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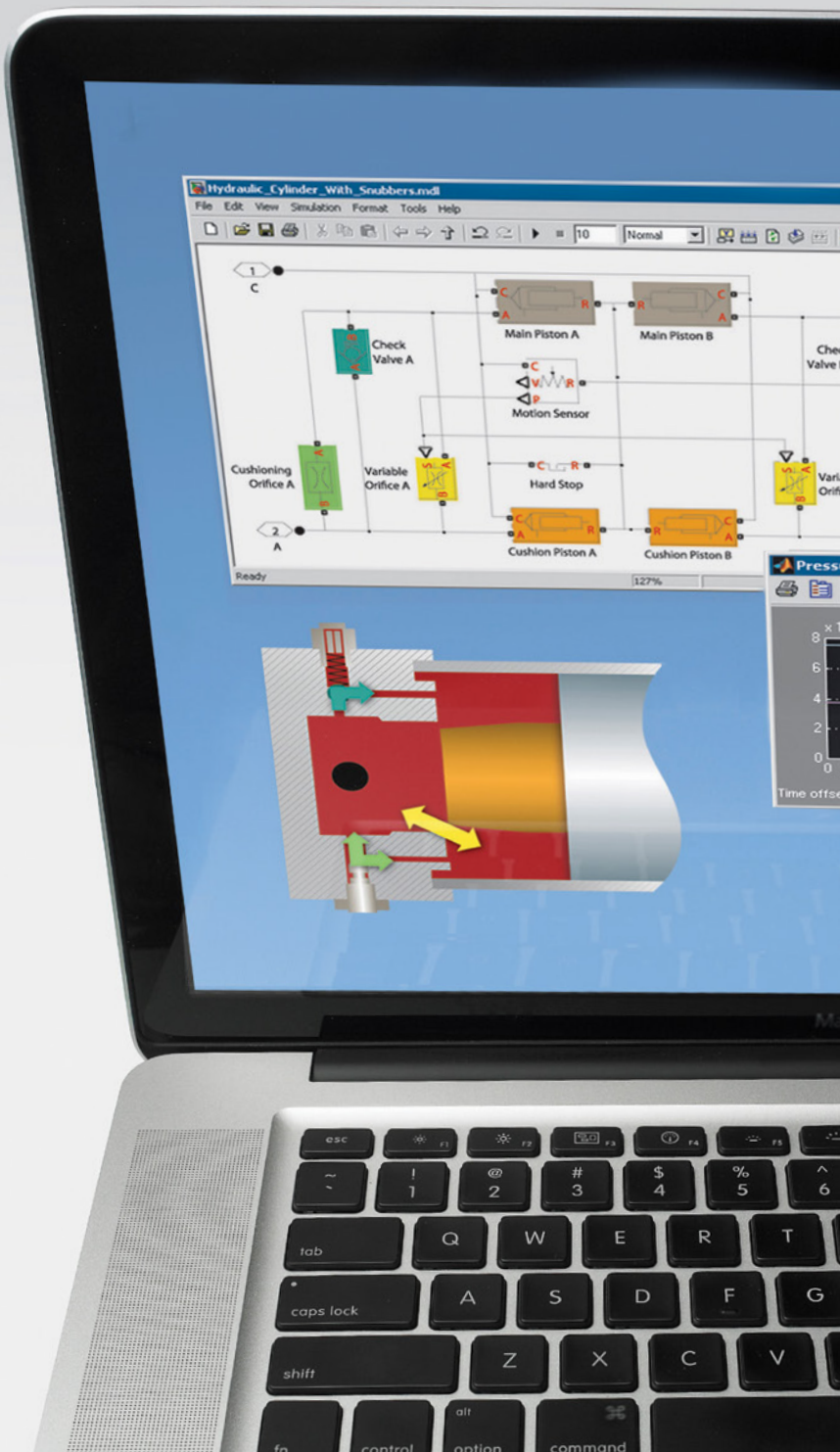

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CONTENTS

FEATURES

ON THE COVER

The Concept IAA is a world record-breaker for aerodynamics. Read about how Mercedes-Benz engineered a Cd figure of 0.19 in our "Active in aero" feature on page 14.

REGULARS

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EDITORIAL

Real-world efficiencies

Improved vehicle efficiency was one of the main themes of September's Frankfurt Motor Show. In this month's feature, "Active in aero," we report how **Mercedes-Benz** and **Audi** used the show to reveal concept vehicles that employ active aerodynamic elements and other advances to reduce drag.

Mercedes-Benz surprised show-goers with the Concept Intelligent Aerodynamic Automobile (Concept IAA). The concept is a world record breaker for aerodynamics, according to the company, with a Cd figure of 0.19. At around 80 km/h (50 mph), the vehicle automatically switches from shorter design mode to longer aerodynamic mode by lengthening its form with a number of active aerodynamic features. At the rear end, eight segments made of carbon-fiber-reinforced plastic deploy to extend its length by up to 390 mm (15.4 in), "substantially" reducing drag. Combined with deploying flaps in the front bumper and active wheel rims, the transformation reduces the car's Cd value from 0.25 to 0.19.

Audi showed the all-electric e-tron quattro concept, a five-door crossover technology study that is lower and more aerodynamic than the Audi Q5 and Q7 production models it could be slotted between. The e-tron's stated range per charge of more than 500 km (311 mi) is attributed in part to its aerodynamic design. Its 0.25 Cd would be a segment best if produced, according to Audi. Static aero refinements combined with electrically actuated aero elements on the hood, ahead of the rear wheels, and at the rear improve airflow to the 0.25-Cd level.

For decades, European-market OEMs have been at the forefront of aerodynamic design to enable efficient high-speed driving. European market automakers have also led in overall efficiency out of commercial necessity and government mandate for lower CO_2 emissions.

Experts at UK-based **Emissions Analytics** see U.S.-market OEMs getting closer to 2025 U.S. federal fuel economy targets by adopting approaches from Europe.

The **U.S. EPA**'s Corporate Average Fuel Economy target of 54.5 MPG, the equivalent of window sticker fuel economy of about 41 mpg, is a long way from current economy levels. The U.S. passenger cars and light trucks tested by Emissions Analytics currently achieve 24.9 MPG in real-world driving, so they could require a near two-thirds increase to reach the target. By contrast, European vehicles already achieve 36.8 MPG, but with a region-specific model and engine mix.

The U.S. could raise its sticker fuel economy by 4.6 MPG to 29.5 MPG by continuing the switch to smaller four-cylinder engines and other downsizing technologies, according to Nick Molden, CEO of Emissions Analytics. Adopting more direct injection and variable cylinder technologies could add a further 3.7 MPG to reach 33.2 MPG. To match the European 36.8 MPG, an additional 3.6 MPG could be achieved by adding more diesel engines to the mix. That leaves less than a 3-MPG gap to hit the target.

Molden says that "there is a race on in Europe to see if advances aimed at cleaning up diesel emissions will be sufficient to open up the CO_2 and fuel economy advantages of these powerplants, especially in light of significant under-reporting of NOx emissions by **Volkswagen**'s engine-management software. If not, further gasoline hybridization will be needed for the U.S. to get to its 41-MPG target."

The global vehicle-electrification market is expected to grow by 13% CAGR to 2019, driven by the North American and Asia Pacific regions, according to a recent study by **ReportsnReports.com**. The North American vehicle-electrification market is projected to grow at a CAGR of 16.4% from 2014 to 2019. Growth will primarily be propelled by increasing prices of conventional fuels, sales growth of electric vehicles, more stringent emissions regulations, and greater demand for engine downsizing and better fuel economy. In addition, governmental tax exemption and subsidy are expected to create better opportunities for electrification.

If most market-based drivers do not push U.S. consumers toward more efficient vehicle choices, government-incentivized boosts might be needed.

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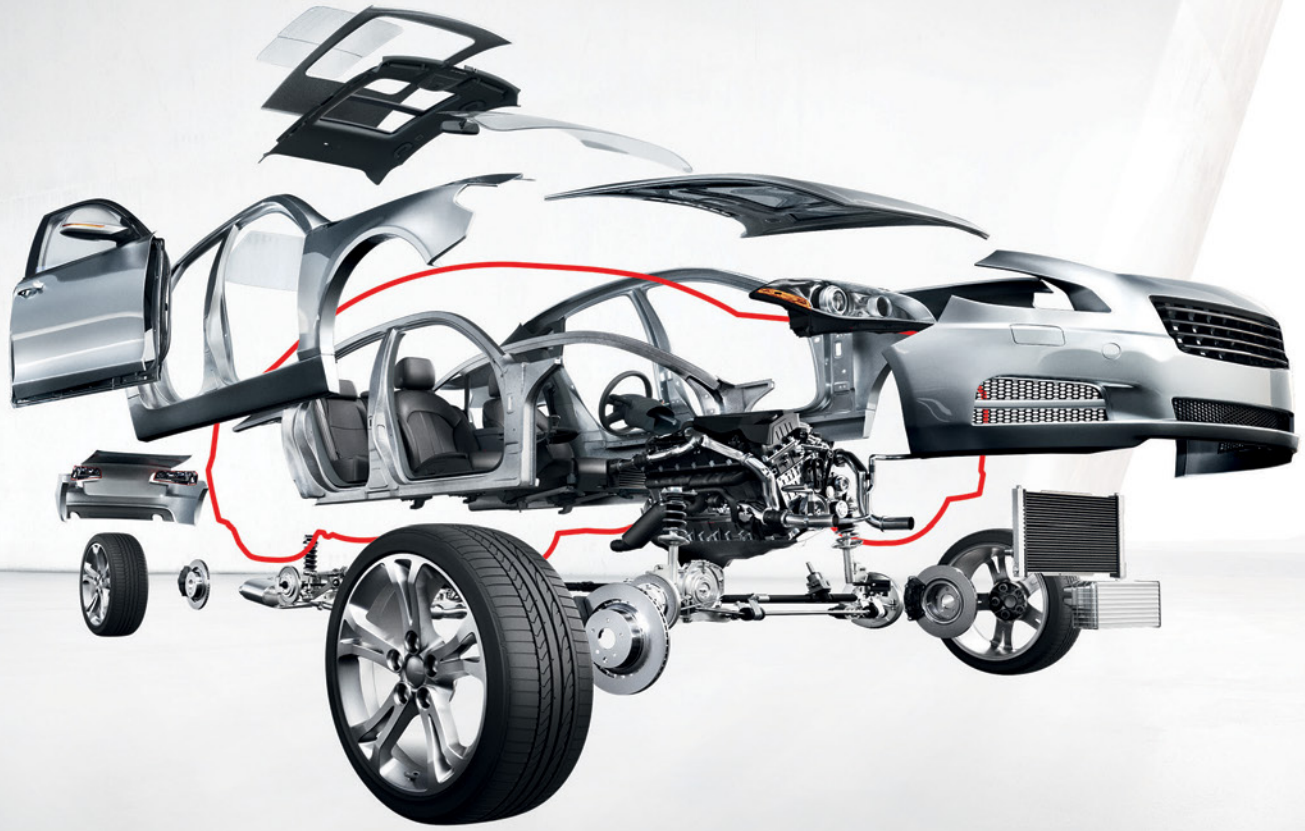

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ELECTRONICS

Can ads help in vehicle-to-vehicle rollout?

Xerox feels that advertising could help reduce V2X costs such as those for traffic management facilities.

During the long development of vehicle-to-vehicle/-infrastructure communications, collectively referred to as V2X, design teams looked at many ways to cover costs by using the signals for other tasks. But the long wait for a government mandate requiring V2X has reduced the options, leaving advertising as one of the few potential ways to impact costs.

A U.S. **NHTSA** (National Highway Traffic Safety Administration) study predicted that V2V equipment and supporting communications functions such as security management would cost approximately $341 to $350 per vehicle in 2020. Whether the safety benefits offset these costs is one of many questions facing the agency as it nears a decision in 2016 on whether or not to require V2X on all vehicles.

The automakers who may have to design these modules into vehicles are exploring ways to use the technology in different ways to amortize costs. The main role of 5.9-GHz dedicated short range communications (DSRC), the U.S. technology for V2X, is to send signals that will alert vehicles that another car is a potential threat.

Even though a mandate would put V2X on par with seat belts and airbags, strategists have explored ways to amortize or reduce costs. V2X modules were once viewed as a free communications link for firmware over-the-air updates, real-time traffic monitoring, and other tasks. But when no regulations were issued, cellular technology began filling these roles.

"If there's an alert for a traffic jam two miles ahead, why not use cellular?" said John Capp, Director, Global Vehicle Safety at **General Motors**. "For more immediate safety messages, DSRC is definitely the way to go."

As cellular chipped away at the applications base, it also knocked down the idea that V2X costs could be justified even without a mandate. Neither automakers nor car buyers are likely to invest in a technology that won't be useful until a large number of vehicles can talk to each other.

"DSRC will be free, but companies will have to invest in hardware," said Erik Coelingh, Senior Technical Leader, Safety Electronics & Functions at **Volvo**. "It's always difficult for customer number one to pay for something without gaining any benefit from it."

Some observers feel that advertising may be sent to vehicles to help offset some of the cost. That's especially true for vehicle-to-infrastructure communications, which will require roadside beacons. DSRC data may also be sent to data-processing centers. Ads could help pay for these installations.

