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A quarterly publication of SAE INTERNATIONAL and SAE INDIA

Indian Air Force acquisition

Dassault Aviation Rafale fighters

Getting greener

HCCI vs. conventional engine technologies

Student competitions

- Baja SAEINDIA highlights
- Rise of the underdogs

Volume 2, Issue 2

June 2015


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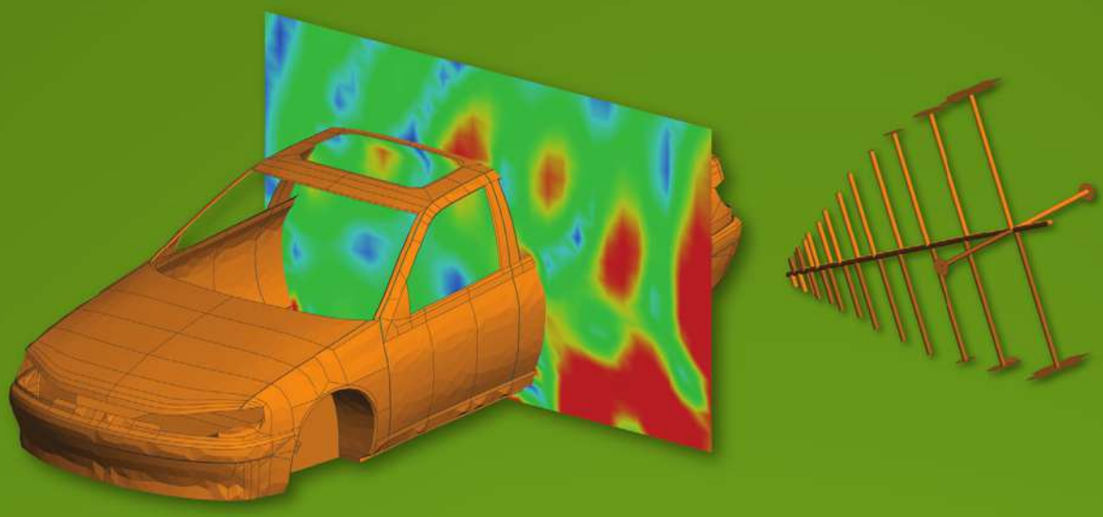

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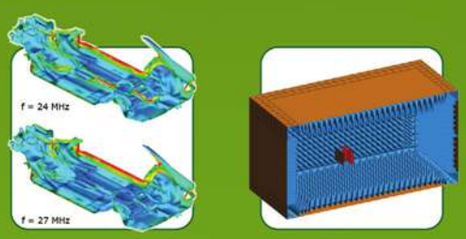

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EDITORIAL

High-voltage developments

The concept of higher-voltage vehicle electrical networks between those for 12-V conventional and 200- and 600-V full hybrids and electric vehicles is not new, with development experiencing fits and starts over the past few decades. However, tightening efficiency and emissions regulations and increasing demand for onboard electrical power means that higher voltages, in the form of supplemental 48-V subsystems, are nearing production.

One sign of this was on display at the 2014 Los Angeles Auto Show. The **Audi** Prologue show car, which provided a glimpse of the company's design future, also more quietly previewed a new 48-V electrical system coming to future Audis.

The company attributed some of the large show car's relatively low fuel consumption and CO_2 emissions to the new 48-V system. Powered by a belt starter generator, the set up enables mild powertrain hybridization with brake-energy recovery. The displacement of high-wattage loads to more efficient 48-V networks is expected to be the next step in the development of a new generation of mild hybrid vehicles.

In addition to improved fuel economy and reduced emissions, 48-V systems could potentially save costs on new electrical features and help better address the emerging needs of future drivers. A new report from **Autelligence** on 48-V automotive electrification analyzes the technology and provides an outlook on future introductions. The report notes that the new technology is "extremely economical because it can be easily integrated into an existing vehicle architecture and the small 48-V battery means battery costs are reasonable," said Christopher Breitsameter, Head of Business Development and Strategy, **Continental** Powertrain Division.

Challenges to 48-V system implementation remain. At the 2nd International Conference on Advanced Automotive 48V Power Supply Systems organized by **IQPC Automotive** in Düsseldorf last November, experts from car makers and suppliers discussed the need for an international 48-V standard. Initial steps have already been taken with a LV148 standard proposed by Audi, **BMW**, **Daimler**, **Porsche**, and **Volkswagen**.

It makes sense to have a common global standard, according to Paul Bloore, Product Validation Manager for **Controlled Power Technologies**, because 48-V hybrids are currently the most cost-effective way of meeting stringent CO_2 emissions in the buildup to 2020 European regulations. This is compounded potentially by a shift from the current NEDC to the more aggressive WLTP test.

Electric engine boosting could benefit from 48-V networks. **Hyundai** and **Kia** are developing a mild-hybrid diesel powertrain using an electric supercharger in conjunction with a 48-V network. According to Bloore, electric boosting using energy recuperated, rather than lost in friction from the brakes, not only reduces emissions, but also can have a positive impact on vehicle performance and drivability.

The rapidly growing interest in 48-V networks was also discussed at the **SAE International** 2015 Hybrid & Electric Vehicles Technologies Symposium held in Los Angeles in February. Dr. Mazen Hammoud, **Ford**'s Chief Engineer for Electrified Powertrain Systems and SAE Fellow, said that the 48-V working voltage is the best compromise for mild hybridization. (See http://articles.sae.org/13908.)

Although the higher voltage provides no real electric-only drive capability, there is better capacity for capturing braking regen energy, and it's a good stop-start enabler, Hammoud said. A mild hybrid can provide more than 3% increased engine-off time versus a 12-V stop-start vehicle in real-world driving conditions. In addition, according to ECE-R 100 regs for direct current under 60 V, shock protection is not required for 48 V, helping to lower cost.

The consensus of global forecasts suggests that 48-V mild hybrids will soon come to dominate the market. Compared with 200-600 V full hybrid and battery electric vehicles, the lower-voltage approach avoids the need for high-cost safety features and large battery packs. CPT estimates that if 48-V and related emissions-reduction strategies could be universally applied to the more than 100 million vehicles forecast to be produced per year from 2020—98% of them with gasoline and diesel engines—annual CO_2 emissions could be reduced by 100 million t globally per year.

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Building the SAEINDIA brand

In retrospect, the 2014-15 season for SAEINDIA has been truly one of consolidation in putting systems in place, evolving policies for the future, resolving long outstanding issues in administration. We created Operating Boards to plan and decide their activities and empowered them to budget their plans and implement them.

Dr. Aravind Bharadwaj
President, SAEINDIA

As a new initiative, we started Knowledge Round Tables in Mahindra Research Valley and **UCAL Fuels** and provided a forum for the members within the organization to exchange ideas and information on cross functional disciplines and invite experts to address them on topics of current relevance and importance. Plans are also underway to start a similar forum at **WABCO** and for other major industries where we have sizable members.

AWIM National Olympics was organized in the month of January in Chakan, Maharashtra, and the fun, excitement, and joy of children who participated in the competition and won prizes should be seen to be believed.

We have made important decisions to acquire premises for SAEINDIA Western and Bangalore Sections, which will help our offices to function with lot more autonomy and professionalism and accelerate our programs and activities. This has been amply proved by SAEINDIA Southern Section, which is functioning from its own premises and conducting many programs and workshops strengthening its operations and finances.

We are also making all preparations to organize ITEC INDIA 2015, a unique event partnering with IEEE IAS (Industry Applications Society), and we expect the event to galvanize the electric mobility industry to double up its pace in the coming years.

We have lined up professional development programs including the International Lecture Series and are also planning webinar programs through a newly created web platform.

The Aerospace Board and Off Highway Board are planning major programs during the proposed visit of Mr. Richard Greaves, President, **SAE International** to India in July 2015. The Aerospace Board is planning a seminar on the Make in India concept announced by Mr. Narendra Modi, Prime Minister of the country.

The symposium organized by SAEINDIA's Northern Section on fuels, lubricants, and after-treatment devices in April 2015 in Delhi received robust support from the Industry and the registration of delegates. This symposium will address issues critical to the industry as government is making the manufacturers compliant to Euro IV emissions, bringing India in tune with the global norms.

We are chalking out a plan to build the brand SAEINDIA as a professional society committed to the cause of development of the mobility community by creating knowledge-sharing platforms and conferences that address issues of critical importance for the future to make SAEINDIA move forward as a society with deep and abiding concern for the industry as a technology leader.

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SAEINDIA News

AWIM National Olympics held in Chakan

A World In Motion (AWIM), abiding by its unique name, rightly amalgamates fun, challenge, teamwork, and leadership. The 7th AWIM National Olympics was held from the 10th to 12th of January 2015 at **Mahindra Vehicle Manufacturers** Ltd. in Chakan.

This was a great opportunity for little champions' dreams to come true by taking their machines to an automobile manufacturing proving grounds. A total of 152 students, 76 teachers, and many industry volunteers from 17 cities across the nation attended this event.

On the 10th of January, the teams were registered for the event, and all teams were briefed on the rules and marking format.

On the 11th of January, the main event began, for which student design teams from class 5th and 6th grade participated by making "skimmer" and "jet-toy" vehicles for the track, and they also designed dream cars that they perceived as future cars of the science age. About eight teams for skimmer and 30 teams for jet-toy participated in the grand finale.

Mr. Vijay Dhongde, CEO, **MVML**, welcomed Dr. Pawan Goenka, Executive Director, **Mahindra & Mahindra**, and briefed how his vision helped to increase the AWIM initiative from two cities to 17 cities across India.

Dr. Pawan Goenka's presence raised the energy among the children (they were pumped with enthusiasm); his vision of benefiting children getting a boost. He visited the skimmer and jet-toy tracks and also witnessed presentations made by the little champs. Later he shared his thoughts, interacted, and guided children to be better engineers in the future, and expressed that these children are the future of our country.

He also appreciated the efforts of the volunteers across the country who invested their time in teaching children beyond their textbook knowledge. He visualized how seeds of "Make in India" have been well sown at schools with activities such as AWIM. He relived his school days while spending time with these children. He also reiterated the fact

AWIM National Olympics inauguration.

Students' presentation.

Dr. Powen Goenka's interactions during the AWIM Olympics.

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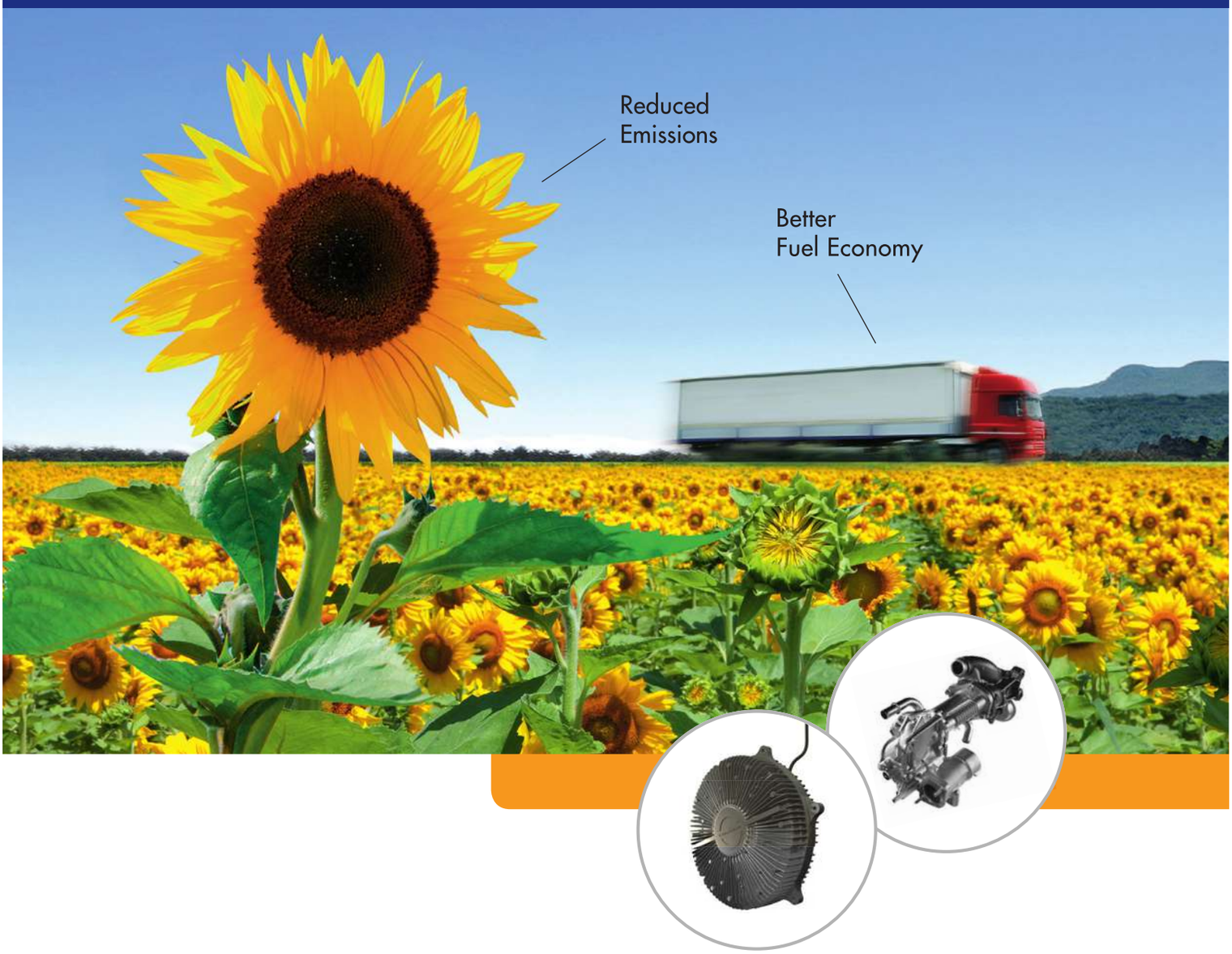

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that the automobile industry has helped Indian society to grow and develop day by day.

On 12th of January, teams visited the Chakan plant with a lot of enthusiasm; the bright minds excited to see the plant. They were on a tour to Maxximo BIW, Maxximo TCF, and Gyanodaya where they were explained vehicle manufacturing details.

AWIM National Olympics winners.

KLU hosts National Student Convention

Student presentations.

The host school, Kalasalingam University, put on a bike show.

