MOBILITY ENGINEERING™

AUTOMOTIVE, AEROSPACE, OFF-HIGHWAY

A quarterly publication of SAE INTERNATIONAL and SAE INDIA

Auto Expo 2014
Highlights of 69 models

Monitoring fine particles
Pegasor Oy improves measurement

More electric aircraft
Enhancing maintenance, minimizing workload

Formula One: 2014
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Vol. 1 Issue 3
June 2014

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The Suzuki Ciaz concept car was one of 69 debuts at Auto Expo 2014 in Delhi. Read the highlights of the show starting on page 59.

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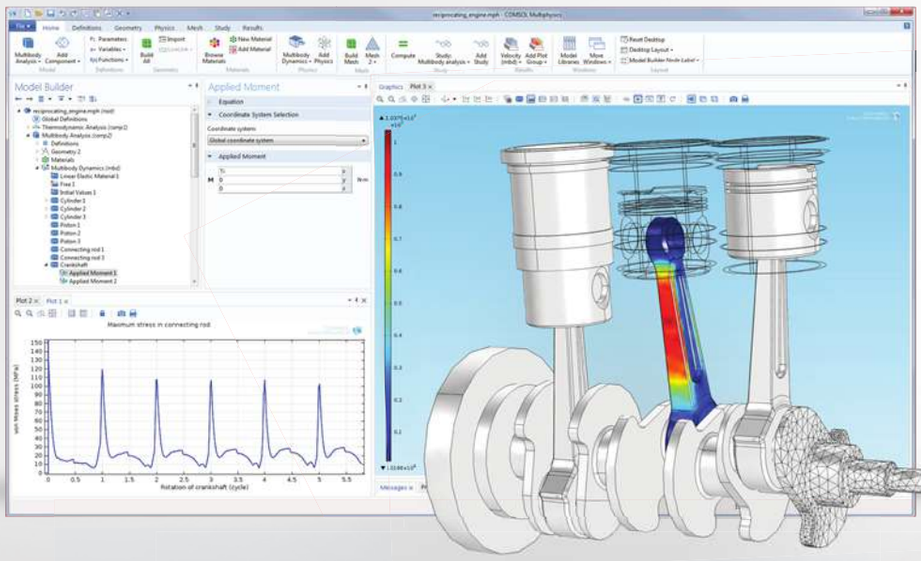
MULTIBODY DYNAMICS: Model of a three-cylinder reciprocating engine with both rigid and flexible parts is used for the design of structural components.



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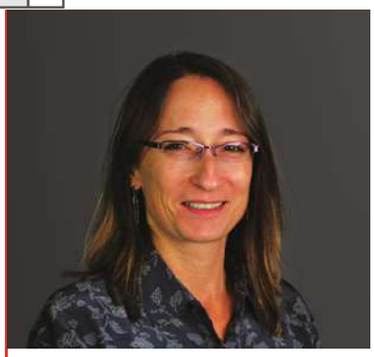


EDITORIAL

Coming clean globally

According to a report, "Science and Engineering Indicators," released in February by the **National Science Board** (NSB), the policy-making body of the U.S. **National Science Foundation** (NSF), "it has become increasingly clear that the U.S., Japan, and Europe no longer monopolize the global R&D arena."

In fact, the report states that since 2001 the share of the world's R&D performed in the U.S. and Europe has decreased, respectively, from 37 to 30% and from 26 to 22%. Simultaneously, the share of worldwide R&D performed by Asian countries grew from 25 to 34%. China led the Asian expansion, with its global share growing from just 4 to 15%.

In particular, China and South Korea were singled out because both countries have enhanced their domestic R&D "by making significant investments in the S&T [science and technology] research enterprise and enhancing S&T training at universities. China tripled its number of researchers between 1995 and 2008, whereas South Korea doubled its number between 1995 and 2006."

The report does not identify what those researchers are actually researching, but it doesn't seem to be improvements in air quality; in mid-February of this year, Beijing was declared as "almost uninhabitable for human beings," according a study by the **Shanghai Academy of Social Sciences**.

The *Daily Mail* out of the U.K. wrote of the study that Beijing "was only saved from last place [out of 40 major global cities] by Moscow.

Timing of the release of the study was opportune. *Bloomberg News* reported Feb. 16 that Beijing's hazardous smog levels had "eased after firework displays traditionally marking the end of the Lunar New Year festival added to hazardous levels of atmospheric contamination. Micrograms-per-cubic-meter concentration of PM2.5, fine particulates that pose the greatest risk to human health, fell to 74 near Tiananmen Square in central Beijing at 9 a.m., according to data on the website of the city's air-monitoring center. The average in the previous 24 h was down to 191 from 432 over the same period at yesterday noon."

The **World Health Organization** advises day-long exposure of no higher than 25.

According to the NSB, the rise in S&T investements by Asian countries is due to their "attention on crucial sectors of the global economy, including high-tech manufacturing and clean energy." The report does not talk about crucial sectors of local economies employing people who cannot get to work, or to shop, or do anything outside, in a healthy manner, mainly due to a lack of "clean energy."

From the Feb. 16 Bloomberg report: "'The recent pollution may be caused by fireworks,' Li Zhenlong, 30, who works in the energy industry in the Chinese capital, said yesterday. 'We shouldn't completely forbid firecrackers. This depends on people's own free will, while the government should largely promote not doing it.'"

While the government comes up with its promotion plans urging people to just say no to firecrackers, maybe it could also focus on other ways to diminish "the recent pollution," similar to the steps taken by President Obama around the same time in February when he announced that he was directing "the **EPA** and **NHTSA** to develop and issue the next phase of medium- and heavy-duty vehicle fuel efficiency and greenhouse gas standards by March 2016."

According to a White House fact sheet, the first round of standards for such vehicles, finalized in 2011, "is projected to save 530 million barrels of oil and reduce GHG emissions by approximately 270 million t (298 million ton)." (Anyone willing to bet that new standards for the off-highway industry can't be too far behind?)

There have very recently been some clues that Chinese leaders are getting serious about directing some research toward finally addressing the smog problem, such as with the announcement of a 10 billion yuan ($1.6 billion) "reward scheme" for cities that significantly reduce pollution. Even if the country today implemented tougher emissions standards for all forms of vehicles, and closed all low-tech polluting manufacturing plants, some experts predict that China could "still have this problem in around 10 or 20 years."

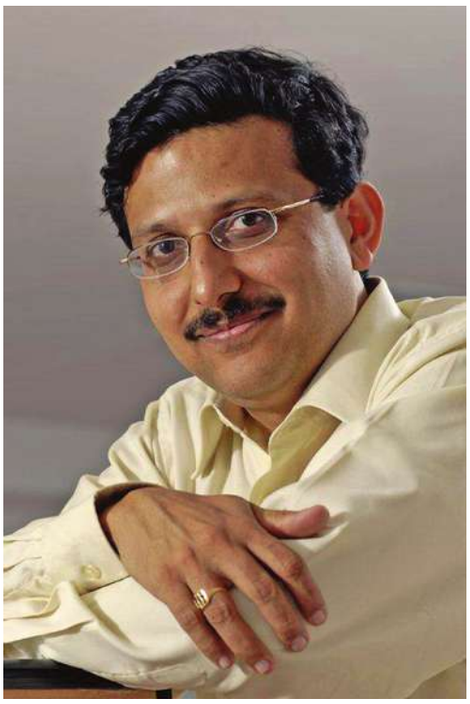
And that is the primary reason to take action and start today.

Jean L. Broge
Managing Editor

FOCUS

Building upon success

At the outset, I would like to place on record our warm appreciation to Mr. Shrikant Marathe for providing sterling leadership and taking **SAEINDIA** on an excellent growth trajectory in all spheres of activities during his term as President. There has been significant growth in professional membership, and student membership touched a new high during his term.



Dr. Aravind Bharadwaj
President, SAEINDIA

He took strong initiatives to develop a partnership with **SAE International** reflected in the joining of the 1st Commercial Vehicle Congress with the 8th Mobility Conference to form the SIMCOMVEC event late last year, which was a runaway success in all parameters despite an industry slowdown and subdued sentiments. This magazine, *Mobility Engineering*, was launched in December 2013 as another joint venture with SAE International, adding tremendous value to professional members. The International Lecture Series has been initiated, and the three lectures conducted have been well received by the industry and mobility professionals.

The new Managing Committee, comprised of experts from industry and academia, will align with the objectives set out by leaders in SAEINDIA's Vision 2020. The document envisages an increase in membership to an ambitious target of 10,000 professional members, made possible by effective retention of membership and scaling up the satisfaction index of members through active communication and constant interaction. In short, the voice of members will be captured, analyzed, and acted upon toward achieving member delight.

We shall embark on a strong leadership succession plan with increased participation from industry leaders and active volunteer members. We shall endeavor continuously to increase visibility of the SAEINDIA brand. We shall ensure increased frequency of professional development programs and offer SAE International training modules, including webcasts and online programs to our members.

We shall continue to strengthen and reinforce the SAEINDIA office to ensure that we are able to offer a better value proposition in terms of projects, programs, and activities. And we will sharpen our focus on the aerospace and off-highway verticals in partnership with SAE International and other like-minded organizations.

Baja SAEINDIA and Supra SAEINDIA will be organized with continuous improvements based on the experience gained over the years. Strong initiatives to get visibility and recognition from industry and media including print and electronic media will be planned and implemented.

We shall scale up our Career Start Program with the involvement of a talent acquisition and management team comprising human resource professionals and take it to the next level by increasing the participation significantly from both the industry and the student communities.

We are determined to consolidate our gains and improve our organizational structure to ensure deliverables are met to the utmost satisfaction of all stakeholders, making SAEINDIA truly an active and vibrant premier professional society in India.

Best wishes,
Dr. Aravind Bharadwaj
President, SAEINDIA

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SAEINDIA
News

Student off-roaders kick up dust (and mud) at Baja event

The 7th edition of Baja **SAEIndia** indeed lived up to its theme, "Raise the Bar."

Baja SAEIndia gives colleges from across the nation a platform to showcase their talent and knowledge by building an off-road recreational four-wheel vehicle that is put through various static and dynamic "tests." Each team's goal was to create a safe, easily transported, easily maintained, and fun-to-drive prototype Baja vehicle without any direct involvement from professional fabricators. Teams were also free to design their own transmission as long as they adhered to the 60-km/h (37-mph) speed cap.

From the 327 teams that registered for Baja SAEIndia 2014, 125 qualified for the finale. The three-day event (held Feb. 21-23 near Indore) commenced with a Static Evaluation round in which the engineering design of the vehicles was assessed, as well as the cost to build them and the marketing plan behind them.

The Dynamic Evaluation round tested vehicles for acceleration, speed, hill climb, and maneuverability.

Held on the final day was the Endurance event. Teams competed for 4 h on a specially designed off-road course. Assessed was each vehicle's ability to operate continuously over rough terrain containing obstacles in any weather condition.

SAEINDIA News

Flagging off the Endurance round was Dr. Pawan Goenka, Executive Director & President, Automotive & Farm Equipment Sectors, **Mahindra & Mahindra** Ltd., along with notable personalities from the industry. **Sant Longowal Institute of Engineering and Technology** (Junkyard Warriors), **Sri Govindram Siksaria Institute of Technology and Science** (GS Racers), and **College of Engineering** (Team Nemesis) were caught in a nail-biting fight throughout the event, but it was team Junkyard Warriors that took the checkered flag.

It was heartening to see thousands of students come together once again to celebrate the spirit of Baja. Increased participation from colleges over the years in Baja SAEIndia reflects growing popularity and national significance. Participation has multiplied over the years from 500 in the inaugural season to 6500 this year.

Critical to its long-term success, Baja SAEIndia gives young engineering talent an opportunity to showcase its skills and acquire a real-life experience responding to challenges.

The whole experience of attending the event, watching the race, and seeing the excitement on the students' faces was summarized flawlessly by Goenka when he said, "There's no way to capture on camera the experience of being here."

Priya Gunasekar, Assistant Director, Programs Development, SAEINDIA

Industry NEWS

TRW JV adding products to Indian manufacturing plant

TRW Automotive Holdings Corp. has announced that its Indian joint venture, **RANE TRW Steering Systems** Ltd. (RTSSL), has expanded to manufacture TRW airbags and the latest generation of seatbelt systems. RTSSL is applying TRW's global manufacturing standards to produce driver and passenger airbags and seatbelts at the facility and will make around 320,000 units per annum initially, with an increase in manufacturing capacity to approximately 810,000 units in the coming three to five years. "India is a very important market for TRW and we look forward to our continued partnership with Rane to manufacture a broader range of advanced technologies that help to protect drivers and occupants there," said Frank Mueller, Vice President and General Manager for TRW Occupant Safety Systems. "As a global leader in safety, we are committed to providing affordable safety for all drivers and in all regions—to deliver the safety everyone deserves." RTSSL is a 50-50 joint venture with the **Rane Group** based in Singaperumal Koil near Chennai. Since 1962, TRW has had a presence in India through its **Brakes India** Ltd. joint venture with another third party. It has continued to establish further partnerships to offer a full range of safety products and now supports 10 manufacturing locations.

India in need of 1290 aircraft in next 20 years

According to **Airbus**' latest market forecast, Indian carriers will require 1290 new passenger aircraft valued at US$190 billion between now and 2032 to satisfy surging annual demand. India's annual passenger traffic growth rate of 8.6% is well above the regional Asia Pacific average growth rate of 6.1% and the world average 4.7%. Of the requirement for 1290 new aircraft, some 73% will be for growth and 27% for replacement. The new passenger aircraft include 913 single-aisles such as the A320 and A320neo Family, 322 twin-aisles like the A350 XWB and A330, and 56 very large

Today one in 20 Indians travel by air, and in 2032 this will increase fivefold to a quarter of the population taking at least one flight, according to a market forecast report from Airbus.

aircraft such as the A380. By 2032, today's fleet of 343 aircraft will more than triple to some 1233 aircraft. By 2032, Airbus forecasts that 36% of India's fleet will be wide-bodies, more than doubling today's level. This is a result of increased capacity of international as well domestic routes with larger aircraft like the A330 and A350s.

Chennai-built trucks expand Fuso's African presence

Daimler India Commercial Vehicles Pvt. Ltd. (DICV) and **Mitsubishi Fuso Truck and Bus** Corp., a Daimler company, recently launched DICV-made trucks in Tanzania, the fourth market since the start of export in May 2013. The Fuso truck range manufactured at DICV's Oragadam plant comprises five models spanning medium-/heavy-duty—25 to 49 t (27.5 to 54 ton) referred to as FJ, FO, and FZ—and light-/medium-duty—9 to 16 t (10 to 17.6 ton) referred to as FA and FI. The trucks, already available in Sri

The Fuso truck range manufactured at DICV's Oragadam plant comprises five models spanning medium-/heavy-duty (25 to 49 t) and light-/medium-duty (9 to 16 t).

Lanka, Kenya, and Zambia with more markets to follow in Africa and Asia, will be sold through the exclusive dealer **Diamond Motors** Ltd. in Tanzania. With a presence in more than 35 African markets, Fuso claims it almost doubled sales in the first two months of 2014 to 1060 units from 580 units in the same period of 2013. The market expansion is part of **Daimler Trucks Asia**'s Asia Business Model introduced in 2013, which is attempting to create synergies between the Japan-based Mitsubishi Fuso and DICV.

Tata Motors enters Philippines market

With its Manza sedan, Vista hatch, Indigo sedan, and Indica hatch passenger vehicles, **Tata Motors** is establishing operations in the Philippines. The company at the April 3-6 Manila International Auto Show announced its intention to export those models to the country, which is a member of ASEAN (Association of

Executives from Tata Motors and Pilipinas Taj Autogroup pose at the 2014 Manila International Auto Show with the Manza sedan—one of the first to be exported from India to the Philippines.

Southeast Asian Countries). Tata will also export the Xenon, Ace, and Super Ace from its commercial vehicles range." We are very confident with our distribution partner [**Pilipinas Taj Autogroup** Inc.] and we believe that their extensive network, along with our global expertise, will bring into the Philippines market a range of exciting Tata vehicles," said Tata's Johnny Oommen, Head, International Business, Passenger Vehicles. "We hope our new range appeals to customers and builds trust in the brand, which is integral for us."

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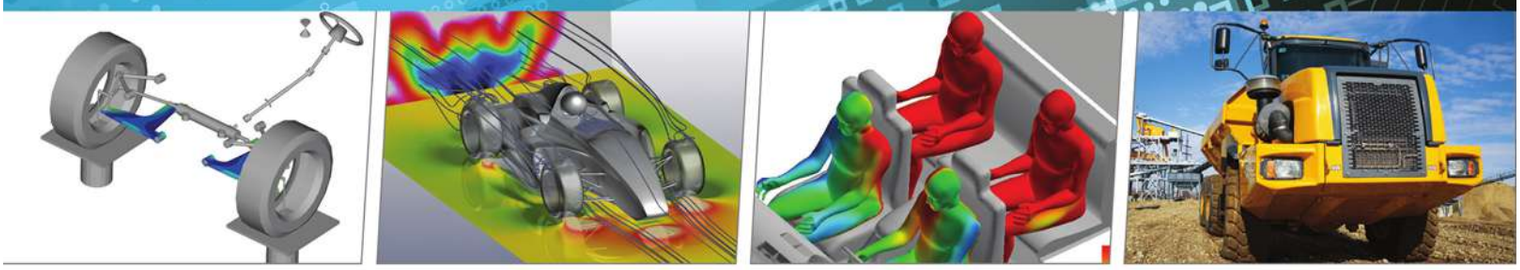

Multiphysics involves the coupling of CAE solutions to enable simulation of a wide range of physics while leveraging the advantages offered by each solution. Applications include the coupling of Structural Mechanics, Computational Fluid Dynamics, Multibody Dynamics, Thermodynamics, Electromagnetics and others. **Altair Smart Multiphysics** adds the additional component of performing optimization around these coupled solutions to assist in rapid identification of an optimal design.

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TECHNOLOGY Report

OFF-HIGHWAY POWERTRAIN

Perkins offers electronic engine range for lesser regulated countries

Building on its mechanical 1104D-44 model, **Perkins** recently launched a new electronic 4.4-L engine for OEMs exporting to and manufacturing in lesser regulated territories. The 1104D-E44 is a four-cylinder engine that offers higher levels of fuel tolerance and operational robustness while meeting Tier 3 equivalent, Stage IIIA emissions standards.

The four-cylinder electronic model shares many of the components of the mechanical version allowing equipment OEMs to move seamlessly from one emissions Tier to the next, while optimizing fuel economy and boosting overall machine performance thanks to the common-rail fuel injection system.

Suitable for all major applications in construction, agriculture, and electric power, the 1104D-E44T/TA offers a variety of build options for specific machine groups, enhancing its versatility in terms of integration and ongoing maintenance. Industrial Open Power Unit and generator set versions will be available when production begins in the latter half of 2014 while the company is working on a specific structured platform for tractors for 2015.

Designed and built at Perkins Wuxi facility in China, the 1104D-E44 offers higher levels of fuel tolerance and operational robustness while meeting Tier 3 equivalent, Stage IIIA emission standards and was engineered to specifically combat the problems of varying fuel quality in lesser regulated territories.

Available in two versions, the 1104D-E44T is a turbocharged unit offering power ratings of 80.4 to 99.9 hp (60 to 74.5 kW), while the more powerful 1104D-E44TA (shown) is a turbocharged aftercooled model that tops out at 142.1 hp (106 kW) at 2200 rpm, with peak torque of 556 N·m (410 lb·ft) at 1400 rpm.

Designed and built at Perkins Wuxi facility in China, the new model has been engineered to specifically combat the problems of varying fuel quality in lesser regulated territories. A new upgraded fuel system increases tolerance to poor quality diesel, supported by improved filtration to capture any debris present.

The new model has also borrowed from Perkins Tier 4 engines with multi-vee front-end auxiliary drive systems that are self-tensioning, which minimizes maintenance.

Jean L. Broge

AEROSPACE PROPULSION

Maintenance tools for improved engine bearing performance

Of all industrial sectors, aircraft engine manufacturing and maintenance have possibly the most stringent requirements and specifications for rolling bearings and related components. A number of advanced bearing maintenance products, such as customized induction heaters and sophisticated thermal cameras, can help aircraft engine OEMs and maintenance providers meet such exacting standards.

Aircraft engine applications typically call for specially designed rotating components, including deep groove ball bearings, spherical roller bearings, and cylindrical roller bearings. The bearings' rings and rolling elements are made from corrosion-resistant steels with high levels of cleanliness and homogeneity. The bearings are also heat-treated under close metallurgical control.

To prevent damage to new bearings before mounting, engine OEMs and maintenance providers are urged to follow these well-established bearing handling practices:

- Store bearings in locations where the relative humidity does not exceed 60%
- Protect bearings from excessive vibrations emanating from operating machinery that can cause raceway damage
- Store larger bearings lying down, with proper support for the bearings' entire side faces
- Keep bearings in their original packaging until just before installation.

Bearing heating and installation

Selecting the right bearing installation method is key to prolonging life expectancy and reducing the risk of premature failure. Although other methods such as ovens and hot plates are still used, induction heating is generally considered the most modern and efficient way to mount mid-size and larger bearings. Heating expands the bearings' rings and allows them to slide easily onto shafts,

developing a secure interference fit when the bearings cool.

Modern heaters generally have advanced energy-saving features and the capacity to handle bearings of different bore sizes.

Larger engine bearings can also be mounted using oil injection. With this method, engine shafts are machined beforehand with oil ducts and grooves. During installation, a pressurized oil film is injected between the shaft and bearing inner ring, minimizing the mounting force required.

Bearings should be installed in a dry area protected from contamination by dust, dirt, and moisture.

An engine OEM converts to induction heating

In a recent example involving a small engine for civilian aircraft, an aircraft engine OEM wanted to gain greater control over its bearing installation process by converting to induction heating. Previously, the engine's bearings were heated for installation using hot plates, but the method proved slow and failed to keep up with the OEM's production goals.

The OEM began researching induction heating, and decided upon a heater with a preset temperature cycle to exert more control over the process and prevent overheating. It also wanted a heater capable of preparing bearings more quickly than previous methods.

Engineers from the bearing manufacturer devised a solution by modifying an existing induction heater's software. The modifications equipped the heater to heat bearings to the optimal temperature every time without operator intervention. This eliminated the risk of bearing damage due to operator error.

The customized heater also met the OEM's production requirements. The heater's induction coil is located outside the heater's body, allowing it to prepare bearings weighing up to 40 kg (88 lb). The heater automatically demagnetizes bearings after heating them, reducing the risk of bearing contamination by small, potentially damaging particles.

After the customized heater proved successful in the small aircraft engine application, the OEM acquired additional heaters and implemented induction-heating practices at its other engine production and repair facilities.

Modern induction heaters often can be customized to meet the special requirements of aircraft engine OEMs. (SKF)

Monitoring engine bearings

Recent advances in digital technology and instrumentation have resulted in new generations of condition-monitoring devices, including IR thermometers, data collectors, and electrical erosion detectors. These instruments facilitate noncontact, noninvasive inspection of aircraft engine bearings and other rotating components during engine testing or maintenance.

A notable example is thermography, which detects thermal energy in the spectrum's IR band. Handheld thermal cameras have become more sophisticated, allowing users to find hot spots in operating engines from a distance of 10 ft (3 m) or more. The temperature variations are depicted as different colors or shades on a display screen.

One newly introduced camera has a 160- by 120-pixel detector and a measurement range of -20 to +350°C (-4 to +662°F). Hot and cold extremes and temperature differences between any two points can be instantly displayed on screen.

A new type of spring-operated mechanical pullers is now available that efficiently removes aircraft engine bearings without damaging other components, such as shafts and housings. The pullers' spring-operated arms can be positioned behind the targeted component and allow users to remove bearings even in extremely tight quarters.

Handheld thermal cameras remotely detect hot spots in operating engines, alerting maintenance personel to potential problems. (SKF)

An alternative to pullers is oil injection, especially for larger bearings. This versatile method can safely remove engine bearings mounted on either tapered or cylindrical seatings. An injection of pressurized oil reduces the removal force needed by 90% or more depending on the seating. To use the oil injection method of dismounting, engine shafts must be prepared in advance with the necessary oil ducts and grooves.

This article was written for SAE Magazines by Paul Michalicka, SKF USA Inc.

AUTOMOTIVE ENERGY

Novel nanocatalysts for fuel cells

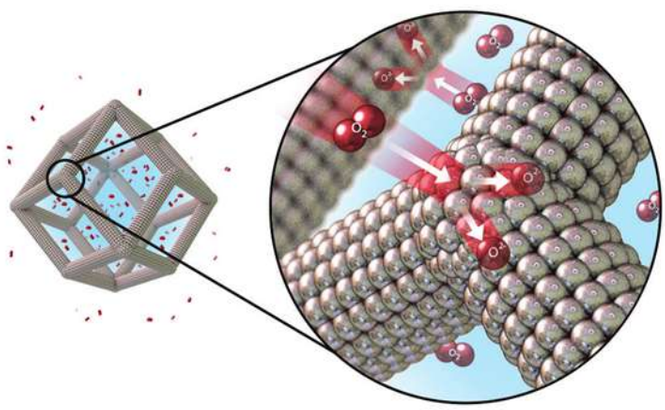
One of the biggest obstacles to widespread adoption of clean hydrogen fuel-cell-powered cars and trucks is the high price and rarity of the platinum and platinum-family catalysts that the stacks need to make electricity. The costly metals are critical to carrying out the crucial oxygen-reduction reaction at the fuel-cell cathode, the place where the water "exhaust" forms when oxygen molecules from the air combine with protons filtering through the polymer membrane and electrons arriving via the external circuit.

Recently a team of chemists and materials scientists at the **U.S. Department of Energy**'s **Lawrence Berkeley National Laboratory** (LBNL) and **Argonne National Laboratory** (ANL) developed novel three-dimensional "nanoframe" substances that have demonstrated much better catalytic activity (the tendency to facilitate reactions) for the fuel cell's key cathodic oxidation reaction. The order-of-magnitude jump in performance it exhibited compared to the state-of-the-art catalysts—platinum nanoparticles deposited onto carbon substrates—is reportedly almost unprecedented. The activity of the catalyst also exceeds by an order of magnitude the 2017 target set for the technology by DOE planners.

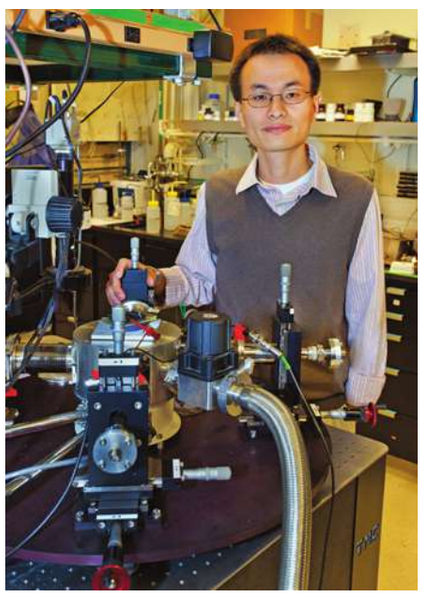
The bimetallic catalysts of platinum and nickel feature hollow, high-activity, high-surface-area faces both inside and out, which makes them significantly more efficient and potentially far less expensive than today's counterparts, according to the team's recent paper in *Science* magazine.

The catalysts also work in water-alkali electrolyzers, which split water into oxygen and hydrogen and could be a potential source of hydrogen fuel depending on the cost of the electrical power to run them. Alkaline water electrolyzers have a pair of membrane-separated electrodes immersed in a liquid electrolyte made highly alkaline with caustic potash, or potassium hydroxide. The researchers tested the new electrocatalysts in the crucial cathodic hydrogen-evolution reaction, and activity was enhanced by almost one order of magnitude compared to platinum-carbon.

