9 concept three-wheeler at the Tokyo Motor Show in October 2015, many were impressed by its technology and almost unnerving, mantis-like visual presence. Yamaha has a history of stunning concepts for the Tokyo show, so it's likely few thought a production version would ever see real roads. But two years later at the same show, Yamaha unveiled the world's first 3-wheel leaning motorcycle and amazingly, production of the Niken began in the second half of this year.

The Niken is a brazen mechanical-engineering statement, in the vein of Yamaha's 1993 forkless GTS1000. Based at the company's HQ in Iwata, Japan, the main Niken development team was comprised of eight Yamaha Motor Company (YMC) staff, four of whom were engineers. Takahiro Suzuki was the Project Leader for Niken development, with chassis development handled by Ryuta Mitsuoka.

Meaning 'two swords' ('ni·ken') in Japanese, the label refers to the two front wheels carving up twisty roads and originates from a 17th-century style of swordsmanship which proved a revolution in combat. Based on the popular Yamaha Tracer 900 sport-touring motorcycle, the Niken is powered by a similar 847-cc, liquid-cooled, DOHC 3-cylinder engine with crossplane-crankshaft that's been retuned via fuel-injection mapping and a slightly heavier crank.

Clever Ackermann parallelogram

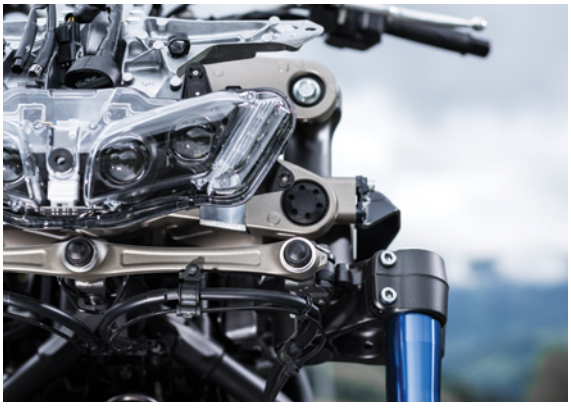
Invented in 1817 by German carriage builder Georg Lankensperger (and named for Rudolph Ackermann, who filed the patent), an Ackermann linkage permits wheels tied by an axle to independently track the required radius of a turn, as the inner wheel must follow a tighter radius than the outer to prevent wheel slip or scrubbing. Yamaha calls its Ackermann setup the Leaning Multi-Wheel (LMW) system. The goal for the Niken was more riding fun with less stress, and it was keenly engineered so that experienced motorcyclists would not have to alter their riding style.

The Yamaha LMW parallelogram uses Ackermann steering geometry with separate steering and lean axles, a 20-degree caster angle and a fixed track of 410 mm (16.1 in). An offset steering knuckle and tie rod keep the geometry consistent throughout the full range of lean regardless of steering input, and the parallel linkage connects to two fork stanchions mounted to the outside of each front wheel to create the fixed geometry. This allows the front wheels to turn and articulate in their own radius, even during lean.

On the Niken, maintaining low friction in the parallelogram was key in creating a natural feeling as the motorcycle moves throughout its roll axis. To accomplish this, the LMW linkage uses a combination of bushings and tapered-roller, ball and spherical bearings. All adjustments are factory set, with the only provisions a front-wheel "toe" adjustment and a steering-head adjustment to correlate handlebar-to-wheel alignment.

The engineering team noted that reaching the Niken's maximum lean angle of 45 degrees was one of its biggest challenges, in concert with creating an Ackermann setup that still behaves like a normal motorcycle — including requisite counter-steering inputs. The innate stability provided by the two-wheeled front end allows for aggressive chassis geometry, including a trail specification of only 74 mm (2.9 in)—25% less than a typical sportbike.

ALL IMAGES: YAMAHA



Yamaha calls its Ackermann setup on the Niken the Leaning Multi-Wheel (LMW) system, and keen engineering and exceptionally low friction permit natural riding inputs for experienced motorcyclists.

A separate steering axle using an offset steering knuckle and tie rod keeps the geometry consistent throughout the full range of lean, regardless of steering input.

Also at the 2017 Tokyo Show, Yamaha unveiled its MOTOROiD concept the company called an "unleashed prototype." The electric two-wheeler may be the next radical Yamaha to stun on the street.

Based at Yamaha's Iwata HQ, the main Niken development team was comprised of eight Yamaha Motor Company (YMC) staff, four of whom were engineers. Takahiro Suzuki was the Project Leader for Niken development, with chassis development handled by Ryuta Mitsuoka.

Two of everything

Most modern streetbikes feature a 17-in front wheel, but the Niken uses two 15-in front wheels fitted with 120/70R15 V-rated tires specially developed by Bridgestone for the Niken. Each front wheel combines with a 298-mm (11.7-in) brake rotor and four-piston radial caliper. Along with reduced inertia, the smaller front wheels and outboard-mounted forks provide the space required for steering and suspension articulation, including the 110 mm (4.3 in) of suspension stroke.

Each of the two stanchions for the front wheels serves a different role. The 43-mm (1.7-in) rear stanchion provides shock absorbing capability with full preload, compression and rebound-damping adjustability. The 41-mm (1.6-in) front stanchion provides direction setting and holds the wheel/brake assembly in alignment. The left and right stanchions can be adjusted and operate independently.

The Niken's unique and complex chassis features an investment-cast-steel head tube connected by a steel-tube frame to the aluminum swingarm-pivot assembly and aluminum rear subframe. The 552-mm (21.7-in) aluminum swingarm is 15 mm (.6-in) longer than the Tracer 900's for increased stability; compared to the Tracer's 1500-mm (59-in) wheelbase, the Niken's is only 10 mm (.4-in) longer. But the rider sits 50 mm (2 in) further rearward, helping promote a near 50:50 front-rear weight distribution with the rider on board.

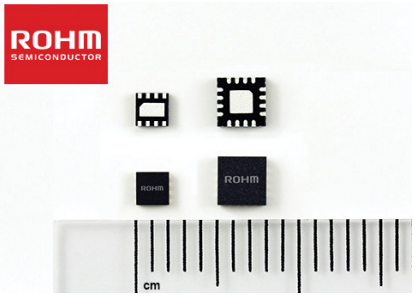
Yamaha claims a 263-kg (580 lb) fully-wet weight for the Niken, which is 70 kg (155 lb) more than the same spec claimed for the Tracer 900. A slightly shorter transmission secondary ratio (16/47; 2.938:1 vs. 16/45; 2.813:1 for the Tracer) helps maintain acceleration targets and the Niken provides the latest in electronic controls, including a quick-shift system, ABS, cruise control and traction control. Beyond the additional grip provided by the dual front wheels, it's engineered to operate like a typical sportbike

Powersports industry followers should note that also at the 2017 Tokyo show, Yamaha unveiled its electric MOTOROiD concept. Cannily described as an "unleashed prototype," the MOTOROiD won a Gold honor at the 2018 International Design Excellence Awards (IDEA). We can't wait to see what Yamaha unleashes next for production—and if the radical Niken is any guide, don't be shocked if it's electric. ■

PRODUCT BRIEFS

SPOTLIGHT: ADAS SENSORS

Ultra-compact Buck dc/dc converters



ROHM's (Kyoto and Santa Clara, Calif.) BD9S series of automotive synchronous secondary buck dc/dc converters have a high reliability and low power consumption in a compact form factor with a temperature range of -40 to +125°C (-40 to 257°F). The products are offered in a leadless package with wettable flanks, making them suitable for use in applications such as radars, cameras and sensors that can be used for assisted driving. Comprised of very compact, high-efficiency automotive-grade power supply ICs, the BD9S series includes an enable function to adjust the start-up time and a PGOOD output indication to improve system functional safety. This broad lineup of products supports output currents from 0.6 to 4.0A. Offered in the "industry-leading" (according to a ROHM September 2018 study) 2 and 3 mm^2 (0.003 and 0.004 in^2) space-saving packages, they deliver high efficient operation, resulting in a best-in-class power conversion efficiency of 90% (at 3.6-V input/1.8-V output).

For more information, visit http://info.hotims.com/70472-400

Image signal processor

Renesas Electronics Corp.'s (Tokyo, Japan) integrated open image signal processor (ISP) solution further eases and speeds the development of automotive smart camera applications based on the Renesas high-performance R-Car V3M and R-Car V3H System-on-Chips (SoCs). Integrating the ISP on the R-Car V3x SoCs and leveraging **MM Solutions**' (Sofia, Bulgaria) automotive camera development kit (AutoCDK), the open ISP solution on R-Car SoCs enables automotive Tier 1s to simplify the sensor calibration and tuning process for camera applications, including front camera and surround view, offering high flexibility and faster time to market. Part of the Renesas autonomy platform, the open ISP supports a range of development needs, from low-level-programming ISP capabilities via the open interface for users with deep in-house ISP expertise, to the AutoCDK that allows users to jumpstart their development leveraging the MM Solutions tools and image quality expertise. Key features: high flexibility and cost efficiency, high performance and rich feature set, and support for a wide range of ISP expertise and easy to deploy.

For more information, visit http://info.hotims.com/70472-401

Bluetooth-enabled electronic bore gages

The L.S. Starrett Company (Athol, Mass.) offers two new Bluetooth-enabled series of electronic digital bore gages with a range of accuracy and convenience features for increasing measurement throughput when inspecting internal hole dimensions. The 781BXT AccuBore electronic bore gages are a trigger-operated gaging system, and the 770BXT electronic bore gages, operated via thimble rotation, feature IP67 protection against dirt and coolant, making them suited to harsh machining environments. Bluetooth wireless technology in both bore gage series enables fast, robust measurement data-acquisition capabilities without the encumbrances and limitations of cables. According to the company, wireless technology also provides an "ideal platform" for manufacturers bracing to meet the comprehensive big data requirements of Industry 4.0.

For more information, visit http://info.hotims.com/70472-402

Servo press

Press plants are facing constantly increasing challenges with regard to a higher efficiency and effectiveness in production—this is the case for both automobile manufacturers and the supplier industry. The MSP 400 servo press from **Schuler** (Canton, Mich.) offers many smart functions, high productivity, process reliability and intuitive operability. Suitable for both progressive and transfer mode, the 400-ton (363-t) press can travel at an oscillating stroke of up to 70 strokes per minute thanks to the highly dynamic servo drives, and thus offers high performance in this price segment. Schuler has designed the control of the machine in the style of an intuitive smartphone app: operators can select from predefined movement profiles or program them freely. This significantly reduces the inhibition threshold for exploiting the machine's potential.

