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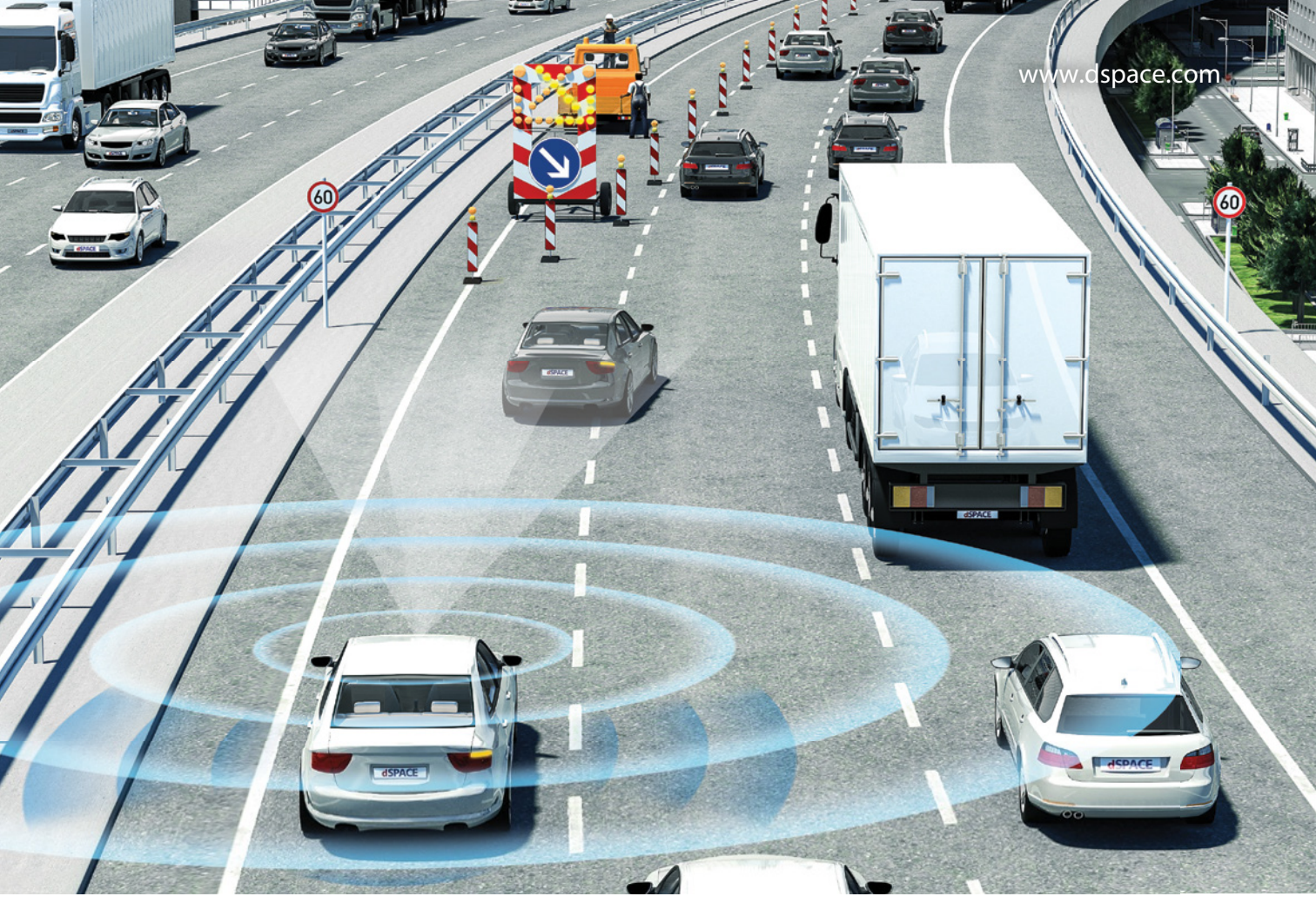
## Sports cars
Taking center stage in Tokyo

## Time to get personal
Enabling customization and anticipating needs

## GM and TARDEC
Co-developing a fuel-cell Colorado for military evaluation

January 2016 | magazine.sae.org/auto




# Innovative Driver Assistance Systems – On the Road to Autonomous Driving

The idea of self-driving vehicles offers great potential for innovation. But the development effort has to stay manageable despite the increasing complexity. And it can: With a well-coordinated tool chain for function development, virtual validation and hardware-in-the-loop simulation, in which perfectly matched tools interact smoothly throughout all the development steps. Whether you're integrating environment sensors or V2X communication, modeling vehicles and traffic scenarios, or running virtual test drives.

Get your autonomous driving functions on the road – safely!

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VOLUME 3 ISSUE 1







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# SENSORS TO SYSTEMS


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MOTION AND MOBILITY

## VIDEO

### SAE Eye on Engineering: Cameras replace mirrors

In the quest for greater fuel economy, vehicle designers are focusing more on improving aerodynamics. In this episode of SAE Eye on Engineering, Senior Editor Lindsay Brooke looks at the next radical improvement to aerodynamics: removing the rearview mirrors from the doors. It can be viewed at https://youtu.be/QDXE1V2u8fY. SAE Eye on Engineering airs in audio-only


form Monday mornings on WJR 760 AM Detroit's Paul W. Smith Show. Access archived episodes at www.sae.org/magazines/podcasts.

## FEEDBACK | CORRECTION

### Closer look at 'world record' aerodynamics

The **General Motors** EV-1/Impact had a Cd of 0.185, just beating the **Mercedes-Benz** Concept IAA (read

**Mercedes' Concept IAA boasts a Cd figure of 0.19. Active aerodynamic features include eight CFRP (carbon fiber reinforced plastic) segments at the rear that deploy to extend the car's length by up to 390 mm (15.4 in), reducing drag.**

"Mercedes' concept stresses connectivity, record-breaking aerodynamics" at http://articles.sae.org/14347/). That was in the GM wind tunnel in 1991 (the car came out several years later). I put in the lip at the trailing edge of the hood to kick the air up over the windshield wipers. We were trying to find some good OSRV mirrors, but the project was put on

hiatus before we could find any really good ones, and the car ended up using **Mazda** Miata mirrors. Even with those mirrors, though, it got a 0.185. Ugly as sin, but 0.185.

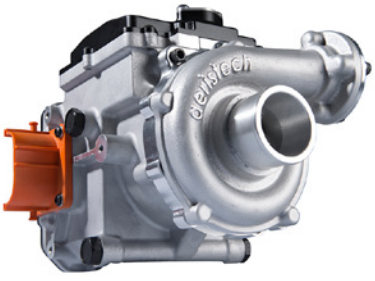
**John R. Callister**
**Senior Lecturer, Director of the Harvey Kinzelberg Entrepreneurship in Engineering Program, and Faculty Advisor for Cornell FSAE Racing at Cornell University**

*John and other readers are correct in stating that the EV-1 and other vehicles have a lower Cd than the 0.19 of Mercedes' Concept IAA, which was said to have "record-breaking aerodynamics" in the November 2015 issue of* Automotive Engineering *and at http://articles.sae.org/14347/. What the author of that article neglected to note is that Mercedes' claim to world-record aerodynamics for Concept IAA is specifically for a four-door, four-seat vehicle. We apologize for the omission of this detail.*

**-Editors**

## Most-viewed articles

The following are the top 5 most-viewed automotive-related articles of the month as of early December. Additional articles across all transportation sectors can be read at http://articles.sae.org/.