"Many models rely on some form of advertising," said Joe Averkamp, Senior Director, Technology, Policy & Strategy, at **Xerox**. "You need to make sure it's subtle and not distracting."

DSRC has multiple channels, so it's possible that one could be used to send localized ads or other information. That will depend on how bands are allocated.

"Advertising questions are still unresolved," said Mike Shulman, **Ford**'s Global Driver Assistance and Active Safety Manager. "Seven DSRC channels have been allocated. Safety messages will go on one channel, things like traffic-light communications could go on another. An ad message channel has not been defined."

Some managers feel that advertisers will build an alternative infrastructure in the years before regulators mandate V2X and automakers start shipping equipped vehicles.

"There are other ways to do advertising that can happen sooner and are possibly less costly," Capp said.

Terry Costlow

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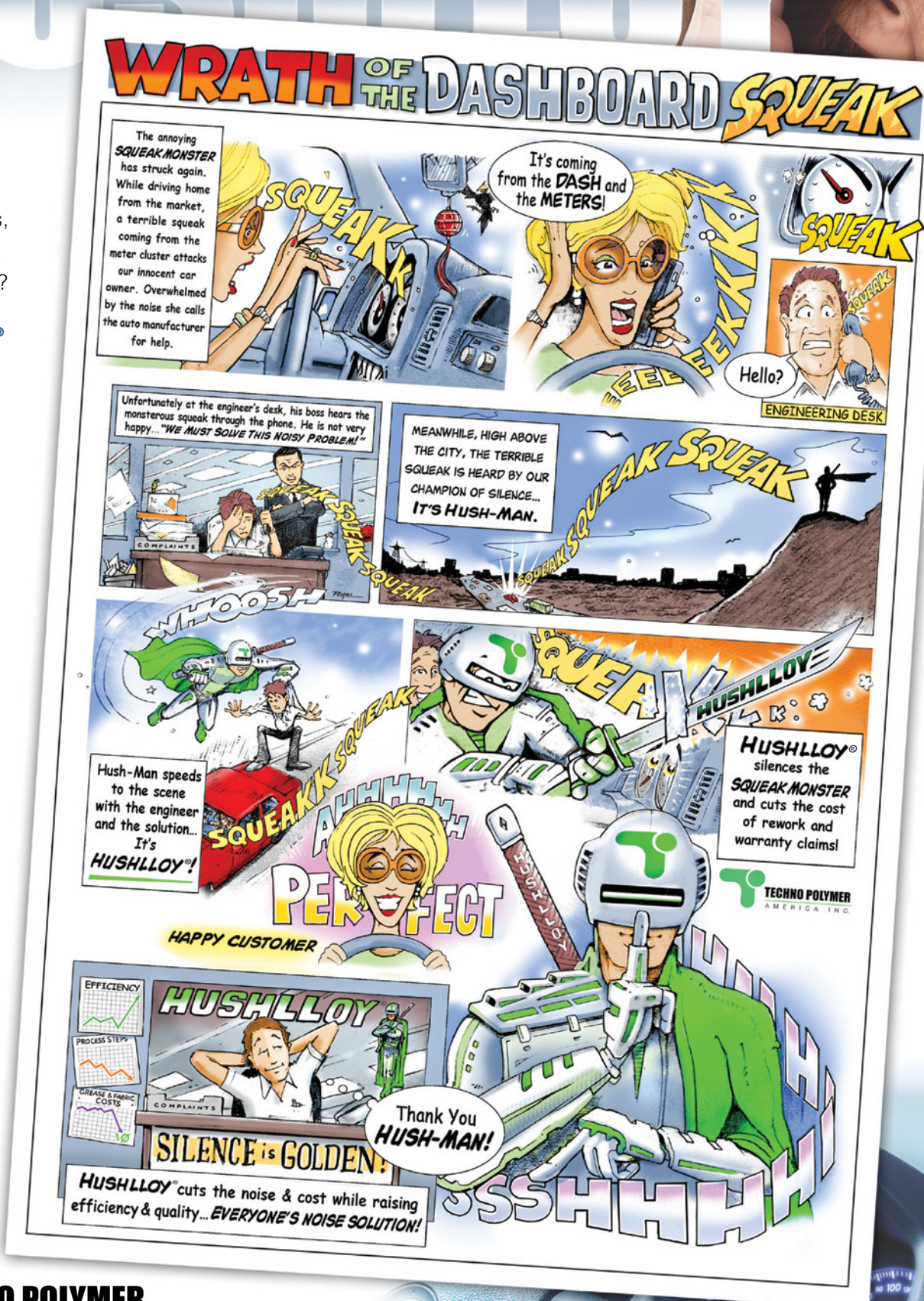

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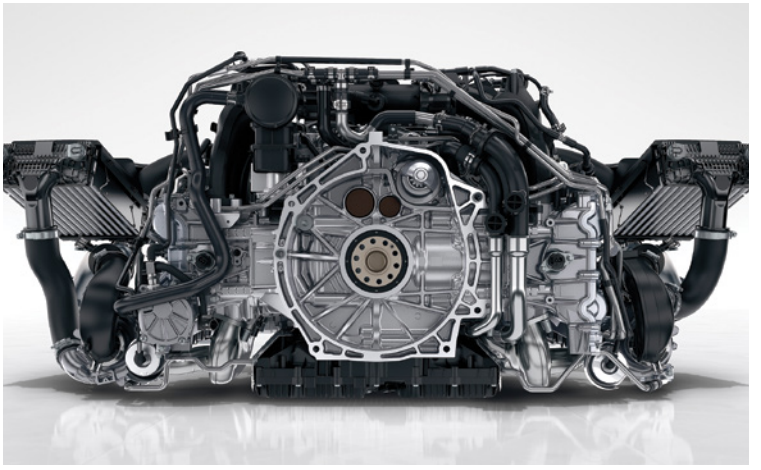
POWERTRAIN

Porsche unveils new downsized, boosted 3.0-L boxer six

Semi-ghosted view of the 2016 Carrera shows engine air-intake and exhaust gas paths, along with intercooler location. The all-new 3.0-L boxer six delivers 42% more peak power than the original 1974 Turbo of the same displacement, with significantly higher fuel efficiency.



The latest Porsche boxer six features plasma-coated cylinder bores, lighter crankcases, an engineered-plastic oil pan, and direct injection that operates at up to 250-bar system pressure. The water pump is now clutched and can remain disengaged at low coolant temperatures, for reduced friction.

The words "**Porsche**" and "turbo" have been synonymous with ultimate high performance since 1972, when the automaker first used boosted engines in the mighty 917/10 Can-Am racecars. For 2016MY, the company is introducing all-new turbocharged 3.0-L flat-six engines for the 911 Carrera and Carrera S road cars, replacing naturally aspirated (NA) 3.4-L and 3.8-L units. The 911 that carries the specific "Turbo" designation, however, will continue to use a 3.8-L engine.

The 3.0-L Carreras were unveiled at the 2015 **Frankfurt Motor Show**. The downsized-and-boosted "boxer" brings new levels of efficiency and added power; the Carrera gets an extra 15 kW (20 hp) taking peak output to 272 kW (365 hp). The Carrera S produces 309 kW (414 hp), also a 15-kW improvement. The new engines use two **BorgWarner** turbos, one per cylinder bank.

The S version of the 3.0 L features modified turbine compressors, a specific exhaust system and tuned engine management. Boost pressure is 0.9 bar (13 psi) in the Carrera and 1.1 bar (16 psi) in the Carrera S. The new engine also produces more peak torque—an added 60 N·m (44 lb·ft), delivered from 1700 to 5000 rpm, to provide 450 N·m and 500 N·m (331 and 368 lb·ft), respectively. Both variants are rev-limited to 7500 rpm.

Performance of both the Carrera and Carrera S is slightly improved, the S fitted with PDK (dual clutch) and Sport Chrono Package achieving a claimed 0-100 km/h in 3.9 s, and top speed of 307 km/h (190 mph). But fuel consumption and emissions are markedly better; the S with PDK achieves a combined figure of 7.7 L/100 km, an improvement of 1.0 L/100 km. Claimed CO_2 emissions are 169 g/km for the regular Carrera, 174 g/km for the Carrera S.

According to Porsche technology spokesperson Nick Perry, the new 911 models will not be badged "Turbo." He also explained that the very high performance 911 GT variants were a "separate topic" with regard to the application of turbocharging: "The current Turbo will continue to be described as that; the model offers a different image and attributes to those of the Carrera. We have turbochargers in the Panamera, Cayenne and Macan, but there, too, we use the designation Turbo for top of the range versions."

Inside the new boxer

Track-to-road technology transfer is a major element of Porsche's engineering creed but its racing 911s have NA engines to meet regulations. "The NA GTRS 4.0-L engine will continue to power our 911s in the motorsport realm," Perry explained. "But for road cars there is a multitude of criteria to meet, which is why we are introducing the new engine."

He described the new engine as a "step-change"—the 3.0-L being all-new and not a derivative of the 3.4 and 3.8 engines. The move is similar to when Porsche went to liquid cooling (1998MY) to reduce drive-by noise, improve performance and efficiency, running the engines hotter and achieving better combustion. Another step-change came in 2008 with the introduction of direct fuel injection.

Porsche is making no formal comment about the new 3.0-L turbo family forming the basis of engines for other models ranges including the Boxster and Cayman, but siblings can be expected.

The use of forced induction has required a new engine airflow system for combustion and intercooling at the rear of the Carreras. The engine gets its combustion air centrally in front of the rear spoiler. From two lateral ports on the air filter box, the airflow reaches two induction channels to the lower-mounted turbochargers. The compressed and heated air then flows through two intercoolers located laterally behind the wheel arches and onwards to the engine's induction manifold via the throttle plate. Two other ducts guide the air for cooling the heated combustion air (also from the air screen in the rear lid) to the intercoolers.

The 3.0-L's injectors are located in the

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Ghosted view of the MY2016 Porsche 911 Carrera Cabriolet.

Latest version of the 911 gets some minor styling changes including new headlights, but the big news is the 3.0-L biturbo engine.

center of the combustion chamber for greater combustion efficiency. They are fed by two fuel pumps, one per cylinder bank, operating on a system pressure of up to 250 bar (3626 psi). Variable exhaust-camshaft timing facilitates precise control of the charge exchange process. On the intake side, Porsche continues to use VarioCam Plus, adjusting both valve lift and opening duration.

A new cylinder wall coating process, in which a plasma beam coats the bore surface with iron, helps reduce friction losses, according to Porsche engineers. And extensive FEA analysis during the design process helped cut the weight of the aluminum crankcase by 1.5 kg (3.3 lb). A new engineered-plastic oil pan is 2 kg (4.4 lb) lighter than in the previous generation engines.

The water pump now has a clutch that is controlled by thermal management and can remain disengaged at low coolant temperatures. The deactivated pump no longer draws any engine power, and the coolant just circulates slowly. Friction is reduced and the engine reaches its operating temperature more quickly. The same applies to the air conditioning compressor; it can also be completely deactivated via a clutch.

Mode-switching drivetrain

Transmission developments include introduction of a two-disc clutch for the new engines for comfortable operation despite the new 3.0-L's high torque. And the PDK has new operating logic. As in the 911 GT3 and many Porsche racecars, pulling the selector lever back now provides upshifting; pressing it forward triggers downshifting. Porsche is now using a dual-mass flywheel with a centrifugal pendulum in conjunction with the PDK, as well as intelligent overrun cut-off and "virtual" gears.

The centrifugal pendulum is also used with the manual transmission. It has an adaptive vibration absorber that dampens vibrations in the drivetrain over a broad range of engine speeds, according to Porsche engineers.

In combination with the Sport Chrono and PDK systems, the 911 driver now has a "mode switch" which has an additional "sport response" button which activates a pre-conditioned drivetrain response which provides maximum acceleration for 20 s, the optimum gear engaged and engine management adjusted for optimum spontaneous response such as for overtaking.

Active rear-axle steering and suspension

Complementing the new powertrain developments, chassis changes for the 911 include active rear axle steering as an option for the Carrera S. The technology is adapted from the 911 Turbo and the 911 GT3 as well as the exotic limited-production 918 Spyder.

The active rear axle is designed to enhance the turn-in behavior of the 911 and reduces the car's turning circle by 0.5 m (1.6 ft). Porsche is offering a 360-mm-diameter (14-in) steering wheel that is 15-mm (0.6-in) smaller than the previous wheel.

Porsche Active Suspension Management (PASM) is fitted to all Carreras for 2016. It lowers ride height by 10 mm (0.4 in). An optional hydraulic lift system increases the car's ground clearance by 40 mm (1.6 in) via lifting cylinders in the front suspension struts to clear steep garage ramps and speed bumps.

Porsche states that introducing turbocharging for the Carreras was a logical next step in a technology path that began four decades ago. The original Turbo engine of 1974 had a claimed power output of 194 kW (260 hp) and consumed 20.9 L of high-octane gasoline per 100 km. By comparison, the new-for-2016 flat six-cylinder engine produces 42% more power with more than twice the fuel economy, while using the same cylinder displacement. Progress all around!