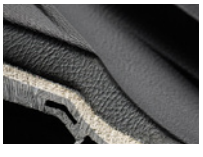
For more information, visit http://info.hotims.com/70472-403

Data collecting, analyzing platform

Cincinnati Test Systems (Harrison, Ohio) and **Sciemetric Instruments** (Ottawa, Canada) have brought the data management and analytics of Manufacturing 4.0 to leak and flow testing with their first collaboration as part of the **TASI Group** (Harrison, Ohio). The QualityWorX CTS DataHub is a turnkey platform for collecting and analyzing data from up to five CTS Sentinel instruments at a time, without requiring complex IT support to set up. It includes a host PC and Sciemetric Studio analytics software. Sciemetric Studio aggregates serialized leak test data for on-demand and in-depth analysis and visualization. For more extensive data collection requirements, the QualityWorX CTS Data Connector allows data from a CTS Sentinel instrument to be pushed to a QualityWorX database, enabling consolidation of production data from leak tests with other tests along the line.

For more information, visit http://info.hotims.com/70472-404

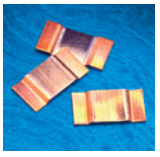
Bio-based foam system



A new series of polyurethane systems in the **BASF** (Florham Park, N.J.) Elastoflex E product group allows weight reductions and foam densities of around 120 g/L without sacrificing any of the unique characteristics of these foams. Up to 30% of the foam weight is saved, depending on the component geometry. With its very robust and fine cell-structure, this thin-light system can be used for components with a much smaller profile of less than 5 mm (0.19 in), producing very light and thin instrument panels or door elements that offer scope for new design options. This latest addition to BASF's portfolio meets strict requirements.

For more information, visit http://info.hotims.com/70472-405

Power shunt resistors



The PSJ2 series power shunt current sense resistors from **KOA Speer Electronics'** (Bradford, Pa.) now offer a 0.2mΩ resistance value. The resistor features a 12-watt power rating and is available in a 3920 package. Offering an ultra-low resistance suitable for large current sensing, the power shunt resistors have a broad operating temperature range of -65 to +175°C (-85 to +347°F). These AEC-Q200 qualified power shunts will now be offered in resistance values of 0.2mΩ, 0.5mΩ, and 1mΩ . The PSJ2 series is suitable for automatic mounting and reflow soldering. Used primarily for current detection, the PSJ2 current sense power shunt resistors are used in transportation and industrial markets in applications such as dc to dc conversion, automotive modules, motor control, and power supplies.

For more information, visit http://info.hotims.com/70472-406

SPI high-side power controllers

Infineon Technologies' (Munich, Germany) new generation of multichannel SPI high-side power controllers SPOC is designed to address interior and exterior lighting applications but also power distribution applications such as door lock and seat heating, as well as lighting and power distribution loads for e-bikes. With the new generation, customers can switch between all products of the SPOC+2 family, for example in case of late requirement changes from an OEM. All products use a common pin out, a common software concept and now also the same package. Compared to the previous generation, Infineon reduced the package size for the high-end product BTS72220-4ESA/E by more than 50% with the ability to switch up to 241 W.

For more information, visit http://info.hotims.com/70472-407

PRODUCT BRIEFS

Plug-in, compact contactor

The EVC 80 main contactor for hybrid and electric vehicles from **TE Connectivity** (Harrisburg, Pa.) expands the company's portfolio of contactors specifically designed for high voltage requirements in hybrid, full-electric and fuel-cell vehicles, as well as in-vehicle charging systems. It features a continuous current of up to 80A and a voltage rating of up to 450V, making it suitable as the main contactor in lower current applications and the pre-charge or auxiliary in higher-power batteries. It also provides enhanced safety, protection and high performance from a hermetically-sealed nitrogen gas contact chamber. The EVC 80 contactor is optimized for applications in tight mounting spaces. Its smaller packaging size allows for more efficient battery disconnect unit (BDU) layouts and optimized heat dissipation.

For more information, visit http://info.hotims.com/70472-408

Boring insert selector tool

The Boring Insert Selector from **Allied Machine & Engineering** (Dover, Ohio) is an online tool designed to save time by simplifying the boring insert selection process and ensures machinists are provided the correct boring insert for each job's unique details. Instead of hunting through multiple catalog pages to narrow the field of possibilities, the online tool guides the user to the correct boring insert for the job in six easy steps. The tool allows end users to select job-specific criteria from drop-down menus, including roughing/finishing, shape, substrate, form, nose radius, and material to be machined. Once selected, users simply click "find insert" to reveal the best choice for their unique boring application.

For more information, visit http://info.hotims.com/70472-409

Process sealed switches

Process sealed switches from **CIT Relay & Switch** (Rogers, Minn.), a division of **Circuit Interruption Technology**, Inc., offer dust tight housing with protection against splashing water, low pressure water jets or temporary immersion up to 1 m (3.3 ft) with a sealing degree reaching up to IP67. Also available with some series are protective splash-proof boots. See individual series types to determine the sealing degree. Sealing options from CIT Relay & Switch range from miniature surface-mount tactile switches all the way up to 40 mm (1.6 in) anti-vandal switches. Lead-time averages 6 to 8 weeks.

For more information, visit http://info.hotims.com/70472-410

Inductive linear position sensors

Harold G. Schaevitz Industries' (Bloomfield Hills, Mich.) ILPS-19 series inductive linear position sensors using LVIT technology are designed for factory automation and a variety of industrial or commercial applications, such as motorsport vehicles, automotive testing, solar cell positioners, wind turbine prop pitch and brake position, and packaging equipment. Suitable for both industrial testing laboratories and OEM applications, the ILPS-19 features contactless operation that prevents wear out from dither or cycling. The series also has six ranges from 25 to 200 mm (1 to 8 in) and 19-mm (0.75-in) diameter anodized aluminum housing sealed to IP-67. Operating from a variety of dc voltages, the series offers a choice of four analog outputs and all include HGSI's proprietary SenSet field recalibration feature.

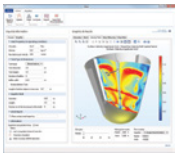
For more information, visit http://info.hotims.com/70472-411

High-voltage coolant heater

Part of its battery and cabin heater families, **BorgWarner**'s (Auburn Hills, Mich.) latest high-voltage coolant heater technology improves battery performance by keeping the battery's operating temperature within an optimal operating range and providing a consistent temperature distribution inside the battery pack and its cells. With its high thermal power density and fast response times due to its low thermal mass, the technology also extends pure electric driving range by using less power from the battery. Additionally, it allows comfortable cabin temperatures to be generated in a short time. The high-voltage coolant heater features a thick film heating element (TFE). A compact contour enables flexible sizes and shapes while low thermal mass results in fast response times.

For more information, visit http://info.hotims.com/70472-412

Simulation software



The latest version of **COMSOL** (Burlington, Mass.) Multiphysics Version 5.4, which in addition to two new products, provides performance improvements and additional modeling tools. It features COMSOL Compiler, giving specialists the freedom to distribute their simulation applications through executable files, and the Composite Materials Module for layered structures analysis. Additional highlights in version 5.4 include COMSOL Multiphysics: Multiple parameter nodes in the Model Builder, Group Model Builder nodes into folders, coloring of physics and geometry selections, several times faster solution time in the Windows 7 and 10 operating systems for computers with more than 8 processor cores; Multiphysics: Heat transfer, electric currents, and Joule heating in thin layered structures.

For more information, visit http://info.hotims.com/70472-413

Modular seat dampers

As in-car entertainment becomes more and more popular, the experience and therewith the comfort of the passengers in the back are highly dependent on the vibration behavior of the vehicle and especially the seats. **Vibracoustic**'s (Darmstadt, Germany) modular seat damper design concept with standardized rubber elements reduces vibrations significantly. The special-tuned mass damper for the seat structure can be adapted to the given package space inside of the seat. The modular "Reqill-Universal" design concept uses standardized rubber elements based on silicon rubber, a custom-fit and cost-effective solution, which is 100% recyclable. It offers the benefit of providing a universal solution that can be customized for any vehicle to damp vibrations.

For more information, visit http://info.hotims.com/70472-414

UPCOMING WEBINARS

THREE WAYS THERMAL CAMERAS MAKE AUTONOMOUS VEHICLES SAFER

Monday, November 5, 2018 at 2:00pm U.S EST

This 60-minute Webinar discusses thermal, or longwave infrared (LWIR), cameras that can be quickly integrated for testing and reliably classify objects in darkness. The cameras see 4x farther than headlights, through most fog, and are delivering improved situational awareness that results in more reliable, and safe ADAS in autonomous vehicles.

The Webinar will explore:

- Challenging but common visibility conditions where thermal infrared cameras provide the most value
- Do thermal infrared cameras detect, classify, or handle both?
- The performance gaps in the safety suite that are solved by thermal infrared cameras

Speaker:

Mike Walters
Vice President, Product Management, Uncooled Thermal Cameras, FLIR

Sponsored by: FLIR®

Hosted by: SAE INTERNATIONAL

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

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NEXT-GENERATION TECHNOLOGIES AND MATERIALS FOR ADVANCED MOBILITY APPLICATIONS

Wednesday, November 7, 2018 at 2:00pm U.S EST

As automotive manufacturers embrace the transition from internal combustion engines to e-mobility and fuel cell propulsion systems, they face new challenges in areas such as thermal management, power efficiency, friction reduction, weight reduction, compact installation spaces, and lower volumes.

This 60-minute Webinar will review recent customer and market trends, highlight advanced material developments and how they are addressing specific industry concerns, and offer a brief introduction to some unique component solutions that are helping manufacturers design safer, more efficient advanced mobility systems.

Speakers:

Michael Blake
E-Mobility & Automotive Sales, Freudenberg NOK Sealing Technologies

Ray Szparagowski
Technical Director, Automotive and HPP, Global Fluid Power Division

Joseph Walker
Global Technology Director, Materials & Laboratories

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Hosted by: SAE INTERNATIONAL

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

UPCOMING WEBINARS

VIRTUAL HARDWARE ECUS: A POSITIVE DISRUPTION FOR AUTOMOTIVE SOFTWARE DEVELOPMENT

Wednesday, November 14, 2018 at 1:00pm U.S. EST

Automotive systems require years of development before making it into a vehicle. With advanced driver assistance systems, infotainment, safety systems, and autonomous driving requiring more compute power and software content, automotive companies need to revisit their approach to software development and test.