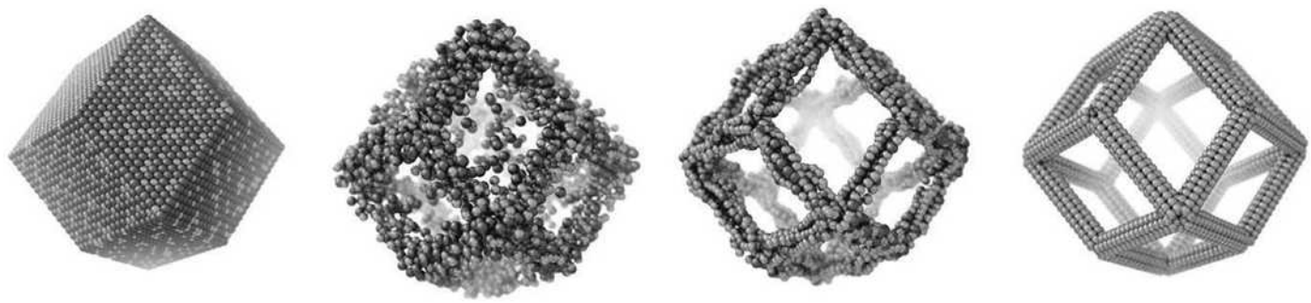
In recent years, intensive worldwide research efforts have focused on creating high-performance electrocatalysts with the minimum costly precious metal content by alloying platinum with cheaper materials and hoping to main-



A new shape for the catalysts of oxidation and hydrogen-evolution reactions could mean more efficient, cheaper fuel-cell stacks, and perhaps even cheaper hydrogen fuel. (Argonne National Laboratory)



Chemist Peidong Yang led the research team at Lawrence Berkeley National Laboratory that discovered the new nanoparticle catalysts. (Lawrence Berkeley National Laboratory)



The original solid bimetallic nanoparticle of platinum and nickel evolves into a hollow framework covered with platinum catalyst sites in this schematic diagram. (Lawrence Berkeley National Laboratory)

tain activity levels. Another promising strategy for improving catalysts involves the development of caged, hollow, or porous materials that contain fewer buried and thus nonfunctional precious-metal atoms. These uncommon geometries can also provide an easier route for tailoring physical and chemical properties as needed, said Peidong Yang, a noted chemist at LBNL and the **University of California at Berkeley**, who led the work.

New bimetallic nanocages

"We started research on nanoparticle catalysis for both solution and gas-phase reactions about 10 years ago," Yang began. "Initially, we focused on single elements like platinum, analyzing the size- and shape-dependent catalytic properties, but the focus in time morphed to bimetallic catalysts, such as platinum-nickel (PtNi) and platinum-copper. Then three or four years ago, something unexpected happened when two of my post-docs placed a platinum-nickel sample into a solvent: two weeks later they found the bimetallic nanoparticles had evolved into new shapes."

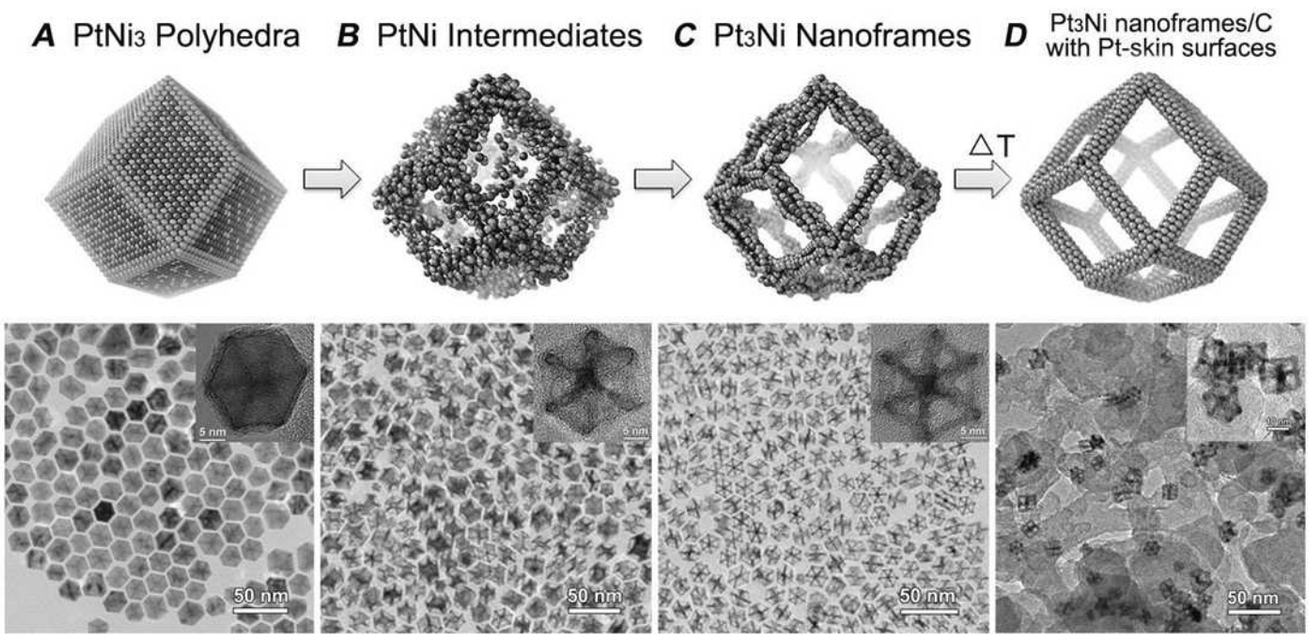
"It was an accidental discovery for us," Yang continued, "but once we saw the 3-D 'nanoframe' structures that had emerged were covered with catalytic sites, we knew that we had something interesting."

Chemist Vojislav Stamenkovic led the research and development team at Argonne National Laboratory that tested the new nanoparticle catalysts. (Argonne National Laboratory)

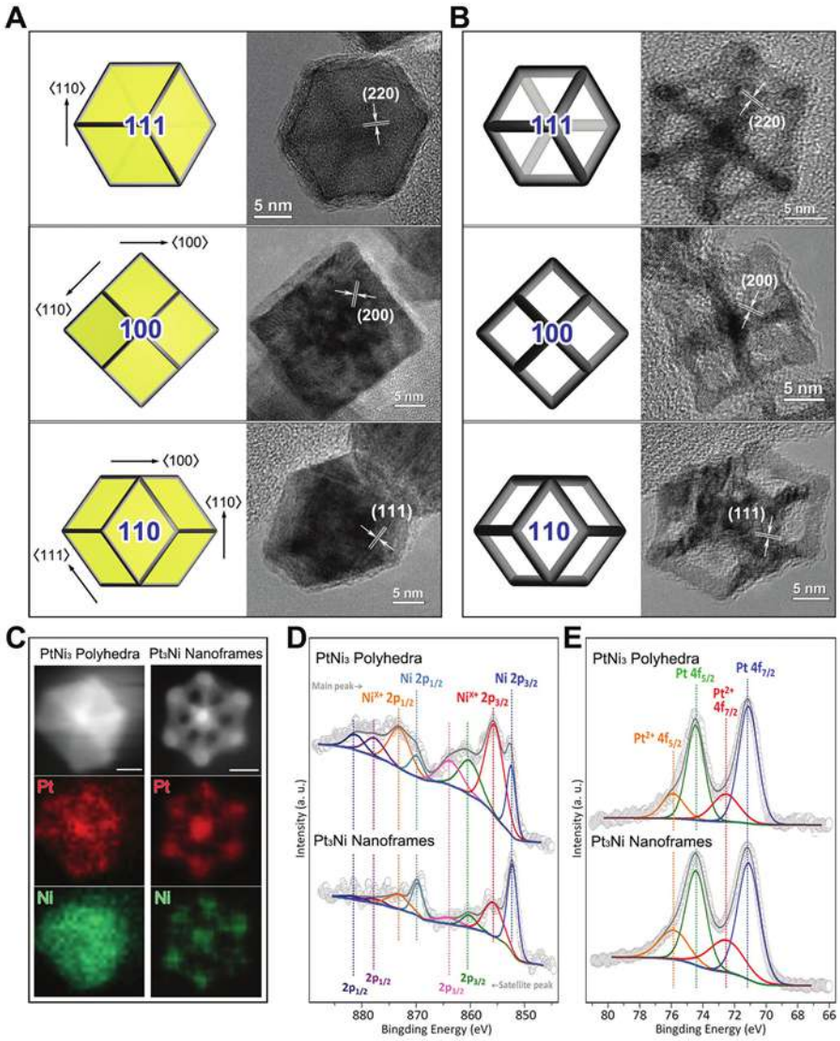
The Berkeley researchers consulted the existing literature and found that a group at ANL led by chemist Vojislav Stamenkovic had already done considerable work on catalytic activity of bulk single-crystal substrates. "Based on research by Voya's team, it was fairly obvious that new bimetallic material could be an amazing electrocatalyst. So we contacted him and began a collaboration" to test it, Yang said.

Opening a hole

It turned out that in solution, the starting material, solid crystalline $PtNi_3$ polyhe-



The same schematic illustrations as before and the corresponding transmission electron microscope photos of the evolution from solid polyhedra to hollow nanoframes. (Lawrence Berkeley National Laboratory)



Electron microscope images and other data collected by the joint DOE lab team identified the unusual shape of the new bimetallic nanoframe catalysts. (Lawrence Berkeley National Laboratory)

dra, transformed naturally into PtNi intermediate species, and then via interior erosion into Pt_3Ni nanoframes with surfaces that provide ready access to oxygen molecules. The edges of the $PtNi_3$ polyhedra, which are platinum-rich, are maintained in the final Pt_3Ni nanoframes, the paper stated. Whereas the original polyhedron consisted of three nickel atoms for every platinum one, the nanoframes had, on average, the reverse ratio.

"Polyhedra have been the usual nanostructures used for decades for catalysis research," Stamenkovic said in a statement. "Our research shows that other options may be available. With frames, we completely opened the structure and got rid of the buried nonfunctional bulk atoms. There are still a substantial number of active sites on the nanoframes that can be approached from any direction."

The solvent, with its dissolved oxygen, causes a natural interior erosion to occur that yields in a hollow twelve-sided, or dodecahedron, nanoframe. Running this reaction at a higher temperature shortened two weeks to 12 h.

After producing the basic material, the scientists wanted to ensure its stability in the harsh electrochemical environment of the fuel-cell stack, so they created a "second skin" of platinum atoms over the nanoframe, boosting the catalyst's durability, to stay active. Annealing, or heat-treating, the nanoframes in argon gas creates a platinum skin on the nanoframe surfaces.

"We suspect that the oxygen pulls the nickel nanoparticles out onto the nanoframes," Yang said. "Then annealing in argon pulls the platinum out onto the surfaces."

Ultra-active catalysts

Both the interior and exterior catalytic surfaces of this open Pt_3Ni framework structure, the paper stated, are composed of a nano-segregated platinum structure that exhibits enhanced oxygen-reduction reaction activity. The nanoframe catalysts achieved more than 36- and 22-fold enhancements in mass and specific activities, respectively, for this reaction in comparison with those of the best platinum-carbon catalysts during prolonged exposure to reaction conditions. The novel material has not been tested in a real fuel-cell stack as yet, Yang noted.

"In contrast to other synthesis procedures for hollow nanostructures that involve corrosion induced by harsh oxidizing agents or applied potential, our method proceeds spontaneously in air," Yang said. "The open structure of our platinum/nickel nanoframes addresses some of the major design criteria for advanced nanoscale electrocatalysts, including high surface-to-volume ratio, 3-D surface molecular accessibility, and significantly reduced precious metal utilization."

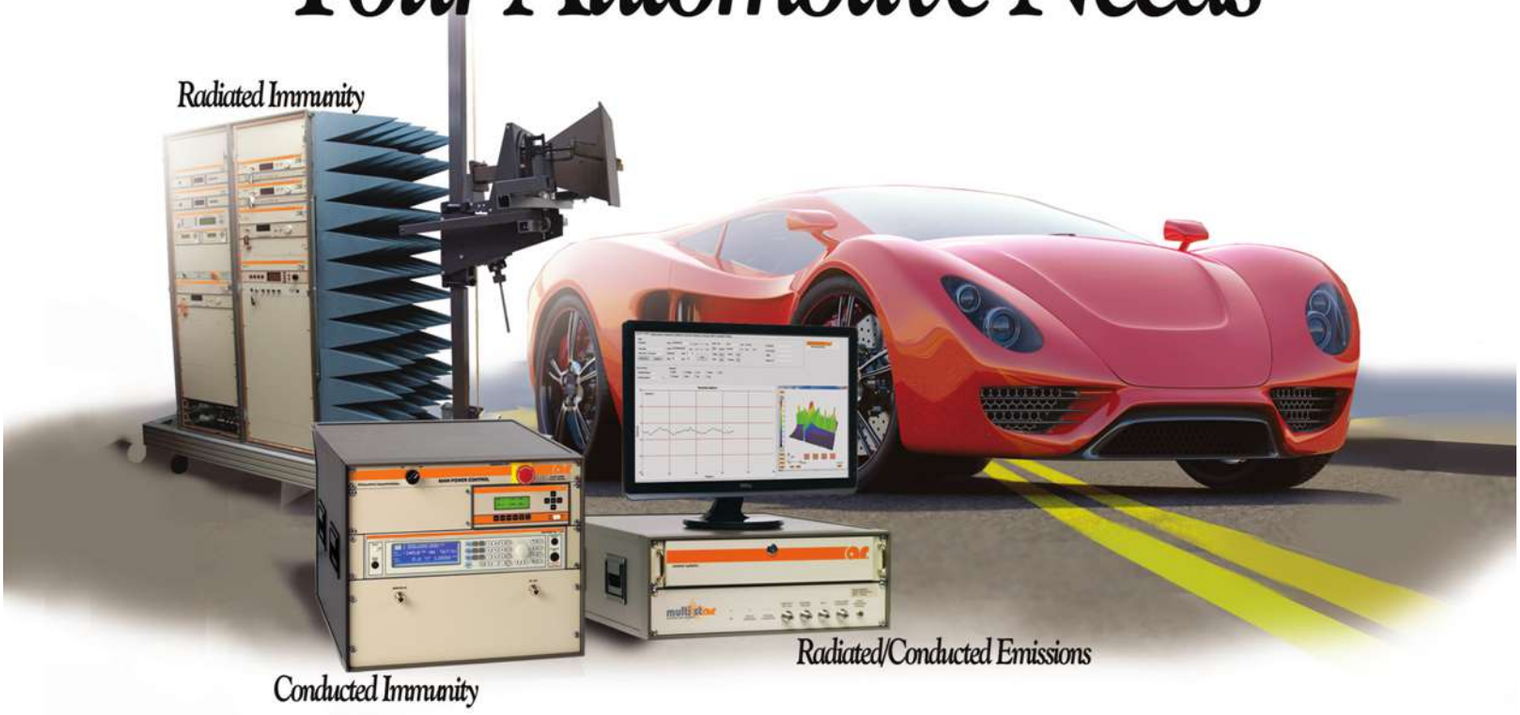
By greatly reducing the amount of platinum needed for oxygen reduction and hydrogen evolution reactions, the new class of nanocatalysts could lead to the design of next-generation catalysts with greatly reduced cost but significantly enhanced activities tuned as needed, the researchers said.

Synthesis of the nanoframes can be readily scaled up to produce high-performance electrocatalysts at the gram-scale. Importantly, the method can be generalized toward the design of other multimetallic nanoframe systems. The process can be readily applied to other alloy systems such as platinum-cobalt, platinum-copper, platinum-rhenium-nickel, and platinum-lead-nickel.

"We're pretty happy with this development," Yang said. "It would entail a significant reduction in use of platinum. And we are quite optimistic about its commercial viability."

Steven Ashley

The Total EMC Source For Your Automotive Needs



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OFF-HIGHWAY ELECTRONICS

Deere offers diagnostics and prognostics in the field

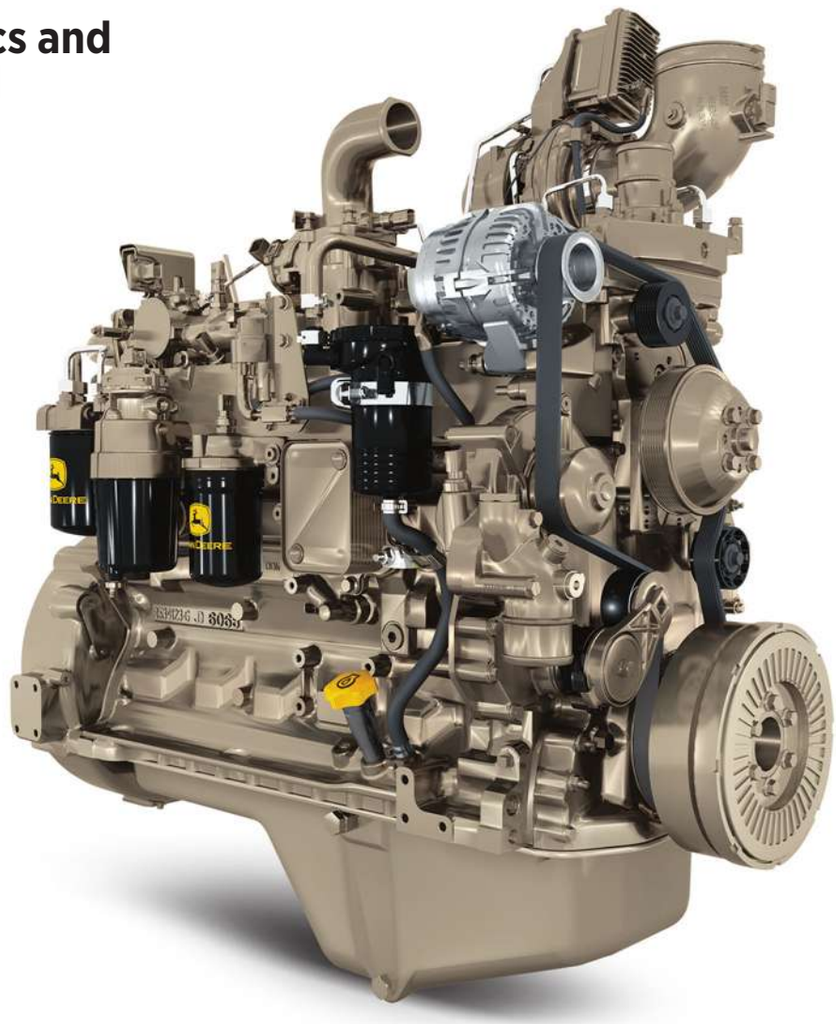
John Deere Power Systems (JDPS) introduced at ConExpo its John Deere PowerSight for JDPS diesel engines installed in OEM equipment. More than just a telematics system, John Deere PowerSight is an umbrella of John Deere technologies and solutions that integrate seamlessly to help customers manage their equipment. PowerSight incorporates four Deere technologies, including the JDLink machine monitoring system, remote diagnostics and programming, machine health prognostics, and the PowerAssist app. The technology solution is available for John Deere Final Tier 4/Stage IV, Interim Tier 4/Stage III B, and Tier 3/Stage III A engines.

The data collected by JDLink is communicated by cellular technology or satellite to a central John Deere server; it is made available online to registered users in the JDLink interface accessible through the MyJohnDeere.com portal or through apps for iOS and Android mobile device. Alerts can be transmitted through SMS text messaging or email.

JDLink enables customers to document operator productivity and determine which John Deere-powered equipment is generating revenue and which is idling. For instance, JDLink Ultimate provides access to engine and fuel utilization data to help customers determine how to better use the machine and manage fuel consumption. The Ultimate, Select, and Express versions of JDLink track hours of engine use.

All four versions of JDLink offered within John Deere PowerSight will feature location and geofencing services that provide logistics management and equipment security. JDLink enables curfew creation and instantly sends an alert when a machine is removed from a job site, and the system allows the timely recovery of stolen machines through GPS tracking.

PowerSight also supports machine optimization by simplifying preventive maintenance scheduling and documentation. The Ultimate and Select versions of JDLink monitor service status and send reminders of scheduled maintenance to help customers optimize equipment performance and extend machine life.



The diagnostics and programming features—as well as machine health prognostics that interpret telematics data, fluid analysis, and other critical machine data—of PowerSight enables John Deere technicians to isolate, identify, and diagnose problems remotely. The technology is available for John Deere Final Tier 4/Stage IV, Interim Tier 4/Stage III B, and Tier 3/Stage III A engines.

The machine health prognostics component of PowerSight is capable of proactively discovering improper engine operation that could lead to downtime. With machine health prognostics, PowerSight proactively analyzes JDLink data, fluid analysis, and other critical machine data. Proprietary condition-based rules logic identifies out-of-spec conditions and operating practices and measures how critical an issue is. After a problem is discovered and evaluated, an alert is sent to the customer and John Deere service representative with recommended solutions to maintain engine health and provide increased uptime.

The Ultimate version of JDLink enables the remote diagnostics and programming component of John Deere PowerSight. JDLink allows a John Deere service representative to read and reset engine diagnostic trouble codes and record performance readings remotely. Service technicians can utilize the data collected by PowerSight to isolate, identify, and diagnose engine issues before visiting the job site.

Jean L. Broge

AEROSPACE AVIONICS

Dassault magnifies focus on its 5X

Dassault Aviation has built into its new Falcon 5X program flight controls and displays experience not only from the Falcon family of business jets but also from the advanced Rafale multi-role combat fighter. This is particularly important for it incorporates many thousands of hours of operational military flying aboard air combat planes, and this brings direct first-hand technological feedback that is unavailable to most other manufacturers of business aircraft.

The EASy II system provides a very precise flight path control and automatic trim, with adjustments during configuration changes, and the autopilot functions through the side-stick controllers for setting heading and altitude, with full envelope protection through the digital flight control system. This allows pilots to extract the maximum aircraft performance (such as extreme angles of attack) in instances of instinctive reactions, such as wind shear or collision avoidance maneuvers, without over-stressing or stalling the aircraft.

This is an area where at the design and development stage, Dassault's fighter heritage is much evident. The new digital flight control system will command all the flight control surfaces, including the slats and flaps and each control surface will be multi-functional to give peak performance at all times. An example of this flexibility can be seen on the aileron, which can function as an aileron but also act as an air brake.

The Falcon 5X is the first aircraft in the business sector to use flaperons—active high-speed deflection control surfaces that can act as flaps or ailerons. The flaperons will always operate in active mode and will enhance roll authority, but the benefit will be seen very effectively on approach, especially in a steep descent where the flaperons will act like a traditional flap because they will increase drag while maintaining a high lift coefficient. This will allow a pilot to be able to fly a steep approach without increasing the approach speed, even on a normal approach. According to Dassault, this will maintain optimal control while giving a good forward visibility, enhanced by cockpit windows that are 32% larger than on average business jets.

The Falcon 5X underwent its first simulated flight, completing an important milestone in the development program, in November 2013.

Dassault Aviation's Falcon 5X's EASy flight deck features 32% more window area, dual HUD capability with SVS and EVS, and an EFB that is integrated into the front panel.

The synthetic vision system (SVS) on the 5X allows the pilot to see the exact position of the aircraft even in instrument flying conditions, and is an important bonus when flying into an unfamiliar destination. The SVS creates a highly realistic image of the surrounding terrain in a simulated daylight VFR condition, using the head-up display symbology and advanced 3-D terrain simulations.

Unique to this system is the breakthrough integration of the symbology between the head-up and head-down displays. By harmonizing this display it does not matter if the pilot is looking up through the HUD or down, as the same layout, same icons, and same image will appear in front of the eyes. This can provide a vital additional safety feature in difficult situations.

As well as the SVS, the aircraft also has an enhanced vision system (EVS) with nose-mounted sensors that are fully integrated to give even further SA during takeoff, approach, and landing, and also during ground maneuvering at busy airports. This provides an image on the new-generation wide-angle **Elbit**-

The virtual flight was performed on the Falcon Simulation Bench at the company's design office in Saint-Cloud, France.

The Falcon 5X is the first aircraft in the business sector to use flaperons—active high-speed deflection control surfaces that can act as flaps or ailerons.

supplied HUD and on flight deck displays and gives an improved image of terrain near the airport and of the airport environment in conditions such as fog, haze, and at night.

The Falcon EVS uses LCD HUD technology features unavailable elsewhere. This gives a brighter video presentation with a unique two-mode setting, optimizing the video for either an approach configuration or a more general-purpose configuration. It also takes advantage of special IR video processing developed specifically to minimize distortion.

The 5X is still two to three years from entering service, but its highly sophisticated avionics systems that are at the heart of the aircraft undoubtedly help project flight-safety capabilities in the direction many pilots have been calling for in recent times.

Richard Gardner

AUTOMOTIVE INTERIORS

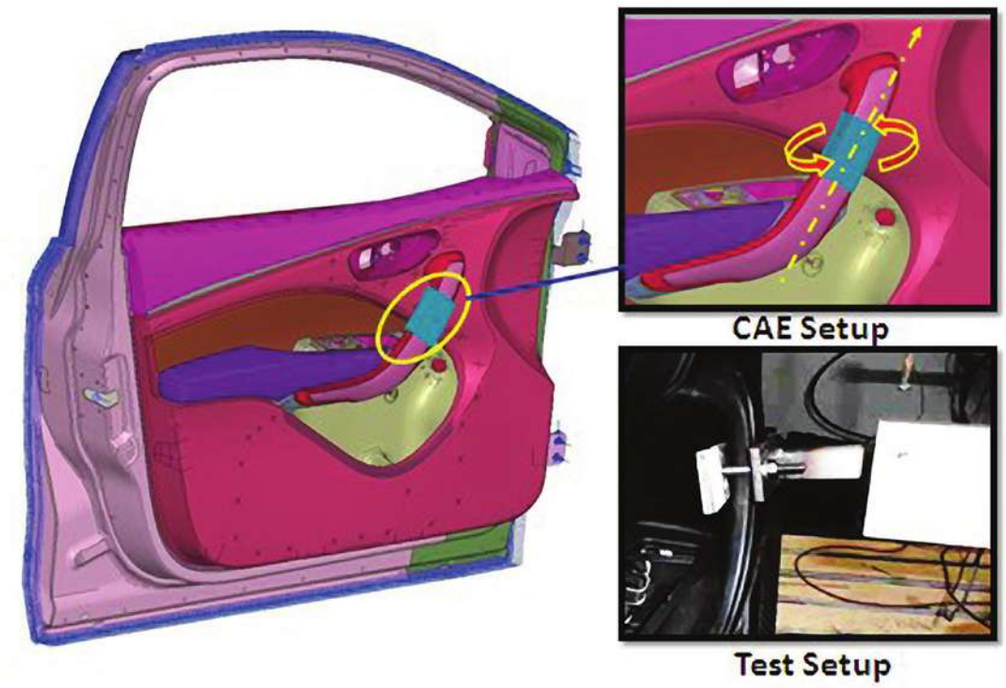
Touchscreen concepts, thin-foam seats among interiors topics at SAE Congress

Technical sessions focused on interiors at the **SAE** 2014 World Congress span the designated technology areas, including electronics, materials, and safety/testing. One example in the electronics area covered multimedia systems.

Takata researchers presented their paper (2014-01-0266) titled "In-vehicle Touchscreen Concepts Revisited: Approaches and Possibilities" as part of the multimedia discussion. The authors review current technologies such as capacitive touchscreens and resistive touchscreens, noting that they both have certain drawbacks—for example, in their distraction potential and their usability.

As an alternative, the Takata researchers focus on the generation of a holistic touch experience: auditory, visual, and haptic feedbacks combined with accurate force sensing for activation and deactivation. Using this approach, two new independent technologies were identified, that when combined offer a

An example of a new smart display surface, posed by Takata researchers, could benefit steering-wheel design, among other applications, by replacing mechanical buttons. The concept incorporates a screen component that provides the ability to graphically filter complex information to the driver and employ "situational context awareness."



Chrysler and Chrysler India researchers found that CAE tools can be used efficiently to predict the stiffness of cockpit systems, but they also observed some deviations in a few stiffness test values toward the CAE predictions. Shown is a rotational simulation/test for a pull handle.

powerful alternative to the current systems with a much greater focus on usability and haptic responsiveness.

The use of force sensing is an essential component to the system. Therefore, the first key technology to this system is the use of a very new and unique, accurate, responsive, repeatable, durable, and linear sensing system, with unperceivable displacement that does not suffer with the inherent issues of flexible printed elastomeric solutions, such as creep, unwanted environmental effects, etc.

The second key part to the system is the use of a fast-acting haptic system that can generate a significant tactile haptic response. In this instance, the technology can also generate an audible component that can be tuned to give direct audio feedback.

By using a static overlay material, a digital button can be recreated, with digitally tunable audible effects, tactile haptic effects, and switching thresholds. This presents new opportunities, such as conventional button replacement or implementation of controls where none was possible before.

By replacing the static overlay with a digital screen overlay, the same system can be applied to create a unique and compelling touchscreen system, without affecting the screen readability, contrast, or visibility.

Such a force-based digital system opens up several potential application areas for further implementation that were compromised, costly, or technically challenged using existing technologies, according to the Takata researchers. Such a system could allow for multi-state force-based switching with dynamic tactile haptic and audible feedback, while reducing the packaging challenge on the steering wheel design. When combined with passive haptic designs, it is possible that a natural evolution of the current interfaces is possible, one that is more in line for future vehicle systems.

With sufficient thought and planning, they concluded, a new holistic interface incorporating the steering wheel dis-

Opportunities exist to reduce seat foam thickness for the Hyundai Sonata, according to Lear and Hyundai researchers. They tested cushion foam pads that were about 20 mm (0.79 in) thinner than those in the production Sonata (shown).

plays, digital center console, and digital instrument cluster can be achieved, not only enhancing the user experience but also allowing the vehicle to continue to evolve toward a semi-autonomous future while minimizing driver distraction.