The 9th SAEINDIA National Student Convention was held at **Kalasalingam University** (KLU) in Krishnankoil, Virudhunagar Dist., on the 30th and 31st of January 2015. Every year, the SAEINDIA collegiate chapters get an opportunity to discuss, display, and celebrate their success of the past year. This is also the occasion when the winners from the six zones meet and battle it out to find the best in the competitions held. This year's event saw active participation of over 1000 students from 86 colleges.

The inaugural function began with the welcome address by Dr. S. Saravana Sankar Vice-Chancellor, Kalasalingam University. The student convention brief was given by Dr. D. Muruganandam, Student Convention-Champion; the inaugural address given by Mr. N. Balasubramanian, Chairman, **SAEISS**, and the Presidential address was given by Thiru. K. Sridharan, Chancellor, Kalasalingam University. The chief guest for this prestigious event was Mr. Oba Noboru, Vice President, **RNTBCI**, and the vote of thanks was given by Dr. M. Uthayakumar, Organising Head, KLU.

On day 1, the winners of Tier 2 regional events competed at the national level, the battle among the six divisions of SAEINDIA SS (Southern Section). The events were: Business Plan Contest, Aero Design and Fabrication Contest, Auto Quiz, Technical Paper Contest, Modeling and Animation Contest, Computer Aided Manufacturing Contest, and Analysis Contest & CAE. Along with the existing events, SAEINDIA SS made history by successfully conducting 12 new events. These events were focused on the nation's goal of "Make in India."

Technology Theatre: SAEINDIA SS conducted the 4th Technology Theatre for student members. The topics included "Challenges in Integrating High Voltage on Automobile" by Mr. R. Ramachandran from **Mahindra & Mahindra**, Chennai; "Digital Manufacturing for Automotive Industry" by Mr. Aiyappan Ramamoorthy from **Siemens**, Chennai; "Automotive crash" by Mr. Aditya Malladi from Mahindra & Mahindra, Chennai; and "New Product Development of Passenger Car" by Mr. Shanmugavel from **Renault Nissan** Technical Business Centre India, Chennai.

Collegiate Club Presentation & Display: The club presentation showcased the achievements, strengths, and

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SAEINDIA News

The convention was brought to a close in the prize distribution and valedictory function.

unique activities of various SAE collegiate chapters. The club display competition and technology theatre ran in parallel at different venues. Various working mechanical models, presentations, and charts were put on display. The SAEI SS Students Executive Council met and discussed the various aspects of running a collegiate club, ways to improve the SAE activities, and also the new SEC members for the year 2015-2016 were announced.

KLU Bike Show: The host college also conducted a bike show where they displayed high power bikes of above 1000 cm^3, which really attracted the student members.

Valediction & Prize Distribution Ceremony: The convention was brought to a close in the valedictory function later in the evening. The welcome address given by Dr. V. Vasudevan, Registrar, Kalasalingam University; the Presidential address was given by Dr. S. Saravana Sankar Vice-Chancellor, Kalasalingam University; and the review of convention by Dr. R Kannan, EEC, Champion.

The Chairman of the SAEINDIA SS, Mr. N. Balasubramanian, addressed the gathering by giving a glimpse of future mega events by the section like Baja South and an additional 10 events at the next student convention. The chief guest for the valedictory function was Dr. Aravind S. Bharadwaj, Sr. Vice President, M&M, and President, SAEINDIA. This was followed by the distribution of prizes and mementos and the vote of thanks by Mr. S. Shanmugam, Secretary, SAEI SS.

New 3D printing event

A new advanced technology called additive manufacturing/3D printing (AM/3DP) is transforming engineering. 3D printing is an innovative manufacturing technology that can transform digital designs into tangible parts in one step without using conventional tools.

The International Conference on Additive Manufacturing, 3D Printing, and 3D Scanning (ICAM-3D) was conducted at **Vel Tech University** and The Hilton, Chennai, India, on February 5th to 8th, 2015, along with ICAM-3D Car Design Challenge for young engineers. Forty teams were registered from all over the country for this event, and six of them were selected to present their model at the event. The top three teams were selected on the basis of their design and knowledge.

Inauguration By Dr. P. Chidambaram, Principle Scientific Advisor for the government of India.

Opening ceremony of the ICAM 3D car design challenge.

Dr. Chidambaram, The Principal Scientific Advisor to the government of India, was the chief guest and inaugurated the ICAM-3D Conference. Dr. Tim Morris, **NAFEMS** Global, gave the awards for the winners and short listed teams of ICAM-3D Car Design Challenge.

Truck racing demonstrates new technology, aero design

Season two of the T1 Prima Truck Racing Championship took place this spring at India's F1 track, the Buddh International Circuit (BIC), with Stuart Oliver of Team **Castrol** Vecton winning for the second year in a row in the 16-lap final race, helping Team Castrol Vecton win the team title. Steve Thomas of Team Allied Partners, who qualified fastest on the first day, was the first runner-up, with Steven Powell of Team **Tata Technologies Motorsports** clinching the second runner-up spot.

The Tata Prima 4038.S for the T1 Prima Truck Racing Championship features 370 bhp at 2100 rpm and an increased top speed of 130 km/h over last year's 110 km/h.

Six teams—also including Team **Cummins**, Team Dealer Warriors, and Team Dealers Daredevils—each raced two Tata Prima Model 4038.S trucks built for purpose. Compared to Season 1, the Tata Prima race truck boasts 10% increased top speed—up to 130 km/h (81 mph)—10% increased acceleration, and 10% weight reduction, along with a new aerodynamic design. Key modifications made to the trucks to meet a mix of safety and performance guidelines per the **British Truck Racing Association** included significant changes to the fuel tank, brake cooling system, propeller shaft guards, seats and safety belts, exhaust, and steering wheel. The trucks went through multiple quality checks, with major testing being undertaken at the BIC and Tata Motors Jamshedpur's testing facility, for high speed run and control.

Tata Motors also introduced a new strategic driver selection and training program in conjunction with the race, to induct and mold Indian truck drivers for future T1 races. Cummins, **WABCO**, **JK Tyres**, Castrol, and Tata Technologies were the main sponsors of the truck racing championship. **Setco Automotive** was one of the sponsors for Team Allied Partners. The T1 Prima Truck Racing Championship is organized by **Madras Motor Sports Club** and conducted under the aegis of **FIA** (Federation Internationale de l'Automobile) and the **Federation of Motor Sports Clubs of India**.

Key modifications made to meet safety and performance guidelines included significant changes to the fuel tank, brake cooling system, propeller shaft guards, seats and safety belts, exhaust, and steering wheel.

Indian Air Force to acquire 36 Rafale fighters

The Indian Government recently announced its intention to finalize the acquisition of 36 Rafale fighter aircraft from **Dassault Aviation** at conditions necessary to meet the security needs of India. Dassault Aviation, which has been a supplier to the **Indian Air Force** for more than 60 years, is grateful for the opportunity to pursue and extend their partnership, said Eric Trappier, Chairman and CEO of Dassault Aviation. "Just as we are delivering the first upgraded Mirage 2000, I am delighted by the decision of the Indian Authorities which gives a new impetus to our partnership for the next decades and comes within the scope of the strategic relationship gathering France and India," he said in a statement announcing the deal.

Patrol flight of two Rafales: a single-seater in full "Air-Air" configuration—6 MICA + 3 supersonic drop tanks of 1250 L—and a two-seater in mixed configuration—2x SCALP + MICA + 3 drop tanks of 2000 L. (Dassault Aviation - K. Tokunaga)

Zen Technologies, Rockwell Collins develop next-gen flight simulator for Indian market

Zen Technologies and **Rockwell Collins** recently unveiled a next-generation rotary wing simulator to serve the "burgeoning need" of the military flight simulation market in India. The companies had previously signed a Memorandum of Understanding (MOU) to combine their strengths in simulation and training to offer advanced and high-fidelity aviation solutions. With the rotary wing platform launch, both companies plan to become key partners to the Indian armed forces. The configurable Rotary Wing Simulator is housed in an ergonomically designed cockpit and addresses both the flight and mission aspects of rotary wing aircraft. Realistic training scenarios are provided using geo-specific cultured terrains, operations flight profiles, and avionics that can be used to train both new

and experienced pilots before missions. The training continuum is customizable for all types of military platforms.

The jointly developed simulator was revealed within four months of signing the MOU, noted Colin Mahoney, Senior Vice President, International & Service Solutions for Rockwell Collins. "This is just the first step in our collaboration," he said. "We see tremendous opportunity to provide indigenous, affordable, and highly effective simulation and training solutions to India's defence forces through our alliance with Zen."

"Over the next few years, the Indian defence forces will be strengthening their aircraft portfolio, both fixed and rotary wing. Moreover, there are a number of existing simulators which may need some mid-life upgrades both in terms of technology and aircraft concurrency," said Ashok Atluri, Managing Director, Zen Technologies. "Therefore, we see a very large opportunity for full mission simulators, flight training devices, and part task trainers, amongst others...Our alliance with Rockwell Collins marks the first time that a global simulator [OEM] has teamed with an Indian simulator manufacturing company to cater to the Indian defence market."

Halla Visteon expands HVAC production capability in India

Halla Visteon Climate Control Corp. (HVCC) recently began production at its new facility in Sanand, in the state of Gujarat, India. The full-line supplier of automotive thermal management solutions is using the Gujarat facility to support its growing business with global vehicle manufacturers and to cater to the requirements of OEMs in the state of Gujarat and western India. The facility has approximately 8890 m^2 (95,700 ft^2) of manufacturing space and the capacity to produce 2 million units consisting of heat exchangers, HVAC modules, and air-conditioning lines. HVCC claims it has the ability to double its capacity at this facility based on business needs. The company has a regional office in Chennai and operates four plants in India—Chennai, Pune, Bhiwadi (near Delhi), and Gujarat.

"India is one of the fastest growing economies in the world and is poised to emerge as one of the top passenger vehicle markets in near future, and we want to be prepared for the tremendous growth opportunity this market offers," said YH Park, President and CEO, HVCC. "This new plant in Gujarat expands our manufacturing footprint to encompass all of the major automotive hubs in India and allows HVCC to bring world-class thermal management technology to vehicle manufacturers in India."

Halla Visteon Climate Control's new facility in Gujarat, India, can produce 2 million units consisting of heat exchangers, HVAC modules, and A/C lines—and has the ability to double its capacity based on business needs.

The EC130 T2's cabin is suitable for one pilot and up to seven passengers. More than 70% of the EC130 T2's airframe structure has been modified from the previous EC130 B4 version.

Airbus Helicopters' EC130 T2 enters Indian market with two launch customers

Airbus Helicopters has signed Indian market launch orders for its single-engine EC130 T2 with **Sanjay Ghodawat Group** and **Global Vectra Helicorp** Ltd. (GVHL), which plan to introduce the single-engine EC130's enhanced version later this year for passenger transport services in Kolhapur and Delhi, respectively. The customers ordered one EC130 T2 apiece. The Sanjay Ghodawat Group is a diversified conglomerate with presence in consumer products, energy, mining, chemicals, and agribusiness. GVHL is India's largest private helicopter company, which will assign the EC130 T2 to Birdie—its on-shore operations division offering charters and religious tourism services.

The EC130 T2's cabin is suitable for one pilot and up to seven passengers. More than 70% of the EC130 T2's airframe structure has been modified from the previous EC130 B4 version. New and updated features include the use of a more powerful **Turbomeca** Arriel 2D turboshaft engine and upgraded main gearbox, along with the incorporation of an active vibration control system and improved air-conditioning, distribution, and demisting systems. Performance of the EC130 T2 has been improved for a higher maximum gross takeoff weight (2500 kg for internal loads, and 3050 kg when external loads are carried), and a speed increase of up to 10 kts from the EC130 B4.

MOTORSPORTS POWERTRAIN

Schaeffler developing novel powertrain for 2015/2016 FIA Formula E season

All FIA Formula E cars are using identical specification technologies in the inaugural 2014/2015 season. Cars are built by Spark Racing Technologies. The chassis is from Dallara. McLaren Electronic Systems supplies the electric motor and electronics. Williams Advanced Engineering provides the 28-kW/h Li-ion battery pack. Racecars get unique powertrains for the 2015/2016 season.

All 40 cars in the world's first all-electric racing circuit run a standardized powertrain, but the uniformity ends in the 2015/2016 season when each carbon fiber/aluminum monocoque chassis **FIA Formula E** racecar can be fitted with a unique electric powertrain.

"We are in the process of developing an electric motor and a new transmission in the defined specification that FIA came up with," said Prof. Dr.-Ing. Peter Gutzmer, Deputy CEO and Chief Technology Officer for **Schaeffler** AG.

Gutzmer and Schaeffler's CTO for the Americas, Jeff Hemphill, sat down with *Automotive Engineering* prior to Formula E's March 14 street race in Miami, the first U.S. stop in the 2014/2015 inaugural season of all-electric racing in Europe, Asia, and the Americas.

As Team **ABT Sportsline**'s exclusive technology partner, Schaeffler is developing a novel power unit to replace the **McLaren Applied Technologies** powertrain. "We are now starting to get parts in for the prototype model," said Gutzmer.

Schaeffler technical specialists are leveraging their extensive application development know-how together with the ABT race team and other technology experts to develop jointly a powertrain for Team ABT Sportsline. Said Hemphill, "One of our strengths in the automotive arena is systems engineering, and we'll apply that systems approach to this development task."

A race crew member prepares dry ice for the air intake ports of the Audi Sport ABT all-electric racecars. (Kami Buchholz)

Each Formula E racecar in the 2014/2015 season uses a 57-lb (26-kg) motor to accelerate the single-seat car from 0 to 62 mph (100 km/h) in 3 seconds. The motor mates to a **Hewland Engineering** five-speed paddle shift sequential gearbox.

Audi Sport ABT driver Daniel Abt told *Automotive Engineering* that the electric racecar's instant torque means "whenever you hit the throttle, it just goes. There is no delay. And there's a lot less noise than if you had a screaming V8 engine behind your back."

Virtually no technical details about the under-development powertrain are being publicized. "I hesitate to talk too much. There are seven competitors producing electric motors for next season, so it's getting very interesting," said Gutzmer.