Stuart Birch

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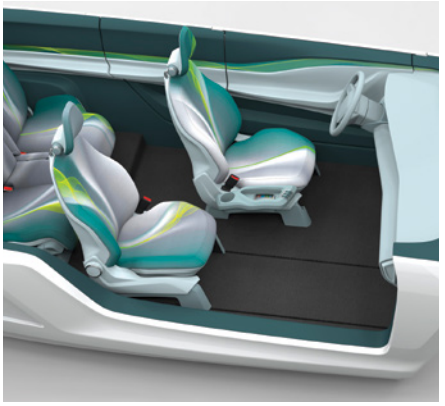
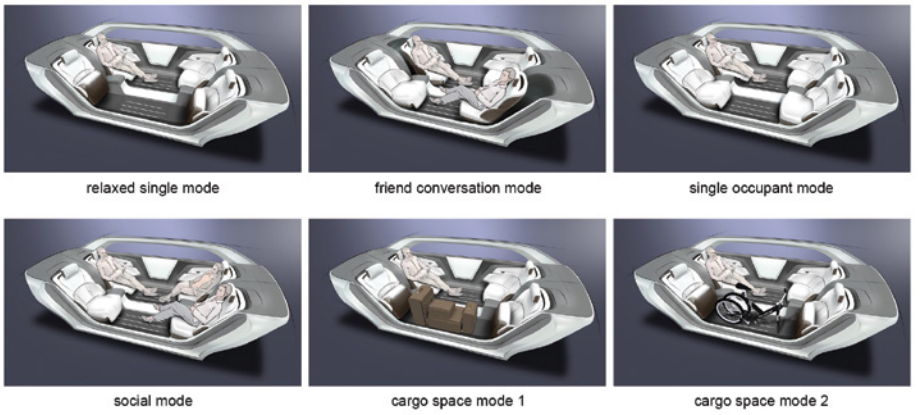
MOTION AND MOBILITY

INTERIORS

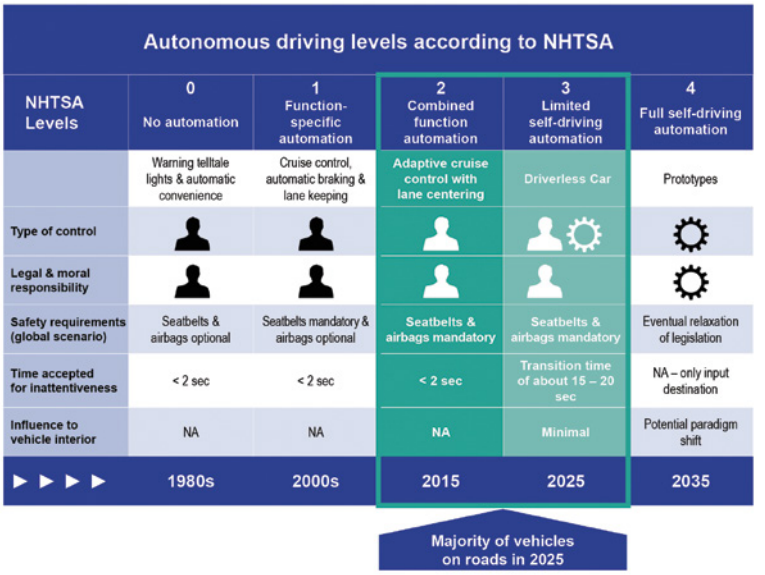
Johnson Controls, Faurecia envision interiors for autonomous driving



Johnson Controls' new SD15 seating demonstrator features a power driver seat mounted to a curved track, eliminating the need for separate, complex mechanisms found in conventional seat arrangements. A control console is mounted directly to the seat structure that moves with the occupant, offering wireless charging options for mobile devices.



Johnson Controls foresees the driver's seat becoming a "comfortable control unit" as additional assistance systems come on board.



"In the future, the role of the person in the driver's seat will shift from that of an 'active driver' to that of a 'supervisor' who must be able to intervene whenever necessary," said Johnson Controls' Dr. Detlef Jürss.

As the automotive industry moves to more autonomous driving, the requirements for vehicle interiors and seating will "radically change" as well, according to **Johnson Controls**. The supplier foresees the driver's seat becoming a "comfortable control unit" as additional assistance systems come on board. Company executives shared their vision of the forthcoming shift at the recent IAA (Frankfurt Motor Show) 2015.

"Autonomous driving is on its way," said Dr. Detlef Jürss, Group Vice President and General Manager Product Group Seating Components at Johnson Controls. "In the future, the role of the person in the driver's seat will shift from that of an 'active driver' to that of a 'supervisor' who must be able to intervene whenever necessary. The seat will become a multi-talented interior component that provides its strengths in safety, comfort, and entertainment."

But it's still a long way off until the vehicle takes over all control functions and the driver simply assumes the role of passenger, according to Jürss. Challenges that must first be overcome include details concerning the necessary investment-intensive infrastructure, liability and legal issues, ethical aspects (who do the safety systems protect?), technological feasibility, and safety.

"The seat will become much more of an integral part of occupant protection, which will be linked with all active safety systems within the vehicle," said Jürss. Anticipated features of autonomous-vehicle interiors include a driver's seat that can rotate to allow direct communication among passengers, or fully recline to a resting position. To enhance safety in such situations, seating components will be linked to the vehicle's entire network of sensors and be capable of interaction, according to Johnson Controls.

The supplier already has developed the first approved fold-flat rear seat structure—similar to a business class seat on an aircraft—for an automaker and is bringing it to series production. The product complies with automotive safety regulations thanks to sensor technology that raises the seat to an upright position in the event of a crash.

Increasing comfort and well-being is another major focus for seating in autonomous vehicles. The seat must be able to react independently to sensor-based evidence of drowsiness or tension—for example, with an automated alarm or position adjustments over longer distances such as a massage function or pneumatic side bolsters.

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Faurecia's Intuition demonstrator for autonomous driving stresses comfort and connectivity for the driver and other occupants.

Intuition incorporates a soft aluminum surface called DecoControl Alu, a monitoring and decorative zone set along the lower edge of the IP. Capacitive switches are integrated into the surface. Also note the "invisible" black screen located on the passenger side, shown here lit up in active mode.

"The seats of the future must offer the occupant, as a passive driver, all possible options for work, entertainment, and communication while traveling," said Jürss, citing the integration of tablet holders, reading lights, and headphones as examples. "We can also envisage making the unused front passenger seat more flexible, turning it into an additional mobile office or living space when unoccupied, and offering non-slip compartments for personal items, drinks, or electronic devices, which can also be charged wirelessly."

The supplier's SD15 seating demonstrator at Frankfurt showcased some of these solutions, which are already under development.

Johnson Controls is not alone in addressing what the interiors of autonomous vehicles might look like. **Faurecia** revealed at the Frankfurt Motor Show its Intuition demonstrator comprised of innovations enhancing onboard connectivity.

Faurecia already is finding that vehicle occupants want more autonomy and more opportunities to personalize their interior with seamless connectivity to the outside world.

"With Intuition, Faurecia is bringing not only better, but more intuitive, connectivity on-board vehicles," said Gherardo Corsini, Customer Marketing Director, Faurecia. "Though we've not yet seen fully autonomous cars, we're starting to develop the technologies needed to bring them to the road while offering passengers a preview of the innovations that will be part and parcel of the vehicle cabin of the future."

Automatic adaptability to the driver's situation is key. When a vehicle transitions to an autonomous mode, Intuition offers more comfort. Drivers can elongate their seat to relaxed mode while the center console slides back so the screen is always within reach. The screen also pivots toward the user for ease-of-use.

The ambience of the vehicle cabin also can adapt to the situation. For example, when the vehicle is in "partial hands-free mode" and the driver's seat is in the "relax" position, interior light settings can automatically change to provide a more soothing environment.

The design study also emphasizes the integration of personal electronic devices. Smartphone and tablet screens can be projected onto the center console's touchscreen to provide vehicle occupants access to mobile functionalities. Wireless charging stations, using induction technology, are located in the side doors, the glovebox, and the center console.

Another innovative feature of the Intuition concept is a "smart" decorative aluminum surface that forms a tactile dashboard, replacing traditional controls with touch-sensitive, integrated capacitive switches. Slight vibration and illumination are used to signal actions. Faurecia says it will increasingly employ this and other types of "infoskin" for switchless controls in its concepts and products. DecoControl Alu, as it's called, is expected to first appear on 2018 model year vehicles.

Invisible screens and high-definition screens are also incorporated. The supplier has developed black panel technology that's integrated with the instrument panel facing the front passenger. The screen remains invisible when not active, lighting up when in use. Located on the center console, high-definition, curved screens offer high image resolution and packaging freedom.

Intuition and all its features are ready for program development with automakers, Faurecia claims. The supplier foresees such designs and functionality inside the vehicles of 2020 and beyond—at the midpoint in the evolution of autonomous cars.

Ryan Gehm

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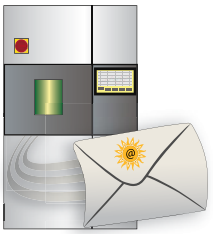

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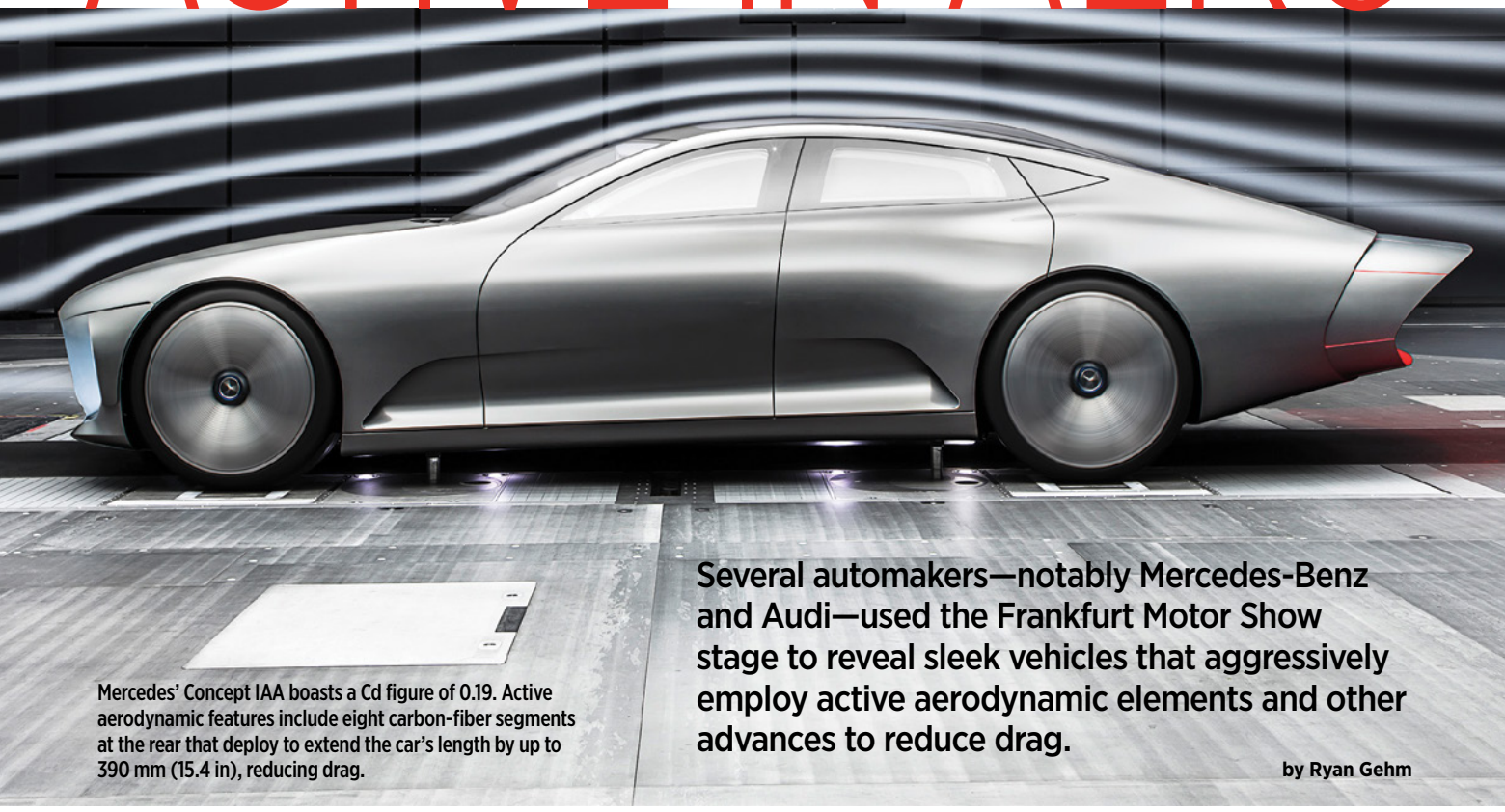

Mercedes' Concept IAA boasts a Cd figure of 0.19. Active aerodynamic features include eight carbon-fiber segments at the rear that deploy to extend the car's length by up to 390 mm (15.4 in), reducing drag.