As part of a Materials session on Advances in Instrument Panels, Seats, and Interiors, **Chrysler** and **Chrysler India Automotive** researchers presented their work (2014-01-1025) on "Strength/Stiffness Simulation Techniques and Test Correlations in Automotive Interior Cockpit Systems."

The development of a cockpit system requires a lot of simulation work to verify its performance prior to prototyping, the authors note. They explain the various CAE methods and techniques used to simulate the virtual stiffness test for the floor console, door trim, and instrument panel (IP) assemblies. They also present the correlation of the CAE results and the lab results, which will reduce product-development time and cost at an early stage, before the prototype is made and physically tested.

What the researchers found is that the CAE tools can be used efficiently to predict the stiffness of the cockpit systems, but they also observed some deviations in a few stiffness test values toward the CAE predictions. Some major areas identified that need more attention to improve the accuracy of the CAE results include: modeling techniques of components and joint representations (fasteners, track, hinge, snaps, welds, etc.); nonlinear material models used for engineering plastics, rubber, and foam parts; the conversion of the physical test setup to the CAE setups like loading applications, constraints, etc.; usage of CAE methods like implicit and explicit solvers, and their benefits and limitations; and types of contact used to avoid penetrations, and load transfers between the surfaces.

Other papers in this session focused on advanced materials for interior applications. Renewable, bio-based fillers consisting of coconut shell and torrefied wood are explored for use in an HVAC case application by **Hyundai-Kia America Technical Center** researchers (2014-01-1026). And **JSP** and **Toyo Seat** engineers presented their findings on a polyurethane-free lightweight seat that features expanded polypropylene (EPP) padding and reportedly results in a 30-50% weight reduction (2014-01-1033).

Human Factors in Seating Comfort is an interiors-focused Safety/Testing technical session that also took place at the SAE World Congress. Researchers from Hyundai-Kia America Technical Center and **Hyundai** Motor Group featured prominently in this session, presenting a combined four technical papers. One of these is "Seat Comfort of Thin Foam Seat Cushions of Varying Densities and Thicknesses" (2014-01-0453), by Michelle Pereny of **Lear** Corp. and Scott Ziolek of the Hyundai-Kia tech center.

Seat assemblies in vehicles present the biggest opportunity for weight reduction among the various other in-cabin components, the authors note. Reducing foam thickness is seemingly an easy way to reduce weight of the seat system; however, making the foam thinner without understanding the impact to the seat system and comfort could be problematic.

For their examination, the researchers selected a Hyundai Sonata seat frame. Three production level seat frames were modified to support the cushion foam pads that were about 20 mm (0.79 in) thinner than those in the current production Sonata; no changes were required in the back structure. The modified foam pads were poured using the same chemical formulation (foam index) but at different density levels.

They concluded that opportunities exist to reduce foam thickness for the Sonata; however, changes to the seat structure and cushion suspension must be investigated for a successful implementation. The next phase of their study will evaluate dynamic performance of the seats through damping and vibration transmissibility objective testing and a long-term ride-and-drive evaluation.

Other organizations represented in the Seating Comfort session include **Toyota Technical Center USA**, **Fiat** SpA, **Wuhan University of Technology**, and the **Korea Research Institute of Standards and Science**.

Ryan Gehm

AUTOMOTIVE INTERIORS | MATERIALS

Prodrive process 'clips' carbon-composite costs by up to 40%

The use of carbon-composite components continues to be an extremely effective solution to weight saving in very high-end premium cars, but its cost continues to limit its application in higher-volume vehicles. Now, **Prodrive**—whose composites were incorporated into several of the cars launched at the Geneva Motor Show—has developed an innovative process to help reduce cost. The company has focused on achieving simpler fixing integration via the elimination of costly bonding of clips, fasteners, threaded inserts, and hinges to provide easier, more robust assembly for interior applications without any reduction in finish quality.

Gary White, Prodrive Composites' Engineering Manager, said: "We are making composite components more affordable by reducing the cost of manufacture, not just of the component itself but also by addressing wider assembly issues. By taking a look at the bigger picture, we think we can help bring the benefits of composites to a larger market more quickly.

"Features normally added in a separate operation, such as clips and inserts for threaded fasteners, can now be molded directly onto the back of high-quality composite panels, producing a more cost-effective part than a conventional bonded assembly, and one with greater mechanical strength. The process removes a major barrier to the wider use of composites."

Historically, composite components have demanded extensive manual input, including layup and hand trimming operations, leading to increased process times and subsequently higher costs. This can be reduced by increased use of automation.

White says Prodrive has unlocked "a number" of efficiency improvements by introducing a new process that combines a plastic back-injection molding to house complex fixtures and fittings via a press-molded component.

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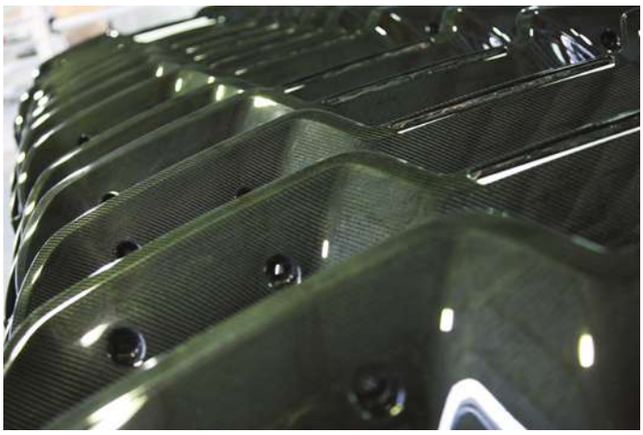


Finished carbon-composite diffusers from Prodrive.

Prodrive's Gary White says the company is now making composite components more affordably by reducing the cost of manufacture.

"The resultant component is around 60% the cost of one made using a traditional method—but is visually identical," he said.

Prodrive has started manufacture of parts for two production applications, both premium automotive interiors.

"One of the challenges of using carbon composite panels is the provision of fastenings for their attachment, which can lead to costly, intricate components," said White. "Conventional solutions involve creating a complex carbon shape to carry the fittings. By molding onto the finished composite, we can match the convenience of an injection-molded plastic part at a fraction of the cost, while providing the low weight, strength, and superb display surface of carbon."

As well as being a very high profile motorsport constructor, Prodrive provides design, development, and manufacturing support for a wide range of transportation technology; its specialist manufacturing areas include carbon composites and ultra-high precision small-batch machined components. Its design capability sees it working with European and U.S. OEMs, focusing on, inter alia, vehicle dynamics, power electronics for HEVs, and precision actuator systems such as active aerodynamics.

In most automotive applications, the company supplies OEMs directly and is able to meet requirements that include very high-quality finish for prominent interior surfaces, said White: "Cosmetic perfection on all exposed surfaces is essential and it has to be sufficiently durable to cope with use and conditions across the world. We validate this by the application of environmental and climatic tests to ensure durability even in the most demanding climates. Parts made using our new process have passed the full range of OEM tests, and we are now ramping up to supply production vehicles."

Innovations by Prodrive, such as its new molding process, are seeing growth in its carbon-fiber business, but the drive to keep costs down continues. A significant aspect of this is to operate as the engineering partner for vehicle manufacturers.

"But improving efficiency requires providing much more than just components," stressed White. "We have established processes that allow composites to be used more effectively. In 2009, we launched the lacquer-free finish that resists stone chips and UV deterioration. Earlier this year we launched colored composites. And now we have integrated molded plastic features onto composite panels. Collectively, these developments contribute to the creation of more competitive products, which means widening the scope of carbon-fiber applications."

Stuart Birch

Carbon integral fixings by Prodrive.

AUTOMOTIVE BODY | ELECTRONICS

Audi to increase laser-headlamp applications, says technology chief

Audi plans to migrate its new advanced laser-based headlamps through its model range, the brand's technology chief revealed during the 2014 Geneva Motor Show.

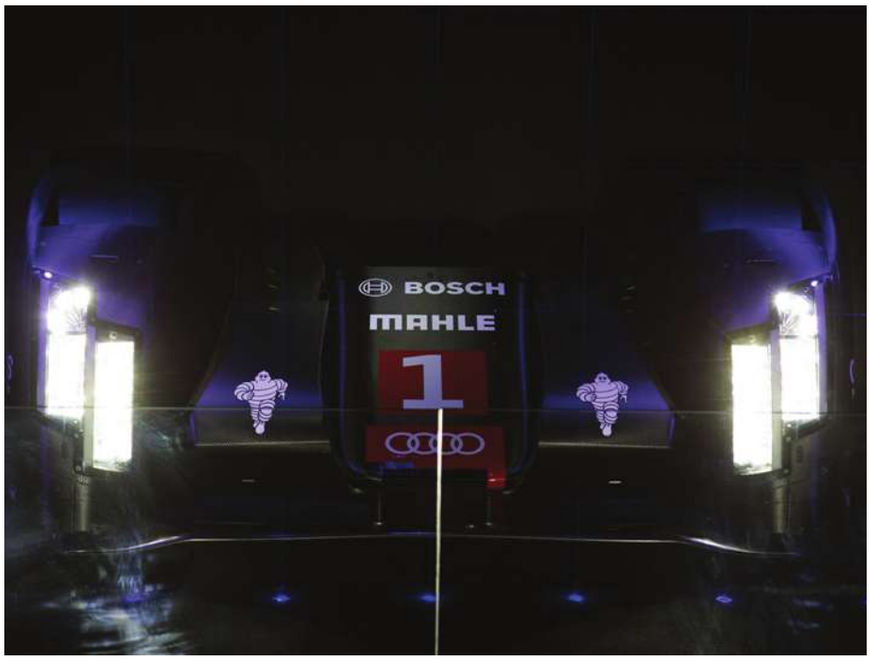
Dr. Ulrich Hackenburg, Member of the Board of Management for Technical Development, told SAE Magazines during a media roundtable that headlamps featuring laser-diode high-beam elements throw a white beam with superior luminosity, optical direction, overall efficiency, and vastly longer life compared to light-emitting diode (LED)-based units now entering the market.

Extensive testing of laser high beams by Audi's Headlamp Development Project Team has shown an effective illumination range of 600 m (1970 ft), with three times the luminosity of LED-type high beams, Dr. Hackenburg reported, with a brilliant beam quality that provides more nighttime visual acuity and less fatigue for the driver, but doesn't hit oncoming drivers like a Sci-Fi movie death ray.

Tier 1 lighting suppliers are expecting Audi to offer production laser high-beam elements in the A8 in the 2016 timeframe, one of them told SAE Magazines. Dr. Hackenburg said initially the powerful laser high beams will be combined with low-beam LED arrays.

Headlamps that feature laser-diode semiconductors typically generate a bluish beam at a wavelength of 450 nm. The beam, generated from the rear of the housing, is directed toward the front through a set of collimating mirrors onto a yellow-phosphorous wafer. Excited by the blue laser, the yellow phosphorous emits a diffused, brilliant white light that is bounced off a reflector, through the headlamp lens, and onto the road ahead. Laser-lighting experts believe automotive headlamps will have electrical-to-optical efficiencies of 50-60%.

Audi broke news of its laser-lighting development last January at the 2014 Consumer Electronics Show, where it displayed the Sport quattro "laser light" concept car (http://articles.sae.org/12729/). That vehicle features a pair of trapezoidal headlamp elements per side, with the laser diodes on the inner ring surrounded by a ring of low-beam LEDs.



Audi will demonstrate the effectiveness of its new laser-diode headlamps on its R18 e-tron endurance racecar (shown) at the 24 Hours of LeMans in June. The first production-car application is expected by 2016.

The company's latest R18 e-tron factory-prototype endurance racecar will have laser diodes integrated into matrix-beam LED headlamps at the 24 Hours of LeMans in June to prove the technology's value in an extreme operating environment.

"Laser light provides a much more homogenous and precise spread in front of the car," explained Chris Reinke, head of LeMans prototype development at **Audi Sport**. Systems cooling is a critical issue in designing laser diodes to meet the auto industry's long-term durability requirements.

Audi used its 2011 R18 to showcase its first full-LED headlamps. It first used LED running lights in 2006, one year before **Toyota** debuted the first production-car LED headlamps on its **Lexus** LS 600h.

BMW has claimed it will be first to offer laser-diode headlamps on its $136,000 i8 range-extender EV, setting up an OEM leadership battle on the lighting-technology vanguard.

Audi has been investigating laser-based exterior lighting systems for about five years, and first showed a laser fog lamp on an A2 concept. Dr. Hackenburg indicated that the automaker has been collaborating with two lighting suppliers to develop production-suitable technologies, but did not identify a vendor.

Likely Tier 1 partners might include **Hella**, which helped develop Audi's LED-based MatrixBeam system used on European A8 models (http://articles.sae.org/12579/), and **Osram Opto Semiconductors**, known to have a significant laser-lighting development program.

Audi officials at Geneva told SAE Magazines that the new laser-diode headlamps will not be available on U.S. models until the technology is approved by federal vehicle safety regulators. The MatrixBeam system also is not yet legal for use in the U.S.

Lindsay Brooke

TRUCK BODY | SIMULATION

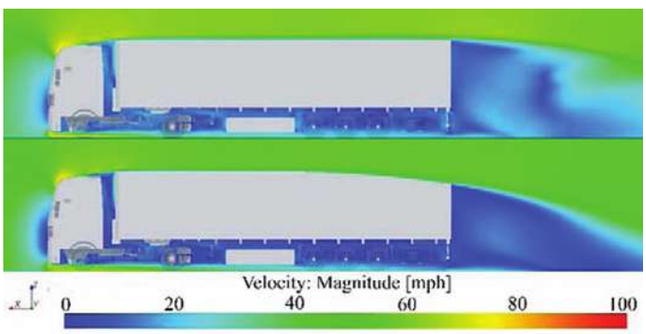
Variable trailer design drastically cuts aerodynamic drag

Tractor-trailer design is significantly influenced by legal conditions regarding the vehicle dimensions and the provision of a maximum transportation volume. These boundary conditions lead to brick-shaped trailer outer geometries, especially at the rear ends. That is why investigations of aerodynamic optimization of commercial-vehicle (CV) trailers are predominantly restricted to detail measures.

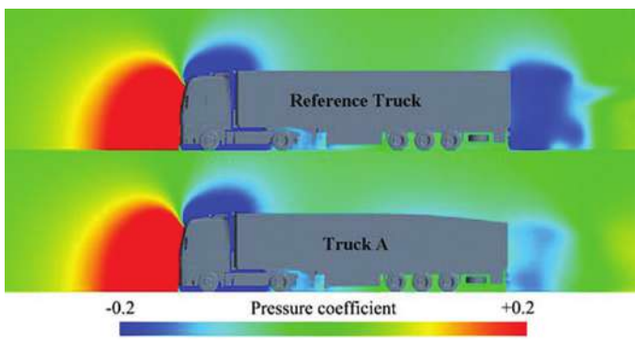
Researchers from **Graz University of Technology** studied the aerodynamic characteristics of general modifications to the outer contour of long-distance haulage trailers, including a new approach for the realization of a variable trailer rear end. The variable adjustment of the sidewalls and the top of the trailer's rear end can take the actual space requirements of the transportation load into account, thereby resulting in optimal transportation efficiency.

The aerodynamic studies were based on truck models according to the European legislation. Because the investigations focused on the rear end of the trailers, the findings are applicable to the aerodynamic characteristics of trailers in different markets, including the U.S.

The first step of the research work entailed the derivation of a generic virtual reference vehicle, which was created as a 3D-CAD model. Therefore, several cab-over-engine semi-trailer tractors for long-distance haulage from six different European truck manufacturers were evaluated and compared. From this investigation, the configuration and dimensions for an average tractor were determined. The same procedure had been performed to collect information of typical semi-trailers with curtain-side configuration for long-distance transport.



Flow velocity of the reference truck (top) and Truck A (bottom). The reference truck shows a large irregular dead water area behind the rear end due to its brick-shaped outer contour; the aerodynamic-optimized shape of Truck A enables the fluid a smooth changeover to the road surface, which leads to a smaller dead water area.



Pressure coefficient distribution (limited by ±0.2). As a consequence of Truck A trailer's bent roof, the flow is exposed to a deceleration that increases the static pressure at the back panel in contrast to the reference. Simultaneously, the influence of the static pressure was reduced by the downsized effective vertical area at the rear end. The result is a significantly lower air resistance force in the driving direction.

Aerodynamic investigations

The semi-trailer truck optimization process was split into two main parts: a coarse geometrical concept study by use of a simplified vehicle model, and a detailed study based on a high-resolution reference truck model.

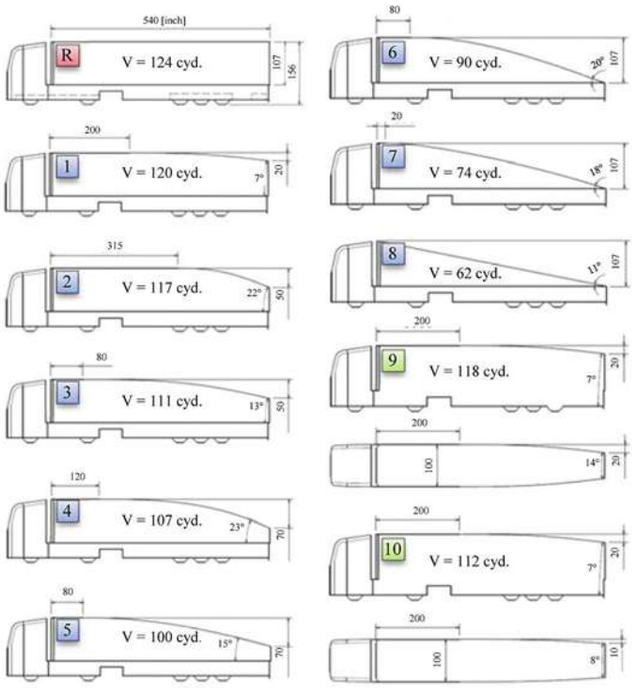
The coarse concept study was based on a simplified reference model, designed in the shape of a single-volume model. During this study, principal geometrical modifications were performed at the outer contour of the semi-trailer. Following that, the air drag of each simplified model variant was assessed by application of 3D-CFD simulations by use of a commercial software.

For the coarse concept study, 10 different trailer variants with varying payload-space "V" were created. The simulation results consider the payload space in comparison to the reference configuration "R". The variant models 1 to 8 were modified by using different vertical tapers at the semi-trailer. In contrast to those, the semi-trailer variants 9 and 10 had been equipped with horizontal boat tails as additional modification. As a result of this study, each geometrical modification decreased the air drag coefficient, but also reduced more or less the semi-trailer's payload space.

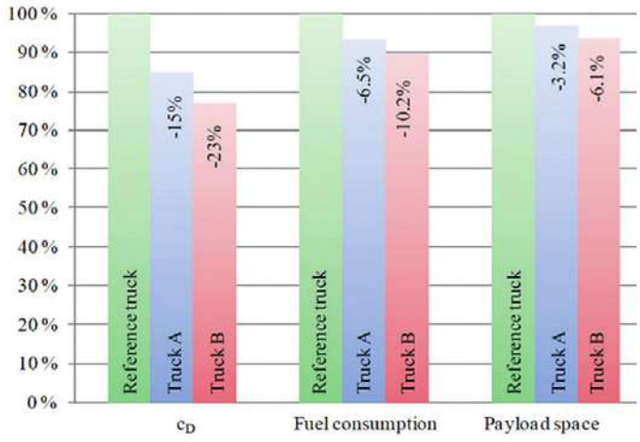
The coarse study demonstrated that geometrical modifications of the trailer had a big impact on the aerodynamic resistance. The researchers selected two variants (models 1 and 9) with a significant reduction of air resistance for further detailed aerodynamic studies. Besides the reduction of air drag, these two variants were selected because of their comparative small decrease of payload space.

The detailed study was carried out to validate the results of the coarse concept study due to higher simulation resolution and to compare the simulation results with the characteristics of present market-available semi-trailer trucks. The geometry of the detailed generic reference truck model was modified to create two optimized truck configurations with a high degree of geometrical information.

Out of the shape of selected model 1, the optimized Truck A was designed with a vertical taper of 20 in (508 mm) at the semi-trailer's rear end. Model 9 (with an additional boat tail) was used as



Geometrical modifications of the trailers.



Results of the detail study, comparison of characteristic values. The difference between the geometries of Truck A and Truck B was a horizontal boat tail of 10 in (254 mm) on each side of Truck B's semi-trailer.

a template for the detail study Truck B. The difference between the geometries of these two configurations was the horizontal boat tail of 10 in (254 mm) on each side at the semi-trailer of Truck B. To enable a comparison of the modification's impact on the trailer rear end, the tractor model remained the same during all variations.

Finally, the aerodynamic drag characteristics of Truck A and Truck B were assessed in detailed 3D-CFD simulations by application of the same boundary conditions as they were applied during the simulation of the generic reference truck.

In contrast to Truck A, the reference truck shows a big irregular dead water area behind the rear end of its semi-trailer due to its brick-shaped outer contour. The aerodynamic-optimized shape of Truck A enables the fluid a smooth changeover to the road surface, which leads to a smaller dead water area behind the rear end. As a result of Truck A trailer's bent roof, the flow is exposed to a deceleration that further increases the static pressure at the back panel in contrast to the reference. Simultaneously, the influence of the static pressure was reduced by the downsized effective vertical area at the rear end. The result is a significantly lower air resistance force in the driving direction.

Results—and the variable trailer rear-end concept

The fuel consumption of each variant was calculated in longitudinal vehicle dynamics simulations by use of predefined engine characteristics of a typical semi-trailer truck engine. The optimized semi-trailer trucks, Truck A and Truck B, obtained a declination of the aerodynamic drag coefficient between 15% and 23% related to the reference truck. Due to these significant aerodynamic improvements, a reduction of fuel consumption up to 6.5% by Truck A and 10.2% by Truck B could be reached. In contrast to the decrease of fuel consumption, the payload space was comparatively slightly reduced, between 3.2% (variant Truck A) and 6.1% (variant Truck B).

The transport efficiency of CVs depends on their payload and different cost factors. Regarding the results of the two optimized truck configurations with respect to aerodynamics, a reduction of fuel consumption and thus a decrease of the operating costs could be reached. On the other side, the payload space shrank, because of the geometrical modifications at the trailers' rear ends. In this way, an improvement of the transport efficiency depends on the type of payload, or more exactly on the freight density.

A large number of trips is carried out with a payload that does not require the entire trailer volume. A considerable share of trips is even performed without payload (in the U.S., the range is 10-13%). This leads to the cognition that the overall transport efficiency can be raised significantly by application of a variable trailer rear end.

A new approach has been developed to support high transport efficiency of future long-distance haulage trailers. With this approach, it is possible to adjust the trailer outer contour according to the required transportation volume, combining both advantageous aerodynamic behavior and improved transportation efficiency.

The researchers presented a lowered trailer rear end that contains an exemplary load configuration with prismatic packets. The complete mechanism can be built into the vertical stakes of a typical trailer and does not enlarge its dimensions. In this configuration, 95% of the total payload space is available for transportation purposes. At the same time, the aerodynamic drag of the truck combination is reduced about 6.5%.

This article is based on SAE International technical paper 2013-01-2414 written by Mario Hirz and Severin Stadler of Graz University of Technology.

AUTOMOTIVE MATERIALS

Forming a strong bond between materials

Lightweighting in automotive design is currently a major trend. This initiative is driven by the need to improve the fuel efficiency of vehicles to meet stricter upcoming regulations. Even so, the challenge remains to ensure optimum mechanical, NVH, and crash-safety performance while designing lightweight components.

When designing lightweight components and assemblies, it has become more common to design them as "hybrid structures" that make use of multi-materials. Use of structural adhesives for joining different materials is beneficial for several reasons.

Conventional joining methods for sheet metal parts and assemblies such as spot welding, riveting, and brazing are not as effective when joining dissimilar materials such as metal and plastics. Conventional joining has certain limitations of lower endurance life and lower impact strength.

While addressing the drawbacks of conventional joining techniques, adhesive bonding enables applications ranging from flexible sealings to high-performance structural bonding. The smooth appearance of the joints produced using adhesives results in lower stress concentrations at the joint edges. Thus, the load is more evenly distributed and stress concentrations are minimized. As a result, a more effective dynamic-fatigue resistance of the component or structure can be obtained. A good joint design will be energy-absorbing and tends to have good noise and vibration damping properties.

Adhesives are used extensively in the BMW i3, which features a carbon-fiber-reinforced-plastic passenger cell and aluminum structures. Dow Automotive, for example, optimized its Betaforce structural adhesives for the program. (BMW)

The major factors that determine the integrity of an adhesive bond are selection of the most appropriate adhesive, joint design, preparation of the bonding surfaces, quality control in production, and condition monitoring in service. Selection of adhesive for a particular application is based on substrate type, surface condition of substrate, curing condition (corrosion protection coating, painting) open time, strength requirements, end temperature conditions, gaps filling, vibration damping, etc.

Researchers from **Tata Motors** examined different aspects of the adhesive bonding process, emphasizing the performance verification of different adhesive joints to meet end-product requirements. Samples were prepared with a variety of adhesive and adherend combinations. These combinations were tested for tensile, single lap shear, T-peel, flexural, and fatigue tests according to standard testing methods. Since the performance of the adhesive depends upon weathering parameters, the test samples were also subjected to mechanical testing after conditioning them under extreme temperatures, exposing samples to fuels (diesel, petrol) and oils (gear oil, axle oil) to simulate actual field conditions.

This material level data generated in lab is used for 1) selection of adhesive, 2) optimization of adhesive curing parameters based on manufacturing practice, 3) carrying out design modification to get desired level of adhesive strength, and 4) inputs for carrying out crash/NVH CAE at vehicle level.

Types of adhesives

An adhesive is a polymeric material that, when applied to the surfaces of materials, can join them together and resist separation. In a conventional car body there is extensive use of adhesives. Depending on the application, the adhesive should satisfy a wide range of requirements such as compatibility with the substrate, open time, curing time, strength, chemical resistance, temperature resistance, fatigue, weldability (for spot weld adhesive), and emissions during baking.

Adhesives can be categorized based on several parameters, including base

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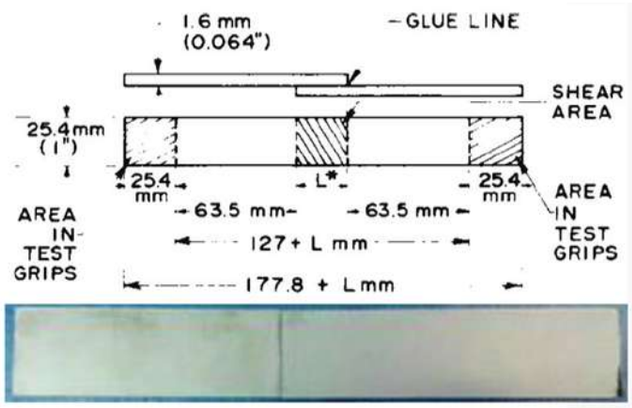


Specimen sample for lap shear test.

materials and their associated properties (see table), as well as number of components: for example, single component, which does not need homogenized and can be used directly on the substrate; and two component, which consists of a resin and a curing agent and requires homogeneous mixing of the two components.

Adhesives also can be categorized based on curing conditions. Anaerobic adhesives cure in the absence of air and can be used as sealing compound and locking compound for screws. Pressure-sensitive adhesives are often used in tape form. They have relatively low strength and are used for applications such as fastening decor strips and emblems. Instant-curing adhesives cure within a few seconds of application at room temperature and have a very small open time, while delayed-curing adhesives usually take more than 24 h to cure and may require a week to attain full strength at room temperature. Heat-curing adhesives require high temperature to cure, generally provide very high strength, and are used for structural bonding applications. The substrate should be able to withstand the curing temperature.

Structural adhesives provide high strength in the range of 10 to 30 MPa (1450 to 4350 psi) and low elongation. They are generally epoxy- or acrylate-based. Mostly based on rubber or silicone, nonstructural adhesives provide very low strength ranging from 0.5 to 5 MPa (72.5 to 725 psi) but high elongation.

Joint testing and validation

To have a robust design guideline for the selection of adhesives, laboratory experiments covering different adhesive materials were performed using two substrates: EDD-513, non-coated steel with thickness of 1 to 1.2 mm (0.039 to 0.047 in); and polypropylene (PP) with 20% talc filled, MFI (melt flow index) of 20 g/10 min at 230°C (446°F) with 2.16 kg (4.76 lb) load and thickness of 3 mm (0.118 in).

Tensile strength, lap shear strength, peel strength, fatigue, and flexural strength tests are designed to evaluate various mechanical properties of the adhesive joints. Glass beads having 0.5 mm (0.02 in) diameter were used to control the thickness of adhesive. In all the cases, thickness of the adhesives was maintained at 0.5 mm. Once the joint was prepared, it was cured according to the conditions mentioned in the technical data sheet.