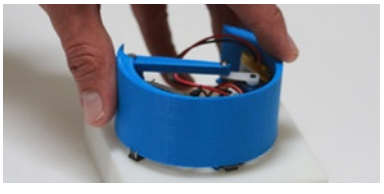



**1 Power struggle produces eSupercharger**
http://articles.sae.org/14433/

**2 BMW, Honda, and Yamaha form Connected Motorcycle Consortium**
http://articles.sae.org/14406/

**3 Elektrobit, Nvidia, and Infineon team up to tackle safety systems**
http://articles.sae.org/14352/

**4 A "drag" no longer: New vision systems close to replacing exterior mirrors at no cost penalty**
http://articles.sae.org/14468/



**5 Harman CTO discusses cutting edge HMI design**
http://articles.sae.org/14424/

# Converging electronics

The merging of automotive- and consumer-electronics technologies is accelerating. One aspect of this trend is the race to let drivers personalize vehicles as they do their consumer devices.

Underscoring the growing links between consumer and car technologies, automotive exhibits at the January 2016 Consumer Electronics Show in Las Vegas will see 25% growth in show floor space over 2015. CES 2016 will feature most major auto brands including **Audi**, **BMW**, **Fiat Chrysler Automobiles**, **Ford**, **General Motors**, **Hyundai**, **Mercedes-Benz**, **Toyota**, and **Volkswagen**.

According to Mark Boyadjis, Senior Analyst, HMI, **IHS Automotive**, there will be more than 460 automotive electronics CES exhibitors in areas including audio, robotics, sensors, telecom, wearables, and auto accessories. In a preview of the event, IHS execs identified key CES trends as HMI (human-machine interface) and user experience, software and security, automated driving, and artificial intelligence.

New HMI technologies include gesture recognition, augmented reality, eye-tracking—all intended to partially augment existing controls. Over-the-air software updating is an industry IHS expects to be valued at more than $35 billion by 2022, driving merger and acquisition activity among automotive suppliers and IT firms.

Automated driving prototypes and demos from OEMs and suppliers are expected to be running all over Las Vegas. Artificial intelligence, involving machine learning and neural networking, is spreading from the consumer to automotive industries.

The automotive presence will be headlined by top industry executives giving keynotes. GM CEO Mary Barra will discuss how her company plans to redefine personal mobility by enhancing the driver experience. The Chairman of the Volkswagen Passenger Cars brand, Dr. Herbert Diess, will reveal the latest "electromobility" developments and next generation connectivity from his company.

The OEM that might make the biggest splash at the show is **Faraday Future**. The new Chinese EV maker, which recently selected a site in North Las Vegas, NV, is expected to preview its luxury electric car that will compete with **Tesla**'s Model S and the upcoming wave of high-end EVs.

Check out our extended coverage of the 2016 CES at http://articles.sae.org/.

POWERTRAIN

# GM and TARDEC co-developing fuel cell powered Chevrolet Colorado for military evaluation

**General Motors** recently announced that its fuel-cell engineering team is working with **TARDEC** (the **U.S. Army** Tank Automotive Research, Development & Engineering Center) to develop a prototype pickup truck with a commercial hydrogen fuel-cell powertrain that is capable of meeting U.S. military duty cycles. The vehicle will be put into daily use and driven by soldiers for 12 months.

A **Chevrolet** Colorado is being converted to a fuel-cell vehicle (FCV) powered by a commercial hydrogen fuel-cell propulsion system. While the two organizations provided no details of the system, it is believed to be a higher-output variant of GM's fourth-generation fuel-cell stack similar to those used in the automaker's fleet of 100 Chevrolet Equinox FCVs.

That system, proven by about 5000 consumers in over 3 million mi (4.8 million km) of real-world testing in the Equinoxes, features a 97-hp (72-kW) electric motor with 236 lb·ft (320 N·m), with three spiral-wound cylindrical pressure tanks capable of storing up to 9 lb (4 kg) of hydrogen—good for 200-mi (322-km) range at 10,000 psi (690 bar). While the Equinox fleet used NiMH batteries, the military Colorado FCV is expected to use a pack based on Li-ion cell chemistry.

**A Colorado 4x4 is serving as the development base for a fuel-cell vehicle capable of meeting U.S. military durability requirements.**

"Hydrogen fuel-cell technology is important to GM's advanced propulsion portfolio, and this enables us to put our technology to the test in a vehicle that will face punishing military duty cycles," Charlie Freese, Executive Director of GM's Global Fuel Cell Engineering activities, said in a statement.

Fuel-cell powertrains offer excellent low-speed torque that military vehicle experts say is useful in off-road environments. They also deliver quiet operation and can

be used as a mobile power generator, making them attractive for both military and commercial applications. They also have a far lower heat signature than combustion-engine vehicles, so they're less vulnerable to heat-based target acquisition systems. And their only emission is water vapor—a byproduct that is useful in long-range desert operations.

"The potential capabilities hydrogen fuel-cell vehicles can bring to the 'warfighter' are extraordinary," observed Paul Rogers, the TARDEC Director. He said his organization's engineers and scientists "are excited about the opportunity to exercise the limits of this demonstrator."

GM since 2011 has been involved with a **U.S. Navy** program in which an Equinox proton-exchange membrane (PEM) type fuel-cell stack powers an unmanned midget submarine, called a UUV (see http://articles.sae.org/13909/).The UUV is being tested in open-water environments. The U.S. government pays GM for its technical contribution to the program.

GM and TARDEC have fuel-cell R&D facilities located in Pontiac and Warren, MI, respectively. The two collaborate to evaluate new fuel-cell designs and materials, and TARDEC's facility enables it to test and integrate fuel-cell systems it has been developing for more than a decade.

**Lindsay Brooke**

**BODY | AFTERMARKET**

## Aluminum welding: The next frontier for technicians

**Aluminum MIG welding requires technicians to learn new techniques, compared to steel MAG welding.**

For automotive designers and manufacturers, finding ways to increase fuel economy has become a primary—and increasingly complicated—goal. In the U.S., regulations now focus on a requirement that every automaker achieve a corporate average fuel economy (CAFE) of 54.5 mpg by 2025. Such dramatic improvements once seemed impractical or impossible, but today they are the new reality for automakers.

In response to these emissions regulations and to the evolving preferences of consumers, automakers have generated a "Technical

Tsunami"—the waves of change resulting in new technologies and new materials like aluminum, magnesium, carbon fiber, advanced high-strength steels, and vehicle-wide proliferation of advanced electronics. Many of these require specialized training to repair. In 2015 alone, automakers introduced 142 new or redesigned vehicle models.

The aluminum-intensive 2015 **Ford** F-150 shed 700 lb (318 kg) compared with previous models. The drastic material change to the F-150, with its longstanding reputation as one of America's best-selling vehicles, caused the industry to stand up and take notice.

## Maintaining a standard of vehicle repair safety with aluminum

As progress has been made toward adopting aluminum for automotive structures, industry leaders have realized that, to keep aluminum vehicles safe, they must consider not just their manufacturing process but also their repair. Collision repair facilities needed to be confident that their technicians knew how to properly achieve complete, safe, and quality repairs on aluminum structures.

Technicians across the industry are learning the necessary new methods for working with aluminum as part of the **I-CAR** Welding

**Aluminum MIG welds, such as this fillet on lap weld, should always be visually inspected and destructively tested before welding on a vehicle.**

Training & Certification program.

Prior to the launch of the F-150, I-CAR and Ford Motor Co. worked together to create and make an I-CAR training curriculum for collision repair technicians. Historically, vehicles debut before the training begins. The F-150 structural repair training course FOR06 has become one of the most popular courses in I-CAR's history. In particular, the program emphasizes processes for welding, riveting, and rivet bonding aluminum vehicles.