Several automakers—notably Mercedes-Benz and Audi—used the Frankfurt Motor Show stage to reveal sleek vehicles that aggressively employ active aerodynamic elements and other advances to reduce drag.

by Ryan Gehm

Major international auto shows are a great venue for automakers to showcase their vision of the future for mobility. Manifestations of that vision are often gleaming, sculpted concept vehicles that push the boundaries of what is feasible—whether technically or economically—today. That is exactly what German automakers **Mercedes-Benz** and **Audi** did at the recent IAA (Frankfurt Motor Show) 2015.

Among its five world premieres in Frankfurt, Mercedes-Benz surprised show-goers with the Concept Intelligent Aerodynamic Automobile (Concept IAA), also referred to as the "Digital Transformer." The concept car is designed to show how far advanced Mercedes-Benz already is in the "digitalization" of automotive development and production, according to Dr. Dieter Zetsche, Chairman of the Board of Management of **Daimler** AG and Head of Mercedes-Benz Cars.

"The Concept IAA shows that the real and the virtual world are merging more and more at Mercedes-Benz," said Zetsche, speaking at the concept's Frankfurt Motor Show reveal. "Never before have we developed a vehicle concept as quickly as our Concept IAA. What previously took up to one and a half years, we managed in less than 10 months thanks to digitalization."

The four-door "coupe" is 5040 mm (198.4 in) long—5430 mm (213.8 in) long when in "aerodynamic mode" (see below)—1995 mm (78.5 in) wide, and 1305 mm (51.4 in) high. Its wheelbase measures 2975 mm (117.1 in), and the front/rear track widths are 1710 and 1770 mm (67.3 and 69.7 in), respectively.

A gasoline/electric plug-in hybrid drive with a total output of 205 kW (275 hp) provides the concept car with an electronically limited top speed of 250 km/h (155 mph). In aero mode, the vehicle manages an all-electric range of 66 km (41 mi) and emits 28 g/km of CO_2. In shorter "design mode," the range is 62 km (38 mi) and CO_2 emissions are 31 g/km.

Record-breaking aerodynamics

The Concept IAA is a world record-breaker for aerodynamics, according to Mercedes, with a Cd figure of 0.19. At around 80 km/h (50 mph), the vehicle automatically switches from design mode to aerodynamic mode, changing its form with a number of active aerodynamic features.

At the rear end, eight segments made of carbon-fiber-reinforced plastic (CFRP) deploy to extend its length by up to 390 mm (15.4 in), "substantially" reducing the after-flow zone behind the vehicle and thus drag. Flaps in the front bumper extend outward by 25 mm (1.0 in) and rearward by 200 mm (7.9 in), improving airflow around the front end and the front wheel arches. The fin in the front bumper retracts by 60 mm (2.4 in) to improve flow along the underbody. In addition, active wheel rims change their cupping from 50 mm (2.0 in) to zero—from five-spoke to flat-disc wheels.

As a result of this transformation, the Cd value improves from 0.25 to 0.19. The frontal area totals 2.16 m^2 (23.3 ft^2). Because the downward slope of the concept car's roofline begins further toward the front, designers incorporated two "rises" over the rear seats to offer the rear passengers sufficient headroom.

In aerodynamic mode, the Concept IAA manages an all-electric range of 66 km (41 mi) and emits 28 g/km of CO_2.

Active wheel rims on Concept IAA change their cupping from 50 mm (2.0 in) to zero—from five-spoke to flat-disc wheels.

Aerodynamic optimizations for the Mercedes concept include windows that fit flush on the outside, a blue LED touchpad instead of door handles, and lowering of the chassis, resulting in a ground clearance of 100 mm (3.9 in).

Other aerodynamic optimizations include windows that fit flush on the outside, a blue LED touchpad instead of door handles, and lowering of the chassis, resulting in a ground clearance of 100 mm (3.9 in). The underbody paneling partially covers the center tunnel, with perforations to allow cooling of the exhaust system, and extensive cladding on the rear axle. Cameras in the side air outlets behind the front wheel arches project images onto the split-screen rearview mirror in the interior, making exterior mirrors unnecessary.

As on the new C-Class, an adjustable radiator grille shutter (air panel) helps to reduce drag. When only low cooling requirements apply, the concentric louvers in the radiator grille are closed to prevent air from entering into the engine compartment. Basic ventilation then occurs primarily via the Mercedes star and the cooling air opening in the bumper.

The aerodynamic features were developed with the aid of numerical flow simulation. The automaker's aerodynamics experts used around one million CPU hours to simulate the airflow, working through around 300 variants. The work involved is roughly equivalent to that required to develop a production model, according to Mercedes. Fine-tuning then took place in the wind tunnel in Sindelfingen.

"The Concept IAA applies intelligent innovations to resolve the conflicting aims of functionality and aesthetics and shows that we still have plenty of ideas on how to achieve further improvements in efficiency," said Prof. Dr. Thomas Weber, Member of the Daimler Board of Management responsible for Group Research and Head of Mercedes-Benz Cars Development.

The concept car also is equipped with a large number of sensors and modules that enables autonomous driving and car-to-x communication. Inside, the Concept IAA continues the design theme of the S-Class and S-Class Coupe. New touch-based functions hint at what the interior of a business saloon might look like in the near future, Mercedes says.

The center console features a trim element of curved glass in which a touch display is integrated. This is where air-conditioning and seat-adjustment functions are operated, and where entry buttons for the different operating menus are located. The exterior aerodynamic elements can be controlled in a new menu.

ACTIVE IN AERO

The Audi e-tron quattro concept's 0.25 Cd owes not only to its low, elongated bodywork but also active aerodynamic elements that deploy at highway speeds.

Electric—and aerodynamic—future at Audi

Revealing its "concrete foretaste" of an all-electric, sport-luxury SUV due to arrive in 2018, Audi took the wraps off the sleek e-tron quattro concept at IAA in Frankfurt. (See http://articles.sae.org/14356/ for more on the vehicle including powertrain details.)

With elongated bodywork for a coupe-like contour, the five-door technology study is 4880 mm (192 in) long, 1930 mm (76.0 in) wide, and 1540 mm (60.6 in) high—"much lower" in height than the Audi Q5 and Q7 production models, between which the e-tron concept is slotted. The e-tron's stated range of more than 500 km (311 mi) is attributed in part to its aerodynamic design; its Cd of 0.25 would be a segment best, according to Audi, where SUVs' figures typically are more than 0.30.

Other "static" aero refinements to reduce drag include a sharp spoiler lip, optimized wheel design, and a completely enclosed floor pan with newly designed microstructures that "resemble the surface of shark skin," according to Audi. Another strategy, commonly seen (or more accurately, not seen) on concept cars, is the lack of side-view mirrors, instead employing discreet cameras that relay images to the driver inside the vehicle.

Also similar to the Mercedes Concept IAA, electrically actuated aerodynamic elements—located on the hood, ahead of the rear wheels, and at the rear—deploy at 80 km/h and above to further improve airflow through and around the e-tron.

In the hood, two seals with four louvers apiece regulate the flow of air through the thermal management components installed in the front end. The suction effect on the hood's surface makes it possible to reduce the electrical power of the fan.

At highway speeds the spoiler on the rear hatch extends by as much as 100 mm (3.9 in), thus elongating the separating edge. Concurrently, the diffuser extends to the rear. The targeted merging of the airflow from the roof with the underfloor airflow provides for positive aerodynamic effects, according to Audi.

In addition, electric motors in the side sills are activated, moving the rear segments of the strips 50 mm (2.0 in) outward so that air flows past the rear wheels.

The 0.25 Cd takes into account the active devices; Audi Communications could not share how much those elements improve drag. "The drag coefficient is determined not just by the basic shape, but also by the overall concept of the car and the exact design of the add-on parts," a spokesperson shared. "The basic shape offers an excellent foundation for this very low drag coefficient…The active aerodynamic elements are an integral part of the concept. The individual measures physically interact with each other and have been carefully developed as a package."

This design language was developed in close collaboration between designers and aerodynamics engineers, making extensive use of Audi's wind tunnel facility located within the factory area at its plant in Ingolstadt. For the e-tron concept, the development lasted a few months, according to Audi Communications.

The logical next question is, will any of these active elements make it into a production Audi vehicle? Answer: "The aerodynamic concept of the car was developed with a focus on series production," the spokesperson noted. "Some aerodynamic solutions you see in the concept car will definitely be found in the production vehicle. This depends not only on technical development but also on specific country regulations."

No further details could be provided, other than to say, "We will of course continue working on the aerodynamics toward series production." And so continues the quest to transform a vision into reality. ■

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BMW's new Carbon Core 7 Series buries its carbon fiber deep within its unibody to provide extra strength while reducing weight.

Composites permeate inside and out

Composite materials are gaining popularity for both unseen structural components and for exterior eye candy.

by Dan Carney

According to **Lux Research**, automotive use of carbon-fiber-reinforced plastics will swell to $6 billion by 2020, making the segment larger than the aerospace industry's use of carbon fiber despite the lower cost of automotive-grade parts.

"The onset of mainstream adoption in automotive will drive volumes that will dwarf other industries, but companies wanting a piece of that action will need to be positioned before the inflection point in the market, or pay a massive premium to buy in late," warns the Lux report.

With this in mind, carbon fiber supplier **Toray Industries**' **Zoltek** subsidiary plans to double the production capacity of its Jalisco, Mexico, plant to 5000 ton (4535 t) per year, staring in April 2016. Jalisco and a plant in Hungary produce large tow fibers, for which increasing demand for automotive structures will result in a shortage of production capacity by early 2016, the company says. Large tow fiber has 40,000 or more filaments and is suitable for the kind of reinforced plastic components commonly used in cars.

In response, Zoltek says it plans to double its current total production of 13,000 ton (11,800 t) of large tow fibers per year by 2020. Indeed, the Frankfurt Motor Show saw use of carbon-fiber materials accelerate into new applications, such as the structural reinforcement of the new **BMW** 7 Series' steel unibody, which the company has branded "Carbon Core."

BMW uses carbon fiber from its subsidiary **SGL Group**. "The use of our carbon fiber-based products in the new BMW 7 Series is another milestone in the large-scale serial application of carbon materials in the automotive industry," said Jürgen Köhler, SGL Group CEO.

Köhler also agrees with Lux Research's view of the value of getting a head start in this market. "This project also further underlines the great potential of carbon fibers for innovative automobile applications and demonstrates that SGL Group's long-term development of the entire value chain is paying off," he said.

Chopped fiber flexibility

Another application in the spotlight in Frankfurt was **Lamborghini**'s use of forged-composite components for the Aventador Super Veloce Roadster. Maurizio Reggiani, Lamborghini's Director of Research and Development, pointed to forged-composite carbon-fiber components on the car such as its instrument panel surround as an example of an emerging technology.

Benefits of forged composites, which use chopped carbon fibers rather than pre-impregnated fabric sheets, are cost and its easy formability into shapes, he said. "This is a low-pressure vacuum process instead of high pressure," Reggiani explained.

The resulting product is heavy and not as strong as conventional carbon fiber, in exchange for its lower cost and greater flexibility. But that doesn't mean that it is worse, only different, Reggiani insists. "In some cases, there are advantages," he said. For example, the random distribution of fibers produces unique, one-of-a-kind appearance for every part. "The appearance is really cool in some cases."

Lamborghini's forged composite technology is on display on this Aventador's instrument surround and is valued for its combination of light weight and unique appearance.

There is also the matter of tolerance of drilled holes for mounting components. A drilled hole cuts the strands in conventional carbon fiber, weakening it. That isn't a problem with the short chopped fibers of forced composites, Reggiani pointed out.

As Lamborghini gains experience with forged composite technology, it is able to reduce its weight penalty compared to conventional carbon fiber, he added. "It can be really close to the same weight with really good engineering."

Why go to the effort? Because the production time is so much shorter for forged composites, he said: "If you produce a monocoque in 100 hours, for example, it takes eight hours in forged composite."

Conventional success

Costs in conventional carbon fiber are falling, though. While it was once about $50 per pound, today the **Toho Tenax** carbon fiber used by **Chrysler** supplier **Plasan Composites** is down to about $8 a pound, reports Mike Shinedling, Viper program manager at **Fiat Chrysler Automobiles**.

Over time, the Viper has evolved from zero carbon fiber to mostly carbon-fiber bodywork, he explained. The car gained an available carbon-fiber wing in its second generation, then added some carbon

The Dodge Viper's shock tower brace is stronger and lighter thanks to its carbon-fiber construction.

reinforcements in the door frame and A-pillar area for the third generation. By the fifth generation, most of the exterior bodywork was carbon fiber, and this evolution has produced a car that is now lighter than those very first Vipers were.

"Any other car that has existed in that same time frame, the weight has gone up," Shinedling proudly points out. Between 100 and 120 lb (45 and 55 kg) of weight loss is attributable to using carbon fiber, he said.

While the carbon bodywork has helped whittle away weight, its

Composites permeate inside and out

This Covestro Baypreg cargo cover boasts strength and light weight.

Clemson University's Deep Orange project car relies on Dow Automotive Systems resins for its weight-saving resin transfer molding carbon-fiber bodywork.

strength was needed for applications like the rear wing and front splitter, which apply significant force to the car at speed.

Shinedling appreciates the appeal of processes with faster cycle times than the time-consuming autoclave process of prepreg carbon fiber. But the cost of tooling for those alternatives doesn't make sense for a low-volume vehicle like the Viper.