All five tests are possible for steel + steel combinations, but

Type	Properties
Epoxy resin	Adhesives used in structural bonding where high strength is required. Generally cures at room temperature (RT) but for accelerated curing, heating is required. Stronger, elongation at break varies from 2-10 % and give a better peeling strength. Typical application includes, structural bonding, hem flange sealing, radiators, heat exchanger, fuel tank, cab
Acrylates	Cures at RT and generally require 24 hours to cure completely. Good impact resistance and peel-strength. Typical application includes, spot welding, body joint sealing, antiflutter bonding, structural bonding, hem flange sealing, glass-metal joining, light housing
Polyurethane	Cures rapidly within few minutes. Provide good flexibility. Strength depends on the thickness of the bond. The adhesives have good water resistance but do not bond all surfaces equally well. Use of suitable primer can address this issue. Typical application includes, antiflutter bonding, body joint sealing, assembly bonding of plastic components: spoiler, protectors, spare wheel compartments, fender, instrument consoles, air ducts systems, window guiderails
Cyanoacrylate	Known as super adhesives, rapid curing (within few seconds) in damp conditions. Requires at least 40% relative humidity (RH) to cure. Typical application includes, gaskets, flat surface bonding, metal to metal bonding, metal to plastic bonding, plastic to plastic bonding, bonding of rubber and EPDM parts, thread sealing, bonding of caps in cylinder head covers, gearboxes, crankcases, axle housings, shaft/hub
Rubber	Cure through evaporation of the solvent. Low strength. Not used for structural bonding but used in liquid gasketing. Typical application includes, common sealing in the assembly shop, transaxle, protective strips, name plates, pattern plates, mirrors, rubber seals, butyl rubber for vibration damping.
Silicone	Adhesives with relatively low strength but good high temperature properties and flexibility. Typical application includes, sealing of oil pans and housing covers, high temperature applications like engine parts

Types of adhesives based on base materials and associated properties.

for the other two combinations—PP + PP and PP + steel—only lap shear tests could be done. For every combination of substrate and adhesive, five samples were prepared and tested.

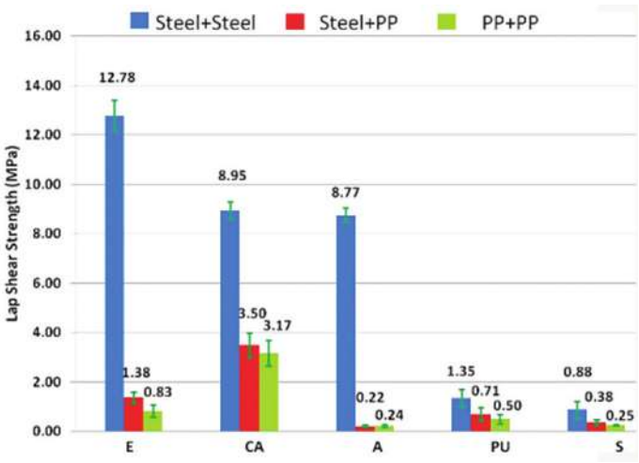
To determine the effectiveness of different adhesive systems, processing variables, and surface pretreatments, it is necessary to expose adhesively bonded joints to various environmental and loading conditions that can simulate actual service conditions. The predominant factors in climatic exposure are solvent, moisture, and temperature. Only a single lap shear test was carried out to evaluate the effect of different environmental conditions on adhesive joints.

It is clear from the test results that adhesive performances are substrate-specific—i.e., all the types of adhesives are not suitable for every type of substrate. Each type of adhesive has some advantages and disadvantages—i.e., even if an adhesive is compatible to a particular substrate, it may not perform well in all the environmental conditions.

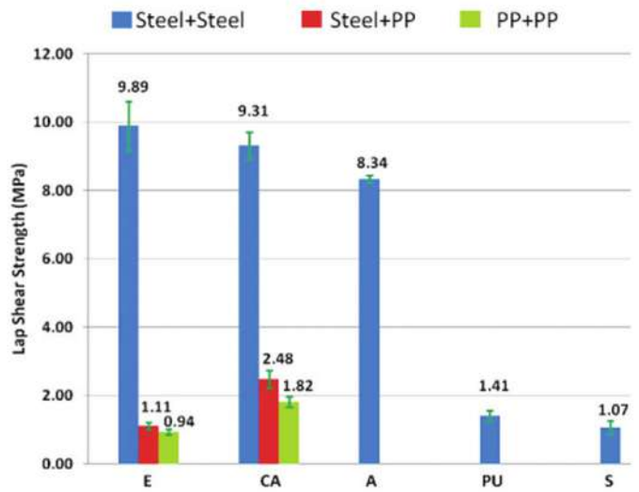
For example, the lap shear strength of five different types of adhesives was determined with steel, PP, and steel + PP substrate combination. With steel substrates, epoxy-based adhesives provide the highest strength, followed by cyanoacrylate (CA) and acrylic-based adhesives. One of the problems associated with CA is that after curing, it becomes very hard and brittle. Polyurethane (PU) and silicone-based adhesives, though compatible with steel substrates, can't be used as a structural adhesive because of their low strength but can be used for applications where high elongation and gap filling is required.

It is very difficult to find a suitable adhesive for bonding PP because of its very low surface energy. However, CA can provide good bond strength for PP to PP joint. Most of the time it was observed that the adhesive did not fail but the substrate itself failed.

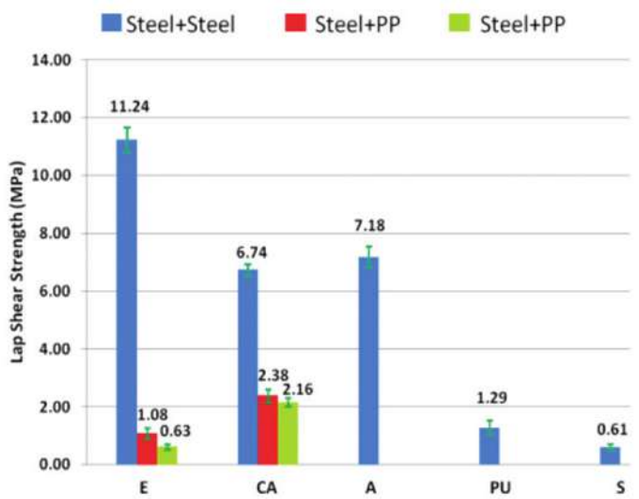
Epoxy-based adhesives can also provide good strength but the failure mechanism is adhesive type and not cohesive type—i.e., the joint does not fail through the adhesive but separated out from the PP surface, which is not acceptable. The other three adhesives—i.e., acrylic, PU, and silicone-based—are not compatible with PP, and therefore a PP to PP combi-



Lap shear strength of adhesives with steel, PP, and steel + PP substrates in dry condition. (E=epoxy; CA=cyanoacrylate; A=acrylic; PU=polyurethane; S=silicone)



Lap shear strength of adhesives with steel, PP, and steel + PP substrates after axle oil immersion.



Lap shear strength of adhesives with steel, PP, and steel + PP substrates after temperature and humidity cycle.

nation for these three adhesives was not considered for future tests.

For the steel and PP combination, again CA is the best possible solution available. Though epoxy provides moderate strength, it is not acceptable due to adhesive failure. Again, the other three adhesives were not compatible with PP.

Research conclusions

A proven substitute for conventional mechanical joining, adhesive bonding in the automotive industry has led to a new direction of producing lightweight and energy-efficient cars. The most important aspect in designing an adhesive joint is the appropriate choice of adhesive, and surface preparation plays a vital role in achieving the optimum performance of the joint.

Based on its study, the Tata Motors research team discovered that epoxy-based adhesives are superior in structural bonding of steels in all conditions; however, they showed very low adhesive strength for PP substrates.

Cyanoacrylate-based adhesives were found suitable for PP substrate with very good bond strength. However, CA-based adhesives have low resistance for high and low temperatures and hence are not suitable for extreme temperature conditions. They also have very poor resistance to petrol and exhibit very low fatigue life.

Acrylic-based adhesives have lower lap shear strength as compared with epoxy-based adhesives; however, these adhesives exhibit the best fatigue life. Acrylic adhesive is recommended when components experience fatigue cycles and moderate shear strength.

PU-based adhesives provide very low strength, but their performance remains unchanged in most of the environmental conditions, except high-temperature aging and gear oil resistance.

Silicone-based adhesives are suitable for high-temperature applications. They are resistant to oil and hence are suitable for powertrain applications.

This article is based on SAE International technical paper 2014-01-0788 written by Debabrata Ghosh, Lokesh Pancholi, and Asmita Sathaye of Tata Motors Ltd. The paper is part of the "Welding, Joining, and Fastening" technical session that took place at the SAE 2014 World Congress in Detroit.

AUTOMOTIVE SIMULATION

Honda, Peugeot stylists make digital renderings a focal point of design

As stylists transition to digital designs with fewer physical prototypes, they are seeking more realistic real-time graphics. **Honda** and **PSA Peugeot Citroën** have each developed programs that let them do more digital designs for overall vehicles and human-machine interfaces (HMIs), respectively.

At the recent **Nvidia** GPU (graphics processing unit) Technology Conference, Honda explained how stylists are reducing the number of clay models of vehicles by using software that renders images that offer realistic visuals that change as materials and lighting are altered. PSA Peugeot Citroën engineers described a system being used from early concepts through the final design phase of digital display system development.

"During the styling phase, movies must be produced to illustrate the HMI concept and/or tools that are needed to simulate in real-time embedded systems," said Alain Gonzalez, Workstations Graphics Technology Expert at PSA Peugeot Citroën. "During the design phase, the final HMI must be simulated with the interior environment in order to visualize reflections on windshield, color, and trim integration, embedded display defaults and also to validate the usability of the HMI."

With the virtual prototypes, stylists and ergonomic specialists can change materials and viewing angles to see how minor alterations can impact HMI readability. The models hold data that let these developers make changes based on the capabilities of electronic controls and displays as well as user requirements.

"We can simulate different intensities and different points of view to see if factors are good or not good for drivers," Gonzalez said. "We can also change the size of the driver, altering the viewpoint to see whether all people see the same thing."

Honda's virtual prototypes let viewers peer inside the vehicle by removing slices.

When these simulations are realistic, there is less chance that changes will be required late in the cycle when physical prototypes are completed. That is especially important in HMIs, since many of the parameters such as color and lighting intensity are subjective. Virtual prototypes are helping reduce the number of prototypes that must be built.

"We're reducing the number of physical mockups we need, but we still need physical mockups of digital displays. There's still a lot of trial and error in HMIs," said Benoit Deschamps, Imaging Solutions Team Leader at PSA Peugeot Citroën.

Honda has taken a different approach, focusing on full-body design. The automaker put together hardware and software that lets vehicle designers change viewpoints, change materials, and examine what's behind the skin.

"For computer-graphics-based

Real-time systems let PSA Peugeot Citroën create HMIs and determine how they'll look to different-sized drivers.

design, we need physically accurate results, not just artistic representations," said Daisuke Ide, System Engineer at Honda R&D. "We also need real-time performance. To accomplish this, we developed a rendering software solution called TOPS."

TOPS is a real-time automotive appearance evaluation for non-prototype design that was used in the development of the Accord and Fit. This focus on production vehicles means there is a strong focus on realism.

"When we go forward from conceptual design, we need images to look real," Ide said. "The images need to have the properties of real materials. The software includes the environmental effect on materials. Various material alternatives can look completely different."

The software with the TOPS program includes **Dassault Systèmes**' CATIA tools along with software developed by Honda. It runs on systems augmented with Nvidia's K40 accelerator boards, which use parallel processing clusters to handle real-time graphics. That combination lets designers view vehicles on large screens in much the same way that they now examine clay models and physical prototypes.

"When humans judge appearance, they're always on the move," Ide said. "They need to move and see how body reflections differ. Along with the ability to move, people also want to be able to zoom in and check the details."

The ability to change viewpoints, lighting, and other parameters makes it easier to alter products earlier in the design cycle when it is less expensive to make changes. When designers can change lighting angles as their viewing position, they can spot issues like reflections that can be difficult to perceive.

"Stylists are very conscious of small reflections," Ide said. "On one iteration of a taillight design, they saw that the red reflected onto the white lights. They altered the angle of the glass to eliminate that reflection."

The Honda tools also let design teams look inside and see what's beneath the surface. All components in the vehicle are accessible, so various experts can examine their section of a design by pulling off layers to see a cutaway view. Each layer of these cutaways includes all the components on that section. That's helpful as designs move into production.

"Being able to see real-time cutaways is very important for manufacturing," Ide said. "They can see if all the parts are correct."

Terry Costlow

AUTOMOTIVE REGULATIONS

Fuel-economy and greenhouse-gas emissions rules debated

The passenger vehicle and commercial vehicle industries are working to meet government regulations for emissions and fuel economy while ironing out potential unintended issues.

CAFE (corporate average fuel economy), greenhouse gas emissions, and zero-emission-vehicles mandates from **NHTSA** (U.S. National Highway Traffic Safety Administration), the U.S. **EPA**, and **CARB** (California Air Resources Board), respectively, are keeping engineers and product planners busy.

"Government can affect what consumers do with taxes and incentives, and government can affect what automakers do with rules, regulations, and incentives," Robert Bienenfeld, Assistant Vice President, Environmental and Energy Strategy at American **Honda** Motor Co., Inc., intoned to an **SAE** 2014 World Congress audience in Detroit.

Bienenfeld was one of the panelists participating on the Regulatory Driven Impacts on Powertrain program in the **AVL**-sponsored ballroom at Cobo Center on day two of World Congress activities.

"We would all like to see that regulations be fair amongst consumers and that they be fair amongst automakers and be fair to society, meaning the rules should achieve the desired social benefits without unintended consequences," Bienenfeld said.

Fuel-economy regulations for passenger cars are fair, according to Bienenfeld: "They allow customers to choose the cars freely, and automakers can compete within their segments. The regulations are indifferent as to what technologies we apply. And there's an enormous amount of innovation with literally dozens of technologies competing on a relatively fair battlefield."

But Bienenfeld's words were less flattering when he gave his evaluation of fuel-economy mandates on pickup trucks: "What we see is that trucks have slanted regulations—more stringency for smaller trucks and less stringency for larger trucks. That's a given. But the line should be parallel, and it's not—at least

Current production of the Honda Ridgeline ends in mid-2014. The full-size pickup (Ridgeline Sport shown) is built exclusively by Honda Manufacturing of Alabama LLC in Lincoln, AL. An all-new Ridgeline will be in the marketplace in less than two years.

for the next five years. As a result, it looks like large trucks are subsidized by cars and smaller trucks, which is not good for OEM competition. And frankly, it's not the best deal for consumers either."

Christopher Grundler, Director of the EPA's **Office of Transportation and Air Quality**, was asked to comment on mandate fairness during the audience question-and-answer session.

"Robert and I have been arguing about this for at least three years now—this fairness question with respect to trucks," he said. "Of course, fairness is dependent on where one sits. The honest answer is that the manufacturers of large trucks were pretty convincing at the end of our collaboration of creating these standards that they would not be able to meet the same pace of improvement as passenger cars.

"So we changed the slope in the early years to respond to the data and the arguments they presented. So is that unfair? Obviously unfair to Honda, which doesn't make those large trucks. For the people who do make those large trucks, they thought it would be unfair if we didn't make this change."

Production of Honda's only full-size pickup model ends in mid-2014. An all-new Ridgeline pickup truck will reach the marketplace in less than two years.

Another regulation affecting passenger vehicles requires automakers to deliver a certain number of ZEV (zero emission vehicle) credits (via some portion of plug-in hybrid vehicles, battery-electric vehicles, or fuel-cell vehicles) as a percentage of sales. In addition to California, the ZEV mandate has been adopted by the states of New York, New Jersey, Vermont, Maryland, Massachusetts, Oregon, Connecticut, Rhode Island, and Maine.

"And those 10 states count for more than 30% of U.S. sales. For some companies that can be as much as 40% or even 50% of sales," said Bienenfeld.

A re-thinking of the ZEV credits as it relates to PHEVs is needed, according to Bienenfeld. "Now that there have been some [PHEVs] in the market, we can see that plug-in hybrid vehicles deliver a lot more annual electric miles than you would think," Bienenfeld told SAE Magazines.

Government regulations are also changing the product-development landscape for commercial vehicles, which range from heavy-duty pickup trucks, garbage trucks, and school buses to tractor-trailers.

Said Jennifer Rumsey, **Cummins** Inc.'s Vice President of Engineering - Engine Business: "Starting this year for the first time ever in the U.S., commercial vehicles are regulated for greenhouse gas emissions."

Phase one of the regulation treats the engine, which is a common component across many of the different applications, and the vehicle itself separately. "It's a relatively simple and effective way of regulating a complicated industry, and it's already providing benefits," said Rumsey.

Announced in February 2014, phase two of the regulation "is intended to drive further and more significant advancements," said Rumsey, adding, "It must address additional technologies that aren't included in phase one, like transmissions and trailers, and consider how to capture adequately the benefits of integrating these components together."

Kami Buchholz

AUTOMOTIVE CAREER

Job market for engineers remains hot

Automotive industry recruiters know the supply of engineers is thinner than the demand.

The job-openings list includes software engineers with a skill set focused on embedded systems, electrical engineers specializing in ECU design, as well as product design, quality, manufacturing, and test engineers.

"There is an enormous shortage of engineers, and it just seems to get continually worse," Seth Clayton, Director of Recruiting at **Experis**, a staffing and project solutions firm, said during an interview with SAE Magazines at the **SAE** 2014 World Congress Career Fair.

The economic collapse of 2008-2009 left thousands of engineers without a job. And by the time the lights came back on, many engineers had found jobs in other professions, started their own business, or went back to college.

Angela Boesler, Admissions & Academic Advisor for **Walsh College**, watched as the jobs crunch led many people to a career diversion. Beginning in late 2007 "that's when we saw a lot of people, including engineers, coming back to further their education and advance their skill sets to re-enter the workforce."

Baby boomer retirements have added to the slimming of the engineering workforce. "It's been a perfect storm of events," said Clayton.

Even though open engineering positions are easy to find, matching skill sets (as well as matching an employer's job description) can be challenging.

Daniel Hill, Technical Recruiter for **GTA Professional Staffing** in Dearborn, MI, agreed with other recruiters at the SAE Career Fair that job openings for engineers are plentiful. "The resource pool is getting shallow. But some companies want experienced engineers even though they're looking to fill an entry-level position."

First-year career fair exhibitor **Quantum Technologies**, Inc., has been on a hiring binge. Last year, the firm hired 50 people. This year, the company wants to add 30 to its staff, including a senior powertrain design and development engineer, and a senior control systems engineer.

"We're located in Southern California, and it's hard to find automotive engineers in Southern California," said Quantum's Human Resources Manager Kelly DeMello, noting the company's technical specialists develop and produce natural-gas fuel-storage systems.

Keerthi Alapati, an electronics controls engineer at Cummins Inc., talks with job seekers during the SAE 2014 World Congress Career Fair.

Janice Charlton, Human Resources representative for the **Hyundai-Kia America Technical Center** Inc. in Superior Township, MI, said the hiring picture has changed. "We had fewer engineering openings back in 2009, but since then we've been hiring 30 to 40 engineers [yearly] for our facilities in California and in Michigan."

Location can be a hiring draw, or a hiring hindrance.

Sommer Zheng, a business development representative for **Swat Auto Parts** Co., Ltd., had talked with 10 technical specialists by mid-afternoon on the first day of the career fair. She hoped to find a job candidate interested in working as a general manager, a position in China. "America is a place where technical information is spread, so this is the place" to search for job candidates.

Swat was one of 49 companies exhibiting, a drop from the career fair's record 60 firms in 2012, according to Martha Tress, Recruitment Sales Manager for SAE International. "We had several aerospace companies in 2012 that aren't recruiting here now," said Tress, adding that Formula SAE and Baja SAE are becoming big recruitment zones. The number of companies recruiting at SAE's Collegiate Design Series competitions has soared 30% in the last three years, noted Tress.

Experis's Clayton said a large percentage of young engineers are landing jobs before they graduate from college: "Companies know where to find them. They can target them with marketing and with career fairs."

Ben Luther is ready to graduate from the **University of Wisconsin-Madison** in May 2014 with a bachelor of science degree in mechanical engineering. Even though several of his engineering classmates received job offers before graduation, Luther was upbeat about his job search.

"I'm confident something is going to happen. I'm not extremely concerned," he said between career fair booth visits.

While salaries vary from company to company, the pay scale for engineers is rebounding. According to Clayton, "Compared to 2009, wages are typically up 10-15%. And there are pockets of skill sets that have outpaced that."

GTA's Hill said the economic sting of 2008-2009 has left some employers hesitant to spend money. "In some cases, GTA has seen engineers quit a job to get a pay increase," he said.

At least in the near-term, the employment climate looks sunny for engineers.

"If you're an engineer, you're working right now," said Ryan Borra, a recruiter with **Brightwing**, a staffing, training, and consulting firm in Troy, MI.

Said Quantum's DeMello, "There's getting to be a lot more competition for hires. I'd call it a buyer's market for engineers."

Kami Buchholz

Steering a better path

Two new mechanisms developed by NIT Warangal are simpler than the Ackermann type and allow all four wheels to undergo pure rolling.

Steering is one of the most important systems of an automobile. An incorrectly designed system may cause skidding of the tires on the road, leading to excessive wear and a reduction in the life of tires.

It has been a common practice to provide steering to the front wheels. One of the main reasons for this is that the driver holding the steering wheel is closer to the front wheels and this could reduce transmission chain and thus result in better control.

For steering to be close to perfect, the front two stub axles must turn through such angles that when their axes are extended, they must intersect at one point on the extension of the common rear wheel axis. This condition can be expressed mathematically as:

$$\cot \theta - \cot \varphi = W/H$$

where θ and φ indicate the rotations of the outer and inner front wheel stub axles respectively, and W and H are track length and wheelbase, respectively. It may be observed that the rotations of the stub axles are related to the physical dimensions of the vehicle.

One mechanism that is commonly used in all the automobiles is the Ackermann mechanism and is shown in the Figure 1. GAC and JBD are called bell crank levers, while GA and BJ are stub axles of front wheels. The bell crank levers are hinged to the chassis of the vehicle at A and B. The actual mechanism is a four link mechanism ABDC, which is in the form of an isosceles trapezium. AC and BD are called track arms, and CD is called a track rod.

When the driver wishes to make a turn, say a turn to the right, then the bell crank lever DBJ is rotated clockwise through the steering wheel. This makes the left side stub axle also rotate clockwise as shown in the Figure 2.

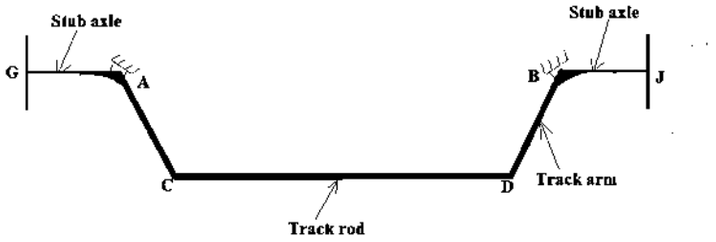


Figure 1. Ackermann mechanism.

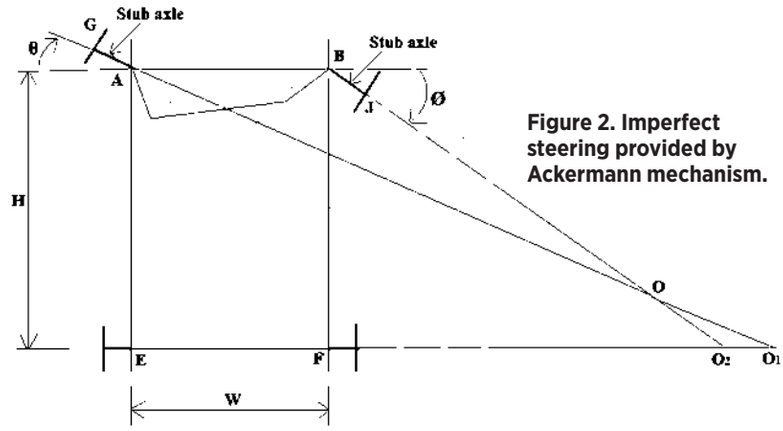


Figure 2. Imperfect steering provided by Ackermann mechanism.

When the axes of the two front wheels are extended, they intersect at a point O, which is not on the common rear wheel axis.

Clearly, the steering achieved is not perfect. There may be one particular turn on the right side for which the steering can be perfect. One similar turn on the left side may also be a perfect steering. In general, the Ackermann mechanism cannot provide perfect steering always.

Despite this drawback, this mechanism has been accepted in the automobile industry because it involves only hinge joints (turning pairs) and is very simple in construction. There is yet another option called the Davis mechanism that always ensures perfect steering. However, this is not being used because it involves many sliding parts (prismatic pairs), which are not advisable.

Two new mechanisms are being developed by **NIT Warangal** that are much simpler than the Ackermann mechanism and always ensure perfect steering. The mechanisms mainly involve transmission of rotary motion of one stub axle to another stub axle through surface-to-surface contact. The surfaces are so designed and shaped that the condition for perfect steering is met always.

The mechanisms developed are now being tested practically. The methods developed being totally mechanical are highly reliable, foolproof, and provide positive drive. Since the mechanisms developed always provide perfect steering, skidding of the wheels is totally eliminated, and all the four wheels undergo pure rolling, which leads to reduction of wear and enhancement of the life of tires.

Tests of the working of the mechanisms can be sent on request. These inventions are under patents. ■

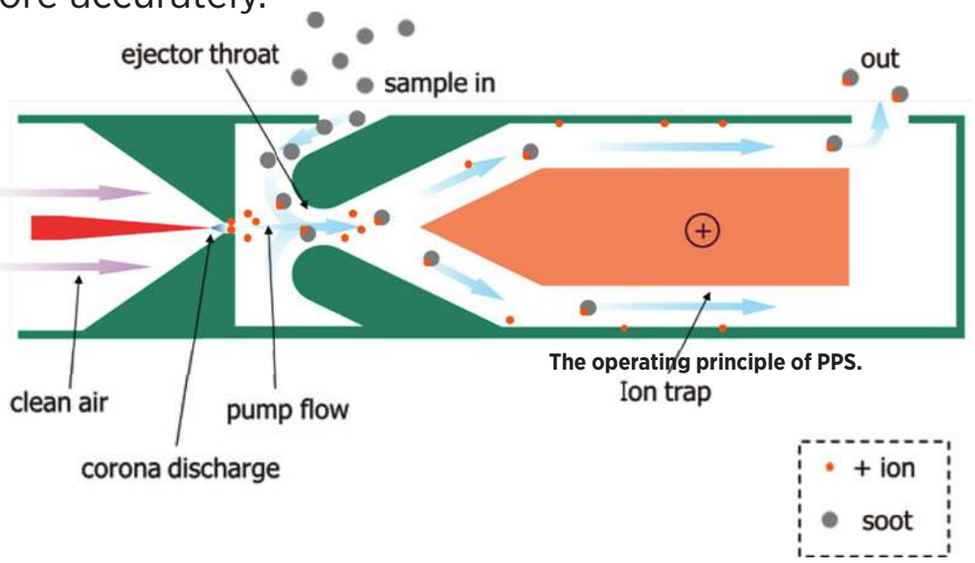
R. Venkatachalam

A. Padma Rao

This article was written for *Mobility Engineering* by R. Venkatachalam (chalamrv@yahoo.com), Professor of Mechanical Engineering, and A. Padma Rao, Research Scholar, Mechanical Engineering Department, both of NIT Warangal.

Monitoring fine particle concentrations

A robust and versatile system has been developed by Pegasor Oy to measure engine exhaust particulate mass and number more accurately.



The operating principle of PPS.

Fine particles are released into the atmosphere from several sources—such as vehicles, industries, etc.—in variable concentrations and a range of particle sizes from greater than 10 µm to less than 5 nm. It has been shown that the most harmful particles are those smaller than 2.5 µm, which cannot be effectively removed by the body's defense mechanisms in the upper respiratory tract. The smallest of these particles, those below 100 nm, have been proven to easily penetrate not only the upper respiratory system but also the lining of the lungs, cell interstitium, and cell walls. Exposure (either short or long term) can cause a variety of acute and chronic health issues ranging from asthma to heart attacks, strokes, and premature deaths.

These tiny particles are also the most difficult to measure. Currently they are measured with costly, complex, and delicate equipment that requires frequent service and extensive training to operate, and none have been able to be used continuously in field conditions or as part of a permanent installation. The ability of public agencies to mitigate this threat to human health hinges on finding a reliable, accurate, cost-effective method of measuring fine particle pollution.

Pegasor Oy Ltd. of Finland has made an innovation that enables continuous monitoring of fine particle concentrations at low initial investment and life operating cost. In particular, this latest development comes at a very timely and decisive moment, as the EU is now finalizing specifications and approvals for light-duty PEMS (portable emission measurement systems). The EU Joint Research Centre (JRC) in Ispra, Italy, is conducting tests at the moment for five PEMS candidate systems, with Pegasor's PPS-M and its technology being used in two of the candidates.