This 60-minute Webinar discusses how simulation of an electronic control unit, known as a virtual hardware ECU, can be used for the following:

- To start software development early through fast/agile iteration, independent of hardware
- To increase testing coverage
- To accelerate cycles through the virtualization of test benches

Speaker:

Kevin Brand
Senior Manager, Applications Engineering, Synopsys

Sponsored by: SYNOPSYS®

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

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THE QUALITY OF FMEAs

Thursday, November 15, 2018 at 11:00am U.S. EST

Failure Mode and Effects Analysis (FMEA) can anticipate and prevent problems, reduce costs, shorten product development times, and achieve safe and highly reliable products and processes. Stated simply, FMEA is an essential element in achieving reliability objectives for any project or program. However, it has to be done correctly: performed on the correct parts, by the correct team, during the correct timeframe, with the correct procedure.

There is a maxim that says: "Good judgment comes from experience, and experience comes from poor judgment." This 30-minute Webinar focuses on lessons learned from experience with more than 2,000 FMEAs and over 100 companies. It also explores how they can be the foundation for an effective FMEA audit process.

Speaker:

Carl Carlson
Owner, Carlson Reliability Consulting

Hosted by: SAE INTERNATIONAL

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

READER FEEDBACK

The OEM-Supplier disconnect

The editorial commentary by Mr. Brooke in your October magazine was spot on. The OEMs will praise us "supplier partners" once a year, on a very controlled basis, at their annual supplier awards. Such events are private affairs without press coverage. Where they intentionally neglect to include us—and this is a strategic "miss" in my opinion—is at vehicle launch. Most of the magazine reports and road tests rarely include any mention of supplier development or product contributions, aside from who makes the tires. My company is basically an R&D arm for one of the Detroit 3 OEMs and two German OEMs. We provide the investment and design/engineering work and do the testing.

Our work is high-tech and it's seen and felt by the end customer—but we're unknown to them, per our OEM contracts. It would be very easy to include at least some prepared material from us at vehicle launch, which would help us get some visibility—including from Wall St.

Name withheld by request

Lindsay, I enjoyed your editorial in the October issue of *AE*. You are spot on. We at *Car and Driver* are equally frustrated by the OEMs routinely obfuscating who is behind their newest technologies and, as a result, denying access to the experts that are most capable of telling the technical story. Thanks for calling out that lame practice.

Eric Tingwall
Technical Director
Car and Driver

Your Editorial in the latest SAE Magazine was something that many of us in the supply chain have been prodding (really complaining about to!) our OE customers for a long time. We play by their rules: keep quiet and stay behind the scenes. It would benefit both sides if suppliers were given credit for their work when the new cars and trucks are rolled out.

Philip Li
Birmingham, Michigan

Great to read your advocacy for bringing suppliers into the new-product launch activities. We need the equivalent of "Intel Inside" in the auto industry. The OEMs can't do what they do without their supply chain, in particular the Tier Ones.

Pearce Hughes

RE: the October *Automotive Engineering* Editorial—there's not a chance the OEMs will give up their mythology that new vehicle technologies are conceived, engineered and manufactured by them. This will continue to be "off the table."

goFAB88

Your editorial in the SAE magazine didn't mention the supplier companies that are now getting a LOT of visibility in new vehicles—the microprocessor suppliers! **NXP**, **Infineon**, **STMicro**, **Renesas**, **Intel**—they're the 21st-century equivalent of Bendix, AlliedSignal, Delco and dozens of others.

Reza in Cupertino

The ACES hype

Michael Robinet's October "Supplier Eye" hit the nail on losing important Traditional Core Vehicle Systems vs. all the hype about Automated Connected Electrified and Shared (ACES) systems.

As we read and hear about auto companies spending billions on ACES to please Wall Street and "be on the bandwagon," they may be spending less on traditional hardware systems like body, powertrain, chassis and interior systems. Completely autonomous vehicles may be possible when every vehicle on the road is on the same page and people will have 100% confidence; in my opinion we are too far from there. Additionally, nobody knows about the effects of radiation on humans from all the beams emitted and received while we are still debating about the radiations from cell phones, WiFi, etc.

I hope auto companies do it in slow steps like exchanging mechanical hardware components with electrical to reduce weight and fund the safety technologies such as warning drivers about rear and side collisions with good cameras and better assessment overall.

Hari N. Agrawal
President, Hari Engineering Services
Farmington Hills, Michigan

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

COMPANIES MENTIONED

AD INDEX

STATEMENT OF OWNERSHIP

U.S. Postal Service Statement of Ownership (Required by 39 U.S.C. 3685) 1. Publication Title: Automotive Engineering 2. Publication Number: 0474-0100 3. Filing Date: 10/16/18 4. Issue Frequency: Jan, Feb, Mar, Apr, May, Jun, Aug, Sept, Oct, Nov 5. No. of Issues Published Annually: 10 6. Annual Subscription Price: $115.00 7. Complete Mailing Address of Known Office of Publication (Street, City, County, State, and Zip+4) (Not printer): ABP International (d/b/a Tech Briefs Media Group), an SAE International Company, 261 Fifth Avenue, Suite 1901, New York, NY 10016 8. Complete Mailing Address of Headquarters or General Business Office of Publisher (Not printer): SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001 9. Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor. Publisher (Name and Complete Mailing Address): Joseph T. Pramberger, 261 Fifth Avenue, Suite 1901, New York, NY 10016; Editor (Name and Complete Mailing Address): Lindsay Brooke, 400 Commonwealth Drive, Warrendale, PA 15096-0001 Managing Editor: None 10. Owner (If the publication is owned by a corporation, give the name and address of the corporation immediately followed by the names and addresses of all stockholders owning or holding 1 percent or more of the total amount of stock. If not owned by a corporation, give the names and addresses of the individual owners. If owned by a partnership or other unincorporated firm, give its name and address as well as those of each individual owner. If the publication is published by a nonprofit organization, give its name and address). Full Name and Complete Mailing Address: SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001 11. Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages, or Other Securities. Full Name and Complete Mailing Address: None 12. For Completion of Nonprofit Organizations Authorized to Mail at Nonprofit Rates. The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes: Not applicable 13. Publication Name: Automotive Engineering 14. Issue Date for Circulation Data Below: November 2018 15. Extent and Nature of Circulation (Average No. Copies Each Issue During Preceding 12 Months/Actual No. Copies of Single Issue Published Nearest to Filing Date): a. Total No. Copies (Net Press Run): 43,209/45,140 b. Paid and/or Requested Circulation: (1) Paid or Requested Mail Subscriptions (Include Advertisers' Proof Copies/Exchange Copies): 33,902/35,935 (2) Mailed In-County Paid Subscriptions Stated on PS Form 3541 [include paid distribution above nominal rate, advertiser's proof copies, and exchange copies] none/none (3) Paid Distribution Outside the Mail Including Sales Through Dealers and Carriers, Street Vendors, and Counter Sales, and Other Paid Distribution Outside USPS: 3,877/4,815 (4) Requested Copies Distributed by Other Mail Classes Through the USPS (e.g. First-Class Mail) 0/0 c. Total Paid and/or Requested Circulation (Sum of 15b(1), 15b(2), and 15b(3): 37,779/40,750 d. Free Distribution by Mail (Samples, Complimentary, and Other Free): (1) Nonrequested Copies Stated on PS Form 3541: 2,547/1,544 (2) Free or Nominal Rate In-County Copies Included on PS Form 3541 0/0 (3) Nonrequested Copies Distributed Through the USPS by Other Classes of Mail: none/none (4) Nonrequested Copies Distributed Outside the Mail: 971/888 e. Total Nonrequested Distribution (Sum of 15d (1), (2), and (3)): 3,518/2,432 f. Total Distribution (Sum of 15c and 15e): 41,297/43,182 g. Copies Not Distributed: 1,912/1,958 h. TOTAL (Sum of 15f and 15g): 43,209/45,140 i. Percent Paid and/or Requested Circulation (15c ÷ f times 100): 91.5%/94.4% 16. This Statement of Ownership will be printed in the November 2018 issue of this publication. 17. I certify that all information furnished on this form is true and complete. I understand that anyone who furnishes false or misleading information on this form or who omits material or information requested on the form may be subject to criminal sanctions (including fines and imprisonment) and/or civil sanctions (including civil penalties): Joseph T. Pramberger, Publisher.

Q&A

Noriyuki Sato: Developing hybrids devoid of "strange feelings."

Packaging Honda's all-new Insight

Honda's Noriyuki Sato knows hybrids—and how to optimize their packaging. Before joining the 2019 Insight program as chief engineer, performance, Sato-san spent 14 years working on the Accord Hybrid program. A veteran test engineer, he was serving in that role when the first-generation (1999-2005) Insight was showing the world the potential of the modern electrified automobile.

Honda spent 2006 to 2018 evolving Insight through five-door hatchback and four-door sedan models that never came close to challenging the **Toyota** Prius' hybrid dominance. For the all-new 2019 model, the Insight development team settled on a four-door version of the steel-intensive, global compact platform that is shared by Civic, with refined styling that is easier on the eyes than perhaps any other car in the Honda range.

The all-new Insight has Honda's next-gen Advanced Compatibility Engineering (ACE) body structure which incorporates extensive use of high-tensile-strength steel in 340-, 440-, 590-, 780-, 980-, and 1500-MPa grades. The hood is in aluminum.

Packaging the new Insight's energy sources—a lithium-ion battery pack made up of 60 cells supplied by Panasonic, and 10.6-gal (40-L) gasoline fuel tank—under the rear seats enabled Sato's team to expand cargo capacity from the Civic sedan's 14.7 ft^3 to 15.1 ft^3. The 12V battery (an AGM type) used for hotel loads is tucked under the center console. This clever package-engineering enabled folding rear seats for greater utility and expanded rear-seat legroom that's greater than that of the Hyundai Ioniq and Prius C, the car's two main hybrid bogies.

Sato spoke through a translator with Editor-in-Chief Lindsay Brooke about what he calls "the Smart, Green Sedan" development.