"We did look at faster cycle time processes, but it was a financial equation of the tooling cost versus the piece cost," he said.

But future programs may call for that, and the Viper team's experience with the material will be critical for Chrysler as it considers those possibilities, according to Shinedling.

"It has been a good test bed and training ground for us to expand carbon fiber to other vehicles when the time is right," he said. "I think having a vehicle like the Viper allows us to have a core team that is well prepared to execute on other projects that are maybe even medium-volume production."

Composite sandwich

The experts at **Covestro** (formerly **Bayer MaterialScience**) point out that there is plenty of weight to be saved inside cars, using materials like its Baypreg, which is a composite honeycomb sandwiched by fiberglass mats that can be used for parts such as sun shades and rear cargo load floors.

"One of the primary things that is on [OEM customers'] minds is weight," noted Nate Goshen, Industrial Marketing Manager for Covestro. "When you can save them 30-50% weight on a part, that gets their attention."

Additionally, handles and other attachments can be molded into the composite, saving on the number of parts and the labor to assemble them.

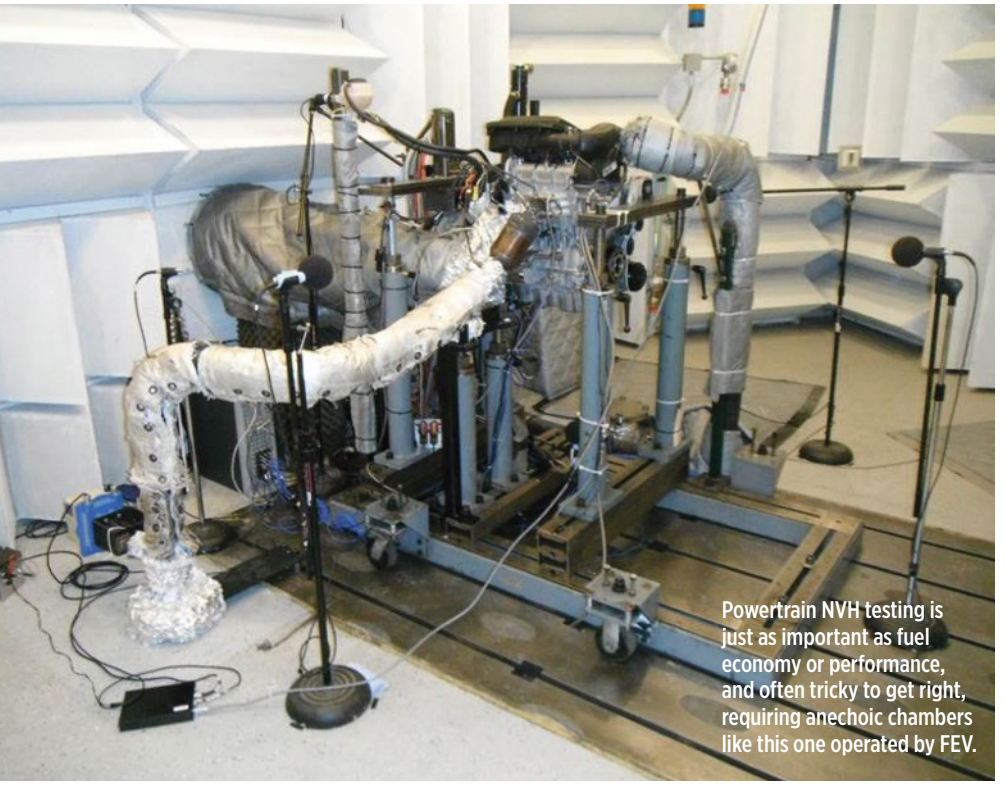
"You get a stiff, lightweight part that meets the requirements," Goshen explained.

Because Baypreg has many variables—the thickness of the honeycomb, the chemistry of the resin, and the weight of the fiberglass "bread" layers in the sandwich—it can be adjusted to meet varying requirements for thickness, weight, and strength.

"You can really tune this chemistry," said Goshen. Further, because it is thermoset, Baypreg isn't susceptible to heat-related degradation in service, he added.

With composites steadily encroaching on car construction from both inside and out, it is easy to see why market forecasts are bullish. ■

Powertrain testing: coping with complexity



Powertrain NVH testing is just as important as fuel economy or performance, and often tricky to get right, requiring anechoic chambers like this one operated by FEV.

With increasing use of electrical components to extend the performance of conventional combustion engines, powertrain development has never been more complicated. The good news is that test and development engineers are harnessing advanced simulation techniques and computer processing to develop the most efficient and fun powertrains ever.

by Bruce Morey

Despite the good news of falling oil prices worldwide, the pressure remains for automakers to deliver efficient powertrains.

"You can call it the road to 2020," explained Joe Strelow, Manager, Test Systems for **AVL**, in an interview with *Automotive Engineering*. "It not just regulations [such as CAFE in the U.S.]; there is a lot of new competition in the wings. I see a lot of renewed energy in the traditional OEMs to bring advanced technologies into their vehicles and generate the same excitement as new entrants to this industry."

That means powertrain consulting firms like AVL need to adjust both tools and practices.

"Not that many years ago, our business was built around three main components of the powertrain—the engine, the transmission, and a single control unit, typically for the engine," he said. Now it is based on five components. These include the engine and transmission as before, and now electric motors, batteries, and a complex network of multiple electronic control units, or ECUs, controlling individual components.

Just within a powertrain dynamometer test cell, this new world has meant changes. Combinations of electric motors working in synchronization with the engine mean multiple sources of torque that need to be controlled. Batteries now need sophisticated emulation.

"For example, no one cared about batteries before; now with the rise of 48-volt systems you need to simulate state-of-health and state-of-charge," he said. This is to understand durability and drivability on electric components like start/stop devices. "Having that thing start and drive away very cleanly and smoothly is a drivability issue that was not traditionally done on engine test beds," he said.

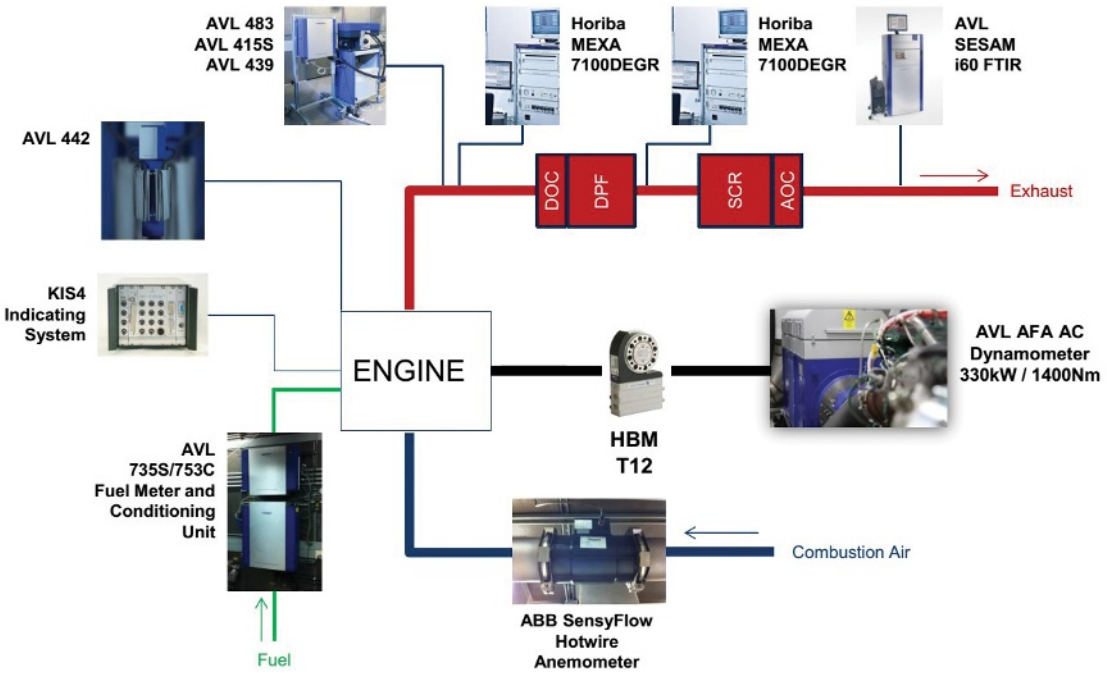
Simulation and testing—complementary intersection

One of the key elements in containing the growing complexity while reducing cost and test time is increasing CAE (computer-aided engineering) simulation, according to Strelow.

"There is a value point at the intersection where simulation and testing meet, and quietly AVL has put together the tools to satisfy a lot of these difficult development tasks," he explained. These include vehicle simulations as well as modeling driver behavior. "[We need to find out] how the car is going to pull away from a stop light when the driver just mashes his foot to the floor because he feels the car is not even running—he panics—versus the person who just eases away," he explained.

To help put driver behavior in the test cell, AVL developed parameterized driver models. Combined with sophisticated vehicle dynamics, their simulation system allows engineers to understand powertrains as they are installed on vehicles and used by drivers.

Powertrain testing: coping with complexity



A typical engine test cell, such as this one at the IAV facility in Northville, MI, is configured for both gasoline or diesel testing and development.

Joe Strelow from AVL noted that the need to develop and test powertrains today includes five basic elements: engines, transmissions, batteries, electric motors, and controls.

"Using simulation has always been around, but it has intensified," agreed Marek Tatur, Director of Test Operations for **FEV**, speaking exclusively to *Automotive Engineering*. The increasing power of software and computers now makes CAE simulation more effective than ever. "For brand new powertrain developments—clean-sheet development—we use plenty of CAE that includes combustion simulations, thermal simulation of operating fluids in the engine, and where possible, mechanical simulation mapping out mechanical and thermal limits," he explained.

As the development program progresses into test, simulation remains important—sometimes in surprising ways. Tatur noted that engineers always verify their CAE simulation results by comparing with test data. As you might expect, they do not always match. After decades of development, he finds that simulations are trustworthy, when correlated with high quality test data.

"Typically, if we are sure the input data to the simulation model is high quality and the test data do not match the simulation model, a problem with hardware components has likely occurred," he explained. "For example, it might be a malfunctioning turbocharger or some other critical component."

Performance increases—engines and computers

Another trend that Tatur observes with his customers is more interest in performance, somewhat in keeping

Ricardo opens new emissions research center

Ricardo opened its new Ricardo Vehicle Emissions Research Centre, or VERC, for development of next-generation of clean, low carbon vehicles in July.

The new facility built by **Ricardo** is capable of carrying out climate controlled tests with a temperature range of -30° to +55°C (-22 to +131°F) and includes humidity regulation. Configured for four-wheel-drive powertrains of up to 300 kW (400 hp) and capable of simulated road speeds up to 250 km/h (165 mph), it was built for a range of vehicles, from passenger cars to light trucks of up to 3 ton (2.7 t).

Of particular importance to Ricardo is the facility's focus on hybrid-electric vehicles and their associated energy regeneration systems and stop/start operation. Ricardo advertises that the facility's exhaust-emissions measurement systems are capable of testing to worldwide regulatory standards including the highest Euro 6/7 and U.S. SULEV standards. It features a triple constant volume sampler (CVS) tunnels. According to Ricardo, facilities of this type usually separate CVS tunnels for gasoline and diesel projects. The VERC additionally has a third tunnel exclusively for the very lowest SULEV emissions.

The vehicle soak space has been constructed as a series of independent climatic zones to ensure sub-zero soaked vehicles are maintained at their target temperature throughout their transition to the test cell and it also includes two integrated cold boxes with separate climate control.

Bruce Morey

Marek Tatur, Director of Operations for FEV, noted that, in testing for U.S. regulations, the OBD requirements are often underestimated, requiring attention during development and testing.

According to Mitch Monroy of IAV, his automotive customers require increased use of controls simulation to fully test today's automotive systems.

with lower fuel prices. Nevertheless, regulatory pressures on fuel economy remain. He observed that gasoline engines have made some remarkable leaps over the past years, with maximum torque levels meeting or even exceeding those of modern diesel powertrains.

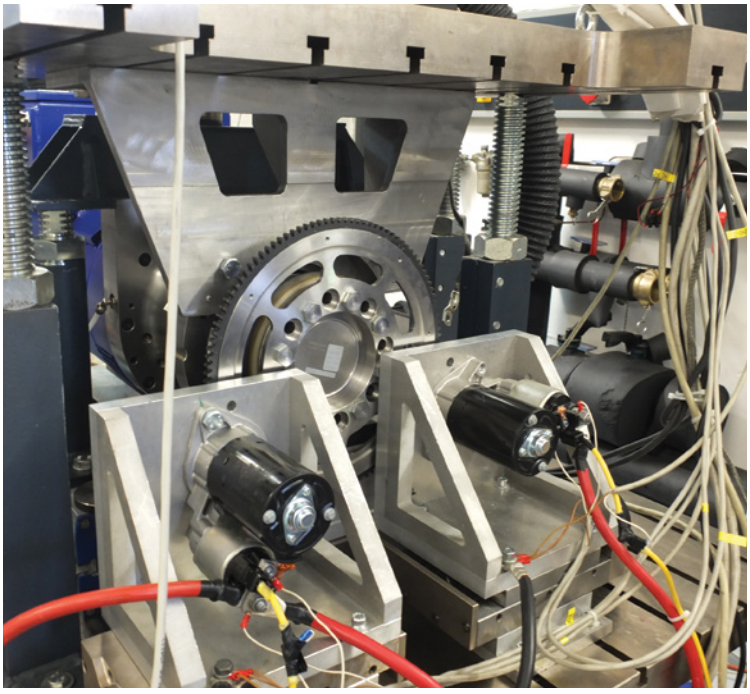
"We have observed a very clear trend towards increased power density. As the displacements of new engines go down, specific performance has gone up, for both gasoline and diesel," he said. "That means we have to adapt our test field accordingly, accommodating higher performance at the upper end of the scale, but still being able to accommodate low displacement engines that have very high specific power. They oftentimes exhibit large torsional vibrations that we have to account for. We have learned how to handle those by developing tools that use advanced multi-body system analysis focusing specifically on driveline layouts."