## Welding aluminum—not difficult, just different

Welding aluminum is not more difficult than welding steel, but it requires a different mindset in a number of areas.

*Setup space*—One best practice that is often recommended by vehicle makers when repairing aluminum vehicles is to set up an environment separate from the steel welding area. The concern is that steel particles in the air could contaminate aluminum and possibly cause corrosion if exposed to water over time.

*Equipment*—When repairing steel bodies, technicians commonly employ MAG (metal active gas) welding, using a shielding gas that is 75% argon and 25% carbon dioxide—a mixture known as C-25. Aluminum, however, requires the use of MIG (metal inert gas) welding with a shielding gas composed of 100% argon.

**MIG welding equipment of pulsed-spray transfer is often recommended for aluminum welding.**

Argon is specified because it offers good cleaning action on the metal being welded. Aluminum materials immediately form a thin coat of aluminum oxide on their surfaces when exposed to air. Moreover, aluminum oxide melts at 3725°F (2050°C), while aluminum itself melts at 1200°F (650°C), so the aluminum would melt before its oxide covering does. The aluminum oxide must be removed, or the technician will be trying to weld through it, which is certain to produce a less-than-desirable weld.

**The I-CAR Aluminum Welding Training & Certification program is done in-shop with an expert I-CAR aluminum welding instructor.**

Technicians should use contact tips specifically designed for aluminum, with an oversized hole for the electrode wire. These tips are stamped with an "A" or "AL." Similarly, shielding gas nozzles must be larger than those used with steel to accommodate the increased gas flow.

Further, to avoid contaminating aluminum surfaces with steel particles, separate hand tools are often used. Cutting tools and abrasives should be dedicated specifically to aluminum as well to avoid cross-contamination.

*Preparation*—Before starting to weld aluminum, technicians need to remove any coatings from the surface and then wipe it clean with a solvent to eliminate any surface contamination. They should use sandpaper or a stainless steel brush to remove the aluminum oxide from the weld zone and clean the area again immediately before the welding operation begins.

*Technique*—Creating welds with aluminum differs from working with steel. Technicians should use the push technique, rather than the pull technique. This method enhances the ability of the shielding gas to clear aluminum oxide from the aluminum.

Also, the electrode wire should stick out farther from the welding torch, and the torch should be held farther back from the welding surface. Note that the technician should always use the electrode wire

recommended by the vehicle maker.

Typically, more amperage is required for welding aluminum than for steel, and the welding transfer method is different. When working with steel, generally the short-circuit method is employed so that, when the electrode hits the steel, it short circuits and breaks off. For aluminum, however, the preferred transfer technique is a pulsed spray in which the weld bead breaks off before it is sprayed into the molten puddle.

Whereas steel holds heat from the welding torch in one area, aluminum transfers the heat throughout the part. Because of this greater heat transfer efficiency and aluminum's low melting point, the welding speed should start slowly but then increase as the welding torch moves across the panel.

To avoid cold starts with aluminum, the technician should create a run-on tab or use a machine with a pre-heating feature. At the end of the weld, craters tend to form in aluminum, so the tech should activate an extra trigger pull when completing the weld, or make a run-off tab.

## The new frontier: What's next?

To master the curves in the road ahead, we need the right equipment, training, and qualified technicians—along with an appetite for learning. Given the dramatic changes in vehicles, it is imperative that the collision repair industry support a robust and earnest "Learning Culture," building businesses that treat learning and knowledge as strategic assets that need to be managed, developed, and maintained.

Once we understand the nature of this new road, we'll be prepared to enter the new frontier of aluminum welding, building an even better framework for approaching whatever game-changing material or innovation is sure to be down the road.

**Jason Bartanen, Director of Industry Technical Relations for I-CAR, wrote this article for *Automotive Engineering*. I-CAR is a not-for-profit education, knowledge, and solutions organization designed to support the evolving needs of the Collision Repair Inter-Industry.**

# TIME TO GET personal


**Artificial intelligence will be used as Visteon creates links between cell phones and dashboard displays.**

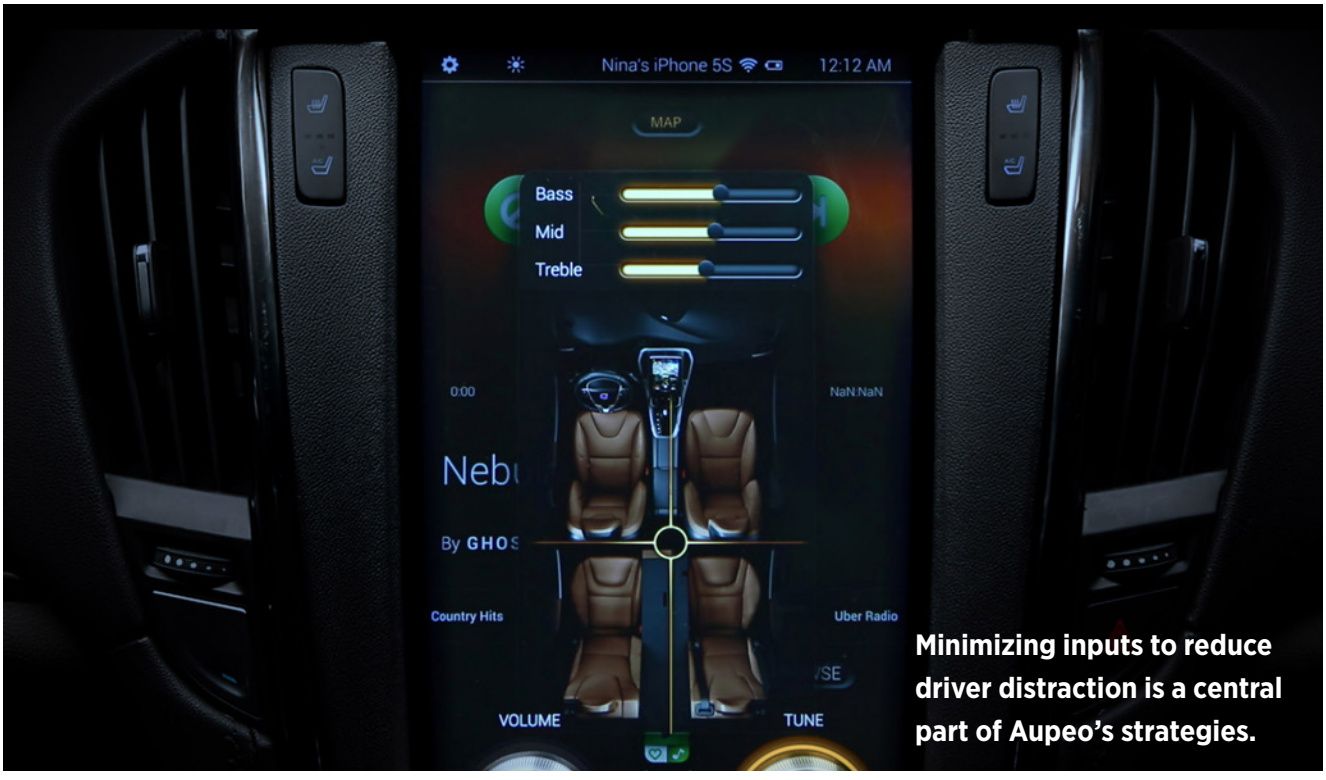
Industry engineers are combining apps, voice, the cloud, and other technologies such as artificial intelligence to enable drivers to customize their vehicles and anticipate their needs.

**by Terry Costlow**

The race to let drivers personalize vehicles is gaining speed. A range of techniques and technologies are being deployed to let drivers do more to make vehicles as individualized as their consumer environment.