The PPS responds directly to the presence of aerosol particles within the sampled airstream, its response being directly proportional to the active surface area of the particles. This response lies between the total number of particles and the total particle mass, hence PPS can be accurately calibrated for both particle mass and particle number concentrations.

A corona charger situated within clean air sheath floods the aerosol with air ions. The clean ionized air mixes effectively with the sampled aerosol, and the surface area of the aerosol becomes saturated with air ions linearly under all anticipated conditions defined by the sensor's operating limits. Instead of depositing the aerosol particles onto an electrode so the charge on the aerosol can be measured, the PPS ejects all but the unattached air ions without depositing them onto anything. This is the secret behind the PPS' longevity, allowing users to have long continuous measurement durations, as long as a year in some cases with utmost effectiveness.

Monitoring fine particle concentrations

The PPS-M sensor is a version of the PPS.

The Pegasor Mi3 unit with integrated PPS-M sensor is a turnkey solution for long-term monitoring of PM and PN emissions either in test cells or onboard road or off-road vehicles.

The air ions are removed from the aerosol as it leaves the sensor using a mobility trap. By adjusting the trap voltage between 50 and 1000 V, the lower cut point of the sensor can be adjusted between 7 and 700 nm. The most typical setting of the trap is 400 V, which corresponds to a 23-nm cut, matching the PMP (Particle Measurement Program) lower cut diameter requirement. This enables linear operation of the sensor from 300 #/cm^3 and up to 1.3e9 #/cm^3—for a range of more than six orders of magnitude. Due to the low residence time of the sample and continuous measurement, PPS has better time resolution than other systems. The standard PPS measures at 100 Hz, and special versions can measure at 800 Hz, making PPS a suitable tool to study engine performance during transients.

The biggest source of error in aerosol measurement is sampling and dilution. These sources of error are effectively eliminated, since PPS-M requires no diluting and can measure hot exhaust directly. This is an important feature in measuring the near future low emitting vehicle fleet.

To make reliable conclusions from emissions levels in different points of measurement—engine out, exhaust aftertreatment out, and legislative CVS (constant volume sample) measurement, sensor intercorrelation must be high and intervariability must be low. For the PPS-M sensor, due to its design and the ion-out opening being the only critical operational parameter, its intercorrelation can be made almost 1:1.

Particle measurements from engine exhaust are most often done from either CVS or hot raw exhaust. It is important that the results from these two locations can be made comparable to each other. PPS-M capability to measure hot raw exhaust and diluted cool CVS sample with the same instrument settings makes result comparisons from both locations easy. The PPS is becoming a de facto reference for methods without such a broad dynamic range. Sampling from the CVS requires the addition of a catalytic stripper (CS), which is needed to deal with the long accepted after effects associated with CVS systems. The PPS-M sensors, when placed in hot raw exhaust and properly sampled CVS, produce the same result, when adjusted for CVS losses (6%) but at a fraction of the cost of other systems.

From the above arguments and results it can be seen that PPS is an excellent, robust tool for investigating engine-out particle number and particle mass emissions. It can perform effectively in test cell, onboard, and remote monitoring applications without any compromise. Pegasor PPS and its technology is a suitable choice to researchers in India who want a cost-effective system to study particulate emission from engines and other sources. ■

This article was written for *Mobility Engineering* by Juha Tikkanen and Vijayaraghunathan of Pegasor Oy Finland. For further information on technical seminars scheduled in India, email india@pegasor.fi.

Juha Tikkanen

Vijayaraghunathan

With the MP4-29, McLaren Mercedes aims to regain winning form in 2014. Shown here (left to right) are main drivers Kevin Magnussen and Jenson Button, and reserve driver Stoffel Vandoorne.

New rules shuffle the F1 deck

New turbocharged hybrid-electric power units and revised aerodynamics may scramble the familiar order in Formula One for 2014.

by Dan Carney

This season will see an almost entirely new slate of rules for **Formula One** that effectively make it a different series. The cars are changed aerodynamically and have dramatically different power sources. Stiff limitations on track testing, wind tunnel testing, and even CFD modeling aim to limit costs and reduce the advantage bigger-budget teams hold over smaller teams.

Championship points will be allocated differently (double points in the last race), and there are two new circuits on the schedule.

The scope of the change will, itself, affect the course of the season, as teams encounter reliability problems stemming from the newness of their equipment, and as relative performance changes as some teams make bigger gains than others from one race to the next.

Ferrari Technical Director James Allison ruminated on what the changes have meant for Formula One engineering staffs and what they will mean to competitors this year.

"2014 sees us, for the first time in many years, have free development of the engine from a clean sheet of paper," he said. "For sure that's going to bring a level of variation of power between the various engine manufacturers. It makes the engine a much more important competitive factor in 2014 than it has been in recent years."

New rules
shuffle the F1 deck

Similarly, the new aerodynamic rules will also create winners and losers. "The rate of development we have aerodynamically through the season will be very steep, and the importance of aerodynamics to the championship will be at least as important as the differences in the power levels of the various engine manufacturers," Allison asserted.

"However, if I had to choose a thing that was likely to be the dominant factor for the whole season, I would choose neither the level of power nor the aerodynamic development. I would say this year reliability is going to be absolutely fundamental."

Turbo V6 hybrid power unit

Perhaps the single largest change for the new season is the replacement of the 2.4-L normally aspirated V8 engines employed since 2006 with an all-new 1.6-L turbocharged V6 engine. This engine is further restricted to a maximum of 15,000 rpm, rather than the 2013 rev limit of 18,000 rpm. Turbo speed is limited to 125,000 rpm.

For the first time, there is a fuel limitation. The engine can consume fuel at no more than 100 kg/h, and the car may carry only 100 kg (220 lb) of fuel for the race, placing an emphasis on fuel efficiency over power.

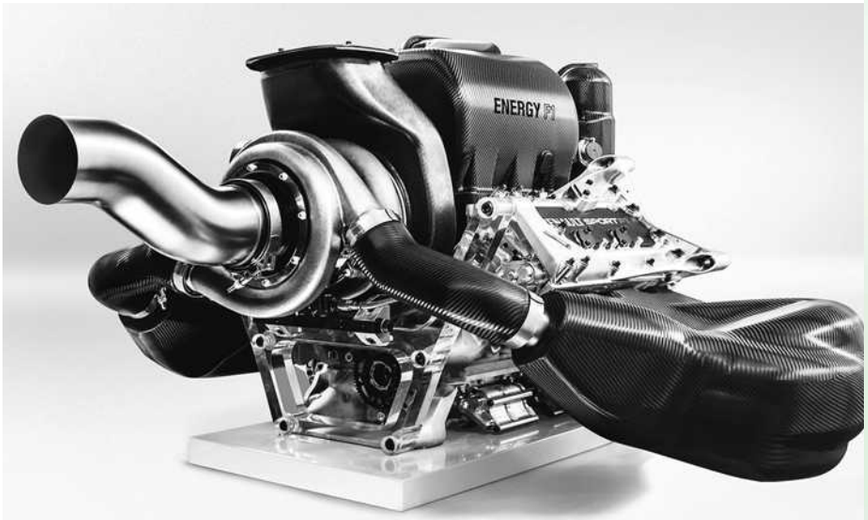
Previously, fuel flow was unrestricted, as was fuel capacity. Teams typically built cars with a capacity of 160 kg (353 lb) of fuel. The V6s are 90° type by mandate in the new rules.

To make up for the lost horsepower of the smaller, slower-turning engine, the internal-combustion engine is supplemented by an Energy Recovery System (ERS), which is a stronger replacement for the previous Kinetic Energy Recovery System (KERS).

"It is much more than just an engine change; it is a completely different system," observed **Williams** Chief Technical Officer Pat Symonds. "We've gone from a slightly hybridized normally aspirated engine to a fully integrated hybrid power unit with novel technology at its heart."

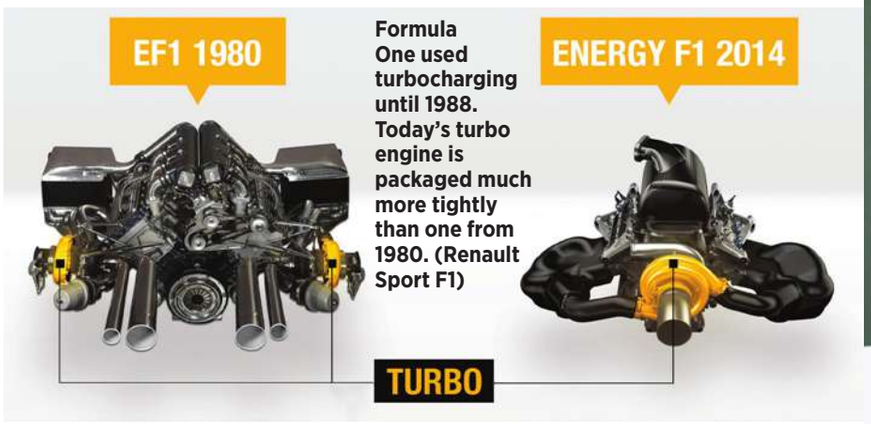
Strong hybrid

That hybrid-electric assist now adds 160 hp (119 kW), double the 80 hp (60 kW) of the previous system. Further, it can be used for 33.33 s per lap, rather than the 6 s last year. An interesting byproduct of this extra power and time is that it consumes more electrical power—4 MJ per lap—than the 2 MJ that can be recovered over the course of a lap, so it cannot be used at full



No longer just an engine, the 2014 Formula One power unit is a single-turbo, 1.6-L V6 ICE with hybrid-electric assist. (Renault Sport F1)

The new power unit's additional components set it apart from last year's normally aspirated V8 engines. (Renault Sport F1)



Formula One used turbocharging until 1988. Today's turbo engine is packaged much more tightly than one from 1980. (Renault Sport F1)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New rules
shuffle the F1 deck

The Ferrari F14T illustrates how the 15-cm (5.9-in) narrower front wing leaves the front wheels more directly exposed to the airflow.

Lower noses are mandatory for safety reasons, but teams' solutions have sparked aesthetic criticisms. (McLaren Mercedes)

power every lap. Instead, drivers will have to marshal their accumulated electric power, accumulating it for use in an attack.

Energy is recovered through the Motor Generator Unit–Kinetic (MGU-K) the usual way: by converting the car's kinetic energy to electric power stored in the 20- to 25-kW·h lithium-ion battery pack. Additional power comes from the electric motor/generator connected to the turbocharger. This is the Motor Generator Unit–Heat (MGU-H).

It works by converting the spinning turbo's energy into electric power to charge the battery. It also serves to limit the turbo's maximum speed and to prevent it from slowing down. By accelerating the turbine with electric power, the cars will have no turbo lag whatsoever. Interestingly, the **Sauber** team further notes that it is technically possible and permissible for the MGU-H connected to the turbocharger to directly supply electricity to the MGU-K that helps propel the car, providing additional electric-assist beyond the specified 33.33 s.

Sauber uses a power unit provided by Ferrari, so the Prancing Horse's car will likely reflect the same capability, even if other teams do not have this capacity built into their cars.

In total, the hybrid-assist system will trim lap times by more than 2 s, according to **McLaren Mercedes**. That compares to a boost of only a few tenths of a second per lap for the old KERS system.

The mass of the complete power unit is specified as at least 145 kg (320 lb), compared to 95 kg (209 lb) for the old engines. Correspondingly, minimum weight for the entire car with driver has also risen, to 690 kg (1521 lb) from last year's 642 kg (1415 lb).

The new power units' total output is predicted to top that of last year's engines, potentially making the new cars faster.

"We have measured power-unit performance on the testbed and have matched the most optimistic predictions," noted **Renault Sport F1** Deputy Managing Director Rob White. "We believe the power unit will deliver a lot of power and will be more than enough to make the cars quick."

V6 combustion power

The new V6 engines will make more low-end torque, supplemented by the torque of the electric-assist motor, for stronger low-end acceleration, while the restricted fuel flow will flatten power at higher revs—revs that will cut off at a lower speed than before.

The exhaust now exits the single turbocharger on the car's centerline, behind its bodywork, to minimize its influence on the car's aerodynamic downforce. (Ferrari)

"The way that the cars deliver this performance will be somewhat different this year due to the power unit and aero regulations," White said. "The driving experience will be quite different, but we will absolutely see real speed out on track."

The question of success in the championship, then, will likely come down to reliability, as Ferrari's Allison speculates. Integrating so many disparate new systems invites the unexpected. Even the thoroughly understood KERS suffered regular failures. But those failures handicapped the affected cars only slightly. Now, a failure of the hybrid-assist system will wreck a driver's race as the car loses seconds per lap to rivals.

Matched to the new power unit is a new eight-speed gearbox. This reflects one more gear than teams used in 2013, but now teams cannot change the ratios of those gears from race to race. For 2014 alone, teams will have the ability to change their ratios once, to correct any preseason miscalculations. That will be the only change allowed.

Gearboxes must last six races each before they are replaced, and teams are allotted five power units for the season. Premature replacements of these parts will inflict dire penalties on the drivers' qualifying positions, which will undercut their ability to score top championship points in the ensuing race.

Aerodynamics revised

The 2014 cars' appearance differs because the rules specify lower noses in a bid to minimize the chance of cars overriding one another in collisions. Now the front end may be no higher than 18.5 cm (7.3 in), compared to the 55 cm (21.7 in) allowed before. Meanwhile, the front wing has been narrowed to 165 cm (65.0 in), from 180 cm (70.9 in), dramatically complicating airflow around the front wheels.

Inside, the chassis' construction has been influenced by the addition of longer, triangular-section impact-absorption tubes that contribute side-impact protection for the driver. The **Infiniti Red Bull Racing** team takes credit for designing these new structures, which are standardized and incorporated into all teams' cars.

Sidepods have grown because of the need to cool all the new systems and devices aboard.

"Overall, the cars will need more cooling this year," remarked Symonds of Williams. "The demands on water and oil cooling may be slightly diminished, but the ERS system is significantly more powerful and hence needs more cooling. We also have to cool the charge air from the turbocharger compressor, which requires a substantial intercooler."

The Sauber team reports that additional packaging space was also needed for all of the electronic boxes. The team's Sauber C-33 Ferrari racecar incorporates more than 40 such electronic boxes, and more than 30 of those require cooling, according to the team.

Bringing up the rear

At the rear of the car, rules have specified that the engine's exhaust will depart from a single pipe at the car's centerline, aft of the bodywork. This is a common configuration in lower-category Formula cars, so it is a familiar appearance to racers, but it is new to Formula One. The purpose is to eliminate the use of exhaust gases to increase aerodynamic downforce, as was done with the previous "blown diffusers," which saw exhaust gas pouring onto the top of the diffuser to increase the pressure differential with the air underneath.

The rear wing has traditionally incorporated a lower horizontal element for a biplane wing, but the lower element has been eliminated. The upper element is now supported by its end plates, which extend downward to mount to the rear bodywork.

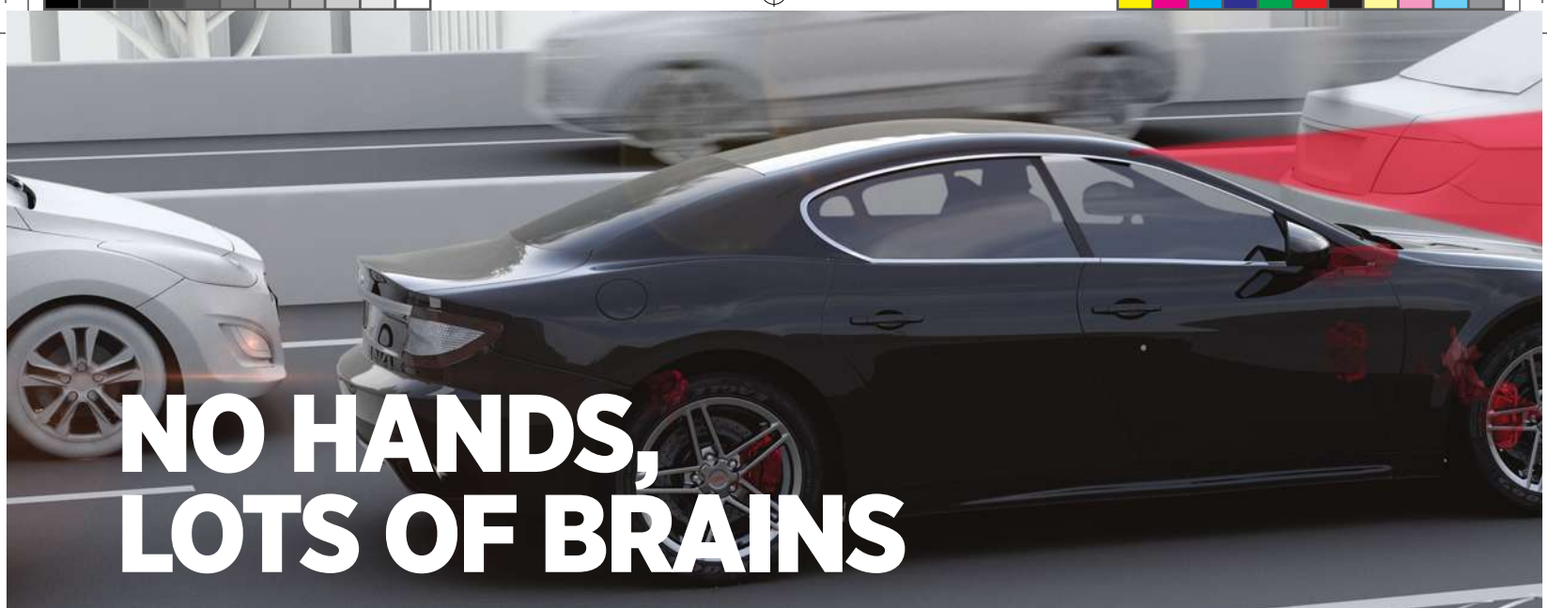
The 2014 cars' rear brakes are now brake-by-wire, so that a computer can negotiate the compromise between regeneration braking and friction braking to best slow the car and recover energy.

A new restriction on the teams doesn't affect the cars' appearance or their initial performance, but could mean cars at the end of the season that aren't as fast as they could have been. To help smaller-budget teams keep up with the juggernaut teams, wind tunnel testing is limited to 30 hours per week and CFD number-crunching is limited to 30 TB of data per week. The thinking is that it helps cap costs and contributes to quality of life for team members who only need to work during civilized hours.

In total, the shuffling of the rules has motivated the sport's engineering teams, said Allison.

"That, for an engineer, is like Christmas every day. This year we've had the additional pleasure, from an engineering perspective, of being able to start with a clean sheet of paper, a completely new project—a complex and difficult project. And to be able to design from nothing the entire layout of a very difficult and complex car."

What could be better? ■



NO HANDS, LOTS OF BRAINS

A hefty amount of computing power built with new hardware and software architectures will be needed when vehicles begin taking over more of the driving tasks.

by Terry Costlow

Autonomous vehicles have garnered much attention in recent months, but many technical hurdles face developers tasked with giving drivers more freedom to do other tasks. Engineers need to develop hardware and software strategies that let electronic control units synthesize and analyze data from multiple sensors quickly, then control actuators that let vehicles avoid accidents.

Many of the sensors needed for increased levels of autonomy are already in use today. But combining all the inputs from adaptive cruise control, lane departure warning, and other systems, then analyzing data in a foolproof manner, is a complex task.

Reliability, redundancy, and testing are critical obstacles to be overcome before vehicles pilot themselves. ECUs are among the many elements that must be enriched for vehicles to start becoming autonomous.

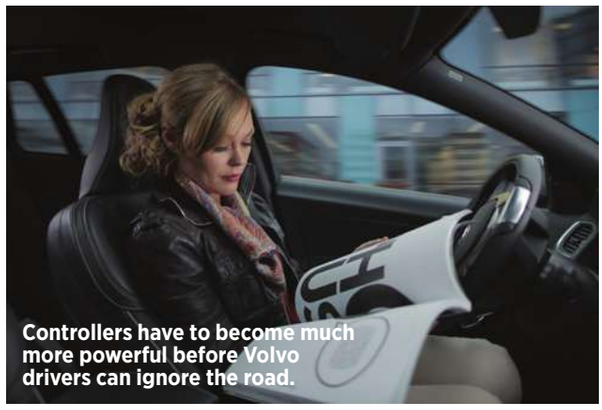
"Several technologies will need enhancements: artificial intelligence, better multi-spectral sensors, sensor fusion, and better fault tolerance including sensor and actuator redundancy," said Brian Daugherty, **Visteon**'s Associate Director of Advanced Development and Intellectual Property. "Other areas include vehicle trajectory models, image recognition, system integrity, and fail-safe strategies."

All these improvements come with a price tag. Another big challenge is to provide autonomous driving functions at an affordable system cost. Planes and trains already operate autonomously, but their cost structure is dramatically different.

"An airliner's autopilot equipment costs more than an entire luxury car," said Bill Riedel, Automotive Director at **Analog Devices**. "Yet the plane's task is quite simple compared to what autonomous cars need to do. Airliners operate under strictly controlled conditions, not in close proximity to dozens of other moving objects, pedestrians, or distracted operators."

Taking control

Making today's stand-alone systems work in harmony will take a lot of computing power. Multiple inputs will have to be compared before the system can make any decisions on braking or steering. Many developers plan to perform these functions in a powerful central controller.



Controllers have to become much more powerful before Volvo drivers can ignore the road.

"There's a trend to offload intelligence from the sensor, moving to a centralized architecture," said Andy Whydell, Product Planning Manager at **TRW** Electronics. "That means sending more data to the central CPU, where fusion is done with more data so you get the most robust understanding."

It will take a lot of computing power to collect and analyze incoming data and tell braking or steering systems how to respond. It's difficult to get enough computing power in automotive-grade microcontrollers without creating a large, complex ECU. Engineers are examining different strategies for centralized and distributed architectures.

"A lot has to happen in the central controller; we're going to need more computing power," said Erik Coelingh, Senior Technical Leader at **Volvo Car** Corp. "It might be attractive to have some distributed computing power, but much of the processing will have to happen in the central controller."

When computing power is distributed, the various sensor systems will do some processing before they send data to the main

When more sensors scan the road, TRW may move intelligence to a central controller.

ECU. As vehicles migrate from semi-autonomous to fully autonomous control, the aggregate computing power will have to rise dramatically.

"Centralized intelligence does not necessarily require a separate ECU; intelligence can be in the radar or camera," said Kay Stepper, Regional Business Manager for Automated Driving at Robert **Bosch** Chassis Systems Control Division. "As we move to higher levels of autonomy, you're talking about bringing in more intelligence."

Software structures

Software architectures are an equally critical aspect of the control technique. Design teams have to determine how to structure software. Given the real-time demands of safety programs, software must be streamlined and written so that data can be understood quickly and easily. Most of today's safety systems don't have an operating system (OS), but it's likely that the main ECU in a semi-autonomous car will need an OS to manage data.

"When all these disparate systems start merging data into one box, that's where the OS comes in," said Andy Gryc, Senior Automotive Product Marketing Manager for **QNX Software Systems**. "When sensor fusion occurs, it's definitely a place for a safety-oriented operating

It takes two

When electronic systems take control of an autonomous car, they need to perform perfectly every time. That's prompting developers to build fault tolerance into systems.

The levels of redundancy will vary. If drivers are paying attention, they can act if a sensor fails. But when more autonomy leads to less driver interaction, engineers need to duplicate components to make systems fail-safe.

"The level of redundancy is coming out of the safety analysis and the safety goal," said Steffen Linkenbach, Head of Systems & Technology at **Continental Automotive** North America. "We will definitely need more redundancies in power supply, actuators, and controllers than we have today."

Without drivers, every facet of safety must be examined. Systems must constantly run diagnostics while they're also performing their central role. If there are problems, the system must act to make sure accidents don't happen.

"It's not just redundant sensors; you need redundant power systems, communications, control units, and braking units," said Erik Coelingh, Senior Technical Leader at **Volvo Car** Corp. "If something goes wrong, the car must detect that and put the vehicle into a safe state. It doesn't have to continue with autonomous driving; it just needs to alert the driver and put the vehicle in the driver's control."

Keeping drivers in the loop is the simplest way to avoid the high cost of backup hardware. Many observers feel that it will take quite some time for the industry to move from semi-autonomous systems that rely on drivers to fully autonomous cars that let drivers do other tasks or sleep. Cost will be a huge factor in this progression.

"By eliminating the possibility of manual backup, these systems become very complex and therefore expensive," said Brian Daugherty, **Visteon**'s Associate Director of Advanced Development and Intellectual Property.

In semi-autonomous vehicles that rely partially on drivers, it may be a challenge to keep them from becoming distracted. Strategists are already examining ways to ensure that they remain focused on the road, not the infotainment system.

"There are different ways to keep drivers involved," said Kay Stepper, Regional Business Manager for Automated Driving at Robert **Bosch** Chassis Systems Control Division. "You can monitor the driver's facial expression or eyes using a camera or you can require the driver to touch the steering wheel for a couple seconds. Automated trains require manual input so the machines knows the driver is still engaged."

Terry Costlow

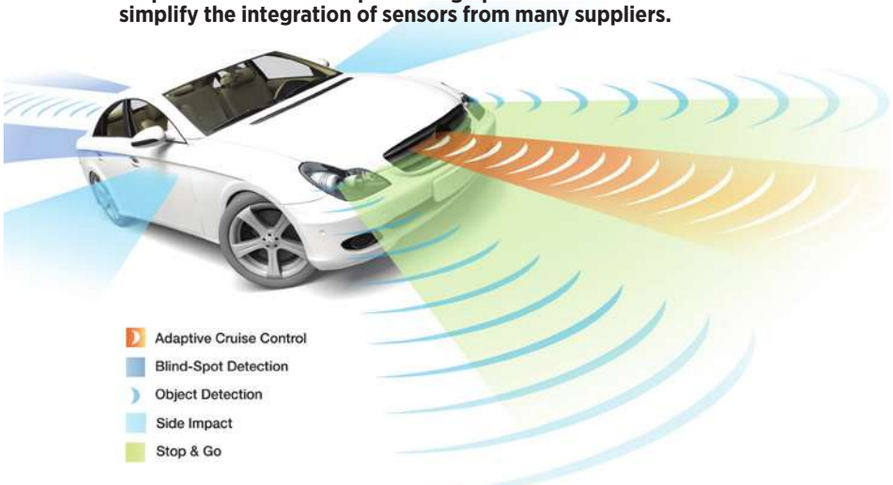
Redundancy will be critical when drivers let go of the wheel, say engineers at Continental Automotive.

When vehicles watch the road and take action, Bosch will also work in the cabin to ensure that drivers remain attentive.

NO HANDS, LOTS OF BRAINS

Operating systems from QNX will help ECUs synthesize data from multiple sensors.

Chip maker Freescale is promoting open architectures to simplify the integration of sensors from many suppliers.



system that's been proven in military equipment, trains, and medical applications."

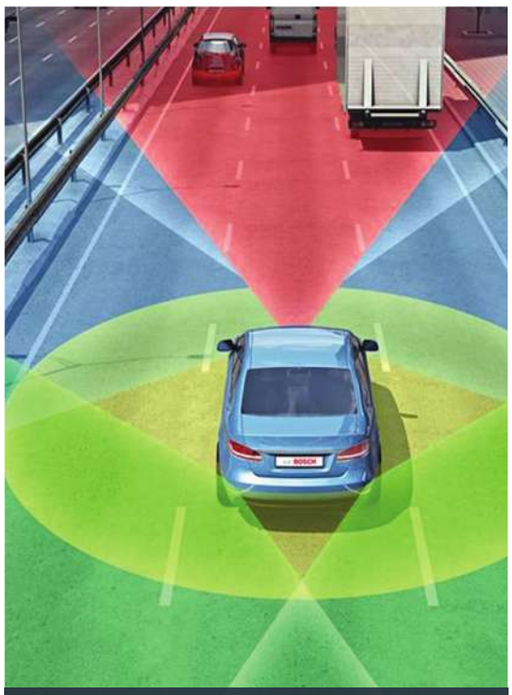
Operating systems will let OEMs run various programs on a single CPU. Some companies are devising strategies that let automakers scale functionality, adding more options for more expensive vehicles. One solution is to mimic current consumer trends.

"The safety-domain ECU may be analogous with smartphones, acting as a host that can run a number of apps depending on the capability of the vehicle and the functions that the OEM wants to offer," Whydell said.

E pluribus unum

Given the many sensors needed for semi-autonomous driving, most systems will comprise equipment from several suppliers. That means developers must find ways to ensure compatibility. Architectures will have to accommodate many different data types and multiple processors.

"Open programming models will be important; people need to do development based on an open standard," said Davide Santo, Safety and Chassis Segment Manager at **Freescale Semiconductors**. "We don't think a closed model is the correct way to go. The Open Computing Language (OpenCL) was developed by a consortium. It works with a massively parallel system and lets you standardize the way you talk to different elements. It lets you maintain coherency in your design."