Tatur also noted that with the challenges in future tailpipe emissions regulations and onboard diagnostic requirements represent a growing demand on development cycle durations and equipment accuracy. With monitors tracking the performance details of both engine and aftertreatment systems, the ideal starting point is when the engine and aftertreatment systems are fully calibrated.

"However, the resulting product development duration is unacceptable," he said, requiring parallel development with HIL (hardware-in-loop)—or micro-HIL—based simulation.

Electronics and computers

This speaks to the importance of electronics in today's powertrain development programs, reflected in the primary degree held by Mitch Monroy, Business Unit Director for Test Services for **IAV**. His Electrical Engineering degree stands out among a field once dominated by mechanical types.



AVL developed a unique test stand for testing start/stop motors, reflecting some of the challenges and opportunities in today's electrified powertrains.

"I am more focused on electronics, especially the electronic control module, combining it with hardware and testing it as if it were in the car," he explained to *Automotive Engineering*. Besides delivering test stands for developing control systems to OEMs and Tier 1s, his group also helps develop models for the controllers, ensuring a proper balance between fidelity and speed. These test stands are in effect simulation laboratories, allowing customers to develop and optimize controller strategies and calibrations.

With increasing electrification of the powertrain, a big challenge (among many) is data communication between ECUs.

"There is an ECU for the powertrain, one for the ABS, ECUs for various body controls, the electric motor, battery—more than 50 for some luxury models," said Monroy. "All effect the powertrain today, and that communications is an area where the customer can get very concerned."

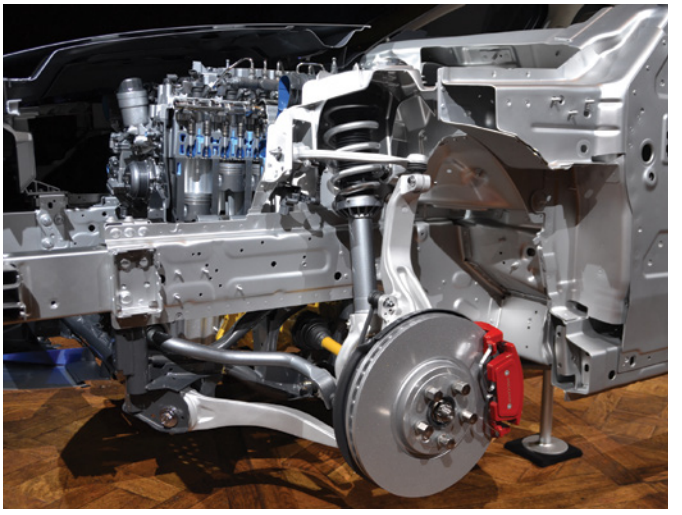
This is another reason why simulations, especially model-based simulations, are so important, according to Monroy, because of the opportunity it gives to run a significant amount of tests. "In a real vehicle that is more difficult to do in a timely and cost effective manner," he said.

Some key factors driving development of the systems Monroy sees goes beyond fuel economy, as important as that is. "Quality in terms of avoiding recalls," he said, alluding to a record year in recalls for 2014. "There is also functional safety, as new systems are all drive-by-wire, and onboard diagnostics as well," he said. "You do not want customers seeing diagnostic lights."

He summarized the importance of simulation test stands, such as those IAV delivers, fulfilling three functions of equal importance. The first is the obvious, testing control strategies. Just as important is the invention cycle, developing those strategies to meet engineering goals, make the driver happy, and create competitive advantage. The third is to simulate and duplicate faults that are difficult to recreate in real vehicles, avoiding recalls and solving them quickly when they do. ■

Jaguar enters performance crossover SUV segment

Jaguar Design Director Ian Callum introduces the F-Pace in Frankfurt. (All photos by Dan Carney)



The F-Pace is more than 80% aluminum by weight even using aluminum for parts like suspension castings and the B-pillar.

The first F-Pace vehicles to come to the U.S. will be powered by Jaguar's 2.0-L Ingenium turbodiesel four-cylinder engine.

In a bid to combat flagging market share due to declining consumer interest in its signature coupes, roadsters, and sedans, **Jaguar** is making its first move into the booming market for crossover SUVs. The 2016 F-Pace, shown at the 2015 Frankfurt Motor Show, is an aluminum-intensive "performance crossover," Jaguar's term for an all-weather, on-road-focused wagon with real handling on pavement and no pretensions that it is meant to conquer the Rubicon Trail.

Philosophically, this is similar to **Porsche**'s wildly popular Macan, a vehicle Jaguar used as a benchmark for the F-Pace. Jaguar calls its foundation the Lightweight Aluminum Architecture, which it shares with the XE and XF sedans. "We recognize that the dynamic benchmark in the segment is the Porsche Macan," acknowledged Vehicle Program Director Andy Whyman.

The company shies from the term "platform" with its implicit parts sharing because the F-Pace is 81% unique from its sedan siblings. The result is a vehicle that is 80% aluminum by weight, which is more than any other crossover SUV, said Kevin Stride, Jaguar XE Vehicle Line Director. Areas that are normally high-strength steel for its strength in crashes are high-strength aluminum in the F-Pace, including the B-pillar and the door-surround stamping. Shock towers are high-pressure die-cast aluminum.

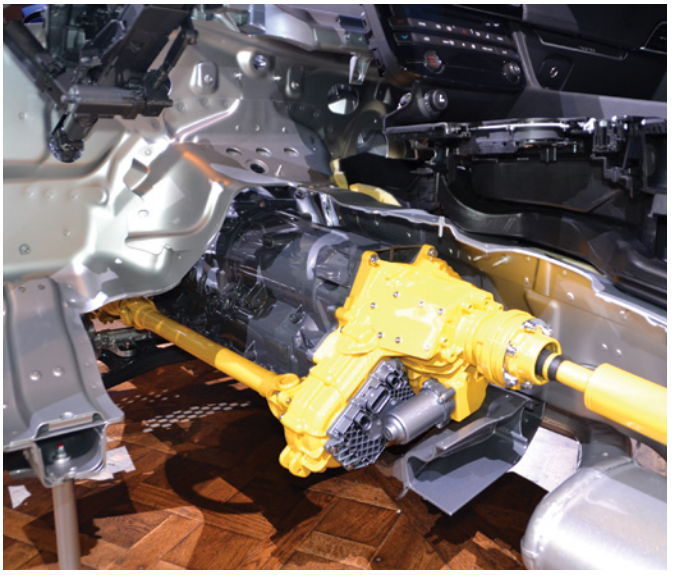
Jaguar boasts that one-third of the aluminum used in the F-Pace is recycled, and the goal is to raise this portion to 75% by 2020. This currently amounts to 30,000 ton (27,200 t) of reused aluminum annually. It should be understood that this refers to the company's reuse of its own scrap aluminum from its stamping facility, and not to the notion that discarded beer cans have found a higher purpose.

That's because most of the aluminum used in the F-Pace is a very specific RC5754 grade developed with **Novelis** for its strength properties. "We are working on using post-consumer material," Whyman said. Floorpan stampings are the most likely application for such recycled metals, he said. "Beer cans are similar to floorpan material," he explained. The structural aluminum is all high-strength.

Other innovative materials include the use of magnesium for a front frame crossmember as well as the common dashboard crossmember. And the vehicle's rear hatch is composite. The resulting body-in-white weighs 298 kg (657 lb), a mass comparable to that of the much smaller **Fiat** 500L's.

With 100,000 h of computer simulation time and 15,000 h of engineering work in the F-Pace's structure, Jaguar has been able to optimize its design to produce a vehicle that is 50% stiffer than the Macan in lateral stiffness at the front end and 35% stiffer across the rear, according to Whyman.

This stiffness, along with Jaguar's own software for the **Bosch** Automotive Steering-sourced variable-ratio electric power



The BorgWarner all-wheel-drive transfer case adds only 8 kg to the F-Pace over the 2WD variant.

steering system, contributes to the F-Pace's crisp steering response, he said.

Front suspension is double-wishbone and the rear is what Jaguar terms an "integral link" double-wishbone design whose castor properties contribute to stability during hard braking, said Whyman. It also provides increased longitudinal compliance to cushion the blow from sharp-edged impacts such as potholes. Dampers are **Bilstein** units. Another aluminum application is for the front steering knuckles, which are forged from cast aluminum blanks for maximum stiffness.

At launch the F-Pace will offer five engines, three of which will come to the U.S. market: a 180-PS (132-kW) 2.0-L turbodiesel four-cylinder, a 340-PS (250-kW) 3.0-L supercharged gasoline V6, and a 380-PS (270-kW) version of the same engine.

The Ingenium diesel engine employs variable exhaust cam timing to quickly heat the exhaust aftertreatment system on cold starts. The engine itself also warms quickly thanks to a split cooling system, variable water pump, and a mapped thermostat. The 1800-bar (26.1-ksi) common-rail injection system and variable-ratio turbocharger are complemented by a cooled low-pressure EGR system to produce minimal NOx.

The gasoline V6 engines are the same as seen in the F-Type sports car, but tuned for more tractable low-rpm response. World markets also get a 300-PS (220-kW) 3.0-L twin-turbocharged diesel V6 and a turbocharged 2.0-L gasoline four-cylinder engine of unspecified output. Company sources indicate that the gasoline four-cylinder will come to the U.S. later.

All engines are matched to **ZF** eight-speed automatic transmissions, though a six-speed manual transmission is available with the diesel four-cylinder in some markets. Rear-wheel drive is standard for the diesel, with optional all-wheel drive and the gasoline V6 models are all-wheel drive only.

The F-Pace's **BorgWarner** all-wheel-drive system is an evolution of that seen on other Jaguar models, one that sees the weight trimmed by 16% and internal losses reduced by 10%. All-wheel-

Jaguar worked with SuperAlloy on the wheels and Pirelli on the tires to ensure that the F-Pace's wheels have some protection against curb scrapes.

drive models weigh only 8 kg (18 lb) more than rear-drive ones.

Power reaches the road through wheels that are available in sizes between 18 and 22 in. The **SuperAlloy Industrial** Co. Ltd. 22-in wheels wear tires with higher sidewalls than those on competitors' vehicles, helping shield them from increasingly common impact damage.

New technology abounds inside the F-Pace, where there is a 10.2-in touchscreen infotainment display and a 12.3-in instrument panel that are powered by an **Intel** quad-core processor with a 60-GB solid-state hard drive. This promises quick, responsive pinching, swiping and scrolling, but Jaguar has retained a familiar rotary knob for volume control for the 17-speaker, 825-W sound system, unlike the interface in **Cadillac** and **Honda** models that rely exclusively on touch surface inputs and steering wheel controls.

All of the system's components are connected via gigabit Ethernet networking, making the F-Pace one of the very first vehicles to employ this technology. This seems appropriate because the F-Pace has a built-in cellular Wifi capability using a roof-mounted antenna for 30% better reception than that of a handheld cell phone, the company said. It supports as many as eight connected wireless devices at a time.

This cellular connection also lets owners connect to their car remotely using **Apple** iOS or **Google** Android smart devices to check whether the doors are locked, whether any windows are open, where the F-Pace was last parked, and the levels of fuel and windshield washer fluid. They can use the app to lock or unlock the F-Pace, start the engine, receive alerts if the alarm is triggered, and reset it remotely.

An innovative new system called Active Key is a **Flextronics**-supplied rubber wristband RFID system that the driver wears like a Fitbit activity monitor. With it, the driver can lock keys and valuables in the car and unlock it by pressing the Active Key to the letter "J" in the F-Pace's rear Jaguar badge. A **Delphi** onboard system communicates with the passive Active Key, so there is no battery in the wristband to discharge.

Four-cylinder diesel F-Paces reach U.S. dealers this fall, with gasoline six-cylinders arriving in 2016.

Dan Carney

Honda's all-new global 2016 Civic targets Mercedes refinement

American Honda Executive VP John Mendel introduces the all-new 2016 Civic sedan at a Sept. 16 media event in Detroit. (All photos by Lindsay Brooke)

Rear quarter view of the new Civic shows the C-segment sedan's larger proportions, sculpted body panels, and small quarter windows.

Honda appears to have committed the resources where it counted to create the 2016 Civic. With a 4-link independent rear suspension mounted on a subframe, hydraulic suspension-compliance bushings, increased use of NVH attenuation techniques, and a visibly significant upgrade in interior design, materials, and overall finish, Honda's 10th-generation Civic shows the automaker's seriousness in raising the bar in the global C-segment.