In the paddock area, Schaeffler's Jeff Hemphill looks at an Audi Sport ABT racecar with the electric motor, battery pack, and other electrified powertrain components exposed. All FIA Formula E racecars in the 2014/2015 season have a power output for practice and qualifying of 200 kW. The power output for the race is 150 kW, plus an additional power output of 30 kW by fan voting for three drivers. (Kami Buchholz)

Jacky Eeckelaert said the next race season is all about increasing the powertrain efficiency. "And the whole package will be lighter and at a lower center of gravity," Eeckelaert, race engineer for

Audi Sport ABT drivers Lucas Di Grassi, left, and Daniel Abt. During FIA Formula E races, all drivers make a mandatory pit stop to swap racecars. There are 10 race teams, each with two drivers and four racecars. Each temporary street course race lasts about one hour.

ABT team driver Lucas Di Grassi, told *Automotive Engineering*.

While Schaeffler has supplied bearing components and alternator overrun systems for baja, endurance, and touring series cars powered by internal-combustion engines, developing an electric racecar powertrain is new territory. Said Gutzmer, "This is the first time that Schaeffler will be providing a functional, complete unit."

One desirable for the Schaeffler powertrain is improved cooling efficiency.

Team owner Hans-Jurgen Abt spoke with *Automotive Engineering* while a crew member put dry ice inside the air intake ports for the battery cooling system and the engine cooling system.

"The dry ice can lower the temperature about 25°C. We need to pull the temperature down because then you can increase the power. In the race you have only the cooling from the air, and it doesn't help if you have not the right temperature to start," Abt said prior to the 39-lap, 1.34-mi (2.16-km) Miami race.

Developing an electric powertrain for a racing application will mean challenges and victories.

"You have to work with suppliers on different materials; that's a challenge. You have to have a very fast loop of re-engineering if re-engineering is necessary," Gutzmer said, referencing some of the challenges. "But the knowledge that we gain during this process will be fruitful for future developments."

Kami Buchholz

ENERGY

New yeast strain enhances biofuel production

A team of researchers from the Cockrell School of Engineering at **The University of Texas at Austin** have developed a new, mutant yeast strain that could lead to a more efficient and economical biofuel production process, and from non-food sources.

Hal Alper, Associate Professor in the McKetta Department of Chemical Engineering, and his team engineered a special type of yeast cell, Yarrowia lipolytica, to significantly enhance its ability to convert simple sugars into lipids that could then be used in place of petroleum-derived products.

"Our re-engineered strain serves as a stepping stone toward sustainable and renewable production of fuels such as biodiesel," Alper said.

Previously, the team successfully combined genetically engineered yeast cells with ordinary table sugar to produce what Alper described as "a renewable version of sweet crude," the premium form of petroleum. Building upon that approach, "a combination of evolutionary engineering strategies" was used to create the new strain of Yarrowia that produces 1.6 times as many lipids as their previous strain in a shorter time, reaching levels of 40 grams per liter, a concentration that could make yeast cells a viable platform in the creation of biofuels. The strain's high lipid yield makes it one of the most efficient organisms for turning sugar into lipids. In addition, the resulting cells produced these lipids at a rate that was more than 2.5 times as fast as the previous strain.

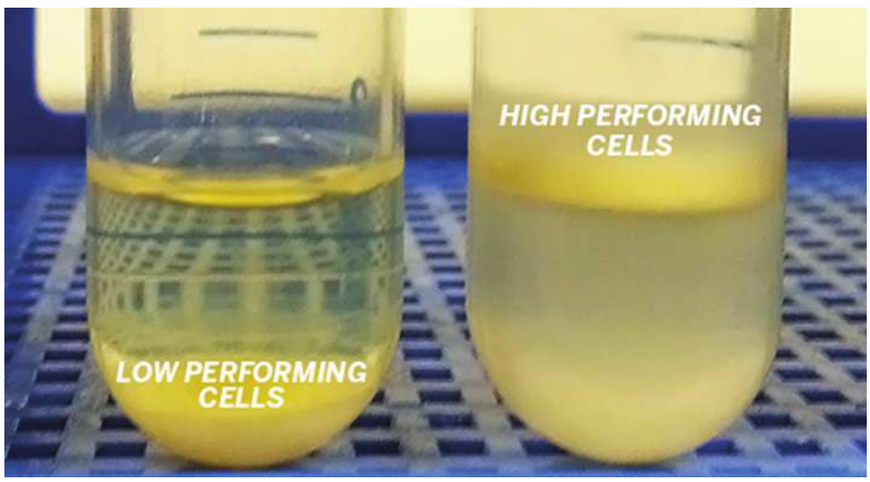
"This significant improvement in our cell-based platform enables these cells to compete in the biofuels industry," Alper said. "We have moved to concentration values that begin to align with those in other industrial fuel processes."

Alper and his team improved the performance of Yarrowia through a combination of metabolic engineering and directed evolution, which involves mutation and selection to identify and cultivate the high-performing cells. The researchers recognized that cells with high lipid content would float to the top of a tube, whereas cells with lower lipid content would settle down to the bottom. The researchers used this "floating cell scheme" to identify the best-performing cells. Researchers used those high-performing cells, which produced more lipids and at a faster rate, to obtain the final yeast.

In addition to using lipids for biofuels, the cell-based platform is able to produce oleochemicals, including nutritional polyunsaturated fatty acids, waxes, lubricants, oils, and industrial solvents.

The researchers' method and platform are patent pending. Alper's lab is continuing to work on ways to improve how the yeast strain converts sugar into lipids, and on the types of lipid products they can produce.

Jean L. Broge



Researchers at The University of Texas at Austin used a combination of metabolic engineering and directed evolution to develop a new, mutant yeast strain that could lead to a more efficient biofuel production process and potentially make biofuels more economically competitive with conventional fuels.

OFF-HIGHWAY POWERTRAIN

Cummins in production with 'simplied' Tier 4 Final engines

Cummins is in production with the Tier 4 Final versions of its four-cylinder QSF2.8, QSF3.8, and QSB4.5 engines will that offer a "simplified technology approach" focused on compact installation packages for space-constrained construction and material handling equipment across the 49- to 173-hp (37- to 129-kW) output range.

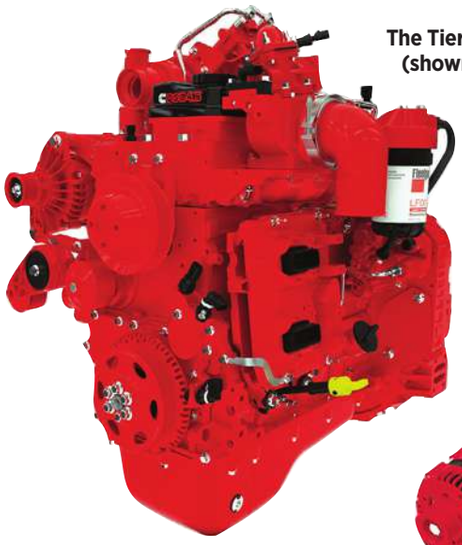
The 2.8-, 3.8-, and 4.5-L engines offer a range of engine displacements and incremental performance across a broad product range. The ability to power-match is also realized with the potential for installation downsizing at two pivotal points—with a new, lower 74-hp (55-kW) rating for the QSF3.8 and a higher 173-hp (129-kW) rating for the QSB4.5.

"With these downsizing opportunities, Cummins is redefining the ability of four-cylinder engines to power compact equipment with simpler technology for applications including skid steers, forklifts, excavators, wheel loaders, telehandlers, air compressors, and more," said Brian Wilson, Cummins General Manager—Global Compact Business. "We anticipated the need to reduce the impact of Tier 4 Final at specific power points, as that option would allow some types of equipment to move to a much simpler and more cost-effective installation solution without any loss in performance."

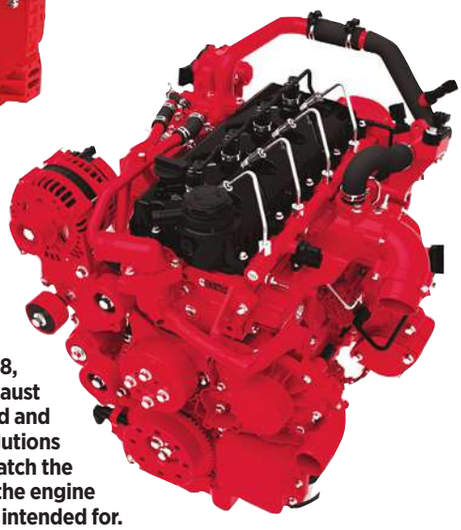
Equipment positioned in the 75- to 90-hp (56- to 67-kW) power band can transition to the new QSF3.8 rating at 74 hp (55 kW) and take advantage of using a simple Cummins diesel oxidation catalyst (DOC) in place of selective catalytic reduction (SCR) aftertreatment or a diesel particulate filter (DPF) system. The 3.8-L displacement ensures that machine capacity and low-end torque performance are retained at the lower 74-hp (55-kW) rating.

Compared to an SCR system, the Cummins DOC reduces the aftertreatment space claim by more than 50% and eliminates the onboard diesel exhaust fluid (DEF) tank and the associated cost of replenishing the fluid.

Increasing the top rating of the QSB4.5 to 173 hp (129 kW) for Tier 4 Final presents the opportunity for equipment using a six-cylinder engine at a similarly rated power to downsize to a much smaller four-cylinder QSB4.5 installation, with the added benefit of fuel consumption savings of up to 10%.



The Tier 4 Final QSF2.8, QSF3.8, and QSB4.5 (shown) are fully integrated with exhaust aftertreatment systems designed and manufactured by Cummins Emission Solutions with "right sizing" efficiency to match the aftertreatment size and technology to the engine output and the equipment types they are intended for.



The Tier 4 Final QSF2.8 (shown), QSF3.8, and QSB4.5 are fully integrated with exhaust aftertreatment systems designed and manufactured by Cummins Emission Solutions with "right sizing" efficiency to match the aftertreatment size and technology to the engine output and the equipment types they are intended for.

The QSB4.5 is performance-upgraded for Tier 4 Final with a compact variable geometry turbocharger specifically developed by Cummins Turbo Technologies for the engine platform to provide higher boost at all engine speeds with impressive levels of torque response.

The QSF2.8, QSF3.8, and QSB4.5 are fully integrated with exhaust aftertreatment systems designed and manufactured by Cummins Emission Solutions with "right sizing" efficiency to match the aftertreatment size and technology to the engine output and the equipment types they are intended for.

For QSF2.8 and QSF3.8 ratings below 75 hp (56 kW), the Cummins DOC provides a "fit and forget" solution, completely transparent to the equipment user as it functions as a filter-free device able to reduce emissions from the exhaust without the need for regeneration or any service cleaning. For applications above 75 hp (56 kW), the Cummins SCR system achieves very high emissions conversion efficiency with filter-free, flow-through operation. The SCR works as an integrated system with the engine combustion so that DEF use is reduced to as low as 3% of fuel consumed. The SCR system is designed to last the life of the engine, helping to enhance the residual value of the equipment.

The SCR system is used in combination with a DOC for higher outputs up to the 173-hp (129-kW) QSB4.5 for premium performance equipment. The Cummins DOC-SCR system allows a greater latitude within the in-cylinder combustion formula to realize faster engine response and improved fuel efficiency.

Emissions control of the exhaust is complemented by a light-flow, cooled EGR system, sized to fit within the QSF and QSB engine envelopes. Due to the high efficiency of the aftertreatment in removing emissions, the EGR system needs to recirculate only a low proportion of the exhaust gases back to the in-cylinder combustion, allowing the engine to not work as hard while allowing equipment users to get the same level of service from a four-cylinder engine as they have from six-cylinder engines.

Jean L. Broge

AEROSPACE PROPULSION

Aerojet Rocketdyne gets a boost from additive manufactured components

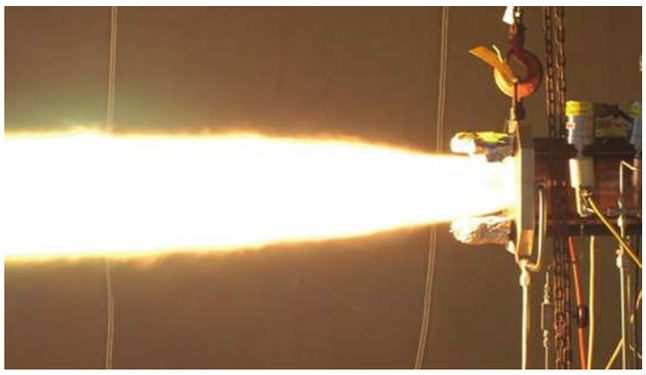
Aerojet Rocketdyne recently completed a series of hot-fire tests of additive manufactured components for its AR1 booster engine at its Sacramento test facility. AR1 is the first advanced hydrocarbon large liquid rocket engine in development by Aerojet Rocketdyne since the merger of **Aerojet** and Pratt & Whitney Rocketdyne in June 2013.

The single-element main injector hot-fire tests were conducted to evaluate various main injector element designs and fabrication methods. Several injectors were fabricated using selective laser melting (SLM), a form of additive manufacturing (AM). AM has become so ubiquitous throughout the industry because it allows for the production of complex engine components at a fraction of the cost of those produced using traditional manufacturing techniques.

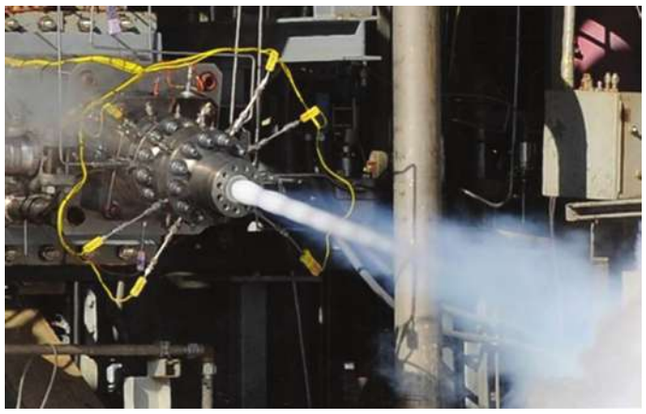
Aerojet Rocketdyne has invested heavily in developing SLM capabilities for application to its rocket engines. Tested in excess of 2000 psi, Aerojet Rocketdyne believes the AR1 single-element hot-fire tests represent the highest pressure hot-fire test of an AM part in a rocket engine application. In the main injector alone, AM offers the potential for a nine-month reduction in part lead times, and a 70% reduction in cost.

The AR1 is a 500,000-lb thrust-class liquid oxygen/kerosene booster engine currently in development as an alternative to the Russian-built RD-180. The 2015 National Defense Authorization Act calls for the RD-180 to be replaced by an American-made alternative for national security space launches by 2019. The AR1 is expected to be a catalyst for U.S. launch providers to compete more effectively in the global commercial launch marketplace.