The new Insight is a triumph of efficient packaging. Was this the greatest challenge for your team in developing the vehicle?
It was one of them, but maybe not the greatest. There are various challenges in every vehicle development. For the Insight, maybe not a challenge but one of the things we tried to focus on carefully was achieving a 'balance' for the car, as a sedan. By that I mean trying to balance the styling, the driving dynamics and ride quality, the fuel economy—and the packaging. Getting a good balance for all those factors was really the challenge. This also included working with the design stylists to give the car a larger, cooler look overall.

Talk about the decision to move the energy sources under the back seat.
For that we needed two things: technology that made the battery smaller, to further miniaturize it, and we needed technology that allowed us to package it efficiently.

One of the sacrifices that had to be made in a lot of hybrids until now is the trunk space, which affects utility. That's where the battery had to go in the past and is something we wanted to improve. Now, with the third generation of our hybrid system we were able to make the battery smaller and to fit it under that second-row seat.

Insight's trunk space is impressive—are you best-in-class in that area?
Yes, I believe we are best in class. Now, let me ask you: What did you not like about the car?

Accelerating under hard throttle there is still that "slipping-clutch" feel and sound of a CVT that I've never liked in hybrids.
Yes, we also think some of the issues to work on moving forward are the engine sound and also that 'gap' in the acceleration. We really want to develop hybrids that aren't just for people who like hybrids, vehicles that regular customers can enjoy without any strange feelings. That's definitely what we want to develop moving forward.

Now that Honda has its new 10-speed planetary automatic in production, the hybrid engineers have an in-house benchmark for smooth driveline performance. Although it's not a hybrid, it's what your hybrid team will have to beat.
Yes, the 10-speed is good! We engineers continue to challenge ourselves internally by improving the technologies in all of our vehicles, hybrids and also other types. ■

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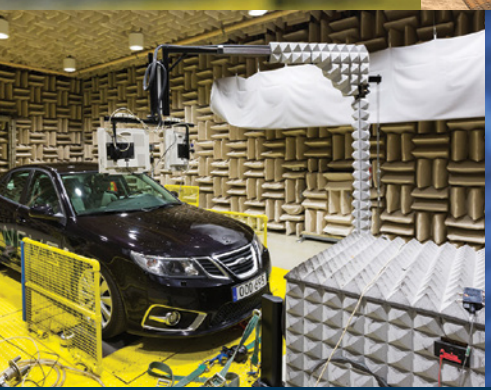

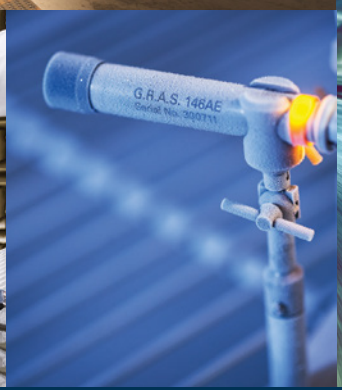

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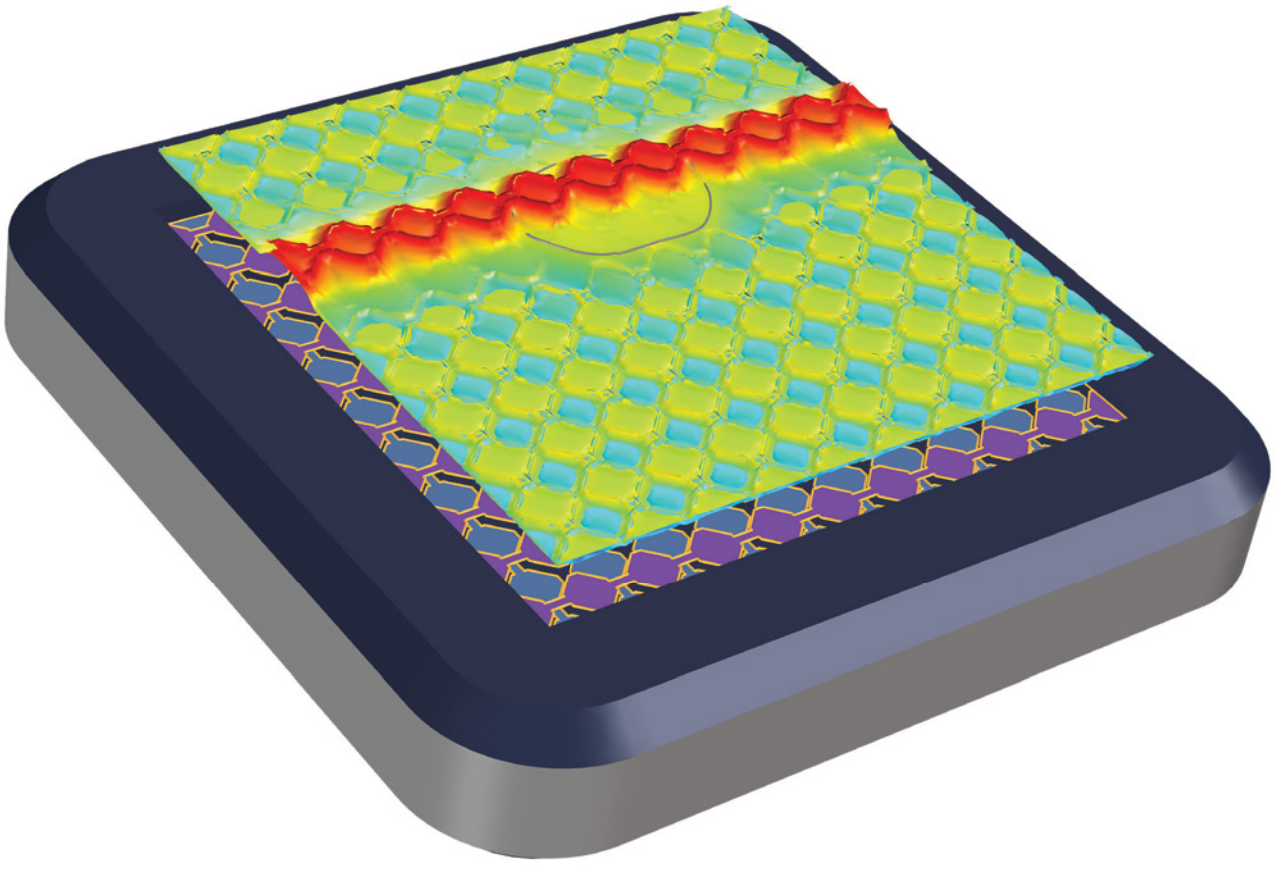

Visualization of electrode arrays in a capacitive touchscreen sensor and the log of the electric field norm when a finger touches the screen.

Many touchscreens developed for modern cars rely on capacitive sensing. Electrodes are embedded in a dielectric material, such as glass, and a voltage differential is applied, creating an electrostatic field. When someone touches the screen, the fields and capacitance change, and the device senses what part of the screen is being touched. To design better touchscreens, you can use simulation to accurately model the electrodes, surrounding metallic housing, and other dielectric objects.

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AUTOMOTIVE MANUFACTURING AND MACHINING

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Aluminum's rising star

Constellium Automotive Structures is booking big business in electrified-vehicle programs

Atlas Copco's smart, connected assembly strategy

Recycling carbon fiber

SUPPLEMENT TO **AUTOMOTIVE ENGINEERING**

Smart manufacturing tools and systems on tour

Wireless tools and production systems intertwined for the Industry 4.0 manufacturing revolution are featured in **Atlas Copco**'s recently-launched traveling roadshow.

Tucked inside a customized 53-ft (16-m) commercial truck trailer are three interactive work stations (Superior Productivity, Wireless Freedom and Quality Assurance). That 1000 sq ft (92.9 sq m) space is a showcase for Atlas Copco products and software that underscore Industry 4.0's intended benefits, ranging from reduced part defects to reduced energy use with multiple wireless tools running on a single assembly controller.

"There is really so much opportunity for customers to improve efficiency, maximize uptime and make wonderful improvements to their operations," Bob Flynn, General Manager of Atlas Copco Tools and Assembly Systems LLC, said at the company's North American headquarters in Auburn Hills, Michigan.

Automotive Engineering spoke with Flynn at an October open house featuring the mobile technology trailer. Atlas Copco's first-of-its-kind Smart Connected Assembly traveling product tour will make multiple stops throughout North America.

The massive evolution to Industry 4.0—which encompasses automation, networked data exchanges and other facets of smart manufacturing—is unfolding differently from industry-to-industry, company-to-company and plant-to-plant. "Some of the bigger automakers are further along in their aspiration and their vision of how they're going to capitalize on Industry 4.0, so they're actually taking steps to do it," said Flynn.

Atlas Copco's technology roadshow was envisioned as a way to show and tell through hands-on product demonstrations how automakers and suppliers can transition to smart manufacturing and assembly operations.

An Atlas Copco product specialist performs a demonstration in the technology trailer's Superior Productivity work station.

Wireless assembly tools

The roadshow features a number of wireless assembly and torque tools. Unlike their cable-connected counterparts, the fast-charging, battery-powered tools also are connected to cloud-based networks.

"Right now, the buzzword is big-data. But data is really just raw material unless you're able to do something with the data so that it serves a purpose. With our software, our Power Focus 6000 controller and our wireless tools, we're providing customers with the ability to view, manipulate, and analyze data," said Will Polumbo, marketing director for Atlas Copco USA.

Quality assurance gets a dramatic upgrade from a traditional manufacturing work process in which a quality operator uses one device for audits, another device to check the torque tools and yet another device for visual inspections.

"Just like tools are being networked to become smarter and provide data to align with the Industry 4.0 vision so that companies can make data-driven decisions, the same thing is being done with quality assurance operations," Polumbo explained. "With smarter tooling, we're able to bring all of those quality processes under one umbrella to simplify a quality operator's tasks. And the best thing is all of the quality data is collected in one place."

Atlas Copco officials expect that thousands of engineers and technical specialists will see the company's smart manufacturing-floor technologies. "When customers visit our mobile technology trailer, we want them to let us know their specific needs, challenges and opportunities," said Flynn, "Our product specialists can help customers improve their current manufacturing process."

Kami Buchholz

BOTH IMAGES: KAMI BUCHOLZ

Citizen's newest development, equipped with double gang tool posts and B axis.