Design teams are pushing personalization well beyond simple tasks like moving seats and picking radio stations to match instructions in key fobs. Apps and other techniques that personalize rental and ride-sharing vehicles are emerging, as are technologies that alter settings even when multiple people share a key fob.

"We work with a speech-recognition company that can tell the difference when




**Minimizing inputs to reduce driver distraction is a central part of Aupeo's strategies.**

you say 'hello, car' and when I say 'hello, car.' It can also prioritize when more than one known person is in the car," said Andrew Poliak, Global Director, Business Development for **QNX Software Systems**.

## Clouds and context

The scope of attributes that can be adjusted is expanding rapidly. A growing number of companies are using the infotainment system to combine context, such as vehicle sensor information, and the content, that includes information available through cloud services.

"The infotainment system's new role is to combine context and content to create value for the end user," said Olivier Charra, Senior Engineering Software Architect, Automotive Solutions, at **Wind River**. "We are moving away from an app-centric model to a user-centric model, with the ultimate goal being to actively present to the user the information he needs, at the right time, with the right level of abstraction."

Ultimately, vehicles should be able to learn parameters such as destinations. Simply altering routes as traffic changes won't be enough. For example, interconnected systems can determine that a typically solo driver needs to navigate to school before going to work.

"If seat sensors show you've got kids in

**MirrorLink can help drivers manage smartphone apps using vehicle controls.**

the car, it will switch the route," said David Taylor, CEO for **Aupeo**.

## Learning what's normal

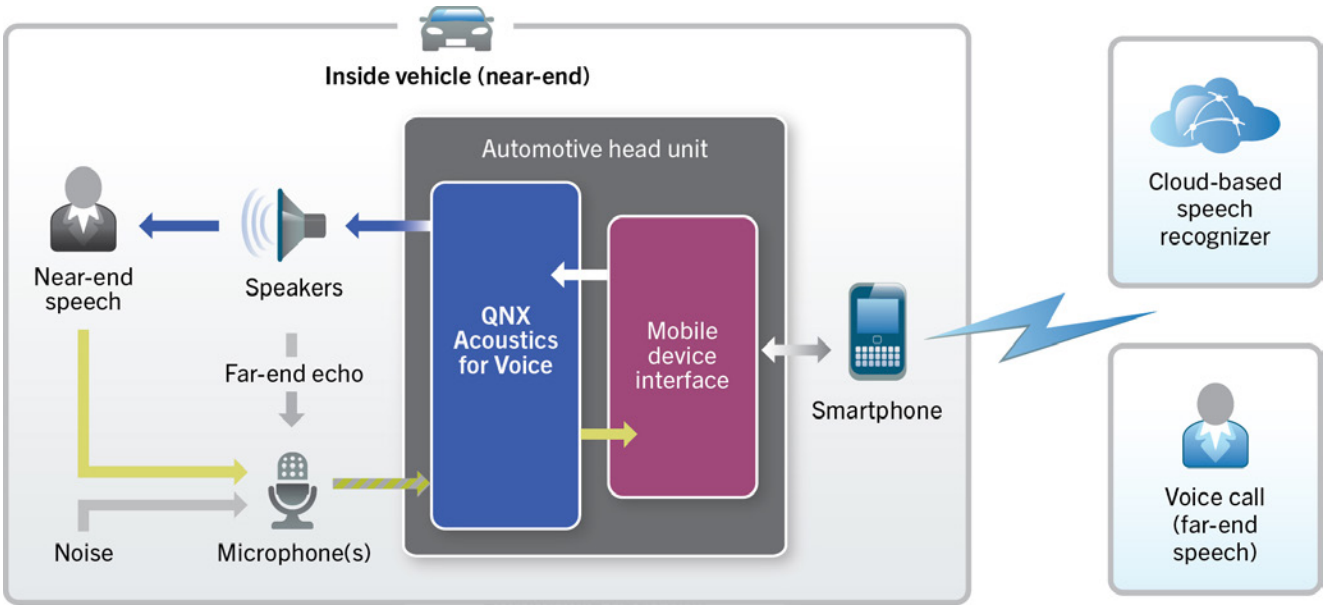
This requires a lot of software. Many design teams are creating programs that learn what drivers normally do and how normality changes so they know what might come next.

"Artificial intelligence could be leveraged to predict things such as radio and music preferences, destinations, routes, traffic alerts, reminders, and which contacts you might be likeliest to attempt to communicate with at any given time, just to name a few," said TC Wingrove, Senior Manager for Product Innovation at **Visteon**. "Whereas smart-key personalization would be limited to a small number of keys for a particular vehicle, app-based personalization could theoretically allow personalization on any vehicle that can interface with the app."

OEMs and Tier 1s who went through the early days of voice recognition may tread slowly before rolling out these advanced capabilities. Users expect high quality from vehicles. If systems mistakenly alter parameters, consumer satisfaction rankings may suffer declines similar to those seen when voice recognition failed.

"When vehicles do personalization, getting things wrong 10% of the time will be very annoying," Taylor said. "The 90% of the time it's right doesn't seem like that big a deal."

Vehicle systems will acquire some of the contextual information from the user ID. Each person's profile contains information such as subscription services related to music, navigation, traffic, or weather.




**QNX is using voice controls to activate profiles that create the vehicle atmosphere users want.**

Connectivity makes it possible for powerful servers to analyze data from vehicles, performing assessments that are more complex than on-vehicle systems can perform.

"Once the car becomes connected, it can basically interact with any service exposing an application programming interface in the cloud based on events or on information from the vehicle itself," Charra said. "The same way we transitioned from feature phones to smartphones, we'll transition from feature cars to smart cars."

## Wait, don't tell me

The industry is generally focused on offering users more options, but having too much information and too many options can be confusing for people controlling a vehicle. Aupeo's Taylor noted that in cars, less can be more.

**Software will be a primary element in personalization technologies. Source: QNX**

"We're moving to a level of personalization intended to help by removing unwanted information from the driver," he said. "If there are no delays on the route to work, there's no need to provide a traffic report."

# TIME TO GET personal

## Mirror, mirror on the dash

A range of technologies can help consumers carry their apps into their vehicles. However, this type of personalization remains clouded by issues like safety and access to vehicle networks.

The most seamless way to link apps to vehicles is through smartphone integration into the vehicle's head unit. A range of approaches makes this a fairly straightforward task for design teams. Some are available widely, others are designed to give OEMs more control over which apps run on vehicle displays.

"There are many current smartphone integration platforms, such as **Apple** CarPlay, Android Auto, and **Bosch**'s solution, mySPIN," said Christoph Wache, Vice President, Engineering, Car Multimedia for Robert Bosch. "mySPIN offers a wide variety of popular apps while providing vehicle OEMs the ability to independently build and white-label specific apps for their customers."

**Bosch is helping automakers bring a range of apps into the vehicle while still maintaining some control.**

Letting users do what they want without compromising safety is a complex challenge for all integration techniques. Many of them provide ways to approve apps that combine user-desired versatility without distracting drivers.

"Some of the alternatives have simplified approaches that limit flexibility," said Alan Ewing, President of the **Car Connectivity Consortium**, which created MirrorLink. "We don't care what a company makes or how they make it, as long as it's safe. We've certified around 16 compliant apps that are available across the industry, our automotive partners have white-listed around 55 apps that can be used on their vehicles."

Many suppliers are designing multiple screen duplication technologies into their systems. While this agnostic approach eliminates some issues, it increases the support challenges. If many OEMs opt for their own mirroring technology, support may become a problem.