AR1 development began in 2014 and builds on Aerojet Rocketdyne's staged combustion experience gained through technology development programs as well as its recent AFRL Hydrocarbon Boost Technology Demonstration and the NASA Advanced Booster Engineering Demonstration/Risk Reduction program. All three programs are part of the company's Advanced Hydrocarbon Propulsion Development Office (AHPDO) in Huntsville, AL.



Aerojet Rocketdyne recently completed hot-fire testing of a single-element main injector for the AR1 rocket engine that was completely built using additive manufacturing.



Aerojet Rocketdyne has conducted hot-fire testing of a multi-element preburner injector for the AR1 rocket engine. A similar multi-element injector built using additive manufacturing will be hot-fire tested this spring.

Rapid development and certification of the AR1 for current and future national security launch vehicles is a key focus for AHPDO, particularly in terms of engine cycles, materials, and AM. The AHPDO office will integrate AR1 development and production activities across Aerojet Rocketdyne's various sites. The company's Los Angeles and Sacramento facilities will offer advanced large rocket engine engineering and specialized manufacturing expertise, the West Palm Beach facility will offer additional manufacturing and assembly work, and Aerojet Rocketdyne's Stennis facility will be used for AR1 engine final assembly and could begin to test as early as 2017, with certification targeted for 2019.

The AR1 is designed to integrate with the Atlas V launch vehicle, as well as provide a versatile propulsion solution for multiple current and future launch vehicle applications. "When you consider the minimal changes to the Atlas V launch vehicle, launch pad, and related infrastructure that are required with an AR1 solution, this approach is clearly the best path toward finding a replacement for the RD-180," said Linda Cova, Executive Director of Hydrocarbon Engine Programs at Aerojet Rocketdyne.

Development of AR1 is currently being funded by Aerojet Rocketdyne with assistance from United Launch Alliance (ULA). Aerojet Rocketdyne and ULA also continue to support the Atlas and Delta launch vehicles such as the RS-68A, RL10, and AJ-60A.

Work on the AR1 full-scale design has been progressing steadily with the team achieving significant milestones over the past months, including the completion of a System Requirements Review, full-scale single-element main injector hot-fire testing, subscale preburner testing, and turbopump inducer testing.

Completion of a vehicle-level system concept review and a main propulsion system Preliminary Design Review are planned major milestones for 2015.

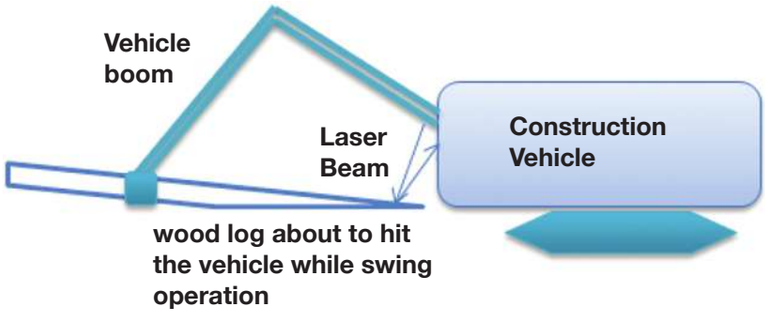
Jean L Broge

OFF-HIGHWAY ELECTRONICS

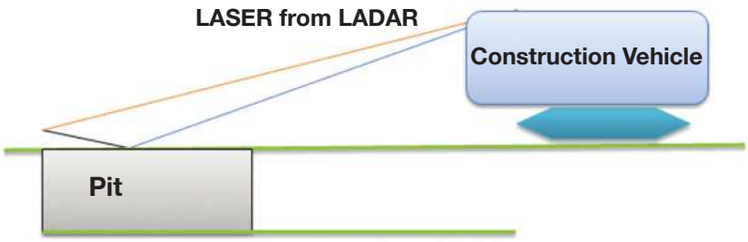
Military technologies aid the fight for improved off-highway efficiencies

There is a never-ending need for technologies that can improve the efficiency of off-highway equipment, while enhancing safety for both operator and the machine. The defense sector of the industry has an upper hand in the investment and invention of such technologies, some of which could, and probably should, find their way into equipment used for agriculture, construction, forestry, and mining. Radar is one such example of technology that was once used just in combat applications, and was very costly, but is now being widely used in vehicles for various applications.

Once closely guarded, many of these technologies are now commercially available. However, as these technologies are made to order and not being mass produced, at present their cost is higher compared to other technologies being used in off-highway equipment. But once they are introduced in vehicles and have higher volumes, the cost will go down.



Shown is a depiction of swing operation with the wood log position being monitored by using LIDAR. Currently, swing operation is done manually. If LIDAR were implemented, automated swing operation could result in higher efficiencies, saving both time and fuel.



LIDAR is also a candidate for pit geometry measurement. A laser beam would continuously scan the surface and measure the geometry of a pit being dug. The captured data would be displayed in the vehicle real time.

SWIR and range-gated imaging

Short-wave infrared (SWIR) works in wavelengths from 0.9 to 1.7 μm, which is not visible to the human eye. Although not visible, light in this wavelength has the same behavior as visible light, so the images taken from a SWIR camera are very similar to those taken from cameras working in the visible wavelength range. However, they are black and white.

In the military, SWIR is used for surveillance, reconnaissance, and night imaging. This technology can find many applications in off-highway equipment.

Off-highway equipment often has to work or drive in low-light conditions. Work lights and drive lights provided on vehicles may not be sufficient during dark and moonless nights. Also, these lights often provide illumination only in close vicinity of vehicle.

There is also a possibility of these lights getting damaged due to various reasons like damage to an electronic control unit, fuse or filament burn out, or smashed bulbs due to flying stones or timber, further reducing the intensity of light available for performing the job or the driving vehicle.

In the absence of these lights, SWIR cameras can provide excellent visibility at night due to their night radiance capabilities.

Since water is opaque to SWIR, such cameras can also sense moisture content. Objects having moisture content appear dark in the image taken by a SWIR camera. The more moisture content, the darker the image. Agricultural vehicles such as harvesters can leverage this technology to determine moisture content in a harvested crop, and thus help estimate the reduction in weight that can happen when grains are completely dried out. This may help in estimating accurately the cost of the harvested crop in advance.

In case of adverse environmental conditions such as rain, fog, smoke, dust, etc., visibility can be reduced to a level where it is not possible to see beyond a few feet. And there would be no way for the operator to know if such conditions were restricted to a few meters or spread over a broader terrain. The operator may keep driving the vehicle in an attempt to cross a low-visibility patch, which may lead into even worse climatic conditions.

Long-range identification may be critical in such cases. Simple SWIR cameras cannot improve visibility in these types of environmental conditions, so adding a range-gated imaging (RGI) feature aids in imaging at long ranges, minimizing the effect of adverse environmental conditions.

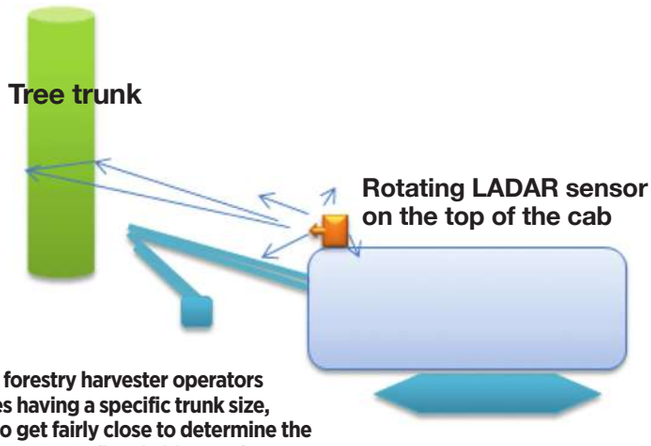
Similar to radars, RGI uses pulsed laser for illumination of objects. Light reflected from these objects is sensed by a camera. Here the exposure time (or "gate") is very short. Delaying of the gate enables the camera to capture only the light reflected from an object. Using this technology, one can see over a much longer range in low visibility conditions.

RGI technology can also provide underwater visibility up to 50 to 100 m. Thus, it can be used effectively in excavators to monitor underwater excavation work.

At present, most off-highway vehicles do not have anything that can see through clouds of dust, smoke, and smog, and best practice in such cases is to halt the work until the operator deems work conditions are safe and suitable, which may not always be correct. Use of RGI to improve visibility in adverse conditions

can help the operator to more accurately sniff out danger before it is too late.

SWIR imaging is gaining popularity and is found useful in many areas, but in spite of its high potential of finding useful applications in the off-highway segment, it is still not being used widely since it is not economically viable. Even more so, RGI cameras are costly at present (around $8000-$15,000) but they offer almost three times better visibility than the naked eye. Due to their high cost, they may only for now be able to find their place in high-end off-highway vehicles, or on jobs where there is a zero tolerance for mistakes and/or adverse conditions may account to casualties.



In the forestry industry, forestry harvester operators must often look for trees having a specific trunk size, with operators having to get fairly close to determine the desired trunk size. 2D/3D LIDARs fitted either on front or on top of the cab can measure the tree trunk size from a distance of 50 to 80 m with resolution as high as 10 mm.

LIDAR

LIDAR (laser illuminated detection and ranging) is like radar, except that it uses a light source instead of radio frequencies. LIDARs are being used for terrain mapping, range-finding applications, imaging, etc., applications.

3D LIDAR can be used to scan surroundings and can provide high-resolution images of approaching objects. For example, forestry log loader machines have to swing the logs to load them on the trailers. While rotating the logs, the operator could inadvertently hit the cab and potentially cause damage to the vehicle and/or operator.

Continuously scanning 3D LIDARs can provide indications of a log approaching the vehicle. When the distance between the edge of the wood log and the vehicle cab goes below a certain distance threshold, the system would sound an alarm alerting the operator about the situation. Fully automated versions of this system could either stop the rotation of the attachment or reduce speed if the log got too close to the vehicle.

Currently, swing operation is done manually. If LIDAR were implemented, automated swing operation could result in higher efficiencies, saving both time and fuel.

3D LIDAR is also a good candidate for construction equipment. For example, in an application that may require measuring pit geometry, a laser beam would continuously scan the surface and measure the geometry of a pit being dug. The captured data would be displayed in the vehicle real time.

Based on measurements before starting work and after finishing work, the final geometry of the pit would be shown on the display. By assessing the geometry of the pit, volume of material moved could be calculated, which could then be used by the contractor to pay the operator of the machine accordingly.

To assess the amount of work done in case of material movement, LIDAR could also be used to measure the size of the mud pile before starting and after finishing the job by construction vehicles. Moving a mud pile or digging a pit could also be automated using a LIDAR sensor.

LIDAR sensors are at present very costly and are not being used widely. They can, however, be found on some of high-end excavators.

Network-centric warfare gets nice

Network centric warfare brings networking techniques into war machines, which will help gather and distribute all the required information to rapidly aid in decision making while working toward one common objective. It includes works in four steps: gathering, distributing, analyzing information in real time, followed by decision making. This in turn helps to improve efficiency and gain operational edge over enemy.

Network-centric systems can help carry out work in a more efficient manner. When more than one off-highway vehicle is working on the same task, or the job to be done is too big and time consuming and is distributed over a fairly large terrain, using network-centric operation mode an entire fleet of vehicles can be deployed to perform the task in parallel, thereby reducing time required to finish the job.

One application when a network-centric operation would be useful is in a canal-digging operation. A fleet of construction vehicles is often deployed to dig a canal. These vehicles would be in constant touch with each other, broadcasting their GPS-based location where the excavation work is going on, amount of job done, direction they are moving toward, their fuel level, etc. This would give a fair idea of how much work is done, how much more time it would take, and could also aid in decision making for new vehicles to join the fleet.

Using a network-centric mechanism, vehicles that have finished their jobs can quickly analyze the work remaining of each other vehicle, and assess what direction to move in order to help other vehicles finish their job faster, and without collision.

Lastly, all the technologies and sensors used on a vehicle for different job profiles may not be needed on the vehicle all at the same time. In this case, modular pods can be brought into off-highway vehicles. Modular pods are used in fighter planes for carrying a variety of payloads or sensor suits. Based on the mission profile, the pilot selects the payloads required on the plane. These modular pods are plug-and-play pods, meant to provide easy fitment, interfacing, and removal of sensor suites on the machine. Depending on the off-highway job profile—i.e. underwater excavation, work in hilly terrains or tight places, open areas, forestry, construction work, etc.—an operator can select the sensor pods required on the vehicle that day.

This article is based on SAE International technical paper 2014-01-2398 by Sanket Pawar, John Deere India Pvt. Ltd.

AUTOMOTIVE ELECTRONICS

Audi details piloted driving technology

Before autonomous vehicles make drivers obsolete, electronic technologies will depend on people to make decisions when something unusual happens. During normal driving conditions, autonomous controls could pilot the vehicle, relying on humans when complex decisions are required.

Audi recently provided technical insight into its piloted vehicle project, in which an Audi A7 concept car drove from San Francisco to Las Vegas earlier this year. The vehicle drove itself most of the journey, though drivers had to remain alert to take over when alerts directed them to resume driving.

The concept car has a range of computers in the trunk. Audi engineers plan to reduce them to a single board over time. The mainstays of the piloted vehicle technologies are an array of cameras, radar, and ultrasonic sensors that are controlled by what's called the zFAS board. It combines sensor inputs to give the car its view of the world.

Audi plans to reduce the hefty electronic system used in its piloted vehicle to a single board.

"All raw signals from the sensors is collected in a sensor fusion box," Matthias Rudolph, Head of Architecture Driver Assistance Systems at Audi AG said during the recent **Nvidia** GPU Technology Conference. "From that input, a virtual environment is created."

Four semiconductors are the basis of the zFAS board. An Nvidia k1 processor collects data from four cameras and "does everything while driving at low speeds," Rudolph said. An **Infineon** Aurix processor handles additional chores. **Mobileye**'s EyeQ3 performs vision processing, while an **Altera** Cyclone FPGA (field programmable gate array) performs sensor fusion.

The software architecture is layered, with the perception sensor programs forming the first layer. Above that, there's a fusion layer that blends data from the sensors with information from maps, road graphs, and other sources. Rudolph noted that combining inputs provides better information and increases confidence in the analysis.

"Radar is not good at determining the width of a car," Rudolph said. "A camera does that well. If we fuse data from each of them we get good information on what's ahead."