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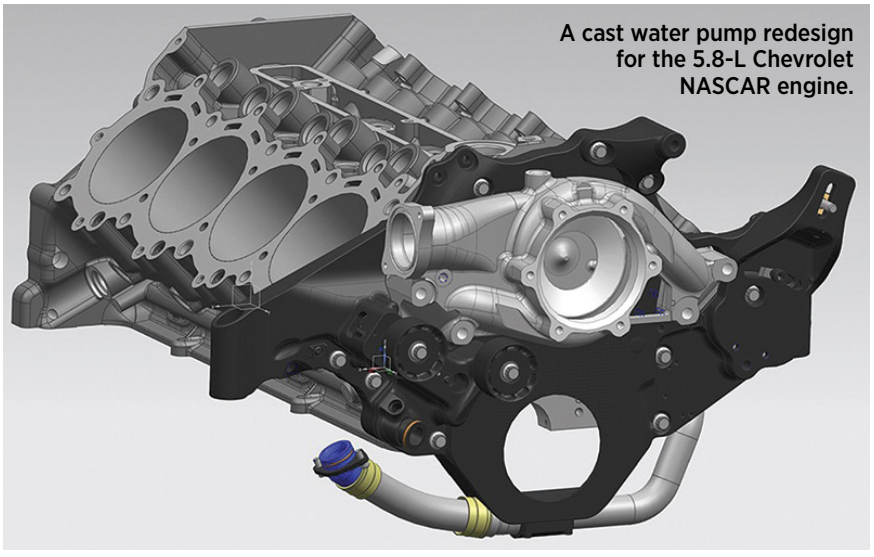
NASCAR's Hendrick Motorsports manufactures virtual components to race ahead

For round 23 of the 2018 NASCAR Cup series championship at Michigan International Speedway (MIS) in August, **Siemens** invited members of the media to attend the race in Brooklyn, Michigan, and speak with members of **Hendrick Motorsports** to discuss how the championship-winning team leverages Siemens PLM (Product Lifecycle Management) software.

The Chevy-powered team was in high spirits at MIS, having just won the previous round at Watkins Glen with driver (#9) Chase Elliott. One of NASCAR's most successful teams (with a record 15 national series owner's titles), Hendrick Motorsports began using Siemens software in its engine engineering department in the early 1990s and has partnered with Siemens since 1997. In April 2018, Siemens PLM Software and Hendrick Motorsports extended their technical partnership through the 2024 season.

Since the partnership with Siemens began in 1997, Hendrick Motorsports has won more than 250 NASCAR national series races and 14 championships, including 12 in the elite NASCAR Cup Series with drivers Jeff Gordon, Terry Labonte and Jimmie Johnson. "If we can take advantage of a change more quickly or develop and implement new ideas faster than our competition, it can result in winning races," said Tad Merriman, engine engineering manager, Hendrick Motorsports. "Using Siemens' PLM Software provides a competitive advantage for our entire organization."

Hendrick Motorsports uses Siemens PLM Software's NX, Simcenter and Teamcenter software for product development, leveraging software-based "digital twins" to gain a competitive edge. "What we do is like having a new product introduction every week for 38 weeks," said Jim Wall, engine program director, Hendrick Motorsports. "You have to reinvent yourself every single week, understanding the advantage is getting your ideas to the racetrack before someone else does."

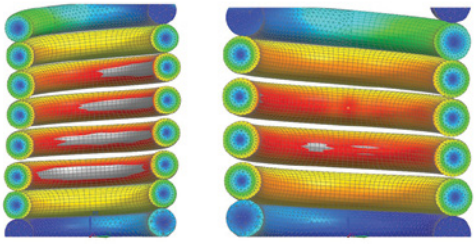


A cast water pump redesign for the 5.8-L Chevrolet NASCAR engine.

Leveraging Siemens NX software—a digital product development solution—allows Hendricks engineers to virtually build and test components of its race cars. "In the last decade, we have moved forward with a more optimal design from the concept stage," Wall explains. "We are using finite element analysis as an upfront tool for the design, so we don't have to break the part before we improve it."

Siemens Teamcenter, a widely used digital lifecycle management solution, serves as the digital backbone to help Hendrick Motorsports manage product lifecycles for its racing operations, enabling "anywhere, anytime" access to information. "Pulling up previous test results is key," explained Bryan Fleck, Ph.D, engine development manager at Hendrick Motorsports. "We'll be talking about something, and I can quickly pull up the result and we'll say, 'Hold on a second, we may have seen something back here' and now you've got two instances of it."

In addition to CAD, CAM and CAE information, a wide variety of data, including track performance data and build sheets, are organized and linked in a way that makes them accessible and comprehensible to everyone in the organization. This is critical in an organization where the next product debut is the following weekend.



A visualization of valve-spring inner and outer stress profiles.

"I'll pick the piston as an example," Fleck explained. "It's a highly stressed part and we're getting pictures back from the racetrack. By Monday morning, I'm firing up the finite element package and starting to do more analysis and we're updating the boundary conditions from the information that has been relayed back from the track. We machine our own pistons, so I can kick off the final design to our CNC guys. They reprogram it using the NX CAM product, and they're machining parts within a day."

Paul Seredynski

BOTH IMAGES: HENDRICK/SIEMENS

Carbon-fiber manufacturing meets—embroidery?

The story of carbon fiber's use by the automotive industry in medium- to high-volume manufacturing has for decades moved through chapters of high expectation and low likelihood. Carbon fiber still remains—mainly for cost reasons—essentially a super-premium material.

But now, a carbon-fiber application called Tailored Fiber Placement (TFP) has emerged—via the unlikely technology route of the embroidery-machine industry.

The TFP material is not for ornamental embroidery of seats, dashboards or door cards, but for series-production components such as a gearbox casings and pedal box or engine ancillary brackets, saving weight and adding strength without cost penalties.

Julius Sobizack, CEO of **ZSK**, a TFP forming and embroidery machine manufacturer near Dusseldorf, Germany, explained, "TFP allows complex 3D shapes to be created from a 2D preform in a quick and consistent way, with a lower cost structure. It unlocks significant design and engineering potential, with dramatically reduced carbon fiber wastage and facilitates the combined use of the material with thermoplastics—in a single part."

He is confident that TFP using technical embroidery has ever wider potential.

In the UK, the **Shape Group**, manufacturer of tooling and high-carbon composite parts to the transport industry, has used ZSK's embroidery machines to develop an automatable method of manufacturing fiber preforms combined with thermoplastic fibers. CEO Peter McCool, who formerly held senior positions with Super Aguri F1, Lola Cars and Amlin Aguri Formula E, explained that a commingled preform comprised of thermoplastic filaments and carbon rovings is easily consolidated into a net-shape part using a heated press.

Shape has produced an example: a TFP wheelarch liner fitted to the ultra-low-volume **Elemental** RP1 sportscar that combines track capability with road legality. Said McCool: "The TFP component is very light, yet tough enough to resist stone and grit impact and acts as a structural component. The preform is very close to the final component shape and the complex curves and corners are readily formed under low pressure."

The Elemental RP1 roadster uses wheel arches fashioned from TFP carbon fiber.

Carbon fiber, stitch by stitch

Instead of weaving all the fibers into a perpendicular arrangement then cutting to the required shape, TFP allows the functional fibers to be arranged in "bundles" exactly where they are most needed for structural performance and stitched into position on a compatible textile or polymer base layer. Production is entirely scalable through the addition of more multi-head laying and embroidery machines, ZSK said.

Melanie Hoerr, ZSK Technical Department Manager, said: "The benefits of being able to lay the fibers in the direction of load—instead of cutting across the fibers of a pre-woven sheet—have been clearly demonstrated in tests on components with holes: TFP allows the fiber to be laid around the hole."

Under tensile testing, instead of failing at the opening, the part fails as though no hole was present and withstands up to 50% higher load before failing. Hoerr added that carbon fiber roving can be tailored exactly to a requirement: "For a composite, we know the direction of load. This is important, because carbon fiber can take the most load in the fiber direction. With standard technology using non-crimp fabric, you are limited to specific degrees: 90° to 45° or minus 45°."

Using tailored fiber placement, there is an "endless" roll and the fiber can be laid precisely as needed, shaping a part exactly to how it is required to look as a finished item.

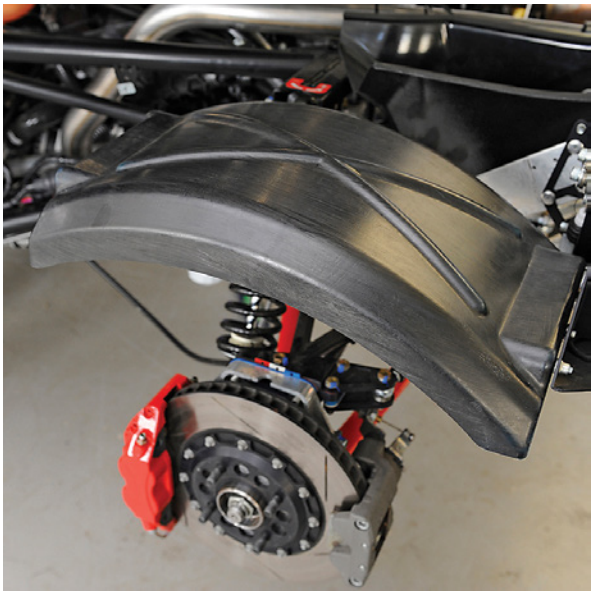
"With the embroidery machine, we lay the carbon-fiber roving on a base fabric and use zig-zag stitching every 5 mm to 8 mm to place it. So it is flexible and can be folded or pressed out in a heated mold later to create a 3D shape, the design capability being integrated into the fiber placement."

Improved performance, reduced waste

A key advantage of TFP is that, through selective stitching, it provides absolute freedom of positioning, ensuring that the fibers do not move during processing yet still permitting the pre-form to be folded where required. This means that a complex carbon composite 3D component can be produced economically and consistently, with short cycle times. The ability to vary the stitching properties locally means the preform can be stretched, bent or folded without wrinkling. Furthermore, fiber wastage is only 1% to 2% of the total instead of an average 20% to 30% depending on the part.

"The ability to align and orientate fibers for required strength and stiffness with zero waste will enable TFP to become the dominant carbon fiber manufacturing process for optimized preforms. Combining multiple materials in a single preform and thermoplastic matrix offers so many advantages and opens new opportunities for component design," McCool said.

Stuart Birch



TFP carbon fiber has the required toughness for a wheel liner, while helping the Elemental RP1 roadster achieve its overall light weight.

FROM TOP: ELEMENTAL; ZSK

Lightweight aluminum crash-management assemblies are a Constellium Automotive Structures specialty. This welding cell is in the company's new White, Georgia, plant.