American Honda Executive Vice President John Mendel unveiled the Civic sedan—part of an all-new model range that will also include a 2-door coupe, 5-door hatch, sporty Si, and high-performance Type R—at media events in Detroit and L.A. on Sept. 16.

"In developing this car—the platform was signed off in early 2012—we targeted not just the best competitors in the Civic's segment but the best overall, regardless of segment. This was a very ambitious program," Mendel told *Automotive Engineering*. He said **Audi**'s A3 was the primary competitive bogey, along with the **Mercedes** CLA. Mendel frankly admitted that the incumbent Civic was a disappointment to the company, being widely

2016 Civic cockpit has improved ergonomics. Driver's H-point is 20 mm lower than previous model, with lower floor, IP, and engine.

criticized for its use of cheapened interior materials and a perceived loss of the fun-to-drive character that helped Honda sell over 40 million examples since 1973.

This also is Honda's first truly global Civic, sharing a common architecture, build process, and bill of material in all regions. Previous-generation Civics differed in many details between North America, Europe, and Asia, he said.

As reported in early 2015 by *Automotive Engineering* (see http://articles.sae.org/14040/), the 2016 Civic is Honda's first application of its new Global Compact vehicle platform that will also underpin the next-generation Accord and HR-V crossover. Engineers working at the Raymond, OH, R&D complex noted that consolidating the company's two highest-volume vehicle platforms will dramatically boost production scale, by millions of units.

The program, which was spearheaded by the Ohio team and led by veteran program manager Mitsura Kariya, also integrates a new modular approach to components and systems. The new sourcing plan greatly expands Honda's use of global vendors, going farther outside the kieretsu than ever before.

The new model rides on a wheelbase that is 1.2 in (30.5 mm) longer and nearly 2 in (50 mm) wider than the outgoing car.

Two all-new powertrains will be available: a 158-hp (118-kW) 2.0-L naturally-aspirated four featuring the latest i-VTEC valvetrain, offered with either a 6-speed manual or CVT (continuously variable transmission); and a 174-hp (130-kW) 1.5-L direct-injected turbo engine, the first boosted engine offered in a production Honda, mated only to the CVT, itself to be built at Honda's Russells Point, OH, factory. **EPA** fuel-economy ratings are 31/41/35 mpg (city/hwy/combined) for the 2.0-L with CVT; 31/42/35 mpg for the 1.5-L turbo.

Civic uses the latest version of the company's so-called ACE (Advanced Compatibility Engineering) body structure that is claimed to be 26% stiffer in torsion than the previous car and incorporates 12% ultra-high-strength steel. Attention was paid during early layout to returning to the classic Honda low-cowl driving position. To achieve this, the driver's H-point was lowered by 20 mm (0.8 in) to bring it to the same level as Audi's TT. Height of the floorpan, instrument panel, and engine mounts were commensurately reduced. Cabin volume is increased by a claimed 3.7 ft³ (105 L), with 2 in (51 mm) more rear legroom. Trunk space is 2.6 ft³ (74 L) larger than that of the 2015 model.

Large LED taillamps add to the new model's stylish flair.

Detail of the new Civic's roof-to-bodyside construction.

The comprehensive safety suite features available "Honda Sensing" active technologies including, for the first time on Civic, adaptive cruise control with a low-speed follow feature.

The new Civic will be built at Honda's Alliston, Ont., and Greensburg, IN, assembly plants for North American customers. Engines will come out of Anna, OH.

Automotive Engineering will have more details of the car's development and technologies in an upcoming issue.

Lindsay Brooke

Opel designs a new Astra

Astra five-door is lighter and more compact than the outgoing model. (Newspress)

Opel launched the fourth-generation Astra at the 2015 IAA (Frankfurt Motor Show). The car is more compact than the model it replaces and weighs up to 200 kg (440 lb) less. A five-door hatchback and five-door Sports Tourer estate were on display at the show.

The Astra (a **Vauxhall** in the U.K.) will be the first vehicle to feature **General Motors**' **OnStar** Connectivity system in Europe and comes with the option of matrix LED headlights, which Opel claims is the first time this feature has been offered on a European C-segment car.

"There was a lot of really close work between our engineering, product planning, marketing, and design guys on a daily basis," said Malcolm Ward, Opel/Vauxhall Exterior Design Director. The new car uses the Opel design language dubbed "Sculptural Artistry."

"That is really all about very fluid sculptural shapes with some very precise technical elements," explained Ward. "On a secondary level, we always try to give a lot of emphasis to the wheels, so we sculpture the surfaces very strongly so that the car sits better on the road. We are always trying to make our cars look as low and as wide as possible.

"When the car actually gets lower, then that's already helping us; that's the first point from the architectural standpoint," Ward continued. "But if you actually look at the car itself, just the way we have positioned a couple of the lines, you can see where the blade is, the undercut in the shoulder, but more importantly, how we have treated the whole C-pillar, what we call our breakthrough C-pillar. By stretching that black graphic as a window graphic, the whole window graphic still leans rearward, like in the previous generation, but with this breakthrough C-pillar, connects from the rear glass to the side glass and really makes the car look a lot lower than it actually is. That was the real technical challenge for our organization.

"Quite often manufacturers put a chrome accent on the belt," Ward added. "Again, that's a visual trick to try and get it to look lower. We deliberately put it on the DLO (daylight opening, above the doors) on the upper part, not on the lower part, because actually, with that breakthrough C-pillar, your eye automatically goes there. Then the chrome element gives a connecting link from the front to the rear that tells you that's how low the car is and in actual fact it's another 30-40 mm higher, as you can see. That was one of our big visual tricks."

The new Astra's track is wider than for the outgoing model, which also gives the design team more opportunity to work on the visuals of the car by exploiting the width around the wheels. Ward explained: "That gave us the chance to get even more sculpturing in the wheel arches, which again catches more light, and

Astra Sport Tourer made its debut at 2015 IAA. (Newspress)

The Astra interior will feature OnStar for the first time in Europe.

when it catches more light the car looks more efficient. When shadow and light play together in the right way, that's how you can make the car look like it's a lot more athletic and more efficient."

Any long-running series of models takes each new version through a change of profile, but Ward and the Opel design team wanted to retain the coupe-like profile of the outgoing Astra. "Only by staying with the overall profile of the car can you really communicate how much more efficient, how much lower and wider it has become. When you change the whole profile, a customer has no reference," said Ward.

This presents other challenges because aerodynamically, a more vertical rear is preferable. "You can see it's really pushed forward and pushed down, which is bad for aerodynamics," explained Ward. "So just by choosing this profile, we had lots of discussions at the beginning of the program. We convinced the organization that this was the right thing to do for this car, for the brand to really signal that even with a more difficult profile, it can be very aerodynamic. We committed to compensating for the lack of an upright rear in other parts of the car."

The sculptured and dynamic design theme is what the Opel design team has set out to bring to the interior too. "We've given the whole interior a very horizontal accent," said Ward, "At the same time we have simplified all the interfaces that you have with the car. For example, all the HVAC buttons are linked together and separated from the main infotainment area. The infotainment system is quite **Apple**-like in its appearance with some fine chrome elements that give it this premium appeal. I think that's what this interior is all about."

John Kendall

Peugeot Fractal demonstrates a new take on sound design

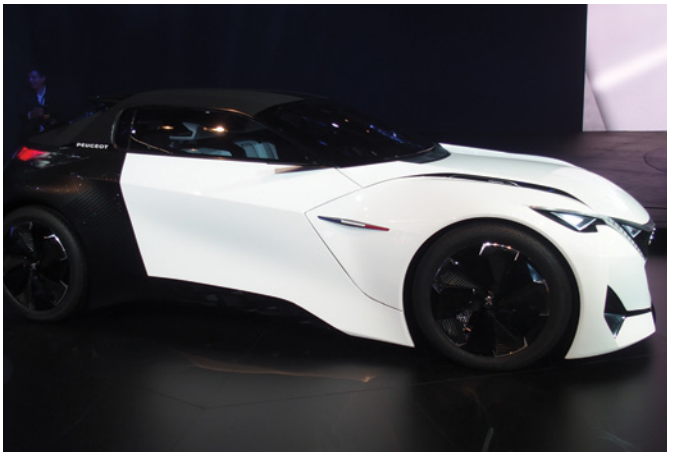
Peugeot used the 2010 SR1 concept to introduce its i-Cockpit touchscreen-based system, designed to control heating and ventilation, navigation, audio, connectivity, and the trip computer. The first-gen system entered production in the 2012 Peugeot 208. The company took the i-Cockpit concept one stage further in the Fractal electric urban coupe concept at the 2015 IAA Frankfurt Show, to include sound.

The concept plays a "sound signature," created by DJ and sound designer Amon Tobin, which is triggered when the driver opens the car using the smart watch remote locking system. "Behind this concept of an electric car—that is not really new, there was this question that electric cars emit no sound," explained Matthias Hossann, Head of Concept Cars and Advanced Design at Peugeot.

"In France, sometimes if you say you are driving an electric car, people say they are very sorry for you because they think it is not as exciting to drive an electric car. We thought about that and agree that you lack some pleasure with an electric car because it emits no sound. I have had this experience because even when you start an electric car, you don't know that it has started."

The Peugeot design team's thinking was that sound is part of the conventional driving experience, giving the driver an indication of speed, for instance. "We think that by developing some specific sounds, we can generate some specific emotions, some specific driving pleasure, and also a more precise driving experience," explained Hossann.

As a result, Peugeot has developed some more specialized sounds for the Fractal. "The best example is the GPS," continued Hossann. Most of us have had the experience on a busy road of missing a turn even though the navigation system has given the instruction. The Fractal designers have used directional sound to help. "We think that by developing some sounds that come from one side, for example the right, with a command to turn right in 300 m, followed by some other sound from the right, will



Fractal is an electric urban coupe concept with Peugeot's latest generation i-Cockpit interior integrating sound.

Peugeot Fractal concept can be accessed using a smart watch, which triggers a "sound signature" when the vehicle is unlocked. (Newspress)

give a better driving experience."

The Peugeot design team has worked with Tobin since the beginning of the project to design specific sounds. "We have shared the design process with him, we have discussed process, material, shape, and sound," said Hossann—all the functional sounds such as the turning indicators and warning sounds.

As well as presenting the possibility of designing an EV with specific functional sounds, there could be a practical application. All electric cars sold in the European Union from 2019 will be required to make a sound at speeds up to 30 km/h (19 mph) to warn pedestrians of their presence.

The Peugeot team thinks this could be an opportunity to develop a specific sound signature for Peugeot electric cars. In addition, the Fractal design team has tapped into other value judgments that car buyers make about cars, such as the quality of the sound of the door when it closes. "That is why, for example on this car, we have developed a sound for opening and closing the doors," said Hossann.

More than 80% of the Fractal interior is manufactured using 3D printing. (Newspress)

The designers also considered current personalization of cars: "Personalization today is a lot of adding things like stickers and paint. Tomorrow, you could have the same body, but just personalize the sound like a smartphone such as the door opening."

Sound has also been used to determine interior design features. "The best shape is an anechoic chamber. In fact, we work with parametric design. We don't design just by drawing every line and making it look right," said Hossann. "We just work with an algorithm. We define a shape—it's a new way of conceiving things. This shape is impossible to produce by stamping, or with carbon fiber, or injection molding."

Hossann pointed to the inner door panel: "That's why we use a lot of 3D printing. More than 80% of the interior of the car is produced by 3D printing. Again, this is possible because it is a concept car, but it's something that we believe could change the car industry in fact."

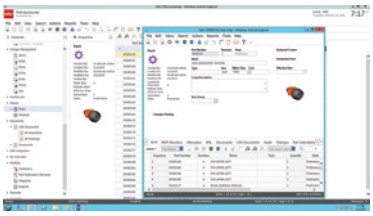
"At this stage it's difficult to have the speed and the volume," said Hossann. "But for example for small items like some décor, you can imagine in the future a customer might be able to choose a specific area where they can add some specific décor and have this printed at the dealer and fitted to the car.

"We designed the car like a classical designer, but we almost designed the way of thinking about our car. We had a big discussion about the way of thinking about things and developing them. On a classical car you have a door panel, you add some foam to make the car more soundproof inside. Tomorrow we can imagine having an efficient shape for sound so that you don't need to add soundproofing material, so you can save weight."

John Kendall

SPOTLIGHT: PRODUCT LIFECYCLE MANAGEMENT

Cloud PLM solution



Infor Product Lifecycle Management (PLM) Accelerate, powered by **Aras**, is a new PLM solution designed for automotive, industrial manufacturing, high-tech, and aerospace and defense customers. Available for both on-premise and private cloud (single-tenant) deployment, this latest offering provides a full-featured, highly scalable, flexible and secure PLM solution. Infor PLM Accelerate is designed to adapt with the unique business practices of discrete manufacturers, allowing users to manage the process from ideation to manufacturing through distribution. It features a singular web framework that uses an open architecture. This approach establishes a comprehensive PLM solution suite to manage processes throughout the enterprise and supply chain. The user interface features drag-and-drop functionality. Compliance-grade security is used to protect all intellectual property through customizable permissions, authentication, and access control. The solution is also capable of scaling both up and out to support organizations of all sizes and compliance needs, including the management of petabytes of complex CAD data. Infor PLM Accelerate can integrate with Infor and non-Infor enterprise resource planning (ERP) solutions through Infor ION, a purpose-built middleware component.