Bosch may distribute intelligence, putting microcontrollers on individual sensors.

Programs will have to handle many types of data. That's not just because input will come from radar and cameras. Vision systems alone often employ different types of processors.

"As far as artificial vision is concerned, the standard architectures available today go from reduced instruction set cores to vector accelerators, but none of them are optimal for all types of calculations," said Paolo Ruffino, ADAS Marketing Manager at **STMicroelectronics**. "You'll need them both for artificial vision and autonomous driving."

Looking forward, managers must determine how to keep this software up to date. One solution to this challenge, which also exists in infotainment and other systems, is to transmit updates wirelessly. While the approach used for cell phones eliminates the expense of dealer visits for upgrades, the risks of altering safety software makes many companies nervous.

Over-the-air updates is an area where there's a great deal of uncertainty," Whydell said. "Clearly, with the growth of telematics, there's a path to be able to do over-the-air updates. For OEMs, how to allow information from outside the vehicle to have access to the central system, including the ability to overwrite software, is unsettling. Over-the-air is the least secure way to update software." ■

ALTERNATIVE FUELS FACE CHALLENGES

With gasoline prices seeming to stabilize and fuel-economy measures taking hold, is there a compelling need for alternative fuels? Automotive engineers offer some surprising reasons why there is.

by Bruce Morey

Oil companies are opening vast new reserves using hydraulic fracking technology. At the same time, fuel-efficiency measures seem to be taking hold, with drivers in North America using less gasoline and diesel. Vehicle refueling stations and the existing vehicle fleet are ill-equipped to accept much more ethanol.

Is it time to write off future development in alternative fuels? Not in the least, but the reasons for using alternatives are growing more complex. As Ron Graves, Director, Sustainable Transportation Programs at **Oak Ridge National Laboratory** (ORNL) told **SAE** Magazines, there are restrictive U.S. **EPA** Tier 3 emissions regulations looming, as well as the international motivation to reduce CO_2 emissions through even better fuel efficiency. Automakers are looking ahead to the U.S. CAFE 2025 and European Union 2020 efficiency targets. With natural gas reserves rising and prices plummeting in response—to below gasoline prices on an energy-equivalent basis—another question is how best to use natural gas as an alternative fuel.

Octane and alternative fuels

Higher-octane fuels are good for fuel efficiency, said Tom Leone, an engineer in the Research and Advanced Engineering group at **Ford**, in an interview with SAE Magazines. Today's modern engine sensors will retard spark to prevent knock if a low-octane fuel is used. This is a condition most common when the engine runs at a combination of high load and high torque, according to Leone. Retarding spark is easier on the engine and reduces noise, but the trade-off is decreased efficiency and torque. The converse is true: the higher the octane, the more spark is advanced, enabling higher torque and efficiency.

Leone also pointed out that the trends in engine technology that automakers are using to increase fuel efficiency—gasoline turbocharged direct injection (GTDI) to downsize and downspeed; cylinder deactivation; and hybridization—would also benefit from higher-octane fuels.

Enter ethanol. It is a naturally higher-octane fuel and when blended with gasoline raises the octane level. With the phase-out of MTBE as an additive, ethanol was a natural to replace it. To show how important this is, Ford conducted a study looking at the benefits on GTDI engines using E10, E20, and E30 splash-blended fuels, using an EcoBoost 3.5-L engine (see **SAE International** technical paper 2013-01-1321). The results, presented by Leone, were a bit surprising.

In a tank-to-wheels comparison, with octane ratings increased through higher levels of ethanol, Leone summarizes the results in terms of increasing efficiency and decreasing CO_2 emissions. "Higher octane alone was good," he said. "Higher octane combined with higher compression ratio was better."

But increasing compression ratio without higher-octane fuel can actually degrade efficiency and increase CO_2 emissions. All three scenarios were tested on FTP and US06 cycles, and high CR without higher-octane fuel caused degraded performance on the US06 cycle. Conclusion? Better results come with more octane.

Increasing octane through alternatives

Why is ethanol for octane so important? The quality of the new oils produced from fracking in rockbound, or tight, reservoirs is worse. As a result, "octane is becoming a bit more difficult to produce and, more importantly, more costly to produce," said Terrence Higgins, Executive Director, Refining and Special Studies for **Hart Energy**. "This oil is a poor gasoline feedstock," he said, speaking at the SAE 2014 High Octane Fuels Symposium. It contains more paraffin, resulting in a lower-octane fuel.

He explained in a follow-up interview with SAE Magazines that there are a number of ways refiners can produce higher-octane gasoline. One is through reforming low-octane components such as naphtha into gasoline. This increases cost slightly because the refiners lose gasoline yield. It also produces LPG and fuel gas, which the refiners sell. The concurrent boom in natural gas in North America means there is an abundance of low-cost LPG and fuel gas.

"The greater the [price] difference between gasoline and fuel gas, the greater the opportunity cost [in creating gasoline with higher octane]," explained Higgins.

For these reasons, refinery octane levels (octane of gasoline prior to blending with an additive such as ethanol) have dropped from an average of 87.25 AKI in 2003 to 85.5 AKI in 2013.

"The decline in refinery octane has been due to [availability of] increased octane provided outside the refinery—that is, ethanol blending," Higgins said. "There will be further declines in required refinery octane as ethanol blend-in increases, but that will be offset by refinery octane loss related to desulfurization" from the future implementation of the U.S. **EPA**'s Tier 3 regulation, which requires sulfur to drop to 10 ppm.

Shell's Pearl GTL facility illustrates the problem with exploiting natural gas through gas-to-liquid conversion: It took more than eight years and $19 billion to build.

E30 as an alternative fuel

If ethanol is good as an octane enhancer, the question becomes: how much? The extreme as a truly alternative fuel is E85, which is now legally defined as containing at least 51% but no more than 83% ethanol. While E85 as an alternative has its advantages, fuel experts such as Bill Woebkenberg, U.S. Fuels Technical and Regulatory Affairs, **Mercedes-Benz**, noted that a mid-level ethanol blend (MLEB) is better. These range from roughly E25 to about E35. "With about one-third ethanol blend, you get about two-thirds of the benefit of using ethanol," he said.

However, taking full advantage of an MLEB fuel, such as E30, requires OEMs to develop MLEB-optimized engines and compatible fuel-delivery systems. "The components needed for an MLEB engine are similar to today's FFVs [flexible-fuel vehicles]," he said, including probably larger fuel pumps, higher-flow fuel injectors, and corrosive-resistant components.

New sensors will also be critical for an MLEB engine. "Today's methods of mitigating knock will be insufficient," said Woebkenberg, noting

that measuring the level of ethanol rather than inferring it before injection is critical to maximize engine efficiency and protect it from knock.

But wait…there is more: "There is research from groups like ORNL that there is more benefit to an MLEB fuel than higher octane. Additional cooling from ethanol is one," he said. Also, ORNL tested 87 AKI E0 gasoline in its neat form and in mid-level alcohol–gasoline blends with 24% isobutanol/gasoline (IB24) and E30 in a high-compression-ratio configuration. E30 showed exceptional anti-knock beyond its octane number, and it enabled the peak torque to double relative to regular-grade gasoline. This means an MLEB-optimized engine would enable even further downspeeding and downsizing.

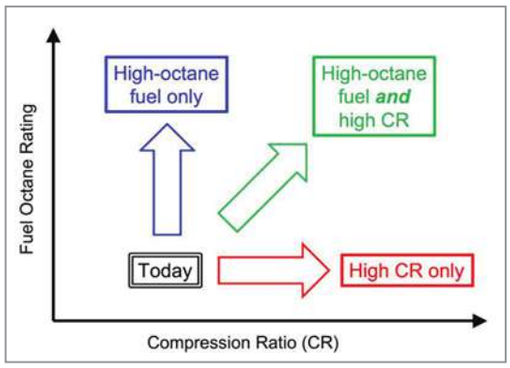
Practicalities—infrastructure and legislation

The best MLEB may not be E30, according to John Eichberger, Vice President of Government Relations for **NACS** (a global association representing convenience stores and fuel retailers). He'd prefer the ethanol level to not exceed E25. "We found that while costs to upgrade pumps from an E10 or E15 certified equipment to E25 could be as low as $5000 per pump, even going to a 26% blend will most likely require us to upgrade to equipment certified for E85," he told SAE Magazines. E85-grade dispensing equipment is as much as four times more expensive than an E15 pump.

The voice of regulators will be vital. "While EPA certified that FFVs can operate on E0, E85, or any level of ethanol in between, the EPA currently does not have any specific regulations for MLEB—E16 through E50," explained Marilyn Herman, President of **Herman and Associates**. "EPA has granted waivers for use of up to E15 for use in conventional vehicles, but has not granted any waivers for fuels between E16-E50 for use in conventional vehicles."

She cautions that removing barriers and streamlining regulatory requirements requires lead time. The process has started. She reports that the EPA requested comment on MLEB in its Tier 3 emissions proposal.

To put things in perspective, Herman uses the phase-out of leaded gasoline as an example. Starting with the Clean Air Act Amendments in 1970, Congress established a major national program to phase out the use



The best efficiency is achieved with a combination of high compression ratio and high-octane fuel, according to studies performed by Ford on an EcoBoost engine.

The 2015 Chevrolet CNG-capable, bi-fuel Impala can run on both cleaner-burning, mostly domestically produced compressed natural gas or gasoline. A separate CNG fuel tank, mounted in the trunk, enables the driver to switch between fuels at the push of a button. (Mark Finkenstaedt for Chevrolet)

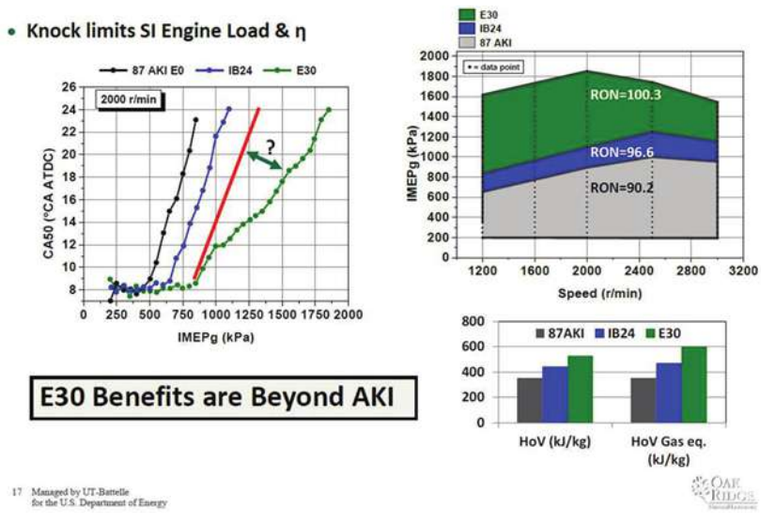
Refueling infrastructure tough nut to crack for CNG

The problem with introducing truly alternative fuels is the vast dispensing infrastructure that has arisen for gasoline and diesel. There are more than 1.3 billion light-duty vehicles worldwide, the vast majority fueled by gasoline or diesel. To supply these vehicles, there are about 7000 oil rigs worldwide, according to the U.S. **Library of Congress**, and 700 refineries converting petroleum into gasoline, diesel, and other products. In the U.S. alone there are more than 150,000 locations with pumping equipment specialized in dispensing gasoline up to E10. In comparison, there are only about 2200 E85 public refueling stations and about 450 CNG public refueling stations.

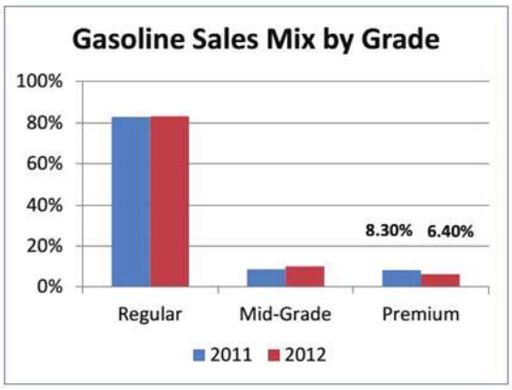
Expanding that infrastructure will be expensive. Natural gas refueling stations vary in expense, according to the **U.S. Department of Energy**'s Alternative Fuels Data Center (AFDC). They range from $2 million for a heavy-duty fast-fill to as low as $10,000 for a unit that can be installed in a home. However, the inexpensive consumer unit may deliver as little as 0.5 gal/h (1.9 L/h).

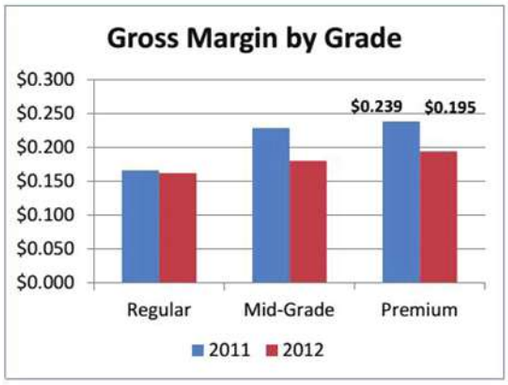
And, since LNG is stored and dispensed as a super-cooled, liquefied gas, protective clothing, face shield, and gloves are required when refueling a vehicle, according to the AFDC.

Bruce Morey



A study conducted by ORNL showed that benefits of increasing ethanol/gasoline blend had benefits beyond enhancing octane. (Derek Splitter and Jim Szybist, ORNL)





Source: NACS State of the Industry Report of 2012 and 2011 Data

Data from NACS, representing 84% of the 150,000 retail fuel stations in the U.S., show that the lowest octane grade of gasoline is the one most often chosen by drivers.

of lead to protect the public health and welfare and prevent damage to vehicle emission controls; it was not until 1995 that leaded gasoline was finally phased out entirely from the fuel supply.

There is also the question of consumer choice. Leone from Ford stresses a clear point. "Our testing demonstrates the advantages of higher-octane fuels," he said. But today's world is a mix of high and lower octanes. Drivers can choose which to put in their tank, but that may not be enough. Why? To design engines with higher compression ratios to use higher-octane fuels requires voluntary compliance. "Most customers will not pay extra for premium fuel if a lower-priced alternative is available," he explained.

Natural gas every day?

Natural gas is cleaner than oil, and in North America it represents a plentiful domestic source of transport fuel that is far cheaper on a gasoline-gallon equivalent to conventional gasoline. Could it represent an everyday fuel?

"Natural gas vehicles have not played a significant role in U.S. transport, and will likely not grow market share dramatically in the coming years," said Andrew Soare, Senior Analyst at **Lux Research**. Consumers are motivated by more than just fuel price and dislike natural gas vehicles because of reduced trunk space, limited vehicle selection, and fewer fueling options.

However, Soare believes fleet applications are ideal for natural gas. Driven more by economics and price, fleets have predictable driving patterns, he noted. Typically, organizations such as municipalities can also justify a dedicated refilling station, refueling overnight using cost-effective time-fill stations. This is reflected in the offerings from OEMs, who concentrate on offering CNG-powered cargo vans, stripped chassis, pick-up trucks, and taxis.

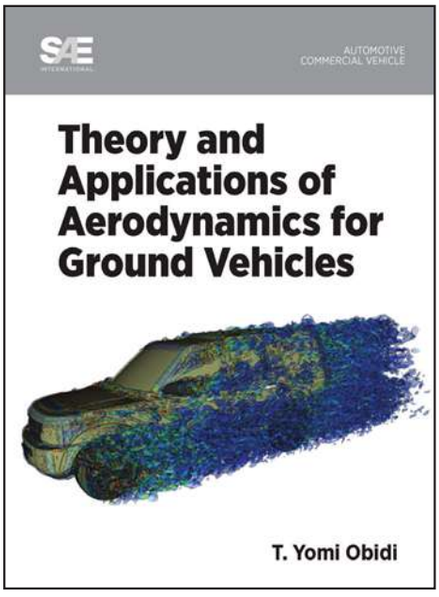
Converting natural gas into something closer to a drop-in fuel that uses today's existing infrastructure would make it a more viable everyday fuel. One technology is converting natural gas into diesel using gas-to-liquid (GTL) technologies. **Shell** and the South African company **Sasol** have such facilities already operating in the Persian Gulf, and the latter is in the planning stages for one in Louisiana.

"There are a number of other companies looking to scale down GTL, such as **Sierra Energy**, **CompactGTL**, and a few others. While these solutions are still a few years away from a sizable impact, finished fuels from natural gas (GTL) is positioned to grow in the U.S.," said Soare.

Another approach is to convert natural gas into ethanol, a technique pursued by **Coskata**.

"Coskata has been operating at the pilot and demonstration scale for over five years producing ethanol from natural gas," said Bill Roe, the company's CEO. He reports that the ethanol produced meets the **ASTM** standard for fuel-grade ethanol. This means that natural gas could be used to increase the octane levels and improve performance of more standard gasoline-based engines through its conversion to ethanol. Roe said that Coskata's path to ethanol requires less energy than GTL. It is also more scalable, allowing smaller projects than the typical GTL multi-billion-dollar projects. ■

NEW BOOK COVERS ESSENTIAL CONCEPTS OF DRAG, LIFT & STABILITY



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P140556

More electric, integrated fuel systems

Engine system reliability can be improved by advanced electric architectures, while the reduction of hydraulic components, fuel tubes, and fittings can enhance the maintainability of the engine and minimize pilot workload.

Global warming and environmental friendliness considerations have recently been key for multiple global industries. In the commercial aviation industry, reduction of aircraft emissions, including CO_2 and noise, is an urgent priority. Both aircraft and aircraft engine manufacturers are striving to improve designs to accommodate the needs of commercial airlines. Engine manufacturers in particular have worked long and hard to improve each engine component, e.g., compressors, turbines, combustors, etc.

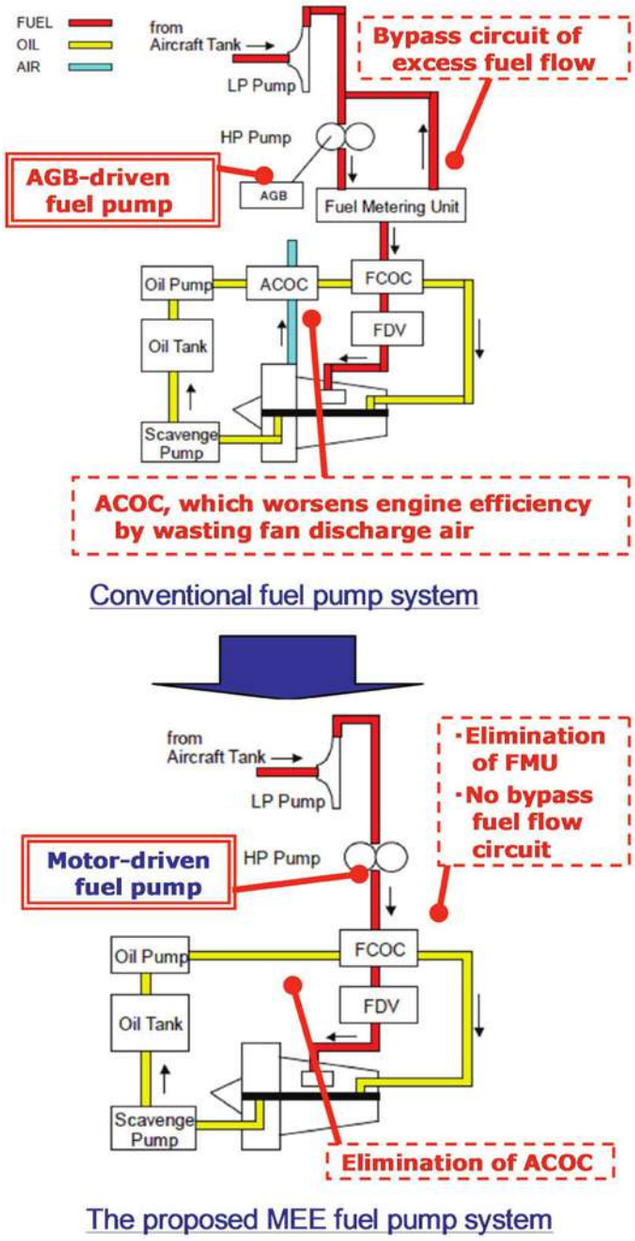
However, the need for another approach to further improve engine efficiency motivated researchers from **IHI Aerospace** to focus on the system approach, including the control system, fuel system, or other engine systems, ultimately resulting in MEE (more electric engine).

MEE is a new engine system concept that seeks engine efficiency improvements, which results in a reduction of engine fuel burn and CO_2 emissions. The key concept of the MEE system involves the architecture for the electrical power generation by the engine and changing the power source for accessories from mechanical/hydraulic to an electric motor.

IHI focused on the electrification of the engine fuel pump system because of its contribution to fuel-burn reduction. The researchers conducted a feasibility study of the MEE fuel system for an assumed small-size turbofan engine, and the result indicated an improvement in specific fuel consumption (SFC) by about 1% during cruising. The SFC improvement would be accomplished by removing the fuel bypass circuit and eliminating the ACOC (air-cooled oil cooler), which worsens engine efficiency.

There are several technical challenges for the practical design of the MEE motor-driven fuel pump system. Failure of the engine fuel pump may induce IFSD (in-flight shutdown) of the engine and result in catastrophic failure of the aircraft. To avoid such critical situations and ensure better reliability than that of the conventional system, a fault-tolerant design of the electric drive is mandatory.

For the MEE fuel pump system currently being developed, IHI has proposed the use of a permanent magnet brushless ac servo motor. In the servo motor control system, the electrical current is adequately controlled cor-



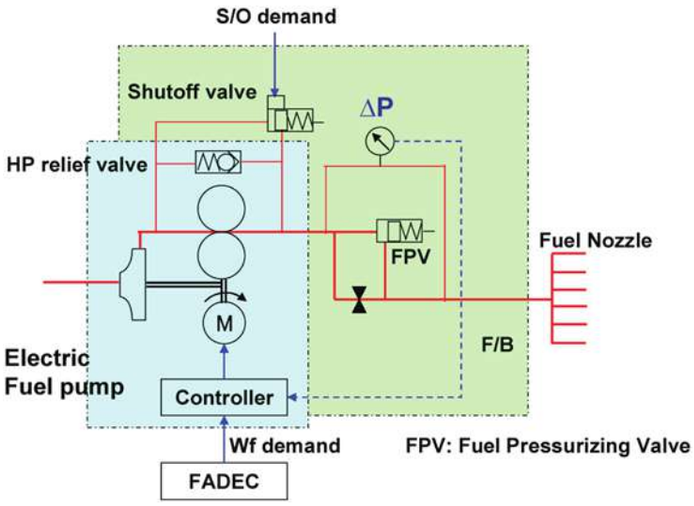
Schematic of an MEE (more electric engine) electric fuel pump system vs. a convention fuel pump system.

responding to the required torque from the fuel pump. The control system contains a limiter function to avoid overload of the motor, and a motor power-off function for emergency shutoff of the fuel supply.

In addition, IHI proposed the introduction of advanced fault-tolerant technologies such as a unique active-active redundant motor control system to the MEE. The active-active control enables the supply of the same amount of fuel to the engine combustor in case a single open failure occurs in one of the redundant motor systems.

Conventional vs. MEE fuel systems

In current commercial aircraft, the aircraft system consists of various subsystems, and each subsystem is independently designed to accommodate the specific requirements or operational conditions designated for each subsystem. The independency sometimes causes duplicated functions and complicated system design.



Schematic depicting the MEE fuel pump system.

One typical example of a segregated system is the engine fuel system. It is independent from the aircraft fuel system and both systems are designed to accommodate various conditions, which are designated at the interface point between aircraft system and engine inlet. Integrating the aircraft and engine fuel system would be helpful to construct a more efficient and simplified system, but it seems not to be practical in the conventional aircraft system.

The aircraft system contains electric motor-driven fuel boost pumps, shutoff valves, and cross-feed valves as a minimum. There may be fuel transfer pumps, such as electric motor-driven pumps or ejector pumps, for transferring fuel between the tanks. In the case of a twin-engine aircraft, the left- and right-hand engines are supplied with fuel from the left and right wing tank, respectively, during normal operation. If IFSD occurs in one of the engines, the cross-feed valves would be activated to supply fuel from the opposite side tank to avoid an imbalance of fuel mass.

The engine fuel system consists of an AGB (accessory gear box)-driven fuel pump, FMU (fuel metering unit), and FPV (fuel pressurizing valve) at a minimum. Performance characteristics of the fuel pump are determined so that the pump supplies sufficient fuel flow with the obtained fuel inlet condition and engine operating condition.

Typically, the fuel pump consists of an LP (low pressure) impeller pump and HP (high pressure) gear pump. The LP pump increases fuel pressure at the HP pump inlet for the proper suction of fuel.

A more electric architecture supports the integration, simplification, and reconstruction of the aircraft and engine fuel system because of increased controllability, a modular design, and flexibility of component installation.

The MEE electric fuel system simplifies the engine fuel system by eliminating the fuel bypass circuit and compli-

cated FMU. In addition, the MEE fuel system increases the flexibility of the engine fuel pump installation, because it is not necessary any more to attach the motor-driven fuel pump to the engine AGB. The location of the pump may be moved to an area other than the external surface of the engine. It means that the engine fuel pump is possibly considered as one of the components within the aircraft fuel system, and a possible location would be in the nacelle, fuselage, or wing.

Current aircraft fuel systems and engine fuel systems have duplicated functions, such as a boost pump, which enables the provision of proper suction of fuel from the tank, and a shutoff valve that shuts off fuel to the engine combustor. An integrated fuel system would remove the burden of the aircraft and engine interface condition, removing the duplicated function as much as possible and simplifying the system construction.

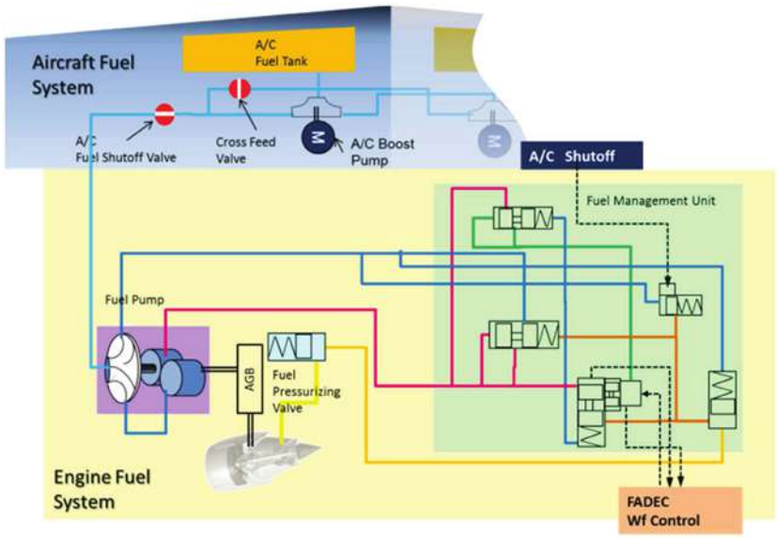
Integrated fuel system benefits

A reduction in fuel burn is expected through the introduction of the MEE electric fuel system, which eliminates the loss in fuel system efficiency caused by the AGB-driven pump system.

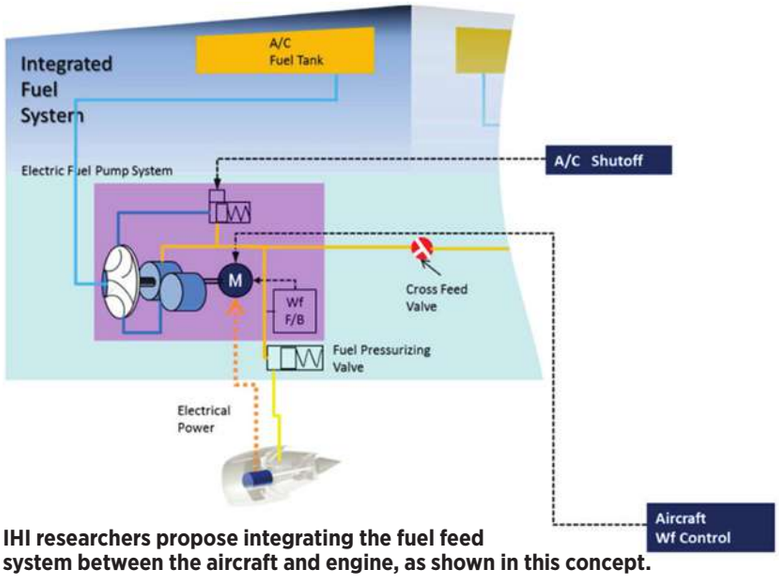
Also, the number of components in the fuel system would be minimized. In the conventional aircraft fuel system and engine fuel system, which are separated from each other, there is a duplicated function between the aircraft components and the engine components. One of the typical examples is the pressure boosting function to ensure that the engine fuel pump properly suctions fuel from the aircraft fuel tank.