CONSTELLIUM

Aluminum's RISING STAR

Constellium is fast emerging as a leader in EV structures and lightweighting technology.

By Lindsay Brooke

The impact aluminum is having on vehicle manufacturing, on sourcing—and on electric-vehicle engineering—was in full view on a recent visit to **Constellium Automotive Structures**' 431,000-ft2 (40,000-m2) plant west of Detroit in Van Buren Township, Michigan.

Safety glasses and steel-toed shoes deployed for the shop-floor tour, we exit the office area—and spot a towering wall of brown boxes, each bearing the stylized red-T logo of a certain California EV maker. These are extruded-aluminum substructures, neatly packed, and outbound for Fremont.

Walking briskly to keep pace with our host Eric Krepps, the VP and general manager, we observe cells of welding and assembly robots performing, with their human colleagues, an industrial ballet with light metal for customers including **BMW**, **FCA**, **Mercedes-Benz** and **GM**.

Tidy aisles. Clean floors. And the place is humming.

Then we enter Constellium's Ford territory, where a variety of precision aluminum parts and substructures are processed for virtually every **Ford** truck and utility.

"When we won business for the 2015 aluminum F-150, it doubled our output," Krepps noted. "We quickly realized that after launching this one big program, we had to move fast—or risk getting run over by larger competitors."

Landing Ford's biggest and most-profitable program ignited the North American fortunes of the Netherlands-based manufacturer. Then still unknown to many engineers and purchasing staffs in the U.S., Constellium did what Krepps describes as "a lot of missionary work" to give its name more visibility. Curious customers would visit and inquire: 'Can you handle our parts?'

"But when they saw the F-150 line, the typical reply was, 'Well, if you can handle that program, you can handle anything we've got,'" Krepps said.

The subsequent business growth "was like having a hot hand in basketball—you shoot, you score; shoot, score!," he recalled. "Within 24 months, we went from having one plant in Michigan to launching one in Canada, another in Georgia [to where the Michigan plant's BMW volume is shifting] and a new facility in San Luis Potosí, Mexico."

Aluminum's RISING STAR

Constellium Automotive Structures VP and general manager Eric Krepps during a recent plant floor tour in Constellium's Van Buren Township, Michigan, facility.

EV battery structures, with multiple aluminum extrusions and castings, are significant booked business for the company.

A shift in demand

The big-ticket pickup-truck and SUV programs have opened many eyes to Constellium's Automotive Structures, one of the parent company's three business units—the others are Packaging and Automotive Rolled Products, accounting for 54% of total revenue in 2017, and Aerospace and Transportation with a 25% share. In Europe, the Structures unit claims to be No. 1 in large-profile aluminum sections for vehicles (including railcars and commercial truck), No. 2 in hard-alloy extrusions, and No. 2 worldwide in crash-management systems.

"Our customers are typically those adopting aluminum as their strategic lightweighting metal the fastest," Krepps, a manufacturing veteran, noted.

When he joined in 2013, the division's product mix in North America was 20% IP structures, 20% body structures, and 60% crash management systems. In 2018, the IP business is nearly gone, as body structures have grown to 70% of production, and crash-management systems [the highly engineered front and rear assemblies that are designed to absorb energy and deform progressively on impact] have shifted to about 30% of the mix.

More change is coming. "The product mix for Automotive Structures is shifting again," Krepps revealed, "and a significant portion will soon become battery enclosures for EVs."

According to 2017 **Ducker Worldwide** research on aluminum-content use in North American light vehicles, based on industry interviews, adoption of the light metal in new vehicle construction through 2028 will increase at its fastest pace yet. Total aluminum content is expected to grow from 397 lb (180 kg) per vehicle (PPV) in 2015 to 565 PPV (256 kg) by 2028, representing 16% of total vehicle weight.

The trend is consistent with the widespread multi-material design approach, with aluminum dominating vehicle closures and crash structures, in addition to many areas in the body-in-white.

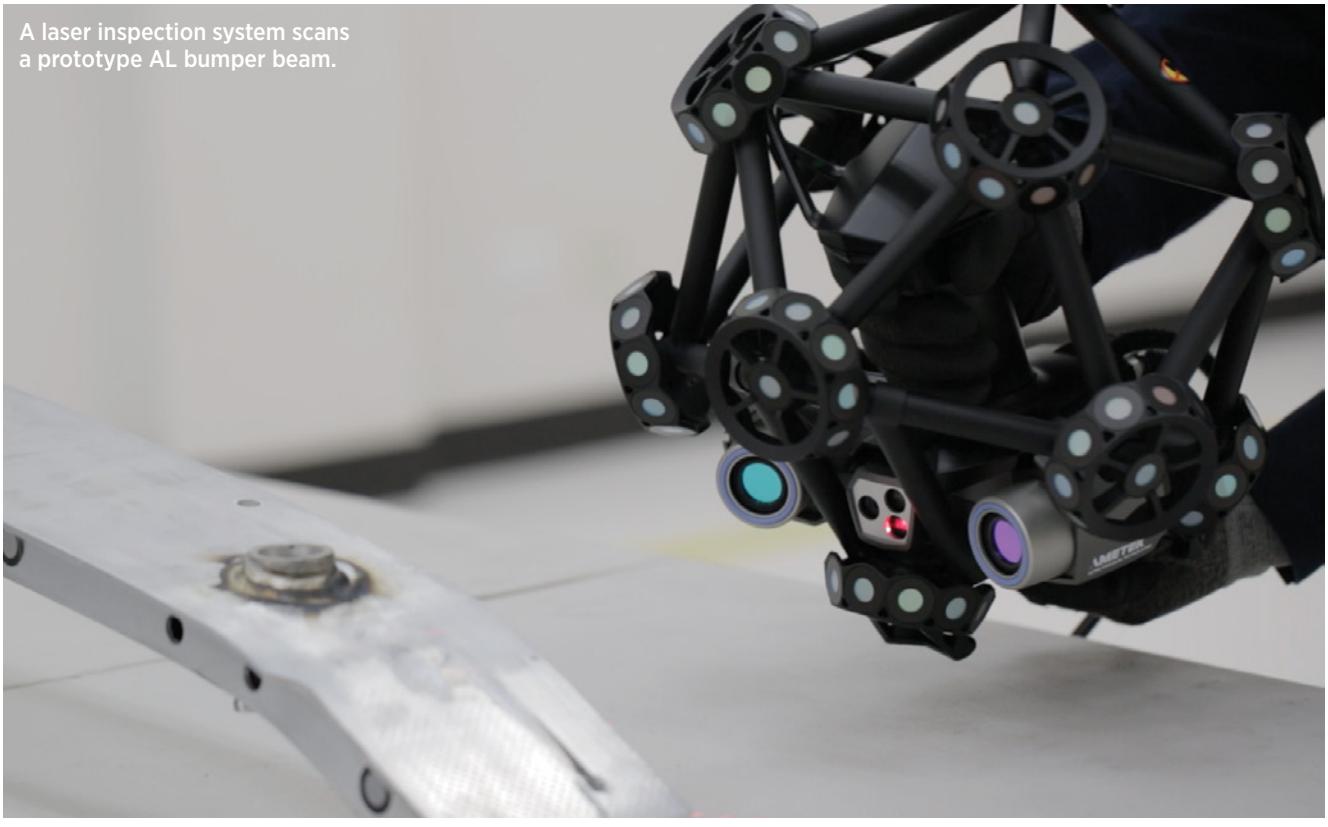
Aluminum "is entering its most unprecedented growth phase since we've been tracking the shifting mix of automotive materials," explained Abey Abraham, managing director-automotive materials at Ducker Worldwide.

In the 2020-2028 projections, aluminum is expected to contribute more than half of the total mass reduction in multi-material vehicle construction.

Krepps and his team see the steel industry's aggressive development of advanced, high-strength and lighter-weight products as vital competition that helps drive aluminum innovation. Some key OEMs including **Audi** (the latest A8), **Tesla** (Model 3), and BMW (the next-gen electric i3 and i8) have shifted to a multi-material approach, to mitigate cost and to leverage the properties of the various metals and composites.

"New steel technology is pushing us—and we're pushing them. I see this battle continuing through the next two product cycles," Krepps observed.

FROM LEFT: LINDSAY BROOKE; CONSTELLIUM



A laser inspection system scans a prototype AL bumper beam.

CONSTELLIUM

R&D competitive advantage

That battle, and the industry's demand for supplier innovation, makes R&D a priority. Constellium, which develops its own aluminum alloys, operates within a facility at the U.K.'s Brunel University London, that is set up exclusively for R&D. Besides a metallurgy group, it has dedicated casting and extrusion lines, "and all the advanced joining technologies you can think of," Krepps said, with Constellium researchers collaborating with adhesives- and aerospace-industry experts, among others. The R&D work has led to new alloys that allow welding of aluminum to steel, and extrusions to castings—important for EV battery structures.

"We're an aluminum company—that's our strength," underscored Krepps. "The high-6000-series and 7000-series alloys that Ford uses, we supply for military land vehicles. And we make a 7000-series alloy for aerospace that's lithium based. SpaceX uses it."

The next big volume play for Constellium Automotive Structures is "all around the electric vehicle—battery trays, packs and subframes," Krepps reported. "Our goal is to be the leader in structural components for EVs." He pointed to the 13 extrusions and multiple cast nodes in a 6-ft-long (1829-mm) production-spec EV battery structure standing near one of the production areas.

Constellium engineers are leveraging aluminum's superior thermal-conductivity properties in various ways to help manage an EV's thermal cycles, which also brings potential mass-reduction benefits.

"Within the chambers of our extrusions and between the battery cells, for example, we use the material properties to protect against thermal runaways, while also helping to keep the battery cell warm and cool depending on the operating environment," Krepps explained.