"Apple's CarPlay and

The push to personalize vehicles with apps extends the industry's climb into the cloud. Most smartphone apps are basically user interfaces for cloud-based services. Vehicle systems may also use the power of remote servers.

"The actual service and its data are in a backend server in the cloud, with this service being in charge of the synchronization between all user interfaces," Charra said. "The part of the application actually running on the smartphone itself is fairly limited. That won't be different in the case of an infotainment system. The infotainment


**Common environments like Apple CarPlay and Google Android Auto can reduce complexity, Visteon's Wingrove said.**

Android Auto make it easier for developers because they are developing for two target operating systems (Android and iOS) versus developing for dozens of different vehicle manufacturers and standards," said TC Wingrove, Senior Manager for Product Innovation at **Visteon**.

App developers hope to increase their capabilities with broader access to in-vehicle systems. However, many automakers will be reluctant to open their networks to outsiders who haven't gone through the rigors of automotive testing.

"The existing actors, **Google** and Apple, are pushing the OEMs hard to expose more vehicle data to the smartphone," said Olivier Charra, Senior Engineering Software Architect, Automotive Solutions, at **Wind River**. "This will be somewhat limited for safety and security reasons, not to mention data ownership, which is a very important topic for OEMs as well."

Safety is a major concern for automakers, who may be held liable if drivers are distracted by apps displayed on the center stack screen. Many strategies limit access when the vehicle is in gear.

"MirrorLink distinguishes between driving and park modes," Ewing said. "People can search the Web or play a game in park mode, but not when they're driving."

Some automakers are expected to maintain control of the app space by eschewing direct links. Instead, they will approve apps that users can run on vehicle systems. Users can personalize their rides using only these apps.

"With embedded apps, OEMs control what apps can be installed on the head unit, and may or may not have app stores where a third-party developer can add an application for users to download," Wache said. "Typically, OEMs implement strict certification and testing requirements to enable applications from partners and third parties to be downloaded to the vehicle."

**Terry Costlow**

system will be just another interface to some cloud-based services."

While the cloud may eventually handle many facets of vehicle customization, radio head units will still need a fair amount of computing power. Cellular links haven't yet achieved automotive grade reliability.

"In an ideal world, most decisions would be made in the cloud," Taylor said. "Unfortunately, connections aren't always good enough, so data may only move between the car and cloud on intervals. Systems do need to be sensitive about the amount of data being sent, which does cost money." ■

# Sports cars take center stage in Tokyo

Mazda RX-Vision concept.

Once upon a time, the Tokyo Motor Show was considered one of the biggest. However, not anymore, in terms of its acreage, numbers of exhibit brands, and visitors; it is now dwarfed by such Asian aspirers as Shanghai, Beijing, and Seoul. The show's allure had hugely diminished when most of the foreign continents lost their Big Sight venue spots for a couple of shows after the Great Lehman Bros crisis.

The show was back in town this year, with the Japanese car, commercial vehicle, and motorcycle manufacturers, suppliers, and specialists returning to the arena with delightful and energetic vengeance. The country still ranks third in the world for new automobile sales (5.56 million in 2014), and the imports have been doing well with a relatively small share (5.2% in 2014) but lucrative business. The importers were back as well, notably with two extraordinary world premieres: one automated concept by **Mercedes-Benz** and the other an ultra-high-performance car courtesy of **BMW**. Prominently absent were **General Motors**, **Ford**, and the envy of the Japanese Four in the premium two-wheel segment, **Harley-Davidson**.

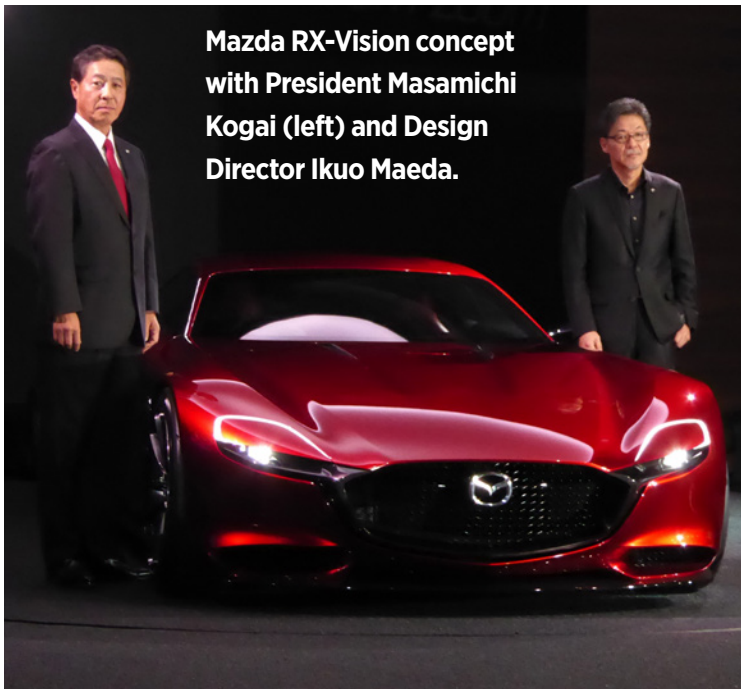
The show's prominent themes were sports cars (the subject of this article), automated driving, electrification, and boxes-on-wheel designs, sometime in combination in single vehicles.

The show opened with **Mazda**'s unveiling of the RX-Vision concept and the revival of its Wankel rotary engine, now officially named Skyactiv-R. The exciting two-seat coupe was shaped under the direction of

Ikuo Maeda, the Hiroshima company's Design Director extraordinaire. It is a mock-up with interior but fixed doors, with few technical details released, except dimensions of 4389-mm (172.8-in) length on a 2700-mm (106.3-in) wheelbase, 1925-mm (75.8-in) width, and 1160-mm (45.7-in) height, riding on 1454/40R20 front and 285/35R20 tires.

Few details were released on the Skyactiv-R engine that was not under the hood, which was so long that speculation was that the motor could have four or even six rotors. It is actually a two-rotor unit, its roots going back to the 16X unit circa 2007 in a curious Laurens van den Acker (now the **Renault** Design VP) era sports car concept. Later, the designation briefly surfaced at a technical workshop but on the screen only.

Mazda's rotary research and development continued after the end of RX-8 production, with some 40 engineers and technicians, according to Hiroharu Akagi, then Deputy Director of Powertrain Development for the rotary and now responsible for Mazda's advanced powertrain research and planning. The 16X project even had a proper alphabetical progression that was not revealed. The numeral 16 indicated the engine's single chamber volume of about 800-cm$^3$ (times two rotors) vs. the last production 13B's 654-cm$^3$. No other internal dimensions have been released to date. The Skyactiv-R may be described in reciprocating piston parlance as "small bore, long stroke."



**Mazda RX-Vision concept with President Masamichi Kogai (left) and Design Director Ikuo Maeda.**

The rotary engine's three dimensions determine displacement: e for eccentricity, the amount of offset between the eccentric shaft center and the rotor center line; R for radius of generating radius, the distance between the rotor center line and the rotor apex; and b for width of the trochoid rotor chamber. Historically, b has been the variable, obtaining different single chamber capacities. The last production 13B twin-rotor and the 1999 Le Mans 24-hour winning R26B shared the same

Yamaha Sports Ride concept.

internal dimensions of e = 15 mm (0.59 in), R = 105 mm (4.1 in), and b = 80 mm (3.1 in). Mazda's first production engine that powered the 1968 R100 coupe had a single chamber capacity of 491 $cm^3$, with a 50-mm (2.0-in) b.