Ensuring that the zFAS boards detect potential threats and respond to them correctly without false alerts is critical. If vehicles stop or swerve to avoid something that isn't a true danger, drivers are likely to stop using the system.

"If the car brakes and nothing's there, it will destroy the confidence of the driver," Rudolph said. "We have had no false positives; that's been proven with over 10,000 hours of driving at an average speed of 60 kph (37 mph) in situations including snow and freezing rain."

Audi looks at moving objects to analyze their potential impact given the vehicle's driving path and speed. All stationary items are viewed with a single goal.

"We look at static images as the same," Rudolph said. "It doesn't matter if it's a wall or a parked car, we don't want to hit it."

Pedestrians are a major challenge for all types of autonomous systems. They're harder to spot and categorize than vehicles, and they have more degrees of freedom. The system uses a single monocular camera to search for pedestrians. Given the erratic behavior of some walkers, Audi doesn't stop for pedestrians unless they're truly in harm's way.

"When we detect pedestrians, we compute the time to contact," Rudolph said. "We're close when the vehicle stops. We want to be close, just a few centimeters away. We do not want to stop far away."

Though the piloted system aims to avoid pedestrians and most everything else, Audi realizes that collisions can't always be prevented.

"If we can't avoid an accident, we steer to use the structure of the car to minimize the chance of injury," Rudolph said.

Such an action would occur mainly when the human driver didn't take over in time to avoid a collision. Audi uses an LED alert system to tell drivers when they need to take charge. They can do that by hitting the brakes or making a sharp steering wheel movement. An internal-looking camera watches drivers so the system knows whether the LED alert needs to be augmented with an audible warning.

"In the piloted driving mode, we may need to get the driver back, so we need to know what he's doing," Rudolph said.

Terry Costlow

AVIONICS

Flight vision system for rotary-wing aircraft

Elbit Systems Ltd.'s Helicopter ClearVision is the rotary-wing version of its ClearVision next-generation enhanced flight vision system (EFVS) for commercial aircraft. This system has been demonstrated successfully in flights onboard various types of helicopter platforms and is in advanced stages of certification with **EASA** and **FAA**.

Helicopter ClearVision covers the full flight envelope and is designed to improve the accessibility of helicopters to destinations that suffer from limiting weather conditions and low visibility situations in day and night.

The system's display fuses conformal flight guidance symbology with synthetic vision presentation and high-resolution EVS (enhanced vision system) video on SkyVis or Skylens. It uses multi-spectral sensors to capture and display the terrain and to penetrate atmospheric obscurants such as fog, rain, snow, dust, or smoke. The sensors are combined and fused on the head-up display, with global terrain database, functioning as a combined vision system (CVS).

The CVS provides a high-fidelity view of the outside world even when actual visibility is zero and enables pilots to see in conditions impairing the visibility of unaided approach. This improves the pilots' ability to execute precision and non-precision approaches and safely land, reducing the risks of Clear Flight into Terrain (CFIT) accidents and possibly contribute to the reduction of lower minimas for both takeoff and landings under the FAA and EASA regulations.

The system's HeliEVS camera is packaged in a single line-replaceable unit, which autonomously performs the complete EVS capability. Functionality is accomplished through real-time image fusion between multiple sensors at multiple spectral bands. The spectral bands were selected based on multi-year studies of the properties of light penetration through poor weather conditions, thus providing the best signal to noise ratio for most weather conditions, day and night. The processing is performed in electronics hardware to minimize latency.

Skylens is the display solution for non-helmet users. Packed in a lightweight, easy-to-install device—as intuitive as a pair of sunglasses, according to Elbit—Skylens is operational in all weather conditions, day and night and provides head-up information and minimizes dependency on airport instrumentation. Skylens displays high-resolution information, images, and video on a high transparency visor, providing see-through transmission.

Elbit's Helicopter ClearVision system integrates electronic vision sensors and head-up display technology, enabling continuous and unobstructed flying, improving flight safety and situational awareness, and minimizing the dependency on airport and helipad instruments. The system is expected to contribute to the reduction of landing minima in the future.

SkyVis provides helicopter pilots with a "head out" view, displaying flight, vehicle, and navigation symbology for day and night operation, in limited weather conditions. An add-on to the pilot's own helmet, SkyVis is easily integrated with minimal footprint in the cockpit. The pilot is able to fly eyes-out and rely on the wide field of data displayed in front of his/her eyes. The system assists during maneuvers close to the ground and in limited visibility conditions such as transition from IFR to VFR without the need to look inside the cockpit, thus improving flight safety and situational awareness.

SkyVis has both day and night displays mounted on the TSO-C164 certified NVG, offering a single, seamless solution for round-the-clock operations.

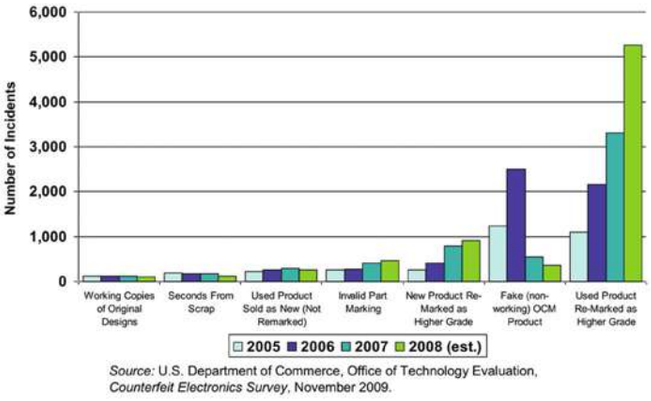
The ClearVision solution is comprised of the HeliEVS camera and the Skylens (shown) wearable HUD or the SkyVis head-mounted display to address both non-helmet and helmet users.

The system is expected to gain airworthiness certification by end of 2016.

Jean L. Broge

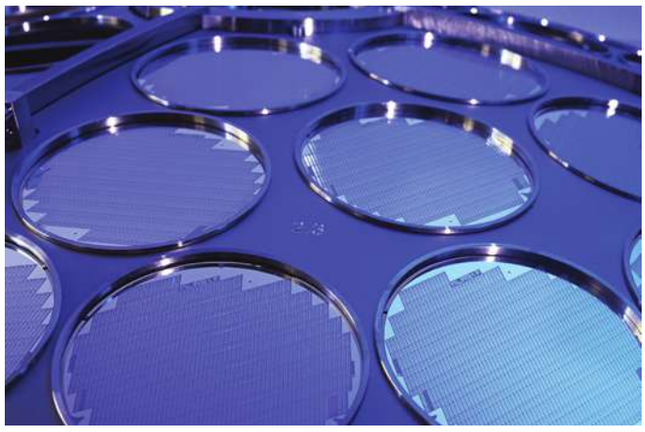
AEROSPACE ELECTRONICS

Counterfeit electronic parts: Manufacture of and avoidance



Source: U.S. Department of Commerce, Office of Technology Evaluation, *Counterfeit Electronics Survey*, November 2009.

Research from the Office of Technology Evaluation shows that counterfeit electronic parts have a variety of origins.



Silicon wafer product prior to being sawed apart.

If a counterfeit electronic part is installed in critical technology such as aircraft, spacecraft, or missiles, the consequences can be quite drastic. The equipment or the product could quit working or not work when needed or fail when put under stress. The cost to replace counterfeit electronic parts can be quite expensive as the **Missile Defense Agency** testified in November 2011 at the Senate Armed Services Committee (SASC) hearing on counterfeit electronic parts in the **Department of Defense** (DoD) supply chain: the cost to replace suspect counterfeit memory devices in the THAAD missiles was $2.7 million.

As a result of the 2011 hearing and related legislation, DoD through the Defense Acquisition Regulations Council was tasked to define what a counterfeit electronic part was along with other DoD contract requirements. DoD defines a counterfeit electronic part as: "An unlawful or unauthorized reproduction, substitution, or alteration that has been knowingly mismarked, misidentified, or otherwise misrepresented to be an authentic, unmodified electronic part from the original manufacturer, or a source with the express written authority of the original manufacturer or current design activity, including an authorized aftermarket manufacturer. Unlawful or unauthorized substitution includes used electronic parts represented as new, or the false identification of grade, serial number, lot number, date code, or performance characteristics."

A slightly different definition was developed by industry and government participants during the drafting of the **SAE International** standard AS5553, Fraudulent/Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition: "A fraudulent part that has been confirmed to be a copy, imitation, or substitute that has been represented, identified, or marked as genuine, and/or altered by a source without legal right with intent to mislead, deceive, or defraud."

A quick glance at how counterfeit electronic parts are manufactured leads one to be concerned about their entry into the global supply chain. Traditional electronic parts are manufactured from highly purified mono-crystalline silicon ingots in clean rooms with workers wearing "bunny suits" and controlled airflow, temperature, and humidity.

Counterfeit electronic parts are not "manufactured" from raw materials but from electronic parts removed from circuit boards found in discarded electronic waste (e-waste) such as recent model computers, smart phones, and laptops. The parts are removed from the circuit boards by using a soldering iron most likely on a sidewalk and subsequently cleaned in a river or rainwater before sorting and re-marking to the buyers' request. Sometimes the counterfeits will have legitimate shipping labels or placed on discarded industry reels.

Early counterfeit electronic parts were easily detected as the re-marking could be removed with an acetone wipe. As the awareness of counterfeits increased, the re-marking advanced to the stage where physical testing may now be required to tell the counterfeit electronic part from an authentic part.

The depth of the aviation, space, and defense industries supply chains as well as the long life of the product most likely contribute to how counterfeit electronic parts can enter the supply chain. The supply chain of the three industries may be 7-10 tiers deep with the lowest tiers unaware of where their product will be used.

At the 2011 SASC hearing, several examples of how counterfeit electronic parts entered the supply chain were detailed. In one case, the subcontractors had purchased transistors from a company that was both an electronics recycling company and an electronics distributor. The transistors had previously been sold as e-scrap but appeared to be in their original packaging.

Aviation, spacecraft, and defense products are long-lived, unlike cell phones and computers that may be replaced every year or when the newest model comes out. The B-52, for example, has an expected service life of 90 years and the F-16, which has been flying since the late 1970s, has no service termination date. Many electronic parts may have a life cycle of three years from introduction to production to low sales. When an electronic part reaches an end of life (EOL), customers will be notified so that they have an opportunity to make one last purchase.

The industries can purchase electronic parts from the original component

manufacturer (OCM), an authorized distributor (AD), or an independent distributor (ID). Each of them have specific advantages and disadvantages. The OCM and AD will typically offer a manufacturer's warranty but may have limited stock, particularly many years after the EOL. The ID may have large stocks but limited warranties.

Solutions to keeping counterfeit electronic parts out of the supply chain can include: legislation, industry standards, reporting of counterfeit electronic parts, authentication marking at the time of manufacturing, testing of every component received at a company, training of employees to avoid purchasing counterfeits, and reducing of e-waste by responsible EOL handling. A 2010 **Department of Commerce** Bureau of Industry and Security publication ended up receiving over 1300 best practices that industry and government could use.

The above listed solutions could be considered "today's solutions" but what future solutions can we envision? The DoD budget will most likely decline putting more pressure on contractors to ensure authentic parts are in their product. The **Defense Advanced Research Projects Agency** is investing in the development of small components (100 micron x 100 micron) that will ensure authentic electronic components. DoD could increase the use of the trusted foundry to manufacture needed electronic parts. The "No Fault Found" aspect of repair and maintenance may need to be more fully examined as counterfeit electronic parts may be causing the problem.

Working to keep counterfeit electronic parts out of the supply chain will need all tiers of the supply chain, from the lowest tier to the end user such as a prime contractor or government agency or department to work together in crafting solutions, responding to reports and encouraging reporting of counterfeit electronic parts, and reducing access to electronic waste.

This article was written for *Aerospace Engineering* by Kristen M. Koepsel, author of the SAE International book titled "Counterfeit Electronic Parts and Their Impact on Supply Chain." She is an Intellectual Property Policy Analyst based out of Washington, DC.

AUTOMOTIVE INTERIORS

Johnson Controls presents interior concept for autonomous driving at 2015 NAIAS

More than 30 innovations ranging from production-ready to exploratory are featured in a luxury-orientated concept interior aimed at autonomous vehicles.

The Innovation Demonstrator (ID15) concept is "based on a D-segment vehicle, which offers a premium interior experience for the next-generation of autonomous vehicles. It enables the driver and passenger to use time efficiently, effectively, and in new ways," Han Hendriks, Vice President of Advanced Product Development and Sales, **Johnson Controls** Automotive Interiors, said during a media briefing at the 2015 NAIAS.

The Johnson Controls' ID15 interior concept features innovations for autonomous vehicle driving.

Leo Schurhaus, Johnson Controls' lead designer for the ID15, said in an *Automotive Engineering* interview that 70% of ID15's innovations are production-ready, 25% are exploratory, and 5% are conceptual.

An electronically controlled seating swivel re-stages the cabin environment during autonomous driving.

Both the driver's and front passenger's upper seatback insert can rotate 18° from the centerline toward the cabin's mid-section. "It creates a nice rotation to the torso so the driver can face the front passenger. At the same time, you can (more easily) rotate your back and neck to be able to communicate comfortably with the people in the backseat," he explained.

A seating rotation solution that moves only the seatback insert underscores the innovation. "The seat does not change position. The seat cushion and the base of the seatback do not change position," said Schurhaus. A rear-seat occupant can press a button to recline the seat and bring the legs up on a leg- and foot-rest as the front passenger seat simultaneously moves forward to create additional leg room.

An autonomous driving mode repositions the steering wheel via moving it as a single piece 5.9 in (150 mm) toward the instrument panel as the driver's seat slides rearward. Driver and front passenger can access a 37° rotating tray-table located underneath the top portion of the center floor console.

The center floor console's lower portion has a forward-located stow space and a two-way sliding cooling bin for beverages. This cooling unit moves forward and rearward without crumpling a stowed bag or other item. "The storage bin in front slides independently, so it's actually moving with it," said Schurhaus.

ID15's sculpted leather surfaces on the upper instrument panel and door inserts were accomplished via a proprietary Johnson Controls production technique. "It's not yet in production, but we're very close to being in production," said Schurhaus.

A team in the U.S. worked on the ID15's concept design along with input from workers in Germany. A team of engineers in China with assist from the U.S. handled the engineering work, according to Schurhaus, who is based in Shanghai. The ID15 model was built in the U.S.