In the conventional system, electric motor-driven fuel boost pumps, which are usually submerged in the fuel tank, pressurize fuel to provide the minimum pressure required by the engine fuel system. Typically, the aircraft boost pump is the impeller type and adds about 50 psi to the tank pressure. However, the engine fuel pump also has an LP impeller pump to boost fuel pressure at the engine inlet because the engine fuel pump is required to supply fuel even though the aircraft boost pump is in operational condition.

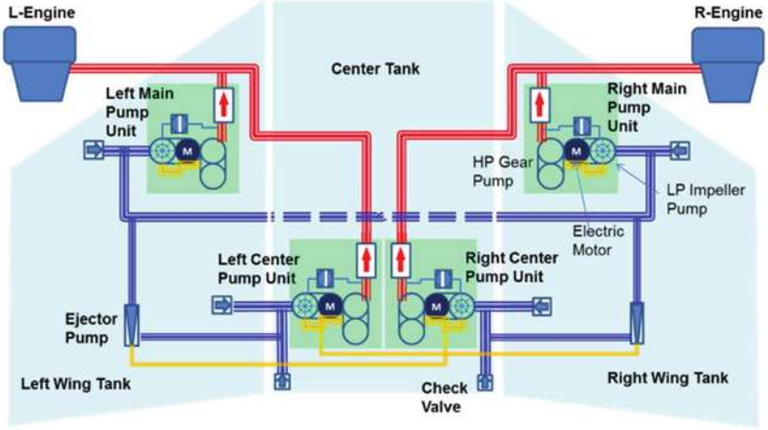
In the proposed integrated system, the boosting function is accomplished by the LP impeller pump in the electric fuel pump unit. The feasibility study of the small-size turbofan MEE fuel pump shows that the single-shaft electric pump, which drives both the LP impeller pump and HP gear pump by the same



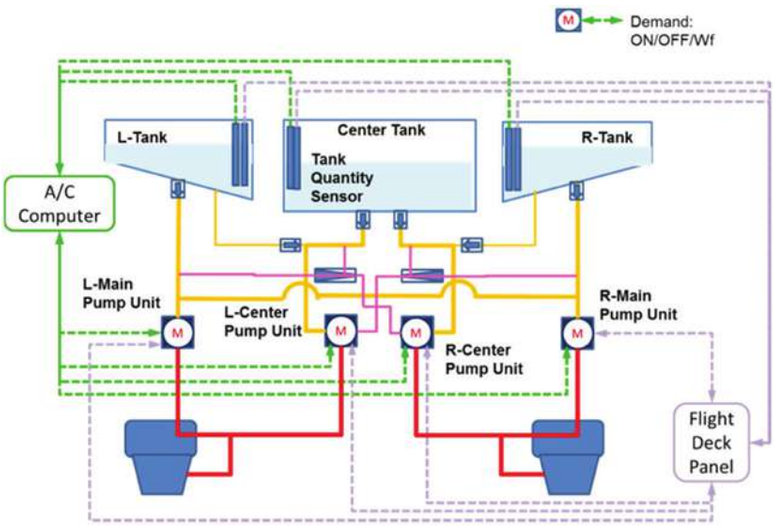
An example of a conventional aircraft and engine fuel feed system.



IHI researchers propose integrating the fuel feed system between the aircraft and engine, as shown in this concept.



This proposed schematic of the integrated fuel feed system concept is for an assumed 150-200-seat single-aisle aircraft with twin engines, such as a Boeing 737 or Airbus A320.



LRU Comparison

Conventional System

	Each per A/C
Elec.Boost Pump	6
ENG FMU	2
ENG Main Pump	2
A/C Shutoff Valve	2
Cross feed valve	1
Ejector Pump	1
Check Valve	9
	23

Proposed Integrated System

	Each per A/C
Elec.Fuel Pump unit	4
Check Valve	6
Ejector Pump	2
	12

Fuel connecting chart of the proposed system shows the fuel line among the tanks, electric pump units, and engines. Redundant electric fuel pump units are connected to each engine.

shaft, can suction fuel during an aircraft boost pump failure. The submerged aircraft fuel boost pumps can be removed, which will not only contribute to a reduced number of components but also remove the submerged components in the fuel tank.

Another possible approach to reduce the number of components is to remove the cross-feed valves and electric transfer pumps. In a conventional fuel system, the cross-feed valve is necessary to have fuel mass balance between the left and right wing tanks in case one of the engines is shut down. In the proposed integrated fuel system, the left main pump unit has fuel inlets connecting to both left and right wing tanks. It is the same for the right main pump unit. The left and right main pump units always suction fuel from both the left and right wing tanks, so the fuel mass balance between the tanks will be maintained automatically, allowing the cross-feed valve to be removed.

In the integrated fuel system study for an assumed single-aisle aircraft, it was estimated that the aircraft boost pumps, engine FMUs, and MFPs (main fuel pumps) in the conventional system would be replaced by four sets of electric fuel pump units. In addition, with the cross-feed valves and aircraft shutoff valves removed, the total number of LRUs (line replaceable units) in the integrated aircraft system is expected to be reduced to about half of the conventional system.

The proposed integrated system eliminates electric valves such as the cross feed and shutoff valves as much as possible. However, in considering emergency situations—for example, severe fuel leakage from anywhere in the system—isolation of the fuel system may be required to avoid loss of the aircraft fuel. For that purpose, the addition of monitoring devices such as fuel-pressure sensors, leak detectors, and electric shutoff valves may be considered. Also, if the aircraft system wants to control the fuel amount in the left and right tanks independently, that would be accomplished by the addition of the electric shutoff valves in the system. Thus, the proposed integrated electric fuel system has the flexibility to incorporate additional electric devices and will support aircraft system requirements.

As mentioned above, the reduction in the number of LRUs will be achieved by introduction of the integrated fuel system. In addition, components that are submerged in the aircraft fuel tanks, such as the aircraft boost pumps, will be removed. One possible location for the electric fuel pump units is the fuselage, inside of the access door.

Currently, LRUs are installed into distributed locations among the aircraft wing, aircraft tank, and the engine. In the integrated system, the LRUs may be installed in one place in the aircraft fuselage, so that replacement of the pump unit will be much easier than the current aircraft/engine fuel system components. Reduction in the number of LRUs, accessibility, and replaceability of the electric pump unit will improve the maintainability of the aircraft/engine fuel system.

Because the integrated system allows for the removal of the cross-feed valves, adjustment of the tank balance by pilots would not be necessary anymore. On/off of the current submerged aircraft boost pumps is usually conducted by pilots to maintain a minimum amount of fuel in the tank, which is previously determined to avoid heating of the pump.

In the proposed integrated fuel system, the electric fuel pump units would be installed outside of the fuel tank, instead of the submerged boost pumps. Pilot operation for the cross-feed valves or boost pumps would not be necessary; thus, reduction of pilot workload would be expected. ■

This article is based on SAE International technical paper 2013-01-2080 by Noriko Morioka IHI Corp. and Hitoshi Oyori, IHI Aerospace Co.

Making sense of HYBRIDS

Developers focus on applications that boost productivity while they strive to improve the efficiency of alternative power sources.

by Terry Costlow

Ricardo's flywheel technology boasts long lifetimes and good cold-weather response.

In contrast to the automotive market, where battery-powered hybrids are the dominant alternative to internal-combustion engines, multiple powertrain options are vying to gain acceptance in the off-highway market. Hydraulics, flywheels, and batteries are all being used to power various elements on vehicles.

Off-highway vendors have learned from automakers, who spent millions and rolled out several hybrid vehicles that have not yet come close to hitting double-digit market shares. Off-highway development teams are focusing in on applications where alternative powertrains bring solid benefits that users will pay for. Design teams are targeting specific tasks that are well-suited to the performance characteristics of their technologies.

"Electrification works well with transient use, something like a power digger where you see a tremendous increase in power demand when it digs into the earth," said Jason McConnell, Business Unit Director of Hybrid & Electrification at **IAV Automotive Engineering**. "When you provide an electric boost for these demands, you may be able to downsize the engine."

Another design company, **Ricardo**, feels flywheel systems have some promise for niche applications that have the ability to recover a lot of power in a short period, in contrast to conventional systems that rely on large energy-storage systems.

"Applications of this nature are excavators and loaders where they are making hundreds of the same motions that require the system to brake the motion once it reaches the end position of a cycle," said Ali Maleki, Business Unit Director for Hybrid and Electrical Systems, Ricardo. "The kinetic energy of moving a ton of dirt can be recovered with a flywheel system and used to propel the excavator to the next cycle."

Dana Holding Corp. is broadening its efforts to commercialize its Spicer PowerBoost system. At the recent ConExpo conference, Dana described another field test platform for its hydraulic hybrid technology. It is now being tested on a telescopic boom handler powered by a 111-hp (83-kW) engine. Previously, the Spicer PowerBoost had been field tested on a 17.5-ton (16-t) front-end loader.

Other suppliers are currently focusing on narrow targets. Refuse trucks are a target for **Parker Hannifin**'s RunWise Advanced Series Hybrid Drive System. A fleet of refuse trucks that use this hydraulic hybrid technology recently surpassed 1 million mi (1.6 million km) of operation. This fleet saw a 43% reduction in fuel consumption compared to conventional diesel trucks.

Live long and prosper

Long lifetimes are one of the key requirements for the off-highway market, where return on investment is a critical parameter. Though hybrids add components and complexity, developers must ensure that downtime is equal if not better than with conventional vehicles.

For electric hybrids, managing the battery pack is a central element in the effort to eliminate costly failures. New strategies make it easier to get more energy from cells without impacting their lifetimes.

"We're seeing incremental improvements in batteries, though a better understanding of discharge rates and failure modes is really changing things," McConnell said. "Some applications now use only 50-60% of the available energy to ensure long lifetimes. When you don't put the cell in a position where it will fail, you don't have to use nearly that large a margin."

Alternative technologies also boast of long lifetimes. Dana and Parker tout the high reliability and low maintenance of hydraulics. Ricardo noted that its flywheel has few points of failure.

"Flywheel performance does not have significant degradation to age or use as a battery system would have," Maleki said. "A battery loses capacity and power capabilities due to age and usage. A sealed flywheel system will not lose this performance as it ages or it is being used. Flywheels also perform better in cold operation where advanced chemistry batteries have significant limitation in cold conditions."

Safe not sorry

Whenever energy is stored, safety becomes more of a concern. The issues related to hydraulics generally follow many of the same principles used for conventional hydraulics, scaled to size.

Design houses such as IAV are doing lots of research into hybrid architectures.

Hybrids typically move elements like wheels and booms that can cause damage or injuries. That means systems must go through risk assessments to ensure that when any kind of fault is detected, operations can be stopped or set to a safe state.

"The electronic control of torque to wheels requires a high level of integrity in design to allow torque security to avoid unintended acceleration or loss of power," Maleki said. The safety integrity levels are therefore high and the designs must take into account redundant methodologies to ensure safe operation in presence of partial failures or safely shut down in catastrophic failures.

The addition of battery packs introduces new complexities for maintenance and post-crash situations. Most hybrids use very high

Plans may grow enough to transform fuels

Fuel for combustion engines has not transformed significantly over the past 100 years, but things may change. Biofuel research continues to advance as engineers develop new techniques that will let engines run on varying mixtures.

There's plenty of activity in biofuels, though they trail natural gas in the race to make the leap from alternative energy source to mainstream fuel. U.S. refiners produced around 1.7 billion gallons (6.4 billion L) of biodiesel fuel last year, according to the U.S. **EPA**. Engine developers throughout the supply chain are working on techniques that let operators run with any mix of fuels on any engine model.

Designers are devising new strategies to utilize the growing output of biodiesel. (National Biodiesel Board)

"The adoption of alternative fuels is a calibration issue," said Bapi Surampudi, Principal Engineer for Engine, Emissions, and Vehicle Research at **Southwest Research Institute**. "To minimize cost, the goal has always been to reuse the same electronics in multiple platforms. Therefore, one challenge is to design a common electronic architecture (hardware and software) that works in all cases."

Researchers are exploring different techniques to efficiently determine the makeup of fuel being used. One strategy is to add sensors that measure fuel in the tank, while another leverages combustion control systems to monitor fuel as it's fed to the engine.

"For self-propelled vehicles, the detection could be a tank-based analysis and a 'retune' or correction method every time the tank is filled," said Chris Mays, Senior Technical Specialist at **BorgWarner**'s Advance Engineering Group. "The sensing method could also be continuous. In this case, OEMs need to determine whether to measure the fuel or the combustion. Measuring the combustion, either directly or indirectly, provides the greatest payback as it accounts for engine component and system variation as well as fuel variation."

The rapid advance in computing power is helping engineers and programmers analyze fuels efficiently.

"Higher-performance electronic control units enable a more precise control of the combustion process and reduced penalty efficiency of the alternative-fuel engine," said Ali Maleki, Business Unit Director for Hybrid and Electrical Systems, **Ricardo**. "New electronic technologies are embedded for better emissions control, gas recirculation control, and precise fuel delivery. There is a significant trend for alternative fuels in the stationary, railway, and truck applications that are more operating-cost sensitive."

As control systems evolve and more biofuels move into production, engineers are continuously striving to eke more work from every drop of fuel.

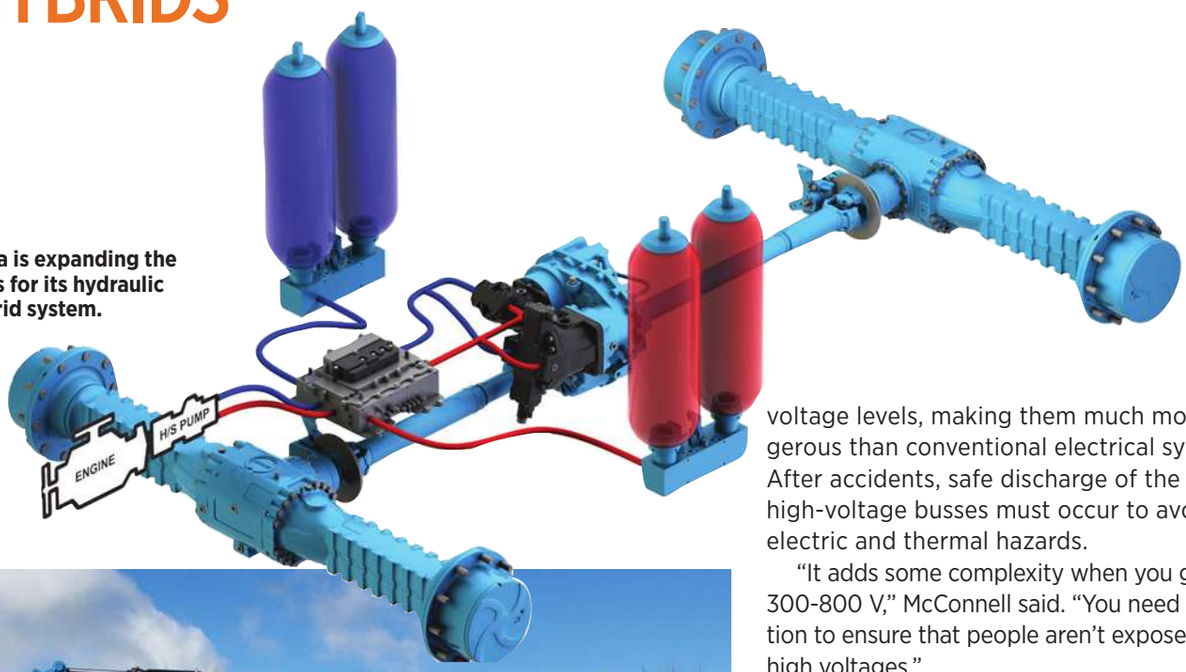
"Engine manufacturers must become knowledgeable of the potential and the drawbacks of different biofuels and gain experience through faster and more sophisticated testing," Surampudi said.

Much of that knowledge will be gained through modeling and simulation. Combustion is very complex, with major differences arising from minor changes, so many tests must be run to improve efficiency.

"Getting good signals at the sensors is one aspect to consider," Mays said. "Simulating sensor responses in the design phase can help give good signal-to-noise response. This can include analysis of sensors in the gas flow stream to make sure they are sensing well-mixed gases and are robust to condensate, for example."

Terry Costlow

Making sense of HYBRIDS



Dana is expanding the tests for its hydraulic hybrid system.

Flywheels capture energy during repetitive motions like digging. (Ricardo)

Refuse trucks are a target for Parker's hydraulic hybrids.

voltage levels, making them much more dangerous than conventional electrical systems. After accidents, safe discharge of the high-voltage busses must occur to avoid electric and thermal hazards.

"It adds some complexity when you go up to 300-800 V," McConnell said. "You need protection to ensure that people aren't exposed to high voltages."

Advancing technologies

Ongoing improvements in efficiency will help hybrid systems gain market share. Designers are looking at many options to help reduce costs and improve performance. For electric powertrain systems, augmenting batteries with supercapacitors may be a viable alternative.

"We want to take advantage of supercapacitors, especially in applications with very high discharge and charging rates," McConnell said. "If you use a conventional battery pack to meet a very high power demand, you've got to have tremendous capacity in the battery pack. If you take advantage of supercaps and batteries, you can reduce battery cost even though you have the cost-adder of supercaps."

Another technique is to maximize the performance of components like sensors. Some vendors have turned to sensor fusion, using information from two or more sensors to determine information that would otherwise require an additional sensor. While some developers work to reduce the number of sensors, other researchers say that it's important to leave the door open for additional sensors that may be needed as technology evolves.

"One main issue is properly defining what the core structure vs. custom features is, while offering flexibility for future expansion as more sensors are introduced into the controller," said Joe Steiber, Principal Engineer for Engine, Emissions, and Vehicle Research, **Southwest Research Institute**. ■

Global VEHICLES

Auto Expo 2014 highlights

The Indian automotive industry is going through a rough patch, with annual car sales falling for the first time in 11 years in 2013, posting a 9.6% dip. The vehicle makers fought hard to deal with a downturn by making the recent Auto Expo 2014 event in Delhi a more exciting event than normal.

Society of Indian Automobile Manufacturers President Vikram Kirloskar is hoping new models unveiled during the spectacle will help revive demand. "There is pent-up demand, but consumers are delaying purchases because of factors like lesser income, high interest rates, and inflation. We are hoping that this Auto Expo will draw them out to trigger demand, although the revival in the automobile market is unlikely unless there is a revival of economic growth," Kirloskar said.

This Auto Expo saw a total of 69 models launched, the highlights of which are presented in this article. Most of the OEMs targeted the compact SUV segment at the event. New technologies making their way into the market include automatic and automated manual transmissions. **Maruti Suzuki** Marketing Chief Mayank Pareek said "We are hoping this auto expo will kick-start gearless cars in India; 30% of total cars will be gearless by 2030."

This year's expo also spotlighted a new category of compact sub-four-meter sedans and utility vehicles. The different tax structure for smaller vehicles in the Indian market prepared the way for this category. The excise duty on sub-four-meter vehicles is less than half that of larger vehicles. So manufacturers can reduce the length of vehicles and introduce new products at aggressive prices. Over the next two to three years, nearly a dozen such vehicles will hit Indian roads.

Mahindra showcased its complete electric vehicle range, from the XUV 500 and Reva Verito to a racecar that will be part of the new Formula E series. Mahindra & Mahindra Chairman and Managing Director Anand Mahindra, who has asked the government to grant subsidies to automakers to promote green cars, has emerged as an key entrepreneur who knows how to take the right risks at right time.

Dr. Pawan Goenka, Executive Director & President, Automotive & Farm Equipment Sectors, Mahindra & Mahindra Ltd. said: "The Delhi Auto Expo 2014 is an important platform for the Mahindra Group given that we are displaying our comprehensive range of mobility solutions. Our automotive sector is putting on display a range of products which highlight our offering of 'accessible technology.'"


Hyundai Xcent


Isuzu D-Max pickup


Mahindra Reva Verito EV

Production vehicles

Hyundai Xcent: **Hyundai**'s first made-for-India compact sedan, the Xcent, is based on the successful platform of the Grand i10. With the Xcent, Hyundai has achieved 90% localization. Hyundai did not reveal much technical information on the car, but sharing platform and design with the Grand i10 it is expected to get a 1.2-L petrol engine with 82 bhp (61 kW) and 113 N·m (83 lb·ft) or a 1.1-L diesel engine with 70 bhp (52 kW) and 159 N·m (117 lb·ft) featured with an automatic or manual transmission. It features dual-tone beige and black interiors including seats, multiple storage options in the door trims and center console, rear air-conditioning vents, smart key with push-button start, and electrochromic mirror with rear camera display. This vehicle will be launched in second quarter of this year.

Global VEHICLES

Mahindra XUV500 diesel hybrid

Tata Bolt


Tata Magic Iris Electric

Isuzu D-Max: Japanese automaker **Isuzu** Motors launched the D-Max pickup truck, betting big on the multi-utility pickup truck segment and expanding its pickup truck range. At the launch, Isuzu Motors India President and Managing Director, Takashi Kikuchi, said: "In India, the pickup truck segment is one of the largest and fastest growing segments in commercial vehicles, accounting for 35% of the total commercial vehicle market. With the growth in the Indian economy, we estimate India to be the world's largest pickup truck market by 2023." The vehicle will be powered by a 2.5-L turbocharged and intercooled four-cylinder diesel engine delivering 134 bhp (100 kW) at 3600 rpm and 294 N·m (217 lb·ft) at 1800-3200 rpm. The rear-wheel-drive 1.2-t (1.3-ton) payload capacity truck is a little more than 5 m (16 ft) long, 1.7 m (5.6 ft) wide, with seating capacity for two. Isuzu chose a five-speed manual transmission with independent front suspension and rear leaf spring suspension to increase payload capacity.

Mahindra Reva Verito EV: The Verito EV is powered by a 72-V lithium-ion battery pack that can be slow charged within 6 h or quick charged in 1.5 h. A 29-kW ac motor transmits sends its output through a single-speed transmission for a top speed of 86 km/h (53 mph) and a range of 100 km (62 mi). The car has four driving modes: reverse, forward, neutral, and boost. Using the platform of the conventional Verito, it is 4277 mm (168.4 in) long, 1740 mm (68.5 in) wide, 1540 mm (60.6 in) tall, with a wheelbase of 2630 mm (103.5 in) and ground clearance of 172 mm (6.8 in).

Mahindra XUV500 diesel hybrid: Mahindra & Mahindra unveiled a diesel hybrid XUV500 SUV based on its hybrid-electric technology systems. Company officials at the show claimed that it gives 18% higher fuel efficiency than its conventional-fuel variant and is also the first manual diesel hybrid in the world. This vehicle is equipped with a 1.5-L, three-cylinder, mHawk common rail direct injection diesel engine assisted by permanent magnet synchronous motor and lithium-ion battery to aid propulsion. The electric motor assists the engine while accelerating at low speeds. Regenerative braking technology ensures electric production while braking to charge the car's battery. It measures 4585 mm (180.5 in) long, 1890 mm (74.4 in) wide, and 1785 mm (70.3 in) tall with 17-in alloy wheels. Officials hinted that this car will be in production in a year's time.

Suzuki SX4 S-Cross: A global model, the SX4 S-Cross crossover brings forward **Suzuki**'s capability to offer the benefits of two segments in creating a new segment for its customers. A sharp body line, wheel arch moldings, skid garnishes, and integrated roof rails emphasize the crossover styling of vehicle. The car on display was equipped with four-wheel drive with four driver-selectable driving modes for better performance in different road conditions. It has a double sliding glass panoramic sunroof of European specification. Aerodynamics considerations are shown by minute details like a roofline that slopes downward toward the rear.

Tata Magic Iris Electric: **Tata** Motors showcased a small commercial electric passenger carrier that company officials claim is first and only car that uses a solar charger in its vehicle segment. It is powered by a three-phase induction motor giving max power of 9 kW at 2100 rpm and peak torque of 42 N·m (31 lb·ft) at 0-2100 rpm with a transaxle single-speed transmission. The Magic Iris Electric has a 100-km (62-mi) range and runs on two battery modules of 110 A·h and 48 V that can be charged in 8 h. The lithium-ion battery modules can also be supplementary charged by the 120-W roof-

Tata Zest

mounted solar panel. The vehicle measures 2960 mm (116.5 in) long, 1512 mm (59.5 in) wide, 1840 mm (72.4 in) tall, with a wheelbase of 1650 mm (65.0 in) and a curb mass of 733 kg (1616 lb). This vehicle has a next-generation infotainment system with vehicle information such as battery range, battery state of charge, battery state of health, etc.

Tata Bolt and Zest: Tata Motors unveiled its new Bolt hatchback alongside its compact sedan Zest twin. Both of the newly launched cars will use the Revotron 1.2-L petrol engine giving maximum power of 85 PS (63 kW) at 5000 rpm and 140 N·m (103 lb·ft) at 1750-3000 rpm. The diesel option will use a 1.3-L Quadrajet diesel engine with max power of 75 or 90 PS (56 or 67 kW) at 4000 rpm and maximum torque of 190 or 200 N·m (140 or 148 lb·ft) depending on gearbox—C510 and C549, respectively. The cars have three driving modes: Economy, Cruze, and Sports. They share the same platform with a wheelbase of 2470 mm (97.2 in) and feature Tata's new signature grille visually flowing into dynamic headlamps, the same layered and flowing design dashboard, and strong shoulder lines and front imparting a wider stance.

Concept vehicles

Bajaj U-car: **Bajaj** Auto's new concept quadricycle two-seater is positioned as an urban transport solution. It is to be powered by a liquid-cooled, four-valve, triple-spark, fuel-injected gasoline engine with an automatic gearbox and front-wheel drive. Bajaj refused to disclose engine capacity, but hinted that it will be less than 650 cm^3. A company official claimed


Bajaj U-car


Chevrolet Adra

Datsun redi-GO

that the quadricycle will even be lighter than the 400-kg (882-lb) RE60, with emissions similar or less than the 60 g/km of the RE60 with a lighter weight around 250-300 kg (551-661 lb). The U-Car was created to decongest urban areas and lower emissions. It is based on a completely new platform designed in-house and is built from readily available plastic and sheet metal. Bajaj is only calling this a concept, and its production would depend on the feedback it gets from the public, though company officials at the show said the production vehicle is already under development.

Chevrolet Adra: Designed in Bangalore, the **Chevrolet** concept resembles a **Mini** Countryman. The name Adra refers to "rock" or "stone" in the Sanskrit language, which company officials stress was chosen because the car was designed with safety first in mind. The preview of a GM compact crossover has angular styling for a pronounced masculine appeal and rugged look, with the flat front fascia, raised hood, and accentuated wheel arches adding to the SUV's brawny looks. It offers all of the advantages of a traditional SUV—such as high ground clearance, exceptional all-around visibility, high seating, and generous interior space—in a compact package. GM hasn't confirmed if the concept will make it to production, nor did the company reveal any specifications for possible production, but the car is expected to have petrol and diesel engine options when launched. It is likely to feature a tweaked version of the 77-bhp (57-kW) 1.3-L Multijet diesel engine from the Chevrolet Sail and Enjoy. At the launch, President and Managing Director Lowell Paddock said: "The Adra is a major achievement for our local designers, who conceptualized and designed the model from the ground up. It represents a new possibility for the fast-growing compact SUV segment."

Datsun redi-GO: **Datsun**, at its first-ever Indian Auto Expo, world premiered the redi-Go crossover concept. The redi-Go packs daytime LED lights twisted to give the concept a unique visual signature and Datsun's "D-cut grille" and LED foglight strips integrated into the bumper. The overall package is short with short overhangs and a crossover-style raised body and twin character lines running from front to rear. The concept has ground clearance indicating off-roading intentions and sports 15-in alloy wheels. There was no specific mention of mechanicals by company officials, and they declined to comment on a product timeline. However, a company official admitted that the vehicle (if produced) is likely to be featured in India first.

DC Design Tia: **DC Design**, the Indian designer of automotive interiors, unveiled its concept Tia, a compact two-seater with two doors and a sleek design. It is equipped with a 1.2-L turbocharged Euro V-compliant engine producing peak power of 120 hp (90 kW) and 190 N·m (140 lb·ft) with a four-speed automatic transmission and 18-in alloy wheels. It is able to accelerate from 0 to 100 km/h (62 mph) in 9 s and has a maximum speed of 160 km/h (99 mph). It is made with a spaceframe roll cage with carbon composite body and gross vehicle mass of 950 kg (2094 lb). The car is aimed at young Indians with luxurious lifestyles that favor an Indian brand name.