There was one oddball production engine called "13A," circa 1967, which had unique dimensions of e = 17.5 mm (0.69 in), R = 120 mm (4.7 in), and b = 60 mm (2.4 in) for a single chamber volume of 655 $cm^3$. The engine was placed in the front overhang and drove the front wheels; therefore, its short length was important.

Akagi said that the rotary team had arrived at an optimized set of internal dimensions, smaller axially (bore) and longer radially (stroke), while closely adhering to the proven epitrochoidal constant. Total length of the apex seals, three sets for each rotor, would be about the same as the production 13B, and a higher compression ratio could be employed, improving thermal efficiency.

On the RX-Vision sports car concept, Design Director Ikuo Maeda confided: "The project is ongoing, whatever powertrain it may employ," an encouraging but enigmatic observation.

As with **Nissan**'s mega sports car vision, the 2020 Vision Gran Turismo, **Sony**'s PlayStation has inspired and digitally helped many a product planner, designer, or race driver in the person's chosen path. Several automobile manufacturers are known to have joined forces and resources with Kaz Yamauchi and his **Polyphony Digital** game in creating racecars that


**Toyota S-FR concept.**

compete on digital tracks. The Nissan concept is the latest example, passionately and professionally created at the Nissan design studio. It is no surprise that the mockup, sans interior, has design cues of the current GT-R, and like the supercar, it is a 2+2 coupe powered by a Le Mans LMP1-type twin-turbo V6 and three-electric motor hybrid system not unlike that of the new **Acura** NSX. The body intends to incorporate a number of innovative aerodynamic features.

**Honda** is another company that has collaborated with Polyphony Digital, but not this time. Its latest concept, called Project 2&4, represents a synergy between two major units of Honda, the automobile and motorcycle design groups, and more significantly represented by two Americans from Torrance, CA, and Asaka, Japan. The sporting machine's hind end bears the automotive "H" and motorcycle "Wing" emblems. The 3040-mm (119.7-in) long and 1820-mm (71.7-in) wide mid-engine concept is built on a welded aluminum backbone chassis with racing type suspension all around. In its normal configuration, it seats one person, the driver in a "floating seat." Remove the panel on the other side, hang a similar seat, and voila!—a daring passenger may be accommodated as on a bike. The 2&4's motive power is provided by the Moto GP (Formula 1 on two wheels) 215-PS (158-kW) at 13,000 rpm, 999-$cm^3$ V4 that drives the rear wheels via six-speed dual-clutch transmission. The vehicle weighs all of 405 kg (893 lb).

**Yamaha** pulled a show surprise. The

**Toyota Kikai concept.**

Hamamatsu-based company has not sold a single car, yet it has played important roles in the design and development of sports cars, as early as 1960s all the way to **Toyota**'s LF-A supercar. Yamaha was commissioned many years ago to develop a sports coupe by **Nissan**. It was equipped with a DOHC inline six and all independent suspension. It ran superbly, according to Fumio Ito, Yamaha's ace Grand Prix motorcycle rider, who remarked that an MG MGA Twin Cam was no comparison. A row between the two companies' presidents put the project on the shelf. Afterward, Toyota approached Yamaha to design and develop a sports coupe that became the 1967 Toyota 2000GT. Nissan then proceeded with its own project, the **Datsun** 240Z.

In the nineties, Yamaha supplied Formula 1 engines of its own design and development to a few constructors, and planned to build a supercar powered by the type OX11 DOHC 3.5-L V12. A lone example, essentially a tandem-seating canopied F1/F3000 designed by Takuya Yura, was unveiled in London in May 1992. The project was aborted in an ensuing economic crunch.

Yamaha showed a city car concept called MOTIV at the 2013 Tokyo Motor Show, with a unique composite tubular steel and carbon-fiber construction conceived by Gordon Murray of Formula 1 fame. Yamaha applied that technology to this year's Tokyo Motor Show surprise, the Sports Ride Concept, a mid-transverse engine, two-seat sports coupe. Its exterior was designed by the young Korean designer Jeung Hyun Choul under the direction of the hugely talented and flamboyant (part-time pop musician) Dezi Nagaya, formerly with **Lexus** and Toyota. Nagaya is proud of Yamaha's motorcycle heritage, and the Sports Ride carries many design cues, a V-nose, and a plastic knee pad in the driver area. The car is compact, measuring 3900 mm (153.5 in) long, 1720 mm (67.7 in) wide, and 1170 mm (46.1 mm) tall, and it weighs only 750 kg (1653 lb). No mechanical details were announced, but not to worry, the powertrain department at Yamaha has produced a large variety of automobile per-


**Honda 2&4 concept.**

formance engines. Nagaya declared that Yamaha was very serious about getting this car to the marketplace.

Toyota presented its interpretation of a bike-like vehicle called Kikai, a translation of "machine." Lots of mechanical pieces are exposed except a central cage that accommodates three people, the central driver and rear/side passengers a la **McLaren**'s F1. Its powertrain is a Prius C-type 1.5-L engine/hybrid system mounted amidships. The steering-column-mounted selector lever and four circular gauges are nostalgic throwback features. Doubtful for the showroom because of its myriads of protrusions, unless it is classified as a bike (unlikely), it is a charming concept for the solid corporate citizen.

Toyota's small 2+2 coupe concept called S-FR, presumably short for Sports, Front-engine, Rear-wheel-drive, could be a perfect addition to the **Scion** range of youth-oriented cars. The popular formula for a sports runabout has outer dimensions that conform to Japan's small car category at 1695-mm (66.7-in) width, just under the 1.7-meter rule. It features independent suspension, not visible in the mockup, again presumably by McPherson struts all around. The classification's engine size is less than 2.0 L, which should be comfortable enough in this age of downsizing, likely a new 1.5-L inline four. According to an attending engineer, Toyota is aiming at a curb weight of 1000 kg (2200 lb) or less. The S-FR's rounded, no-crease bodywork and cartoony countenance are intentional, the said engineer confided.


**Nissan Concept 2020 Vision Gran Turismo.**

It had been a long time since the last non-Japanese world premier graced the Tokyo stage (e.g., **Audi**'s Avus and **Daimler-Benz**'s Maybach concept, the latter a heart-child of the company's Yokohama design studio). This year Munich and Stuttgart brought one each in the form of the sporty BMW M4 GTS and van-like Mercedes-Benz Vision Tokyo.

BMW's M4 GTS coupe is a serious performance machine, its sight squarely set on the racetrack, proclaimed BMW M GmbH. It cites a lap time of 7:28 minutes around the Nurburgring's Nordschleife. Or one could readily do a 0-100-km/h stoplight grand prix in 3.8 s, one's driving license permitting. Unique in the M4 GTS is an innovative water injection that hikes its DOHC Twin-power turbo 3.0-L inline six engine's maximum output by 16% to 368 kW (493 hp) and torque by 10% to 600 N·m (443 lb·ft) compared to the stock M4's. Water is injected into the cylinders above 3000 rpm. A 10-L (2.6-gal) tank is to be filled with a mixture of distilled water and anti-freeze at about every fifth fill-up of gasoline, according to the attending engineer. When the engine is turned off, water is returned to the tank, so no fear of freezing. There had been some precedence with water injection including in the **Saab** 99 Turbo and 1962 **Oldsmobile** F85 with Fluid-Injection Jetfire engine. BMW is offering 700 M4 GTS models.

**Jack K. Yamaguchi**

# 2017 Ford Escape gains major NVH, powertrain, connectivity upgrades

The 2017 Escape's front end is freshened with simplified sheet metal ahead of the A-pillars, giving it a unique "face" among the current pack of compact SUVs. Also new are grille shutters for improved aerodynamics.