"A lot of the ID15's execution is very close to what you would see in production. We built it just like a production interior so it will show the functionality (of the various innovations)," said Schurhaus.

Kami Buchholz

AUTOMOTIVE INTERIORS

Portable shade proposed for cooler interiors

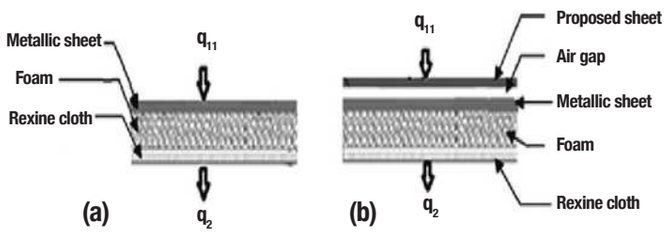


Figure 1. Cross-section of car roof.

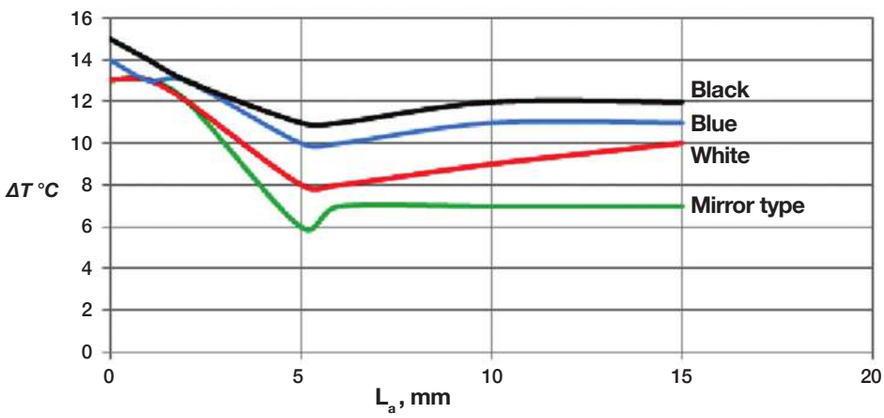


Figure 2. Variation of ΔT with L_a for different colored coatings.

The interiors of cars can get very hot because of solar heating. In tropical countries, especially, a person entering into a car can feel as though he/she is entering into a hot oven. An attachment, named as portable shade, which may be kept above the car, is proposed for preventing the solar heating.

Similar ideas have been proposed. A collapsible elongated sun shield made up of fabric material was developed for the car windshield glass by Zheng in U.S. patent 4815784. A very thin layer of phase change materials has also been proposed for inside a pouch placed in the ceiling of the car. Heat energy is absorbed and released, causing melting and solidification of the phase change materials and maintaining a comfortable interior temperature. Another proposal has suggested that an umbrella could be placed above the car. One drawback is the requirement of a good structural design for withstanding wind loads. Another researcher developed an air bellows that could be placed below the ceiling in a car. Air circulated inside the bellows pumps out interior heat to the atmosphere.

The review of the earlier work revealed that the various types of shades proposed were not only space-consuming but also expensive. Car owners are not willing to have the equivalent of a luggage carrier above the car roof because it could spoil a car's beauty.

So how could a shade be designed to prevent solar heating? A very thin sheet could be placed above the roof that it is not noticeable unless one observes from close vicinity—so the beauty of the car is preserved. Beauty could also be further enhanced by choosing the color of the sheet that matches the color of the car body. The proposed system includes a stick containing a rolling sheet that is drawn out when needed.

The ceiling is mainly formed by a thin sheet of metal of about 2 mm (0.08 in) thick. Below this sheet insulating materials such as foam are pasted. Then a rexine cloth lining is provided for giving a pleasing appearance inside the car. The usual arrangement is shown in Figure 1(a). Heat transfer takes place through the composite wall consisting of these three layers. Figure 1(b) shows the cross section of the car roof with the proposed sheet or portable shade, leaving an air gap of thickness L_a. Most of the solar radiation is reflected back, leaving just a small amount heating the car. The air gap forms one more insulating layer. The proposal that follows explains the concept both analytically and experimentally.

A quantity ΔT defined as a difference between the temperature of the interior, T_i, and ambient temperature, T_a, as $\Delta T = T_i - T_a$, is used for the study. If ΔT is small, it indicates that interior temperature is closer to the ambient temperature and thus shows the effectiveness of the proposed shade.

Experiments were performed during the midday in the month of March at Warangal. The first experiment was without the proposed sheet and a value of 140°C (252°F) is observed for ΔT. Figure 2 shows the results of the other experiments that are performed with various colors of the portable shade and various thicknesses of an air gap. An optimum value of L_a is observed to be 5 mm (0.2 in) for all coatings.

The existence of the optimum air gap is explained physically as follows. When L_a is less than the optimum value, the air gap is so small that it is also like one of the layers of the composite wall, and the heat transfer is purely through the conduction process. When L_a is more than the optimum value, the convective heat transfer process becomes predominant. At the optimum air gap, the conductive and convective heat transfers are balanced and keep the value of ΔT to a minimum.

Next, the effect of coatings was investigated. The ΔT value for a mirror-type coating was the lowest of all. This is because it has the highest reflectivity and hence it is able to reflect back most of the solar radiation. It may be concluded that a mirror-like surface with an air gap of 5 mm is the best. However, it may create a nuisance to the public because they could be dazzled by the highly shining object. The next best choice would be a white color. The designer, however, should strike a compromise to maintain the beauty of the car.

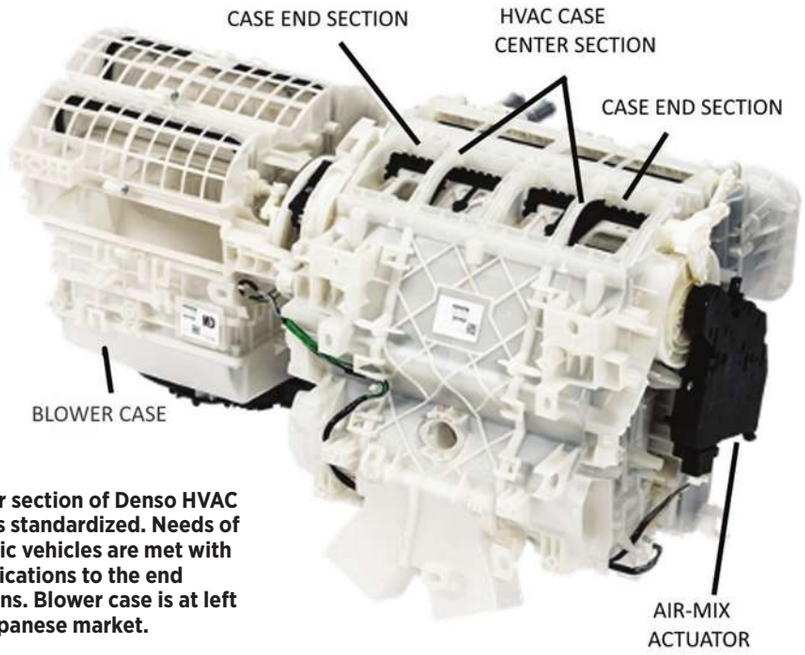
R. Venkatachalam

Ch. Ranjith Kumar

This article was written for *Mobility Engineering* by R. Venkatachalam, Professor of Mechanical Engineering, & Ch. Ranjith Kumar, Research Scholar, both from NIT Warangal.

AUTOMOTIVE INTERIORS

Denso displays more compact HVAC design



Center section of Denso HVAC case is standardized. Needs of specific vehicles are met with modifications to the end sections. Blower case is at left for Japanese market.

The space under the dashboard is precious, and the less that is used for componentry, the more that remains for passenger space in the cabin. But there's one system that presently takes up a lot of space and yet is in the most practical location: the HVAC.

Until the industry moves to another technology, which seems at least a decade or more away, suppliers are focused on downsizing the large cases with heat exchangers, fan, and ductwork that fill so much of the under-dash area. **Denso** featured its newest approach at the North American International Auto Show (NAIAS)—a smaller, lighter climate-control assembly that saves an estimated 20% in its under-dashboard real estate demand.

The design already is in use by **Toyota** on a Japanese market crossover, the Harrier, and two Asian market minivans (Noah and Voxy), but prospective installations in U.S. models are still in the "to be determined" stage.

HVAC case center section standardized

The approach is scalable, explained Jason Hendry, Denso North American Director of HVAC Design Engineering, and is based on the concept of sectioning the design of the HVAC case into three parts. The center section is the largest, optimized for efficiency and performance, basically standardized and for most applications fixed in size. The outer (side) sections are "adjustable"—i.e., sized and shaped for extra performance and airflow if necessary to meet requirements of a target vehicle—and configured to connect the case to a car manufacturer's specific cabin ducting.

The center section, therefore, is usable without significant change in a large range of car sizes. However, it also provides enormous flexibility, as it can accommodate a cold-storage evaporator that Denso has available for cars with engine stop-start. The heater core can be replaced with parts that would enable heat pump operation, which could be required for electric vehicles and some plug-in hybrid designs.

For space saving, one might have expected something on the order of a blower motor integrated with the evaporator case, as was done on the **Scion** IQ, a very small car (10.0 ft/3048 mm). But that aspect of a compact HVAC system did not carry over to larger vehicles, Hendry said. It proved to be an exception for that particular car, as integrating the blower motor into the HVAC case enabled Toyota to clear under-dashboard space on the passenger's side of the IQ. Result: Toyota could curve the dashboard forward, creating extra fore-aft space in front of the passenger. As a result, the passenger seat could be moved forward, which then resulted in a normal size space behind it, producing a seating area for a third adult in the second row.

The separate blower case works better with the conventional cabin layout, where there is a comparable passenger seating comfort requirement on each side. Hendry told *Automotive Engineering* that this new design reduces the HVAC fore-aft space requirement virtually across the full front by 40 mm (1.6 in). That is equivalent to lengthening the cabin by that dimension to increase passenger comfort.

Sliding door for air-mix

The HVAC case air-mix (temperature control) door is a slider type, and incorporates new forming technology, to make it an ultra-thin design. The standardized mounting requires only a single actuator to operate, vs. the previous design that used several actuators to cover all the typical applications. The new slider design also eliminates the need for specific sliding door sealing. The mode doors are conventional flaps. The evaporator is a nearly vertical installation in the case, which helps promote good drainage of A/C condensate.

The blower fan has redesigned wing-type blades, reshaped for higher efficiency. Denso claims they are about 15% smaller and consume 20% less power than a conventional design.

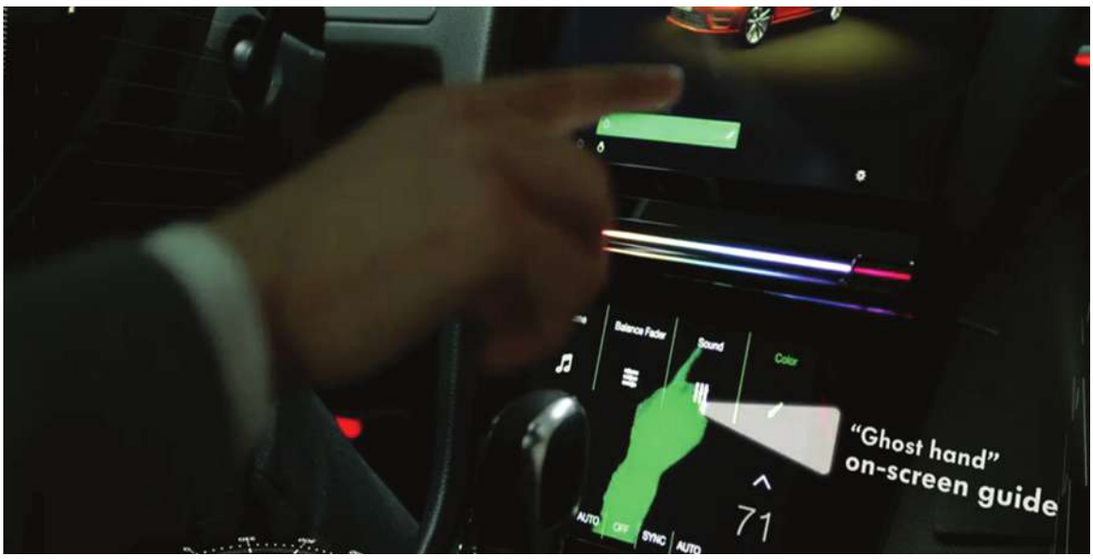
Although the HVAC shown at NAIAS has a blower case with a single fan, Denso also has developed a case with two blower fans stacked vertically. This enhances horizontal splitting of the outside and recirculating interior airflows.

For improved A/C efficiency (and eligible for an **EPA** Corporate Average Fuel Economy credit), most new systems minimize use of outside air in an A/C mode, as increased use of recirculation reduces A/C power consumption. The dual fan permits greater precision with this airflow management approach, as the upper fan can be biased to outside air, the lower fan toward recirculation, with an available mix adjustable for either or both.

Paul Weissler

AUTOMOTIVE ELECTRONICS

Automakers see possibilities, limits for gesture controls



Volkswagen demonstrated that contactless multi-finger gestures can control infotainment in the Golf R Touch at the 2015 Consumer Electronics Show in Las Vegas.

Volkswagen made its first-ever appearance at the Consumer Electronics Show in Las Vegas, in January 2015. In a display of Vegas-style razzle-dazzle, the German automaker unveiled the Golf R Touch concept vehicle, demonstrating how contactless intricate gestures can control infotainment and cabin features.

VW used the term "switchless" to refer to the concept car. The vehicle confirmed the technical feasibility of drivers, for example, controlling music volume by pointing one finger toward a touchscreen—several inches away from the glass—and sliding it left or right. Then, with similar movements of two fingers, the voice navigation got louder, and with three fingers phone volume was adjusted. Swipe your entire hand to the right to advance to the next song, or back to the left for the previous tune. Similar gestures allow contactless operation of the sunroof, lighting, and mirrors—turning the air space in front of the center console into a field for gesticulation.

So, is VW ready to ditch buttons and knobs and introduce **Nintendo** Wii-like means for vehicle operations? Not quite.

"We implemented the Golf R Touch to get our heads around gestures," said Dr. Andreas Titze, Head of Volkswagen's Electrical Development for the Interactive Electronics Department, based in Wolfsburg, Germany. "We pushed the concept of a switchless gesture-controlled car to the limit in order to learn what we can do, what we should do, and what our customers want us to do."