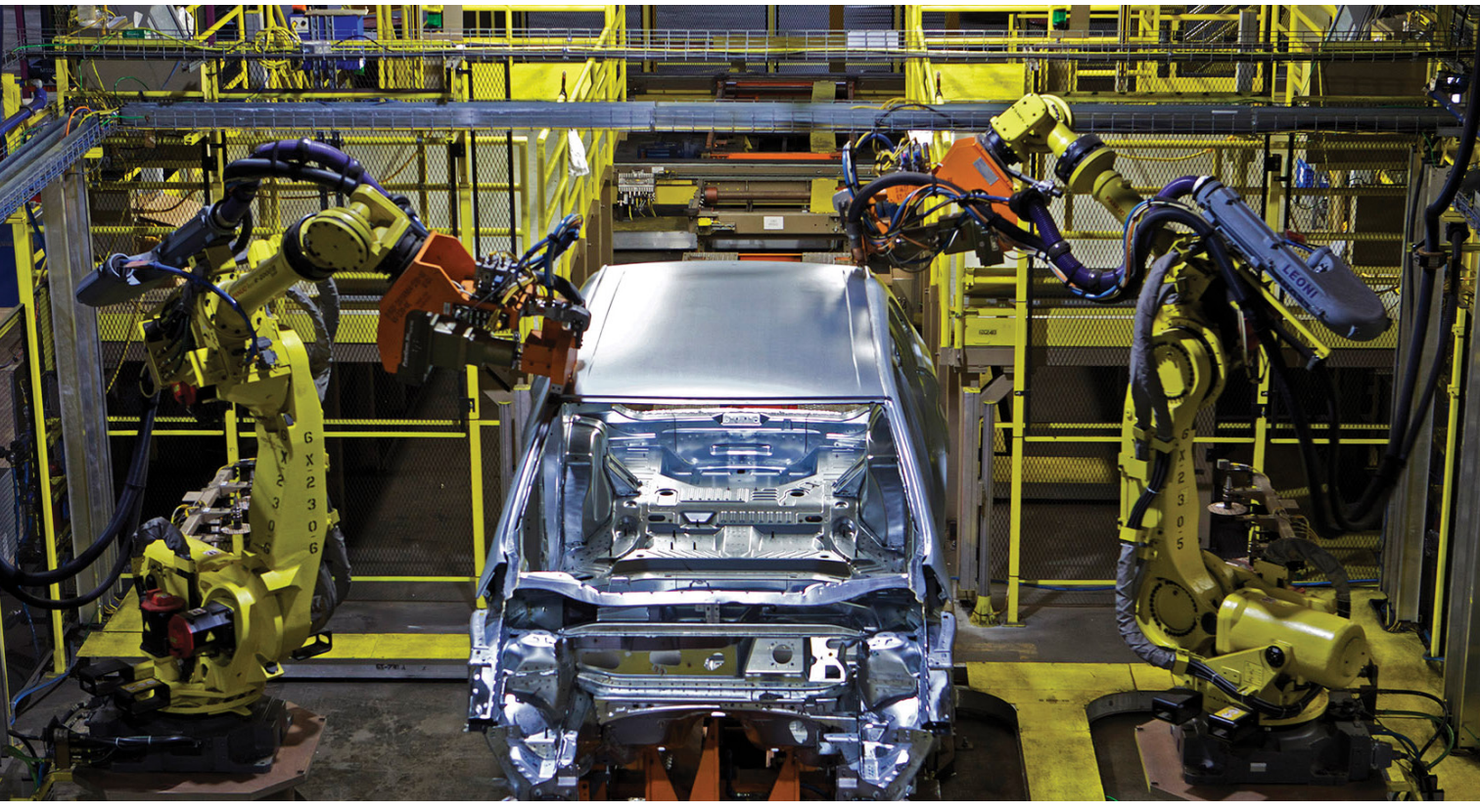
Besides the dozens of new EVs coming from traditional OEMs, Constellium also recognizes "disruptors" with new assembly strategies. "These guys aren't targeting **Toyota** and Ford—they're after a different set of competitors," he said. "They may want to sell 10,000 electric, autonomous vehicles in each of the major markets, so they don't need a $3 billion body-shop investment." Some may even use carbon-fiber bodies with an aluminum battery pack and subframe.

Distruptor companies such as Tesla, Lucid, Rivian, Nio and others will be part of the mobility future. They are far less risk-averse than the established OEMs, Krepps observed, and more accepting of technology advancements. On new ideas, "we won't get an immediate 'no,' whereas the incumbent OEMs require us to bring terabytes of data to support an idea."

And when a new player agrees to a new technology or application, Krepps said it helps "raise the comfort level" of the traditional makers.

"We see the disruptors as a way to advance vehicle engineering overall," he opined. ■

Smart factories must be flexible, connected and secure



Collaborative robots, augmented reality, and big data analytics will enable the factory of the future.

by Ryan Gehm

There's no shortage of advanced technologies at the disposal of automakers in their efforts to manufacture passenger cars and trucks in a safer, more cost-effective and efficient manner—collaborative robots, virtual and augmented reality, artificial intelligence, big data analytics and additive manufacturing, to name a few. But companies should be mindful of how and when to implement such technologies, particularly in existing plants, according to Dan Grieshaber, **General Motors**' Global Director of Manufacturing Engineering Integration.

"This is not about technology for technology's sake," he said at the 2018 CAR Management Briefing Seminars in Traverse City, Mich. "It's about solving specific business problems or changing our environment such that we can solve the problems that we anticipate tomorrow."

This involves integrating new technology with existing equipment. "We simply cannot afford to recapitalize our entire business and just bulldoze everything and start over."

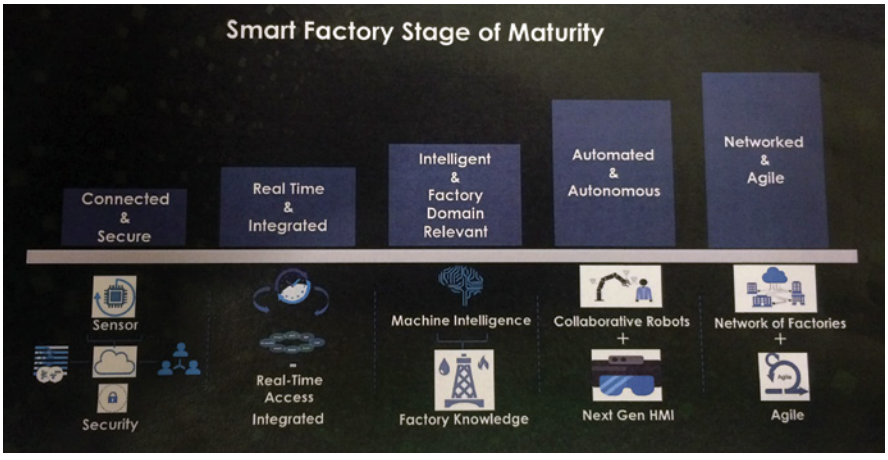
Plant floor safety is a major focus area for technology deployment, Grieshaber stressed. Wearables such as exo-skeletons or robo-gloves can help to reduce the stress and strain workers experience when performing certain tasks. Collaborative robots that assist the operator and make him/her more productive are "game-changers," he said. "The opportunities [for cobots] are really boundless, only limited by your imagination."

Using 3D printing to produce manufacturing tools and aids on-site is another area worth exploring, he said. For example, a shock tower lead-in helps guide the shock into the front tower for alignment, and a push pin ergonomic-assist tool can help relieve the effort by securing the push pins.

"These are things we can make in the plant, on the fly, to solve immediate business problems as opposed to having to contract these things out," he said. "And they're pennies to produce because they don't need to be made out of exotic materials."

(Read more about GM's use of robo-gloves and 3D printing at https://www.sae.org/news/2018/07/3d-printed-tools-and-robo-glove-make-inroads-at-gm-assembly-plant.)

What it boils down to is there is not one single silver bullet to solve all the problems, Grieshaber said to conclude his thoughts. "I think sometimes we can fall into the trap of, 'What's that next miracle drug that's going to help transform our business?' It's really going to be, in my view, a combination of a lot of things, including integrating what we already do today."



There are five stages of maturity on the path to realizing a smart factory, according to PTC.

PTC

Preparing for disruption

"It's fair to say that the plunge into automation, connectivity, electrification will no doubt impact manufacturers—frankly, it already has," said Mike Bafan, President, **Toyota de Mexico**, at the Management Briefing Seminars. He's witnessed all sorts of changes and transitions in the industry through the years, "but none as rapidly and dynamic as the current disruption facing the industry."

Toyota is investing $10 billion in its U.S. operations by 2022, to help prepare it for this transformation. The company's focus is on achieving higher flexibility, acquiring more capability to produce multiple products on the same line, and reducing lead time in the entire enterprise, from design to production.

"The bottom line is manufacturing should facilitate what the customers want," Bafan said.

Smart factories must be flexible, connected and secure

To illustrate the point that Toyota is indeed ready to adjust on the fly to meet customer demands, Bafan shared the story of how its new Guanajuato plant in central Mexico will now produce Tacoma pickups, when the initial plan was to produce Corolla passenger cars. About eight months into the process, Toyota's board of directors decided to focus on building more trucks, sales of which are booming—and advised Bafan of this decision in August 2017.

"When I was asked by our CEO, 'How is this going to change your whole plan now?' I told him, 'No impact.' He was shocked," Bafan said. "We worked hard to design a layout that could be used for manufacturing just about anything—tricycles, trucks, cars."

Growing diversity in powertrain options such as hybrids, plug-ins and fuel cells will only accelerate the need for manufacturing flexibility.

"Ultimately, the consumer will decide which powertrain technology is right for their lifestyle, and we will continue to provide a portfolio of options," Bafan said. "As consumer adoption rates for these advanced technologies increase, we will be prepared to meet the demand. And that's the part of the conversation where manufacturing needs to have a seat at the table—we can't exclude manufacturing."

Data drives decisions

"You really can't have a smart factory if you're not connected and you're not secure," said Jason Dietrich, Senior Vice President, Global Connected Operations Sales, **PTC**, during a Smart Factory session at the MBS conference.

Connected & Secure is the first of five stages of maturity on the path to realizing a smart factory, according to PTC. Adding real-time access, machine learning, cobots and next-generation HMI (human-machine interfaces) ultimately lead to the final stage: Networked & Agile.

"It truly is the extended supply chain," Dietrich said of the final stage. "Data flows from factory to factory. You can compare factories against each other, you have integrated systems, and ultimately you're thinking of ways to use lean and six sigma principles to get more value out of your existing assets."

The security aspect is a major component of smart factories and an ongoing challenge for many automakers.

"We have a huge emphasis on cybersecurity throughout our organization. Our security guys don't like me talking about this, but I don't think this is unique to **Ford**," said Tim Geiger, Principle Architect for Manufacturing, Ford Motor Co. "Our biggest exposure area today that we're still addressing is cybersecurity in manufacturing. There is a lot of exposure there. If anyone doesn't think that's the case, I would take a much harder look at your security organization."