**Ford**'s 2017 Escape gains a new "face" and many technologies under the skin, as part of a significant mid-cycle refresh as the compact utility enters its 11th year of production. This vehicle upgrade includes key investments in engineering and integration—in NVH reduction; two new EcoBoost engines; active grille shutters; adaptive cruise control; more connectivity/convenience features; a completely new front clip; new liftgate; HID headlamps and LED taillamps; and an electronic parking brake that frees up center console space. All are essential for Escape as it battles for the lead in a steadily growing and increasingly crowded market segment.

Escape sales exceeded 306,000 in 2014, putting it about 30,000 units behind segment leader **Honda** CR-V. In third place in sales is **Toyota**'s RAV4, at about 268,000 units. Toyota's North American General Manager Bill Fay recently told *Automotive Engineering* he's confident that RAV4 sales will top 300,000 units in 2016 and projects them to crest 400,000 when the Cambridge, Ont., plant adds the vehicle by 2019.

The first Escape sold about 180,000 units when it launched in 2005. SUVs overall currently generate 33% of industry sales in North America—5 million total vehicles in 2015—and Ford expects them to grow to 40% of overall sales by 2020.

"Beating Honda would be great," said

**Ford invested in an all-new steel liftgate to upgrade the 2017 Escape's exterior styling.**

Milton Wong, the Escape Chief Program Engineer, "but for the engineering team our most important task is listening to the customer." One major voice-of-the-customer upgrade is an extensive NVH attenuation package. It includes the addition of acoustic front side glass; improved windshield sealing; insulated A-pillars; insulated front doors; more aerodynamic exterior mirrors; a new 360° hood seal; front wheelhouse liner insulation; and increased underbody shielding.

According to Wong, the new Escape's active safety package was engineered and integrated "using our portable electrical system hardware and software modules" that the company is leveraging across vehicle platforms to increase scale and reduce cost. The CAN-bus-based electrical architecture, modified for 2016, now supports a suite of camera, radar, and ultrasonic (12 on the vehicle) sensors for the addition of adaptive cruise with forward collision warning, lane keeping and lane-departure warning, and active park assist with side sensing.

Ford's new Sync Connect, which debuts on the Escape, enables remote door-unlocking, engine start, and fuel-level checking via smartphone. The remote engine-start feature on any vehicle is controversial in Canada and Germany, where it is seen by some as wasting fuel and creating emissions in the name of comfort. Its presence on the new Escape may seem to conflict with the model's new stop-start system, Ford's first such application as standard equipment.

Wong promises the stop-start system will operate in a best-in-class, seamless,

**The new electronic parking brake opened up space in the center console area for more storage. The steering wheel is also new for 2017, as is the swing-bin glove box. The cluster carries over with minor changes.**

quiet, and rapid manner. The system includes a unique battery, auxiliary HVAC pump, enhanced starter motor, a battery-management sensor, and brake-pressure sensor. It restarts the engine in less than 0.5 s, he noted.

The stop-start system is fitted to 1.5-L and 2.0-L EcoBoost engines equipped with twin-scroll turbochargers and coupled to the 6F35 6-speed automatic transaxle. These engines will represent 90% of Escape powertrain mix, Wong said. The stop-start offers a 4-6% reduction in fuel consumption in urban traffic.

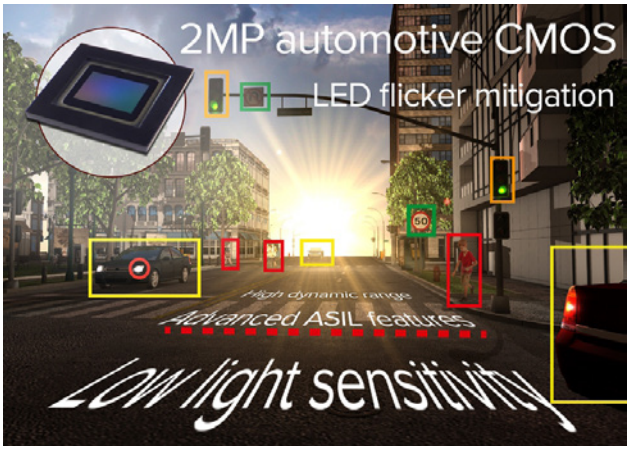
**SAE** power and torque ratings for the 1.5-L EcoBoost were not yet finalized when this article was published but are expected to deliver 180 hp (134 kW) and 185 lb·ft (251 N·m). The 2.0-L EcoBoost is SAE-rated at 245 hp (183 kW) and 275 lb·ft (373 N·m). It uses an integrated exhaust manifold that is optimized for the twin-scroll turbo. Ford also offers a naturally aspirated 2.5-L i-VCT as the standard engine. Wong argues that this is "for greater customer choice"; however, it is puzzling why Ford tolerates the greater plant complexity of the old 2.5 when it has the pair of more efficient EcoBoost units.

Other customer-pleasing features include hill-start assist (holds the vehicle stationary on a hill long enough for the driver to transition from brake to gas pedal); hands-free, foot-activated liftgate; and new linear-rate coil springs that replace the previous progressive-wound springs "for improved suspension control," Wong said.

**Lindsay Brooke**

# SPOTLIGHT: SENSORS

## CMOS image sensor




**Toshiba America Electronic Components**, Inc. has unveiled its newest CMOS image sensor for automotive cameras. The CSA02M00PB is claimed to be the industry's first 2-megapixel CMOS image sensor to be equipped with LED flicker (pulsed LED) mitigation circuit to minimize image flicker caused by LED light sources. When recording LED traffic lights and signs with conventional CMOS image sensors, the output image often flickers, hindering sensing accuracy. Toshiba designed the CSA02M00PB to curtail this flickering and deliver clearer images for faster, more accurate image sensing. The new sensor integrates Toshiba's next-generation High Dynamic Range (HDR) system and backside illumination (BSI) process, which together enable recording of high-precision images. The HDR system uses Toshiba's single-frame method to achieve clear images free of the degraded resolution and blown-out highlights typical of high contrast-light conditions. The BSI process makes it possible to shoot brighter pictures with higher image quality in low light conditions. The sensor meets the requirements of Automotive Safety Integrity Level (ASIL), a risk classification scheme defined by ISO 26262 (the Functional Safety for Road Vehicles standard intended to protect life), and support failure detection, report flagging and control of vehicles. It is also compliant with AEC-Q100 Grade 2 and is suited for both ADAS front-end sensing cameras and viewing applications such as e-Mirror and camera monitor systems. Image output ranges from 45 to 60 frames/s, depending on the HDR exposure condition. Housed in a 9 x 9-mm PBGA package, the sensor features full-HD output resolution of 1928(H) x 1084(V) and dynamic range of 120 dB (by Toshiba calculation) with HDR. The MIPI CSI-2 serial interface facilitates integration into end products. Samples of the CSA02M00PB CMOS image sensor will begin shipping in March 2016.