Fiat Avventura: **Fiat** debuted its global concept Avventura, which is based on the Punto platform and is essentially a rugged version of a road-going hatchback. Fiat raised the ground clearance to 200 mm (7.9 in) for the 3987 mm (157.0 in) long concept. The externally mounted spare wheel isn't mounted directly on the back hatch but instead has a swing arm mechanism hinged to the bumper that allows it to swivel away


Fiat Avventura


Ford Figo

from the hatch. Company officials say that this was done to make the cargo space larger and give the car a sportier, muscular look, which will be liked in India. It will be available as both petrol and 1.3-L 89-bhp (66-kW) variable geometry turbo Multijet diesel variants. The show car has roof rails running along the sides and a couple of bikes hitched to the roof, indicative of a holiday car. It will be launched first in India in third quarter, and outside market possibilities are in process.

Ford Figo: **Ford** showcases an all-new global small car model, codenamed B562, with the name of Figo in India, but in other markets it will be called Ka. The car is expected to be powered by 1.0-L turbocharged EcoBoost engine and will offer rear power windows, Powershift automatic transmission, and Ford's Sync infotainment system. The concept car uses the same modern styling treatment that's making its way across Ford's global hatchback and sedan range. This includes the hexagonal grille and attractive, slim wraparound headlamps, which on the concept reflect the hexagonal theme in their detailing. Company officials declined to reveal any technical details as well as any timeline for production.

Honda Vision XS-1: The Vision XS-1 concept, a global debut at the 2014 Auto Expo, is based on **Honda**'s man maximum, machine minimum concept, which refers to maximizing the available space for people while at the same time minimizing the

Automated manual transmissions come to India

One of the most awaited production cars of the Indian Auto Expo 2014 was the Celerio Automatic. Introduced by India's biggest car maker, **Maruti Suzuki**, there was high hope that its clutch-less operation will make it a big draw for India's stop-and-go urban traffic. The car is expected to help bring automatic gearshifting to the Indian mass market.

The Auto Gear Shift is **Suzuki** Motor Corp.'s newly developed technology that promises a superior drive experience to Indian users. Powered by an intelligent actuating unit, Auto Gear Shift is part of a powertrain that includes a 998-cm^3, 1.0-L, three-cylinder gasoline K-next engine producing 67 bhp (50 kW) at 6000 rpm and 90 N·m (66 lb·ft) at 3500 rpm.

The Celerio is one of the smallest Maruti hatchbacks at 3600 mm (141.7 in) long, with other dimensions of 1600 mm (63.0 in) width, 1560 mm (61.4 in) height, 2425 mm (95.5 in) wheelbase, and boot volume of 235 L (8.3 ft^3). It offers seating capacity for five passengers and has a mass of around 830 kg (1830 lb). Weight optimization was an important consideration to enhance fuel efficiency, with the use of high tensile steel and alternative materials helping achieve fuel economy of 23.1 km/L.

The Auto Gear Shift automated manual transmission (AMT) is equipped with an intelligent shift control actuator for smooth gear changes by coordinating clutch and shift operations in sync. Maruti Suzuki claims that shifting time is shortened compared to conventional gear shifting but with manual transmission efficiency.

Not to be outdone, **Mahindra** launched a five-speed auto SHIFT transmission on its Quanto. The vehicle is powered by a new-generation 1.5-L mCR100 diesel engine delivering a maximum power output of 100 PS (745 kW).

Auto SHIFT also involves an advanced ECU and a hydraulic actuation system that senses demand and initiates gear changes on a highly optimized shift map that is tuned to provide higher fuel efficiency. It also incorporates regenerative braking technology, in which kinetic energy is recovered through an alternator and stored in the battery, which could lead to a fuel savings of up to 40 L (11 gal) per annum, says the company.

Top executives at Mahindra called the automatic in the Quanto the future of transmissions in India. Their confidence in the technology means Indian consumers could expect more AMT variants in other Mahindra models.

Vibhor Jajoo

Maruti Suzuki Celerio

Two-wheelers from Harley and Hero

Auto Expo 2014 was not just about cars. Motorcycles were on display, including these highlights.

Harley-Davidson Street 750: Iconic U.S. bike-maker **Harley-Davidson** launched the Street 750 bike for India. The Street series is the company's first new launch in 14 years. It approached 3000 bikers in 10 countries including some 600 from India—mainly Delhi and Mumbai—for input in designing the bike. It is powered by the all-new Revolution 750-cm^3 X engine, a Harley-Davidson V-Twin engine specifically designed for urban riding with a torque output of 65 N·m (48 lb·ft) at 4000 rpm. It is liquid-cooled to maintain peak performance both in the city and on the highway. A single overhead cam, four valves per head, and a smooth-shifting six-speed transmission all translate to provide a quick throttle response. Cafe-style speed screen, black front fork gaiters, all-black exhaust system, and aggressive slash on the tail section deliver on Harley-Davidson's signature Dark Custom look. Another first on a Harley are the **MRF** Zapper tires developed especially for the Street 750.

Hero iON: Instead of the conventional sources of fuel, the **Hero** iON at Auto Expo 2014 had advanced lithium-air batteries and a hydrogen fuel cell extender packed into the center structure with supercapacitors boosting acceleration. The hub-less wheels use electric motors that use magnetic levitation technology and when needed act as brakes. Its advanced suspension system, called the m-link, uses magnetorheological damping that adapts to road conditions in real time using several onboard sensors. The concept also gets electronically controlled regenerative brakes with ABS and collision avoidance. The superbike has acceleration of 0-100 km/h (0-62 mph) in 5 s and a top speed of 160 km/h (99 mph). Range is 300 km (186 mi) from a full charge.

Hero Hastur: The Hastur is a 620-cm^3 motorcycle intended to take on the middle-weight segment. The bike measures 2015 mm (79.3 in) long, 820 mm (32.3 in) wide, and 1120 mm (44.1 in) tall, with a ground clearance of 130 mm (5.1 in). It features aggressive and modern street-fighter styling with twin projector beam headlights, LED running lights, integrated LED blinkers, and LED taillights. The Hero concept bike comes with a water-cooled parallel-twin 620-cm^3 engine capable of 80 PS (60 kW) at 9600 rpm and 72 N·m (53 lb·ft), mated to a six-speed cartridge-type transmission for efficient power transfer and fuel economy. The all-new engine is very compact and serves as a stressed member of the chassis for best possible mass centralization to aid handling and maneuverability. It also gets Controlled Swirl Injection (CSI) for increase in fuel economy and reduction in emissions. With a mass of just 160 kg (353 lb), the Hastur goes from 0 to 100 km/h (62 mph) in 3.8 s and has a top speed is a 240 km/h (149 mph). The bike uses inverted forks in the front and an adjustable monoshock at the rear.

Hero iON

Hero Hastur

Hero SimplEcity

Harley-Davidson Street 750

Hero SimplEcity: The SimplEcity electric motorcycle weighs just 35 kg (77 lb) for the highest possible performance. It has a removable battery pack for convenient recharging. The top attraction is a regenerative rear wheel braking feature capable through an e-motor/generator. It also features a special "walk-mode," turning on power to roll easy on its side.

Vibhor Jajoo

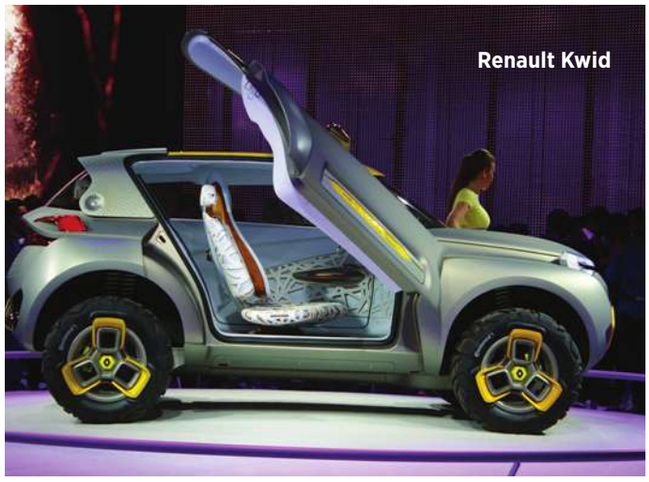
space necessary for all the car's mechanical parts. Honda used its new H concept language for the exterior design for High Tech, High Tension, and High Touch. It will be the basis of a compact SUV in the near future. The concept has single sliding doors on both sides and three-row seating with a capacity of seven that can be configured to maximize luggage capacity. The exterior has a broad chrome front grille and large alloy wheels.

Mahindra Halo: Indian industry giant Mahindra & Mahindra unveiled its two-door, two-seat Halo electric sports car concept. The company said that, depending on the support from the Indian government for EVs, it could be introduced in India or it could very well hit overseas markets first. It is powered by an electric motor developing about 140 bhp for 0-100 km/h (0-62 mph) acceleration in less than 8 s and a top speed of 160 km/h (99 mph). Two range options of 100-150 km (62-93 mi) or 200 km (124 mi) will be available with a customization of the battery pack. It's compact and well proportioned, the LED detailing is well executed, and the "double bubble" roof gives it a sports car look. The designers wanted to convey the idea of an everyday sports car that is easy to live with and drive on a daily basis. A Mahindra official said the concept could also spawn a four-door, five-seat sports car in the future. When it goes on sale in 2015-16, the Halo will reportedly be priced between 30-35 lakh INR. Along with the concept car Mahindra unveiled a fast-charging concept for its existing electric car, the E20, and specially designed for Halo


Honda Vision XS-1

it reduces charging time by 20%.

Renault Kwid: The plug-in hybrid-electric concept is the first global **Renault** launch in India. The Kwid, measuring 1940 mm (76.4 in) wide and 3620 mm (142.5 in) long, is predisposed to run on electric power via a charging plug behind its Renault grille logo, but it also has the latest-generation downsized 1.2-L turbocharged petrol engine mated to a dual-clutch transmission. While the car looks like a hard-core off-roader, it is actually only two-wheel drive. A vertically mounted TFT touch screen display acts as a dashboard and provides access to connected services. Flight Companion, one of its unique futuristic features, allows users to analyze traffic conditions ahead, detect obstacles, and even take pictures of the landscape around. The system can also be manually controlled from the touch screen fitted inside the car. The tablet also facilitates the opening of the trick rotating portion of the Kwid's rear roof. It's a five-seater at heart, but with a twist; the driver sits in the middle with two passengers on either side. The Kwid's exterior has robust appearance due to its protective guards, chunky wings, and oversized wheels. Officially, Renault claims that the intention behind the concept is to show how serious it is about the Indian market.


Renault Kwid

Suzuki Ciaz: In addition to the SX4 S-Cross, Indian car market leader Maruti Suzuki India Ltd. unveiled Suzuki's global debut concept, the Ciaz. During the launch, Toshihiro Suzuki, Executive Vice President, Suzuki Motor Corp. said, "While the SX4 S-Cross is a real crossover with authentic performance, the Concept Ciaz is designed to meet the growing demand in C-Segment market in India, China, and elsewhere." The Ciaz, a classy, urbane sedan specially designed by Suzuki for markets such as India and China, is expected to strengthen company's portfolio in the upper A3 segment.


Suzuki Ciaz

Tata Connect-next: Tata's concept for a future electric/range-extender vehicle with five passenger seating capacity has occupant cooling (vs. cabin cooling) to reduce power consumption with intelligent occupant location and temperature sensors. The distributed HVAC system helps free up cabin space and features a comfortable air diffusion system with layered, hidden vents. It also features extensive connectivity features and a simplified driver control interface, with active controls replacing conventional ones. For instance, a rain sen-

Mahindra shows Formula E car

Being the first and only Indian company to enter the **FIA** Formula E championship, **Mahindra** Racing launched its all-electric zero emission racecar at the Auto Expo 2014. The M1 Electro car will run in the FIA Formula E Championship that begins in September. The car's electric motor, with maximum power of 200 kW and 133 kW in race mode, can propel the car from 0 to 100 km/h (62 mph) in 2.9 s and to a top speed of 225 km/h (140 mph). Advanced electronic control allows the driver to engage push-to-pass button to deliver the additional 67 kW of power for overtaking. Power is delivered to the wheels through a paddle shift sequential gearbox supplied by **McLaren Electronics**. This racecar has 18-in tires supplied by **Michelin** featuring a tread that allows it to run in both dry and wet weather conditions. The car measures 5000 mm (196.9 in) long, 1800 mm (70.9 in) wide, and has a mass of 800 kg (1764 lb). The chassis is made of carbon survival cell and aluminum honey comb structure.

Vibhor Jajoo

Tata Connect-next

sor replaces a wiper stalk and a light sensor replaces a light switch. In addition, the car has a rear-projected touch screen center stack and instrument cluster, an iPod classic-inspired click wheel driver/co-driver center control, a head-up display with augmented navigation, driver warning, and guidance. A

Tata Nexon

transparent inner rearview screen replaces the mirror with panoramic video streaming and transforms into an augmented parking screen when reverse gear is engaged.

Tata Nexon: Tata's Nexon design concept is a modern compact SUV with a fresh design and new-generation human machine interface technology. It features the front mask and daylight opening first seen on the Tata MegaPixel concept. The vehicle is powered by a newly announced Revotron 1.2-L turbocharged three cylinder gasoline engine that produces 110 PS (82 kW) and 170 N·m (125 lb·ft) for a claimed top speed of 180 km/h (112 mph). The engine drives the front wheels, but electric power supplements at the rear for 4WD. The car is driven via a five-speed automatic transmission with electric rear-wheel drive and return fuel efficiency of 17.6 km/L. In town, it can run on only electricity. Designed with wheelbase of 2540 mm (100.0 in), the car is 4000 mm (157.5 in) long, 1730 mm (68.1 in) wide, and 1600 mm (63.0 in) long. It features a panoramic glass roof and a customization of trim on the upper grille and beltline.

Volkswagen Taigun: **Volkswagen** unveiled a near-production concept called Taigun, the SUV that could soon be part of the company's India lineup. The 998-kg (2200-lb) concept is 3859 mm (151.9 in) long without an outside mounted spare wheel, 1728 mm (68.0 in) wide, 1605 mm (63.2 in) tall with roof rails, with a generous wheelbase of 2470 mm (97.2 in) considering its exterior length. It is powered by a 1.0-L TSI turbocharged direct-injected petrol engine producing 108 bhp (81 kW) at 5000 rpm and 175 N·m (129 lb·ft) from as low as 1500 rpm. Teamed with a six-speed manual transmission, claimed fuel economy is 21.3 km/L, top speed is 186 km/h (116 mph), and acceleration from 0-100 km/h (0-62 mph) is 9.2 s. VW already has the 1.2-L TDI motor performing diesel duties, but it is developing a new family of diesel engines and a 1.5-L four-cylinder engine is said to be India bound on the Taigun. The concept has a twin split grille in front that extends into the headlight cluster, LED lights up front and in the rear, 17-in alloy wheels, and rugged under body and side cladding.

Vibhor Jajoo

Europe's aerospace industry looking confident

Talk of further consolidation within Europe's dynamic aerospace sector has been on the lips of industry watchers for several years, but although the major European-based global players have not progressed toward further mergers, the continent's biggest aerospace company, the former **EADS**, has achieved a very significant business restructuring, sweeping all its diverse companies into one giant, three-division entity, and adopting the new corporate identity of the **Airbus Group**.

At one stage it looked as if a proposed merger between EADS and **BAE Systems** might create the world's largest combined aerospace and defense company, but a German political veto put an end to this plan, largely because of sensitivity over the defense aspects of such a deal.

The French Rafale fighter represents the best in today's European military aviation portfolio with a powerful and flexible multi-role supersonic performance. (Dassault)

BAE Systems has a key role in the U.K.'s nuclear weapons program, and while Germans are enthusiastic on commercial aviation, the subject of nuclear defense is one that its politicians and public are happy to leave to the British, French, and U.S. The general reluctance of many NATO nations to maintain their defense budgets has caused a serious knock-on effect rippling through much of the European defense sector.

Legacy air defense programs, such as the **Dassault** Rafale, **SAAB** Gripen, and **Eurofighter** Typhoon, are today still providing plenty of production work, and upgraded versions are on the way, but beyond 2020 these programs are dependent on winning more export orders to avoid serious implications for existing assembly plants.

There are today relatively few new European military air programs, but one of the largest, the Airbus A400M transport, should generate new export sales and will extend production out well into the next decade, but other market sectors, such as jet trainers and surveillance aircraft, are proving very slow to mature into large-scale production.

The need to take a long-term strategic view on aerospace is recognized at the political and technical European Union level. Investment in highly innovative technologies and manufacturing methods is under way in an effort to retain a broad-based leadership role and to stay competitive with upcoming developments and production capacity in the BRIC countries (Brazil, Russia, India, and China). Heavy investment by European companies in overseas assembly plants has seen Airbus setting up factories in the U.S. (civil aircraft and helicopters) and Brazil (helicopters); Rolls-Royce expanding R&D facilities as well as production in the U.S. and Singapore; BAE Systems becoming well established in the U.S. and Australia; and Italy's **Finmeccanica** Group expanding in the U.S.

A new Airbus is born

Snecma's M88 engines power the Rafale, and the core of the engine has been adopted for the A400M's turboprop engine that will be developed in a new open rotor prototype program.

The restructuring of EADS into the new Airbus Group is far more than just a commercial rebranding operation. After decades of transatlantic criticism that Airbus is too political, and regarded by European leaders as a high-profile status symbol that must be subsidized—a claim always denied in Europe—the changes within the new Airbus finally create the accountable and transparent company structure that brings it into line with other global corporations.

Of course, financial assistance will still be willingly given by European governments to help invest in new programs and longer-term research and development, as is the case in the U.S. and elsewhere, but in business terms Airbus is now seen as a highly profitable independent enterprise that has broken free of its state controls.

In repaying government loans through the generation of profits from its civil airliners, it has produced an extremely good deal for European taxpayers. For example, the best-selling A320 family was originally forecast to break even if 200 were sold. Today, the sales total for these single-aisle jetliners is a staggering 10,200, with a backlog of 4200 aircraft yet to be delivered. European governments that have supported Airbus financially collect a royalty on every one sold, so while it will be some time before they see a return from sales of the giant, but slow-selling A380, the A320 has become a commercial success on a grand scale.

The Eurofighter Typhoon is evolving from an agile air defense fighter into a genuine multi-role fighter/ bomber/reconnaissance aircraft.

The Airbus Helicopter Tiger attack helicopter.

The U.K. aerospace industry has a major share in the F-35 program, producing rear fuselage and fin assemblies and the ejector seats and providing the Rolls-Royce lift fan that gives the F-35B model its vertical takeoff and landing capability. (MOD)

Because the delivery timescales have now become so extended, Airbus has recently announced that it is raising the A320 production rate to 46 a month in 2016. Final assembly plants in Germany, France, and China will be joined by a new Airbus factory in Mobile, AL, next year. Just six years ago production was cut because of the financial crisis and falling demand, but since 2010 the demand has returned and monthly flow has gradually increased from 36 to the current rate of 42. By 2018 it could reach a monthly total output of 50 aircraft.

Since the decision to go ahead with the A320neo, with a potential 15% reduction in operating costs, sales have surged and this has created a real challenge, as well as welcome news, for everyone across the global supply chain. Airbus Group CEO Tom Enders has played a key role in steering the new Airbus through a complex, multi-national transition, and he has insisted on developing a close partnership with his supply chain in what he describes as an "extended enterprise." He firmly believes that taking the suppliers into a closer, rather than confrontational, relationship is an important strategy if production costs are to be kept down.

The latest civil Airbus, the A350 family, is making rapid progress toward certification and first deliveries by the end of this year. Four aircraft are now in the test flight phase, with over 1100 h achieved by the first two. One of the development aircraft is being fully fitted out with passenger seats and cabin systems and will soon embark on long endurance test and evaluation flying.

The A350 is being developed into a family of wide-body transports, seating from 276 in the A350-800 to 369 in the A350-1000, and with a nonstop range of up to 8250 mi. Nearly all A350 customers have selected the -900 and -1000 versions, and the -800 may be dropped. All variants are powered by two **Rolls-Royce** Trent XWB engines. The combination of advanced aerodynamics, a wide cross-section fuselage with over 50% made from composite materials, and lean burn engines, will offer a 25% reduction in seat mile costs compared to equivalent size current jets.

Further cost reductions are expected from reduced training requirements due to a common flight deck design and flying qualities shared with all the other Airbus designs, the A320, A330, and A380. The latter remains the largest commercial airliner in production, with a passenger capacity from around 450 up to 700 in a high density configuration. The A330 is still in great demand and is being offered with improved payload and a version is optimized for high density regional routes,

Airbus A330 MRTT tanker/transport of the Royal Australian Air Force refueling an F-18 Hornet.

A Gulf Air Airbus A320. This family of twin jetliners has achieved sales of over 10,200 aircraft and is being produced at a rate of more than 40 each month.

aimed at China and the Asian market.

A military tanker/transport version of the A330 is proving to be a popular choice for many air forces seeking to update their air refueling and military transport fleets. This aircraft is large enough to be able to carry up to 265 troops and their equipment in the cabin while at the same time it carries enough fuel to replenish receiver aircraft from two underwing refueling pods. A **U.S. Air Force**-style refueling boom can also be carried on the rear fuselage center-line, or a third hose and drogue unit.

Business jets

This sector has been well served by European designs over the years but is now one of the most hotly contested sectors in the whole commercial aerospace market, with major competitors including **Gulfstream** and **Cessna** in the U.S., **Bombardier** in Canada, and Embraer in Brazil.

Europe's leading supplier in this market is Dassault Aviation, with its family of twin and tri-jet Falcon aircraft. All feature very high-end specifications, in terms of performance, advanced flight systems, and passenger appeal, and this reflects the company's commitment to heavy investment in R&D and a strong technological heritage inherited from advanced combat jets.

The latest Falcon jet, the 5X, is all-new and will emerge to join the Dassault bizjet family in 2015. It will feature a similar fly-by-wire flight control system to the tri-jet Falcon 7X but will have a larger cabin and "the most advanced flight deck in civil aviation" with numerous head-up and head-down displays, additional integrated enhanced vision sensors, and features to permit safe operation at night and in poor visibility when using runways in restricted locations, such as in mountain valleys.

Dassault has continued to upgrade its family of jets to keep it highly competitive and has worked closely with other aerospace companies in the past on designs for a supersonic business jet, but the lack of a fuel-efficient and quiet engine that can cruise at a supersonic speed over extended ranges has so far defeated all attempts at bringing a viable bizjet-size SST product to market.

European helicopters

The reorganization of EADS saw the strong **Eurocopter** brand morphed into **Airbus Helicopters**. Apart from the name change, this rotary wing business has continued as before, with a world-leading market share in military and civilian markets. It has not developed any heavy lift military products to challenge the **Boeing** CH-47 Chinook, but in all other size categories of helicopter the company has models that offer the latest standards in avionics and flight safety.

The NH-90 is the latest military helicopter and is in large-scale production for European and export customers. It is the most important of the new programs. Slightly larger than the **Sikorsky** S-60/70 Blackhawk and Seahawk, it has a fuselage that can accommodate a sophisticated anti-submarine/anti-surface naval equipment fit, and there is also a utility army version with a large rear cabin ramp.

Other medium helicopters in the Super Puma family are popular worldwide for search and rescue, combat SAR, special missions, and oil and exploration support operations. Smaller helicopters in the family provide paramedic support and police support capabilities as well as general purpose civil and military utility roles.

The main European rotary wing competitor to Airbus Helicopter is **AgustaWestland**, which has a very wide ranging portfolio from the AW101 Merlin and Lynx Wildcat military helicopters to a whole family of new generation small and medium helicopters including the AW139, AW169, and AW189. This latest family has high levels of commonality between the

An Airbus Beluga loading an A330 wing at Broughton, U.K., for delivery to Toulouse, France for final assembly.

The Airbus A380 is still the largest commercial airliner in production. (Richard Gardner)

The new A350 is due to enter service before the end of this year and full production is ramping up in a new factory.

The Dassault Falcon 200S and 7X business jets.

different types and also uses common tools and ground support equipment. A reduction of up to 40% in training time results. This family is aimed initially at oil-rig support, light transport, SAR, and coastal surveillance, but more protected, armed, military transport variants are emerging, offering high speed as well as a low profile for added survivability over the battlefield.

Powered up

Europe's aero engine manufacturers include **Snecma** in France, **MTU** in Germany, and **Rolls-Royce** in the U.K. All are truly international with programs stretching to partners across the globe. MTU is closely involved in partnerships with both **Pratt & Whitney** and Rolls-Royce on civil and military engines.

Rolls-Royce has around 50% share of the world's big fan market with its Trent series, which covers thrust ranges from over 50,000 lb up to 110,000 lb. Trents power all the largest current widebody jets apart from the Boeing 777-300ER, and the latest Trent XWB is due to enter service later this year on the A350.

Development work is under way on enhanced Trent derivatives that might have application on a revised A330 and possibly the A380. Snecma, through its **CFM** partnership with **GE** has well over half the engine market on the A320 family and is sole powerplant on the Boeing 737 classic. The CFM Leap engine is destined for the 737 MAX and A320neo.

Although it has lost out powering the latest 737s and A320s, Rolls-Royce is determined to rejoin this market at some time in the future, possibly via a new Boeing airliner sized between the 737 MAX and the 787.

In the meantime, CFM is moving forward with development of a prototype new-generation open-rotor engine so that if successful a suitable powerplant can be matured in advance of the follow-on 150 seat civil programs that will eventually replace the 737 MAX and A320neo in the late 2020s.

Richard Gardner

COMPANIES MENTIONED

AD INDEX

Q&A

Rachel Nguyen, Director, Global Upstream Planning, Nissan Motor Co.

Bringing Nissan's future into focus

The daughter of a pair of psychologists, Rachel Nguyen, Director, Global Upstream Planning, **Nissan** Motor Co., took her natural inclination for psychology and combined it with her own interests in consumer research and cross-functional teaming to pursue a doctorate in organizational psychology. Now in her 13th year with Nissan's advanced planning department, Nguyen is responsible for looking at the longer-term trends affecting the automotive market and how the automaker thus responds in its future products. SAE Magazines Assistant Editor Matthew Monaghan recently sat down with Nguyen at Nissan's full-line media event in Newport Beach, CA, to discuss her role and the changes happening within the industry.

What is the relationship like between product and advanced planning?

In advanced planning, we do the upstream consumer work and the concept. Product planning is involved because they are the ones that take it all the way through the launch. Product planning works on the actual putting the flesh on the bones, working with engineering and design to make it real and ensure its competitiveness. We work with them to set the direction for this vehicle—what is this next generation or this new vehicle going to be all about. For exploratory work, it's much different. It's more looking at what are the things happening outside of our industry, what are the major shifts that could lead to full-scale changes in what we provide.

What is the primary time frame for your department's thinking?

Today, it's hard to put a time frame on it. When you think about where we're going, we think at least 10 years out, but something could come out with what we learned that could be implemented quickly. So now the balance is having your head in the future but knowing what's happening today. Most of my career in advanced planning I could just rest on knowing the future because the other products were coming. But now it is more about knowing the trends today and modifying something immediately or introducing something faster.

How have you seen buyers' mind-sets change in the past 5-10 years?

About seven years ago, I did some U.S. research talking to [buyers] about lane-departure warning systems and braking assist and the reaction was, 'No way, I need to control that vehicle; I don't want anything taking over from me.' They were pretty adamant about that. Then they get their cell phones and they're in their cars doing things they shouldn't and they want to multitask. The whole use of the vehicle has definitely changed. We've seen more and more appeal of the autonomous vehicle. I've seen some data that shows Europe is less willing to give up on the control of the vehicle, but I think Americans are more open to it than I remember hearing even five years ago.

What are your expectations for vehicle size moving forward?

In my tenure, we went through bigger is better. Every year the starting block was how do we get more size out of this platform for the D-segment sedan. Then energy and oil prices and the economy rightsized us in size, but we're nowhere near where the rest of the world is. It's that just-in-case mind-set that's truly American. People ask if downsizing has ended and I don't know. I think the bigger change is away from personal vehicle ownership. When you start to think about shared use and mobility systems then you see probably different sized vehicles for that. Because the just-in-case isn't there anymore. When it's a personal vehicle I'm not sure people are going to give up driving a mid-size anything. The big global change is this movement toward urbanization. Therefore, we're seeing things move away from auto-centric societies to mobility-centric societies.

How do you forecast something reliant on infrastructure, which Nissan doesn't have as much control over?

The important part is to be a manufacturer that's engaged in that and sitting at the table at the talks about infrastructure. The more that we can be a part of it, the better insight you have to forecast how fast that can happen. That's our goal, developing the relationships outside of just what we make. Some of that is a guess, though, so wait and see or prepare for multiple scenarios.

In preparing forecasts, what people do you rely on to help shape your vision?

We don't have a huge room of data analysts somewhere like some industries do. A lot of it is relying on expertise where you can find it. Sometimes it's going outside. Sometimes it's just talking to the experts that can focus time on that. The role of advanced planning is making sense of things. Nobody outside the company is putting it all together for us and knowing what we're thinking about inside. That's our role to be sort of a group that collaborates internally and externally, wading the boundaries to put it together and make sense.

Matthew Monaghan

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