Critical part transition services

The average age of vehicles on the road is increasing. Manufacturing capacity is focused on new models with shorter program cycles to meet higher demand and new fuel economy targets. These market forces are driving dwindling inventories of heritage service part assemblies with no current capacity or supply chain to produce more, according to **Ricardo** Inc. The end result is an increased risk to both OEM profits and consumer satisfaction. To help combat this, Ricardo has introduced a unique service to re-industrialize complex service parts with critical inventory shortages, leveraging expertise in low-volume and high-complexity powertrain sourcing. This service can also support transition of full transmission programs and key commodities from production to service. To better prepare and handle today's new challenges facing the transition from production to after-sales, Ricardo's Critical Part Transition services include a team of strategy, design, engineering, quality, finance, and low-volume purchasing experts to address the many complex challenges and considerations for automakers and their tier suppliers. A free white paper, including a case study, can be downloaded to learn more about the best practices that should be considered to ensure profit is maintained, back-orders are minimized, and consumers remain satisfied. Visit www.ricardo.com/TransitionServices.

Acoustical spray for improved NVH

Baytec AS (Acoustical Spray) is a new acoustical spray technology from **Covestro**, formerly **Bayer MaterialScience**. The spray forms a durable, customizable part that can be combined with a layer of polyurethane foam. There is a patent pending for this innovative new approach, which uses a higher level of sound-blocking fillers than current solutions. Baytec AS reduces sound across a range of frequencies. This is achieved because the barium sulfate filler in the elastomer blocks low frequency sound and the polyurethane foam absorbs the higher frequencies. Baytec AS can achieve better acoustical performance than current technologies at the same weight, according to Covestro, or it can be lighter with similar acoustical performance to current technologies. The solution can deliver up to 40% weight savings without sacrificing performance. Additionally, Baytec AS can be used to fine-tune the part thickness and sound-blocking capability by concentrating more material at noise hot spots and less material in quieter regions, saving weight overall. The technology meets OEM standards and offers suppliers a streamlined production process that can result in less labor and lower cycle times. Covestro can provide customers technical expertise and assistance in development and prototyping.

Laser distance meter

Schmitt Industries, Inc., a manufacturer of laser distance meters under the Acuity product brand, announces availability of the AR 2000 line, with special capabilities for distance measurement on hot surfaces—e.g., red hot, glowing steel, and for outdoor use in bright lighting conditions with high constant or stray light levels. The AR2000 laser has the capability to measure hot targets up to 2400°F (1315°C), within a range of up to 550 yd (500 m), with an absolute measurement accuracy of 1 mm (0.04 in) and a measurement frequency of up to 100 Hz. For convenient data display and parameterization, Acuity AR2000 sensors are equipped with an OLED (organic light-emitting diode) display and touch keys. Due to their standard interfaces, Acuity sensors are optimized for easy integration into industrial automation and measurement systems. The AR2000 is built to be rugged for applications in harsh environments. The sensor comes standard with RS232, RS422, RS485, and 4-20 mAmp outputs. Options include internal heater and sunscreen for outdoor uses. The sensor also has its own built-in display that can be used to program the laser and take measurements without the use of an external display or PC.

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PRODUCT BRIEFS

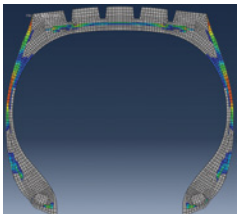
MEM inertial accelerometer

The Model 1525 Series microelectromechanical (MEM) variable capacitive accelerometers from **Silicon Designs** Inc. are a low-cost, integral, inertial accelerometer family. The nitrogen-damped, hermetically sealed devices are designed for zero-to-medium frequency instrumentation applications that require high repeatability, low noise, and maximum stability. Each miniature package combines a MEMS variable capacitive sense element and a custom integrated circuit that includes both a sense amplifier and ±4.0 V differential output stage. Units are available in six full-scale ranges from ±2 to ±100 *g*, with reliable performance over a standard operating temperature range of -40°C to +85°C (-40° to +185°F). The devices are suited for applications including unmanned ground vehicles, remotely operated vehicles, and robotic control systems.

Self-lubricating plastic bearing material

The iglide L500 plastic bearing material from **igus** is suited for continuous operation in high-speed rotation applications under low loads. The material combines high wear resistance in long-running, high-speed applications. Continuous rotational speeds of more than 16 ft/s (4.9 m/s) are possible, and the L500 material performs even under extreme environmental conditions, such as temperatures ranging from -148 to +482°F (-100 to +250°C), as well as media contact. The positive material properties of the iglide L500 enable the self-lubricating operation of electric motors, fans, and ventilators, where sintered bearings were previously used. The L500 material will also be available for the development and production of customer-specific bearing solutions.

Fatigue life analysis software



Endurica LLC has released version 2.32 of its fatigue life analysis software Endurica CL, a computer simulation that can model the development of damage in an elastomeric part operating under complex service conditions. The release includes new features for calculating self-heating, for analyzing rolling structures (e.g., tires and rubber rollers), and for diagnosing cavitation and wrinkling conditions that might occur during loading cycles. Starting from results computed in a standard FEA of the part in operation, Endurica CL computes the number of repeats of the simulated operation that can be endured before cracks develop. The calculation uses Critical Plane Analysis for accurately computing the effects of multiple simultaneous load inputs, Rainflow Counting for the effects of variable amplitude loading, and nonlinear material laws that effectively capture a range of elastomer behaviors (hyperelasticity, cyclic stress softening, strain crystallization, temperature dependence, ozone attack, etc.). Endurica CL accounts for the effects of finite straining and crack closure under compression.

COMPANIES MENTIONED

AD INDEX

Q&A

"We're not usually seeing the exact same part as we had it in InCar in a serial production vehicle; the technologies evolve," said Timo Faath of ThyssenKrupp.

ThyssenKrupp explores steel innovations

InCar plus is the most extensive internal R&D project that **ThyssenKrupp** has ever undertaken. It encompasses the group's interdisciplinary expertise to generate more than 40 individual solutions for cost-effective vehicle weight reduction without sacrificing performance, as well as the use of advanced manufacturing technologies that are validated and can be implemented with current processes. Another component is scalability, with modular lightweight design concepts that can be utilized across multiple platforms and vehicle programs. The project was initiated by developing an independent body-in-white structure to serve as a reference benchmark for the various body solutions. The reference structure is a representative upper midsize class vehicle that was derived through extensive comparative studies of bodies manufactured by various OEMs. With a lightweight index of 2.7, it surpassed its previous InCar reference structure that was developed in 2009, due to improved design and advanced material utilization. Timo Faath, General Manager Technology, ThyssenKrupp Steel North America, Inc., spoke with *Automotive Engineering* about the InCar plus project and some of its promising technologies. Read more and view additional technical images at http://articles.sae.org/14396/.

One of the project's innovations is a B-pillar featuring a new TriBond material. Can you talk about this development?
We have several different solutions for the B-pillar. Our reference structure is already a MBW 1500 tailored tempered (tt) solution. We've developed some hot-stamped solutions—one is MBW 1900 tt and the other is TriBond 1400, a pretty interesting new material development. And we also have some cold-stamped solutions—DP-K 700Y980T and DP-K 780Y1180T...TriBond is a material development; we don't have it in serial production yet. It's like a sandwich material. We take three slabs, to simplify it, stacked on top of each other and run them through the hot rolling mill, the cold rolling mill, annealing, and offer it as aluminized-coated. The only process that is added is that stacking up of the slabs. The slab in the middle is a conventional MBW 1500; the thin outer slabs are lower strength. What that does for us is...no cracks [in drop tower and 3-point bending tests], higher ductility with almost the same strength level. When you look at the plain mechanical properties, the elongation is still defined by the core slab—it's still 4.5-5% elongation. What's really better for that material is the bending angle—for a conventional 1500 it's about 65°, with the TriBond 1400 it goes up to 85°, and the TriBond 1200 it's actually where the test ends at 135° bending angle. So this is the real highlight of that material...It is a monolithic material that can be stamped in a conventional hot stamping process—no process modifications necessary. So this is pretty exciting for us.

How does the new material compare cost-wise?
For a cost and weight comparison, our reference structure—the MBW 1500 tt B-pillar—weighs about 15.4 kg, and with our TriBond 1400 solution we were able to get the weight down to 14.1 kg. To be honest with you, it's kind of difficult for us to do cost calculations on the material because it is not [in production yet]. We do see an increase compared to the conventional material [€38.80] just because we have an additional process step, but this may well go down a little [currently stated as €40.60]. So very attractive weight and slightly higher cost make the solution very attractive... We have a couple solutions [in InCar plus] where the weight reduction comes with reduced cost, just because you save material and material cost is the biggest portion of your part cost; that sometimes works in our favor. But it's still attractive.

Any other possible applications for the material?
It doesn't have to be a B-pillar. So we have a couple of different applications for that material. It will work for front rails as well...I showed a drop tower test of a front rail that looked very good. In today's vehicles, you don't use hot stamping for front rails because it's not enough elongation in the part. But with TriBond we would actually have that option to use it in front and rear rails where deformation is required. That might actually be a better application than the B-pillars. But in B-pillars there's a lot of expensive solutions out there—tailored tempering, tailor welded blanks, tailor rolled blanks—that are very complicated to control from a hot-stamping-process perspective. With the TriBond, you just throw it in your hot stamping press and you've got a ductile part.

You have also presented A-pillar and bumper concepts as part of InCar plus. Which of these technologies is closest to serial production?
That's a tough one. Throughout the InCar project we tried to offer different serial production levels. Some of the solutions our customers can buy today. Some solutions are still under development. The reason why we do it like that is our customers—some of them work on next-generation vehicles, and some of them have a problem today with their serial production vehicle where they need a solution. So we're trying to reach as many customers as possible. Generally speaking, hot stamping is a big topic for everybody, and we know there's some OEMs trying to do it themselves [particularly] in Europe. Whenever OEMs invest in hot stamping, I don't think they want to do it the conventional way—or follow what their suppliers already do for them—they want to come up with more sophisticated solutions. Some of the stuff [in InCar], tailored tempering being one of them, is very promising and I think we'll see a lot more of that in the future in NAFTA; it's already out there in Europe. Pretty much everything that we show [related] to hot stamping is very promising.

Ryan Gehm

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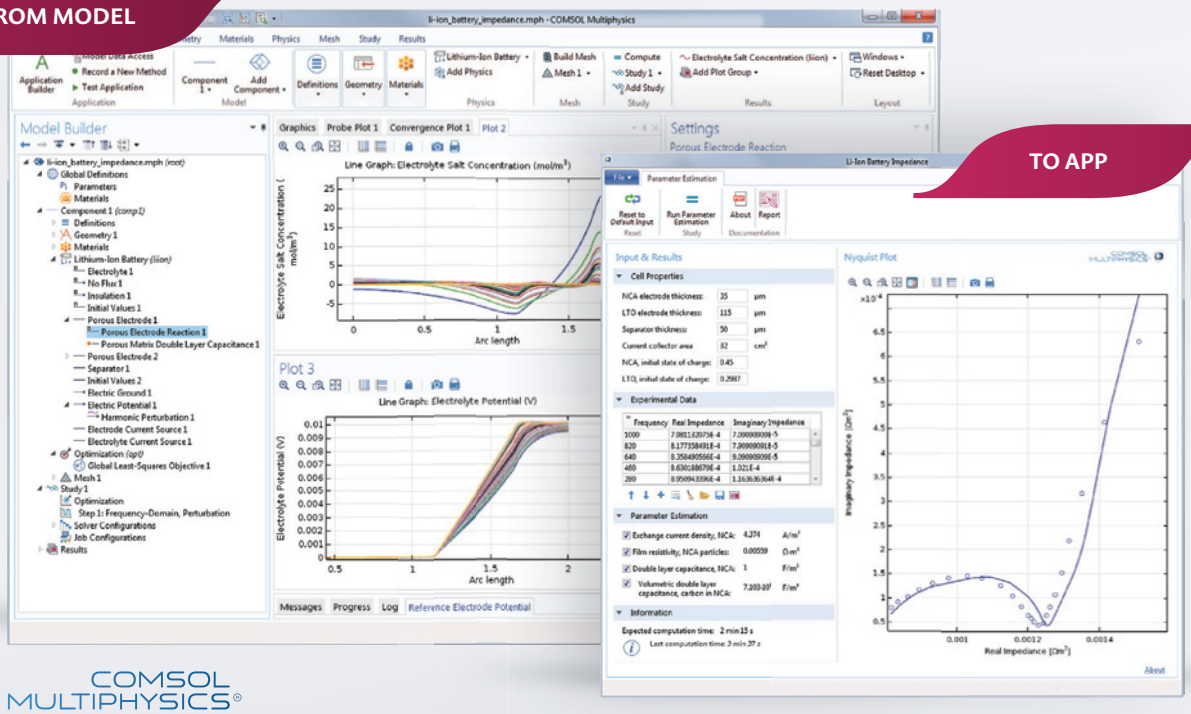

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