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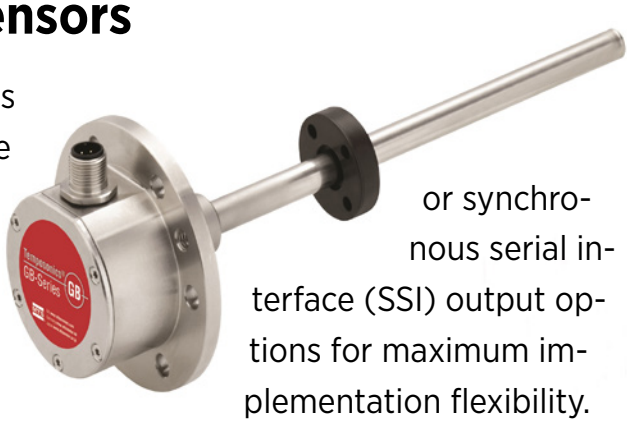
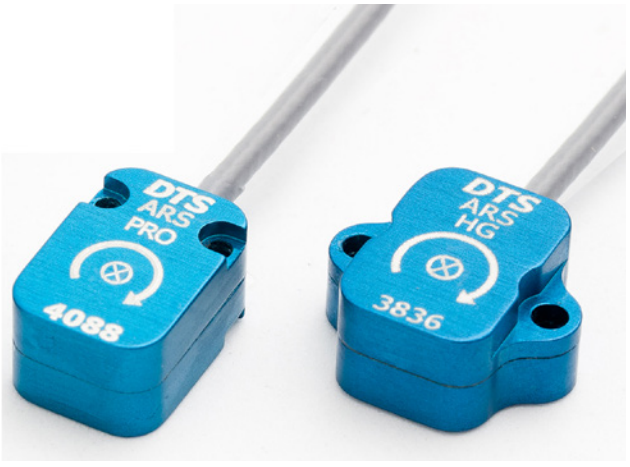
# SPOTLIGHT: SENSORS

## Magnetostrictive position sensors

**MTS Sensors** has increased the scope of its GB-Series of highly accurate, programmable magnetostriction-based linear position sensors so that further applications can be addressed. For these latest additions to the GB-Series (referred to as the GB-N family), the sensor rod (along with fitting flange) and the housing for the supporting electronics have a robust 1.4404 stainless steel (AISI 316L) construction, allowing their deployment in environments where there are corrosive media present. The GB-Series devices feature the company's proprietary Temposonics magnetostrictive technology. Supporting stroke lengths from 25 mm to 3.25 m (1 in to 10.7 ft), they deliver up to 1 µm resolution, ±0.005% (full scale) repeatability and ±0.02% (full scale) linearity. These sensors are available with either analog




or synchronous serial interface (SSI) output options for maximum implementation flexibility. Their operational temperature range spans from -40 to +90°C (-40 to +194°F). They have IP67-rated protection against water/dust ingress when supplied with an M12 or M16 connector. Alternatively IP68-rated protection is provided for cable outlet versions.




## Angular rate sensor

**Diversified Technical Systems**, Inc. (DTS) offers the ARS PRO high-performance angular rate sensor, which is designed for a range of applications including vehicle handling, crash, biomechanics, and even high-rate ballistics testing. The single axis ARS PRO is a silicon-based microelectromechanical system (MEMS) that uses a

# SPOTLIGHT: SENSORS

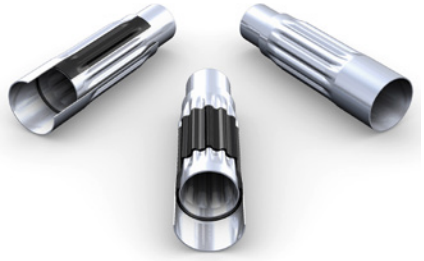
resonating gyro to measure angular velocity. Referred to as "ultra-small and rugged," its other key advantages include dc response, low power requirements, high output voltage, and shunt check capability. All models are linear over the rated range and comply with **SAE** and **ISO** recommended practices for frequency response in all applications. DTS offers full-scale ranges from ±300 to ±50,000°/sec and bandwidths up to 2000 Hz, fully supporting CFC 180 and 1000 testing requirements. The ARS PRO-1500 also is **NHTSA**-specified for FMVSS 2020a rear impact testing. DTS also offers the ARS HG with a 10,000 *g* shock rating—the highest in the industry, it claims—which features reinforced mounting points designed to withstand high energy test environments including blast and missile. All models are packaged in compact rugged enclosures and weigh 2.5 g (0.09 oz).

## Decoupling solutions for RWD and AWD

**TrelleborgVibracoustic** announces two new decoupling solutions for RWD and AWD vehicles that the company claims offer durability, weight, packaging, and tuning advantages. Decoupling elements in the driveline help attenuate noise and vibration by isolating torsional vibration occurring at the prop shaft. They also harmonize the torque ramp-up and compensate the axial displacement and cardanic angle. The NRG-disc (New Rubber Generation Disc) cord-reinforced elastomer coupling features specific cord packages for drive and overrun direction. The design uses different cord types, optimized winding processes, and rubber compounds, enabling any desired spring rate to be set in combination with special bushings to ensure axial force compensation. The coupling's design can be tuned to the customer's isolation and stiffness requirements without a change of geometrical dimensions. TrelleborgVibracoustic's tube-in-tube system replaces traditional flexible couplings and is suited for

**NRG-disc cord-reinforced elastomer coupling**

hybrid vehicles, particularly where installation space is tight. The system incorporates the functionality of a flexible coupling into a prop shaft with "virtually no additional packaging requirements," the company claims. With specific design customizations, the



**Tube-in-tube system**

tube-in-tube unit can also be used as a crash element, absorbing energy in a well-defined manner. Its special elastomer is suitable for use in extreme operating and ambient temperatures. The company is currently offering these solutions to its customers and could start production after validation, according to a spokesperson.

## LED matrix manager IC for adaptive headlights

**Texas Instruments** (TI) has introduced what it claims is the industry's first fully integrated high-brightness LED matrix manager IC for adaptive automotive headlight systems. The TPS92661-Q1 is a scalable solution that enables automobile manufacturers to create LED headlamps that vary beam patterns and intensity dynamically for optimum roadway illumination and enhanced driver safety. The TPS92661-Q1 is a compact solution for shunt FET dimming arrays of high-brightness LEDs and includes 12 individually controlled MOSFET switches to steer current through or around the connected LEDs, thereby providing individual pixel-level light adjustment. A serial communication port facilitates control and diagnostic functions from a master microcontroller, such as TI's AEC-Q100-qualified C2000 Piccolo. Headlamp beam forming and directional


control in an adaptive system previously required considerable board space to house discrete circuits, including multiple transistors, gate drivers, and glue logic; a single TPS92661-Q1 replaces this complex design, reducing board space by 73%, and enables a headlamp system that is completely solid state with no moving parts that can wear out, such as motors or actuators. The TPS92661-Q1 controls up to 96 LEDs from a single serial port and offers individual 10-bit pulse-width modulation (PWM) brightness control.

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Digital *Automotive Engineering*®, January 2016, Volume 3, Number 1. Digital *Automotive Engineering* (ISSN 2331-7647) is published 3 times a year by SAE International®, 400 Commonwealth Dr., Warrendale, PA, 15096. 
(ISSN 2331-7647 digital)
(ISSN 2331-7639 print)



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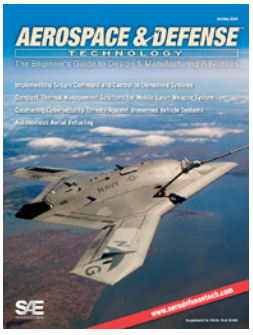


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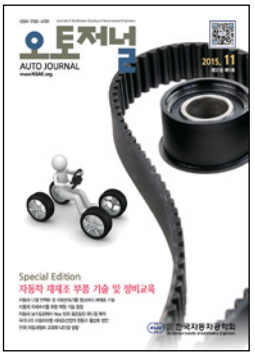


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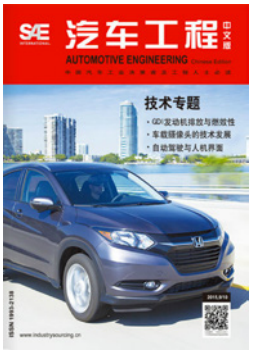


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