Make no mistakes. Volkswagen and other manufacturers experimenting with gesture-based Human-Machine Interface (HMI) are fully vetting these concepts with customers, making sure that familiar controls are preserved before new systems are introduced. "We are not playing with customers or the cars," said Titze. "We are about rock-solid high customer value."

At the same time, the entire industry is doing its best to respond to the evolving ways consumers use phones, tablets, and other electronic devices. "Our customers are changing, and we are adjusting to that," he said.

Benjamin Oberkersch, a spokesman for research, development, and environmental communications at **Daimler** said that **Mercedes-Benz** concept cars, as early as 2010, introduced controls via touchpads, cameras, voice, and eye tracking—but for evaluation, not immediate implementations. "We always show our latest innovations, but long before these technologies are used in series production cars," he wrote in an email.

Market demand, and confusion

"It's not like you have crowds of people with pitch forks storming the capital," said Mark Boyadjis, Senior Analyst of HMI and Infotainment at **IHS Automotive**, a market research firm. "People aren't demanding gesture recognition, but they are demanding an intuitive user interface."

The problem, according to both Titze and Boyadjis, is that offering full-blown gesture control could add rather than reduce user confusion. Boyadjis cited lack of industry standards as a stumbling block. "A left swipe in a **Toyota** could mean something totally different than a left swipe in a **Hyundai**," he said. Even if standards are quickly developed, users will still face a learning curve—not something you want to encounter while speeding down the highway.

Proximity sensors are close

Gesture controls could be viewed as an extension of touchscreens. Touchscreens have evolved from resistive (required a legitimate push on the screen); to capacitive (only needing the finger to be at the screen); to "touch with no touch," in which fingers can be close but not actually in contact.

The use of proximity sensors started in 2012 with the **Cadillac** Cue system—followed by Volkswagen in 2014 with proximity sensors in standard radio units of the seventh-generation Golf.

Proximity sensors aren't only about easier press-targets. They also allow interfaces to change as your hand approaches. For example, if you are using a navigation

The use of proximity sensors started in 2012 with the Cadillac Cue system, with screen choices changing as a hand approaches. That was a precursor to gesture-based controls coming soon.

BMW unveiled its new iDrive Controller system with touchscreen control and non-contact gesture recognition at the Consumer Electronics Show 2015 in Las Vegas.

system, all the screen real estate could be used for the map to maximize legibility. However, when your hand approaches, additional menus or inputs are offered. Similarly, eye tracking could be used to anticipate a desired function simply by looking in a certain direction.

Infrared sensors are sufficient for proximity or crude whole-hand gesture recognition of up, down, left, and right. However, more robust gestures that recognize individual fingers will require either a high-resolution stereo camera or a combination of sensors.

Delphi announced at 2015 CES that its technology—which uses an overhead 3D infrared (mono) camera—will be put into production this year for finger recognition in select **BMW** models for the European market. "It's the same basic technology as [**Microsoft** Xbox] Kinect," said Doug Welk, Delphi's Chief Engineer of Advanced Entertainment and Communications.

"This is the first gesture module to go to market. It's a start," said Welk. "We see a lot of interest in the ability to control the vehicle through non-tactile things, particularly in Europe where displays are very forward, and not convenient to reach out and touch."

IHS's forecast for relatively simple proximity sensors is a rise from 43,000 units in 2012 to a whopping 18 million by 2021. Boyadjis expects whole-hand gesture systems to grow to 4.3 million by 2021—and the full battery of gesture controls to reach about 2 million units by 2021, according to IHS.

Where to draw the line

Nobody expects that gestures will be used to control steering, acceleration, and braking—and already there are signs of backpedaling.

Boyadjis said that **Ford** discovered that customers were confused by overlapping speech, steering wheel, and touchscreen options, so it decided against complex haptics, proximity, and other controllers in its new Sync 3 platform. "Ford appears to be backing away from multimodal, and solidifying touchscreen as the primary input mechanism, with voice as a close second," said Boyadjis.

Bradley Berman

AUTOMOTIVE BODY

The quest for the self-cleaning car

As the winter-that-wouldn't-leave finally does so and many car owners at last dig out their buried cars, the next big issue is getting a car wash. But wouldn't it be great if cars just shed road dirt, grime, and salt automatically?

Such a possibility could be approaching reality as chemists at **University College London** (UCL) and other universities have unveiled a new tough, self-cleaning paint system that maintains its dirt-shedding properties in everyday wear and tear. In tests, the resilient coating worked even after being wiped, scratched with a knife, and scuffed with sandpaper forty times.

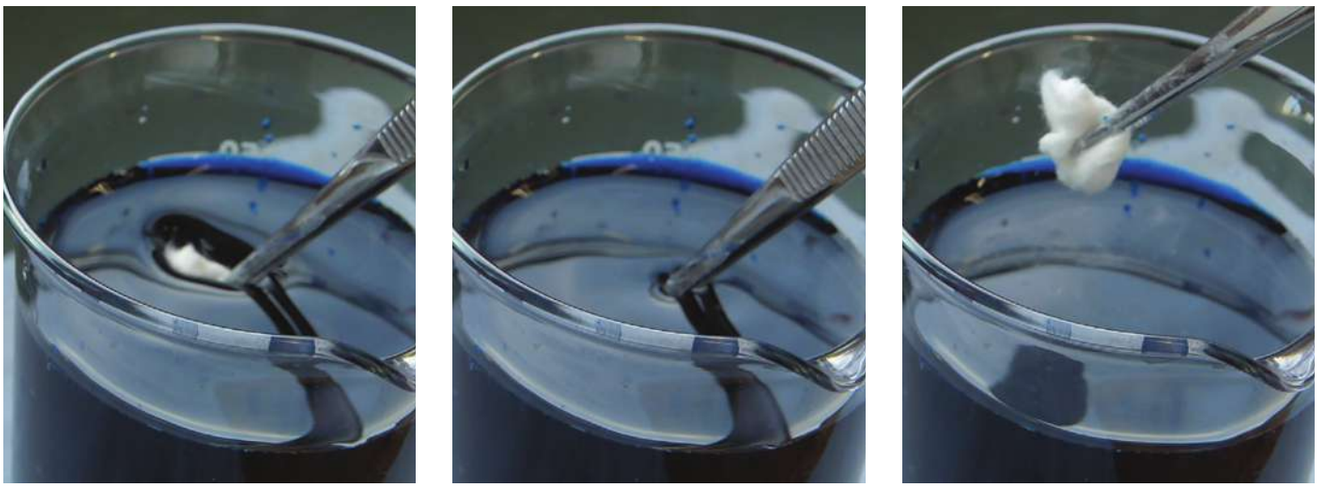
The coating—a thin layer of titanium dioxide nanoparticles covered with a waterproof veneer that can be applied to steel, glass, and other surfaces with spray adhesives—may eventually find application as automotive paint, glass and lighting coatings, even as a protectant for the surfaces of solar cell panels. More development work will be needed to determine if the paint can meet the car industry's requirement for a glossy surface and other needs, the researchers said, but the likes of **Magna International** and **Land Rover** have already inquired about their studies.

Self-cleaning paint

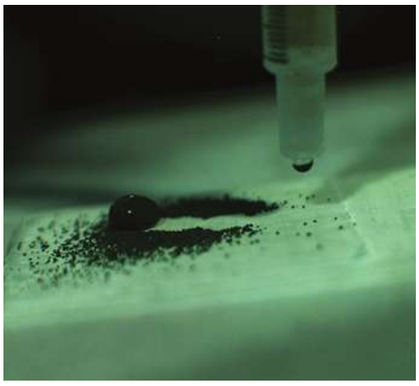
Self-cleaning surfaces work by being extremely repellent to water—a property known as super-hydrophobicity—but often stop working when they are damaged or exposed to oil and grease, said Claire Carmalt, UCL professor of inorganic chemistry, whose research focuses on the development of functional coatings.

Self-cleaning properties, she explained, are based on two effects that combine so that surfaces reject any contact with water. "To achieve a super-hydrophobic surface, what people might know as the lotus-leaf effect," she said, "you need two things: a textured, rough microstructure with multiple tiny protrusions plus what we call a low-energy surface, one with a very low affinity for water—a waxy coating, for example."

"Rather than spreading out like normal and wetting the surface, water on a



These three photos show how a specially treated cotton ball rejects water completely in lab tests.



Water beads up on a super-hydrophobic surface, creating spherical droplets that roll along picking up dirt.

super-hydrophobic surface beads up, creating spherical droplets like marbles that roll along picking up dirt, viruses, and bacteria along the way," Carmalt said. "The droplets act like tiny miniature vacuum cleaners."

Most coatings rub off

Unfortunately, most existing such ultra-waterproof coatings are mechanically weak. They typically rub off easily and fail to function when exposed to oil, she continued: "The biggest challenge for the widespread adoption is finding a way to make them tough enough to withstand everyday damage. But by pairing our paint with different adhesives, we've shown it is possible to make a robust self-cleaning surface. We used materials that are readily available so our methods can be scaled-up for industrial applications."

The study, which was led by Ivan Parkin, head of UCL's materials and inorganic chemistry research group, and included Carmalt, doctoral candidate Yao Lu, as well as researchers from **Imperial College London** and **Dalian University of Technology** in China, was recently published in Science magazine. (http://www.sciencemag.org/content/347/6226/1132.abstract?sid=bd3ee6e4-2734-4351-94d9-7eb99ee7b21a)

According to the report, they "have created an ethanolic suspension of perfluorosilane-coated titanium dioxide nanoparticles that forms a paint that can be sprayed, dipped, or extruded onto both hard and soft materials to create a self-cleaning surface that functions even upon emersion in oil. Commercial adhesives were used to bond the paint to various substrates and promote robustness."

"We used two sizes of titanium dioxide nanoparticles to create the uneven surface," Carmalt said. "A waxy surface—a low-energy surface with low water affinity—was then created by coating the particles with perfluorosilane, a relatively common chemical compound that produces a waterproof surface."

The uneven titanium dioxide nanoparticles essentially form a scaffold that captures tiny air pockets that support the water droplets while the perfluorosilane rejects contact with water. "We found that material works relatively well when exposed to oil; the oil coating supported the water droplets," she noted.

"Our paint worked extremely well for a variety of surfaces in tough conditions which were designed to simulate the wear and tear of materials in the real world," Lu said. "For example, car paint frequently gets scuffed and scratched, and we wanted to make sure our paint would survive that."

Previous dirt-proof paints

Water-resistant coatings for cars are not new. **Nissan** reported last year that it is testing a super-hydrophobic and oleophobic paint that is impervious to water and oils. The technology, sold by **UltraTech** under the name of Ultra-Ever Dry, was applied by the automaker's engineers to a Nissan Leaf. And researchers at **Eindhoven University of Technology** in the Netherlands have been developing a surface coating called DynaClean that not only repels precipitation, but also adds some self-healing aspects.

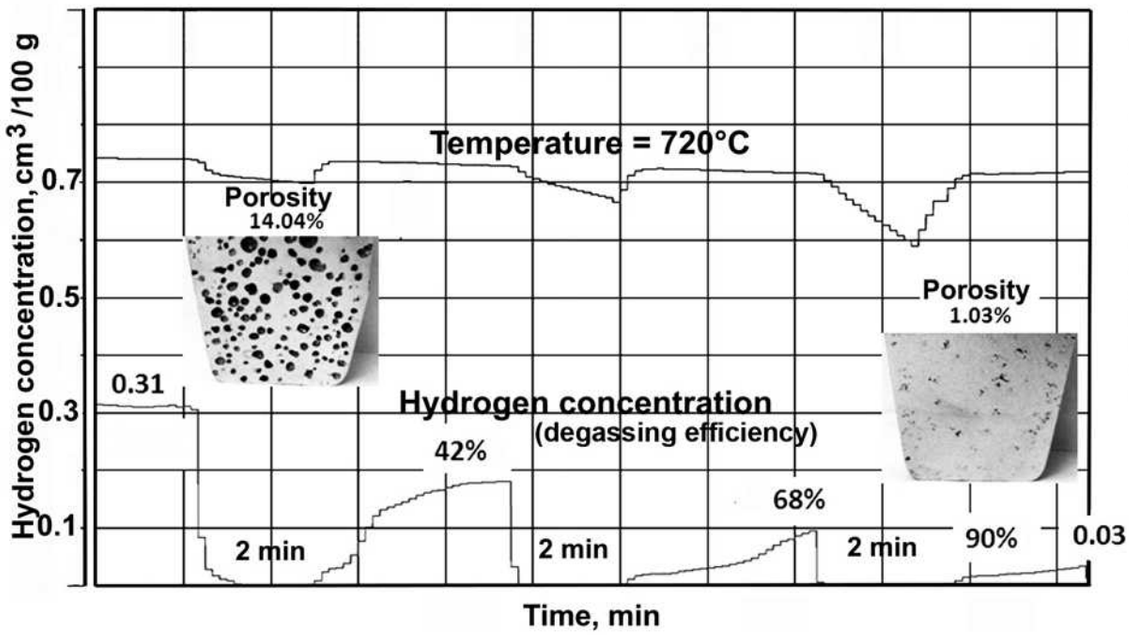
Ultra-Ever Dry is not a paint, but a coating that is applied to the painted car in two steps. The coating consists of a base coat and a top coat. When applied, the aromatic solvents in the base coat evaporate and leave behind a polyisocyanate film, which bonds both to the substrate and the top coat. When the top coat is applied, the solvents evaporate and leave behind silica and a fluorocarbon coating.

One big drawback to Ultra-Ever Dry is that it is not clear. As applied, it is white and hazy, and so it is unusable on windshields or mirrors. In addition, it applies unevenly and its lifetime is uncertain as the chemicals are susceptible to exposure to the sun's UV rays as well as detergents, alcohols, and solvents.

Steven Ashley

AUTOMOTIVE MATERIALS

Brunel pursues ultrasound for 'greener' production of aluminum alloys



The research team, led by Professor Dmitry Eskin of the Brunel Centre for Advanced Solidification Technology, found that ultrasound degassing was just as efficient as the standard method but produced far less waste material (dross) and was much greener.

Treating molten metal with ultrasound is cleaner and more efficient than using argon rotary degassing to produce high-quality castings, according to scientists at **Brunel University London**.

Molten aluminum alloys at 700°C (1292°F) naturally contain a high percentage of dissolved hydrogen—left untreated, the resulting solid metal is highly porous, the university explained. Argon rotary degassing—the most widely-used method of hydrogen removal—is energy-intensive and requires costly components.