Data is a core principle in driving the factory of the future as well as cybersecurity activities, according to Dan Totten, consulting architect for big data & analytics at Ford Motor Co. More than 600 data analysts at Ford are working to decipher the vast amounts of data collected from the manufacturing environment and from vehicles themselves.

Wearables such as exo-skeletons or robo-gloves (shown) can help to reduce the stress and strain workers experience when performing certain tasks.

GM

"I can't do AI [artificial intelligence], I can't do ML [machine learning], I can't do a number of things unless I have the data," Totten said. "The data is telling us stories now [and] actually driving some of our technological solutions to help us deliver on AI, ML and all the different elements within smart manufacturing, as well as at the plant floor and in the vehicle."

Some of the team's early successes stem from collecting data off the vehicle, Totten said. "Those real-time demands are factoring into, from a manufacturing standpoint, 'How do I take advantage of real-time data to be able to drive insights and analytics?'"

Data scientists can play a key role in security by partnering with the cybersecurity team.

"Through monitoring data, you're able to set a baseline and start to get anomaly detection, so you can see where you're out of scope," Totten said. "From a data perspective, being able to monitor it, measure it, understand where you might have an anomaly, and then be able to react to that." ■

Prodrive process expands carbon fiber's manufacturing potential

John McQuilliam, Composites Chief Engineer, believes Prodrive is the first to develop the new P2T recycling process for carbon fiber.

A new process developed by Britain's Prodrive makes it easier and less-costly to repurpose carbon fiber.

By Stuart Birch

Motorsport and advanced-engineering company **Prodrive** recently revealed what it confidently sees as a breakthrough process for recycling carbon fiber. It says the development could lead to a significant increase in use of the material across a much wider spectrum of the automotive industry via a reprocessing chain to manufacture further applications, making it available at lower cost, a hurdle that has generally restricted carbon fiber's use to high-end vehicles.

The new process could make a significant contribution to enhanced vehicle weight-saving measures, allowing recycled carbon fiber to be repurposed for non-load-bearing components and large bodyshell parts.

A further plus: Prodrive's recycling process itself brings complementary financial benefits because it does not necessitate use of an autoclave, saving time, energy and cost.

Finding substitute resins

John McQuilliam, Prodrive Composites' chief engineer, said that any breakthrough in carbon-fiber recycling requires a switch to resins that can be readily melted or chemically separated from the fiber content. He believes that Prodrive is the first company to develop such a process, which it calls P2T (Primary to Tertiary). "In addition to ease of recycling, P2T composites can be processed without the need to heat or pressure during manufacture," McQuilliam told *Automotive Engineering*.

Obviating the use of an autoclave enables the scaling-up of production without major investment, he added. It also introduces the feasibility of multiple "lifetimes," because the material can be repeatedly reused.

The basis of the P2T process is the use of a reactive thermoplastic resin instead of a thermosetting type; a plastic monomer is simply reacted with a catalyst in the presence of the fibers to produce a cured laminate.

The P2T research and development was a joint program between Prodrive and an unnamed automotive OEM that required a high-performance structural material with lower environmental impact than conventional composites—particularly end-of-life disposal and practical recycling.

McQuilliam explained that the challenge facing Prodrive's team was rooted in the traditional materials used for the resin matrix. These are thermosetting plastics, which once set, cannot be readily separated from the composite fibers. Rolls of 'pre-preg' (woven fiber sheets pre-impregnated with resin) are supplied to customers who then cut out 2D profiles and lay them up in molds to produce 3D parts, curing through heating to fix the final shape; thermosetting resins are highly convenient materials to support this supply-chain model.

So Prodrive had to convincingly defy carbon-fiber manufacturing tradition to achieve the required breakthrough, using different resins that led to P2T. The process also delivers benefits beyond end-of-life disposal; he stated that the initial—or primary—components produced by the P2T process use virgin composite fibers, so they have the highest-quality mechanical properties, the equal of conventional thermoset composites and therefore suitable for highly-loaded parts such as suspension wishbones.

Better recycling properties

But with the new P2T-derived material, when the primary part reaches the end of its life, the fibers and much of the

PRODRIVE

Prodrive process expands carbon fiber's manufacturing potential

Vacuum bagging the material together with breather material ensures an evenly distributed 1 bar pressure over the whole.

resin can be recycled by chemical or thermal depolymerization, yielding the raw carbon-fiber material for a secondary part of slightly lower strength, such as a body panel. When the secondary part reaches the end of its life, it can be chopped and remolded into block material to produce 3D solid components—the tertiary-level parts.

Prodrive said the tertiary parts can themselves be recycled several times, until a point is reached where only the re-melted resin is recovered and the fibers are milled to supply other lower-grade parts.

McQuilliam adds that often, different technical advances may end up competing with one another, but in this case, he believes the P2T process complements other current carbon-fiber manufacturing developments in the industry, such as Tailored Fiber Placement (TFP), which is being adopted by many leading composite producers. "TFP uses fewer fibers from the outset by placing them more optimally than in a simple weave pattern, but it still needs an effective recycling process. We can provide that," he asserted.

The P2T process currently is operating at pilot scale, but McQuilliam is confident that new applications could be introduced to series production within twelve months: "End-of-life recycling is a hot topic throughout the composites world, affecting several industries. In marine circles for example, old glass fiber boats have so little residual value they are often broken up and sent to landfill. In the future, environmental legislation will mandate a more considered approach across all industries," he said. ■

PRODRIVE

Daimler is exploring a number of 3D printing options for plastic and metal parts.

MERCEDES-BENZ TRUCKS

Adding 3D printing to **DESIGN, MANUFACTURING PROCESSES**

Additive manufacturing still is fairly new in the high-reliability world of commercial vehicles—but the process is making significant inroads.

by Terry Costlow

Additive manufacturing is beginning to transform operations from early development through fulfilling requests for obsolete components. Integrating 3D printing into the design and manufacturing operations can be a slow process, since a broad range of parameters must be examined, sometimes on a case-by-case basis.

Additive processing has already altered many fields, but it's still fairly new in the high reliability world of commercial vehicles. The technology is often used for prototypes, since production times are far shorter than for parts made with conventional manufacturing techniques. Companies are striving to understand the nuances of components and expand their usage of additive processes.

"We are piloting six 3D-printed plastic, non-safety critical parts," said Angela Timmen, Manager of Interior/Exterior Cab and Major Components at **Daimler Trucks North America**. "DTNA partnered with the 3D printing service bureau, Technology House, to produce the parts via selective laser sintering. The pilot parts were selected based on their long lead times and their lack of tooling. They also provide a safe way to explore and learn the 3D printing process."

Additive processes have become more common in the last few years, so many companies are expanding their capabilities to produce a broader range of prototypes. They're also looking to see how additive parts can be put into production machines.

Caterpillar opened its Additive Manufacturing Factory in 2015 to focus on changing manufacturing environments. This operation helps the company understand the many different 3D printing technologies and explore how they can be used in conjunction with other manufacturing technologies.

"The Additive Manufacturing Factory has two primary functions," said Stacey M. DelVecchio, Additive Manufacturing Product Manager at Caterpillar's Innovation & Technology Development Division. "First, it's a mini-production factory with the ability to fulfill production orders on production-capable 3D printing equipment. Second, it's a lab for our engineers to train on this equipment."

Interest is not just from OEMs. Engineering and technical

Adding 3D printing to **DESIGN, MANUFACTURING PROCESSES**

Caterpillar manufactures rubber grommets using additive-manufacturing systems.

Manufacturing service providers like Protolabs are adding equipment to meet the growing demands for 3D printing.

consulting groups are quite interested, since they're often designing a number of different solutions for OEM projects. When they can make a range of different options without taking the time to set up conventional manufacturing equipment, design engineers can try out far more options, often using creative concepts.

"With additive processes, new geometries which are not possible with conventional forging or casting can be produced, such as piston bowls, honeycomb structures and cooling channels in pistons or cylinder heads with web cooling structures," said **IAV Automotive Engineering** spokesperson Pia Shah. "There's far less machining effort for products like cylinder heads with integrated oil channels or without closing plugs."

There are many factors to be understood. There are a range of different manufacturing technologies, including selective laser sintering, stereolithography, direct metal laser sintering, multi-jet fusion, fused deposition modeling and continuous liquid interface production.

Additionally, the properties of components made with powdered raw materials can be different depending on the selected production technology. Some companies address this complexity by working with specialized contract manufacturers, while others forge links with equipment suppliers.

"It is very important to partner with equipment suppliers," Timmen said. "We use supplier partners now who have the flexibility to keep up with the changing technology to print our parts."

Alter or start from scratch?

Design strategies are among the many questions surrounding the technology. When new designs have honeycombs or other elements that can't be made using conventional design techniques, engineers must use 3D design techniques from the beginning. When prototypes or volume designs mimic existing parts, it's often helpful to design the part for additive manufacturing, but that's not always necessary.

"In some cases, we can use a design that was intended for a conventional manufacturing process," DelVecchio said. "In other cases, we can't. The real question, though, before 3D printing a part that was designed for conventional processes isn't, 'Can we print it?' it's 'Should we print it?' As the cost to 3D print a part continues to come down, we'll see more and more cost-effective applications for additive manufacturing."

The decision to redesign an existing part or start afresh varies widely depending on complexity and whether alterations are needed. Sometimes, it's simple to add features when parts are made with additive processes. Other times, it's expedient to use the existing data files.

"If the full potential of additive parts can be used with a dedicated/optimized design approach and integration of new functions and features, then we usually design from scratch," IAV's Shah said. "If a client wants to use the additive process only to reduce the lead time for prototypes and produce the series parts, for example pistons, with conventional processes like forging, then we use a rather conventional design for the additive prototypes."

Additive technologies also are being used as a way to fulfill demand for outdated components, especially when volumes of older parts are too low to warrant full production runs. The printers can also help companies alleviate backlogs.

"3D printing is useful for sourcing parts for older truck models," Timmen said. "This technology can also provide a solution for backordered parts, which would otherwise cause long delays. DTNA has made significant enhancements to its supply chain ecosystem including processes and new parts distribution centers. Our current supply chain strategy is a rapid recovery system that allows us to deliver parts next day to most of our dealer order volume." ■

FROM LEFT: CATERPILLAR; PROTOLABS