In pilot-scale trials funded by EU Framework Seven Programme, the research team, led by Professor Dmitry Eskin of the Brunel Centre for Advanced Solidification Technology, found that ultrasound was just as efficient as the standard method but produced far less waste material (dross) and was much greener.

"We know from industry that the price of argon gas continues to rise because making it requires producers to liquefy air, which takes a lot of energy," said Eskin in a statement announcing the findings. "There are also issues with the graphite impellers used. If they break in use, the entire batch of alloy is contaminated and useless.

"Our pilot-scale research with quantities of up to 150 kg (330 lb) confirmed earlier laboratory tests that a moving ultrasound probe could achieve the similar end results in terms of the resulting casting quality to using argon but with the advantages of not relying on expensive and fragile graphite rods and expensive gas which cannot be captured and recycled.

"The five-fold reduction of the amount of dross created is another benefit. Recovering useable metal from dross is also an expensive and energy-intensive process that involves electrolysis."

The process also can lead to improvements in material attributes, according to Brunel spokesman Mark Howard.

"U/S (ultrasound) treatment significantly improved both ductility and helped grain refinement which is of interest for alloys where grain refiners are not available," Howard shared with *Automotive Engineering*. "It's aluminum alloys where the issue of degassing is most important—otherwise you have to do a lot of heat treatment/rolling, which is of course costly. Ductility improvement is important because it raises the prospect of being able to produce vehicle panels from initial melt feedstock."

Eskin has been working on this project for about three years now, but solidification science has been big at Brunel for 20 years or more, according to Howard.

Scaling up the trials to the half-ton level is the next goal of the research program. Eskin's team is working ultimately to introduce cost-effective ultrasound degassing earlier in the production cycle.

"Dmitry is hoping to scale up to 500-kg melts this year and to introduce U/S degassing between initial melt and ladle, which will have a longer timescale. Because it can be retrofitted, it's really up to industry on speed to foundry floor," said Howard.

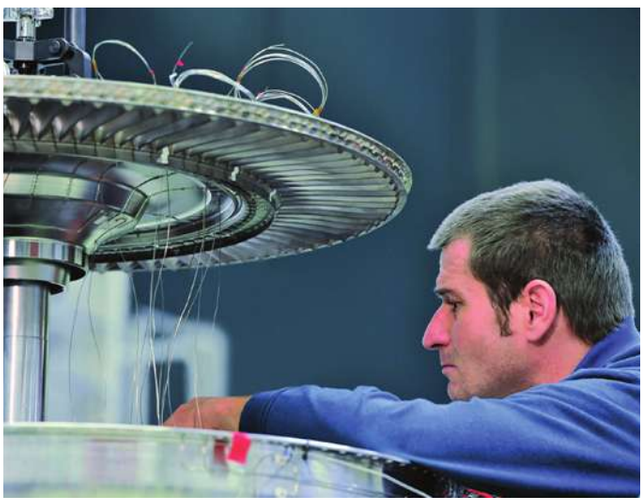
The ultimate aim is to replace components that are currently machined from treated billets to ones than can be cast, Howard shared.

"Economic drivers like producing lighter engines and lighter [vehicle] bodies are pushing process improvements in producing higher-quality alloys much further back in the production cycle to where alloys are first smelted," Eskin explained. "Ultrasound treatment holds out the promise of being able to degas effectively and continuously, and we have already made some steps toward achieving this on the pilot level."

Ryan Gehm

AEROSPACE MATERIALS

MTU develops new turbine blade material in record time



The GTF is assembled by an MTU technician.

A cut-away model of the GTF engine. (Richard Gardner)

MTU Aero Engines announced in March that its internal experts and industry partners have jointly developed a new class of intermetallic, high-temperature materials for highly stressed engine components. Named titanium aluminide (TiAl), this new lightweight material is designed for application for turbine blades and combines the advantages of metallic and ceramic materials.

According to MTU COO, Dr. Rainer Martens, "While the introduction of a new material used to take 20 years or so, we've succeeded in coming up with an entirely new material class and maturing it for production within a mere seven years."

The hardware is already flight worthy and in late September 2014 a development **Airbus** A320neo was the first aircraft ever to take to the skies with custom-made TiAl blades installed in its engines—the new **P&W** Pure Power geared turbofans (GTFs), which subsequently received certification in December. The blades in the new material are fitted to the third rotor stage of the three-stage, high-speed low-pressure turbine developed by MTU for the GTF engine for the A320neo and other new and re-engined aircraft.

Continuing research is underway and the company's materials experts are busy developing an enhanced TiAl alloy aimed at manufacturing more turbine stages from the new material. An environmental bonus of the new material is that TiAl allows engines to be built that use up fewer resources, burn less fuel, and are cleaner and quieter than today's engines.

MTU specialists have been thinking of ways to tap the immense potential afforded by TiAl-based intermetallic materials for aero engine applications for many years. In terms of mechanical properties, it is almost equivalent to the nickel alloys in use today, although its density is much lower, but it has a high melting point and a considerably higher creep strength than titanium alloys. These properties are attributable to the specific composition of the alloy and to the multiple heat treatments especially developed for the purpose.

Turbine blades in TiAl are about half the weight of comparable nickel-alloy components but boast the same reliability and durability. Also, the high aluminum content makes the material resistant to oxidation and corrosion. According to MTU, this is why TiAl is the ideal candidate for applications under extreme conditions—high temperatures and pressures—such as those to be found in a high-speed low-pressure turbine.

"We've been mulling the use of titanium aluminides ever since we started work on this unique low-pressure turbine for the geared turbofan," said Dr. Wilfried Smarsly, a specialist in advanced materials at MTU.

TiAls are seen as enablers to open up new horizons for design engineers, helping to reduce the weight of other engine components. The high centrifugal forces acting on turbine disks and shafts required these components to be made from heavy nickel alloys to have sufficient mass. Thanks to the use of TiAl blades, these centrifugal forces are now much lower. As a result, the disk design can be optimized for appreciably lighter weight, and each reduction in weight will assist in improving fuel economy and CO_2 emissions.

The biggest hurdle that stood in the way of the use of the lightweight material in the GTF was the fact that it is extremely difficult to form. Previously, it turned out impossible to forge turbine blades using conventional, affordable methods.

"We performed thermodynamic calculations to determine the optimum temperature range and phase configuration for forging," said Prof. Dr. Helmut Clemens, who leads the Department of Physical Metallurgy and Materials Testing at the University of Leoben in Austria. Last year, Clemens, an MTU development partner, was honored in Japan with the Honda Award for his groundbreaking research work.

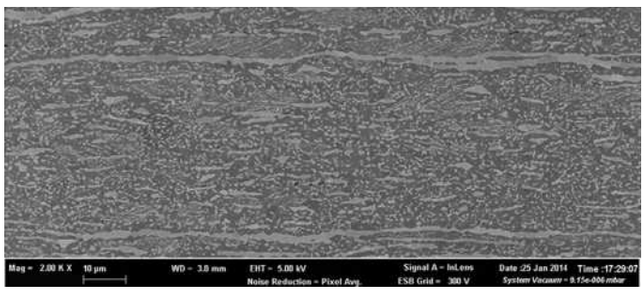
"With the TiAl alloy now developed, forging can be carried out on conventional forming machines—that's what makes things so radically different," he said.

It seems that TiAl is going to feature increasingly as new materials roll out of the realms of advanced R&D into production on new generation powerplants.

Richard Gardner

AUTOMOTIVE | AEROSPACE MATERIALS

Lightweight steel is stronger than titanium



The annealed microstructure of the new lightweight steel shows the FeAl-type B2 precipitates between B2 bands. (Hansoo Kim)

Owing to its strength, formability, joinability, and affordability, steel has been the structural material of choice for mass-produced motor vehicles since it replaced wood in the 1920s, but that doesn't mean that automakers and their materials suppliers ever stopped searching for better alternatives. Witness the recent efforts to build lightweight cars from aluminum and carbon-fiber composites; however, these substitute substances are generally more costly than steel.

Recently, however, three materials scientists at the Graduate Institute of Ferrous Technology at **Pohang University of Science and Technology** in South Korea have come up with another potential option—lightweight steel. Professors Hansoo Kim and Nack J. Kim, together with doctoral student Sang-Heon Kim, have developed a low-density steel alloy that exhibits higher specific tensile strength and ductility than titanium alloys—the lightest and strongest metals known, but potentially at one-tenth the cost, according to a paper published in the February 5th issue of the journal *Nature*. (See http://www.nature.com/nature/journal/v518/n7537/full/nature14144.html)

"Because of its lightness, our steel may find many applications in automotive and aircraft manufacturing," Hansoo Kim stated in an e-mail communication.

Probably the most surprising point about the new steel composition is that it gains its mass advantage through the addition of aluminum, a low-density alloying agent that had been tried many times before but had always yielded unsuitably brittle results. Decades ago metallurgists in Russia and elsewhere attempted to add aluminum to steel, and even though the resulting metal was very strong and lightweight, it invariably had little ductility—that is, when subjected to large forces, it would break rather than bend. Manufacturing products from a low-ductility metal is very difficult.

Photomicrography studies subsequently revealed that the experimental aluminum-rich steel alloys contained a very hard but very brittle cubic crystal of iron and aluminum called B2 that made them mostly unusable. B2 is an intermetallic compound—a crystalline material in which different elements replace other more typical elements in certain atomic sites. In the previous high-aluminum steel formulations, the B2 intermetallic compounds tended to arrange themselves into brittle bands at which the material would shear off when stressed.

Dispersion-strengthened steel

"My original idea was that if I could somehow induce the formation of these B2 crystals, I might be able to disperse them in the steel," Kim said. He and his colleagues realized that if nanometer-scale B2 crystallites were uniformly distributed as a secondary phase throughout the steel's ductile austenite (face-centered cubic crystal) primary alloy phase, they would strengthen the whole by halting microscopic crack propagation much like strong carbon fibers serve to reinforce the more flexible resin matrix in a polymer composite material.

After spending years researching the concept, the trio found that by adding nickel to the mix (which includes carbon and magnesium besides iron and aluminum) and then specially annealing, or heat-treating, the solidified metal, B2 precipitates would evenly permeate the metal in nanometer-sized clusters rather than long bands. The small percentage of nickel, which reacts with the aluminum, offered greater control over B2 formation, as nickel made the crystals precipitate out at a much higher temperature.

Electron microscope images confirmed that Korean scientists had achieved their desired micromorphology, and tensile tests showed that the novel alloy, Fe-10%Al-15%Mn-0.8%C-5%Ni (weight percent), was strong and ductile.

"We developed a new type of flexible, ultra-strong, lightweight steel that is 13% less dense than normal steel and has a strength-to-weight ratio that matches even our best titanium alloys," Kim said.

Production process tests

In their experiment, the researchers melted about 40 kg (88 lb) of the steel alloy in an induction furnace with a protective argon atmosphere and cast it into a rectangular ingot, Kim reported. Following a homogenization treatment—1150°C (2102°F) for 2 hours—the ingot was hot-rolled into strips 3 mm (0.12 in) in thickness. The hot-rolled strips were cold-rolled into 1-mm (0.04-in) -thick sheets that were next annealed at 870 to 900°C (1598 to 1652°F) for 2 to 60 minutes. The sheets were then immediately water-quenched or rapidly cooled to 25°C (77°F).

"All the steps except for the casting are very similar to the existing processes for industrial sheet steel production," he noted.

Subsequent joining tests showed that "our steel can be welded by electrical resistance spot welding, laser welding, and argon TIG welding," Kim said.

He stressed that the team's B2-dispersion method is really more important than the new alloy: "Steel scientists all over the world can make many variants of our steel for their own applications based on the novel microstructure, which comprises a steel alloy matrix and intermetallic precipitates."

The Pohang University researchers are now working with the South Korean company **Posco**, one of the world's largest steel manufacturers, to scale up their technology.

"We are planning a mill trial production of our steel this year at Posco, not for direct commercialization but for checking possible difficulties that are frequently met during scale-up," he said. "If everything goes smoothly, you may see our steel on the market in two to three years."

Steven Ashley

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AUTOMOTIVE SIMULATION

Automatic collision avoidance added to inspection software

While **Delcam**'s PowerINSPECT has included collision detection for some time to warn users when there was a possibility of any collision between the probe and the item being inspected, users had to manually make the required changes to the probe path to avoid the collision.

With its 2015 version, PowerINSPECT software adjusts the probe path automatically if a direct move between inspection features could produce a collision. The software calculates a new motion path that avoids the obstacle, typically by moving up and over the obstruction or around it.

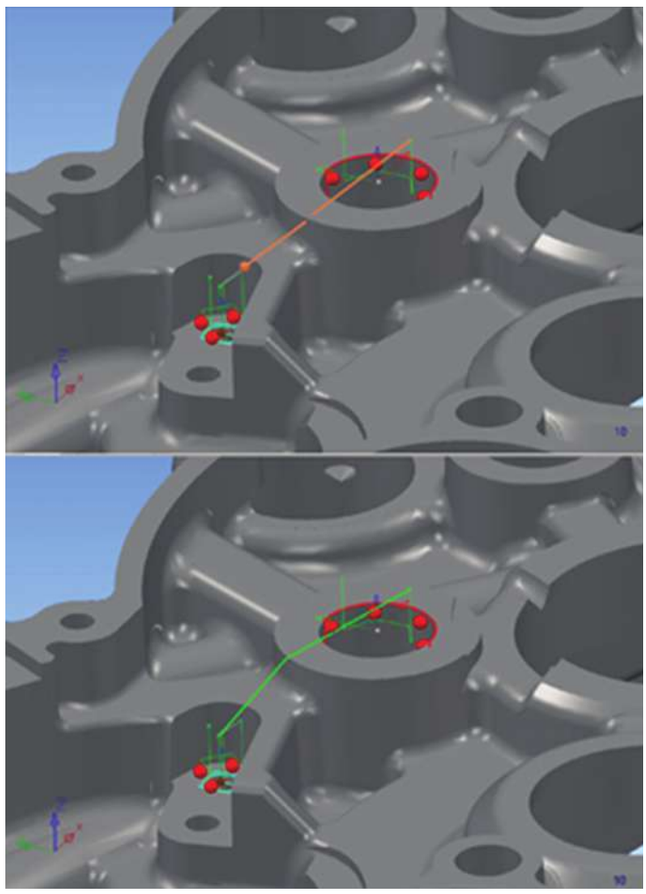
Collision avoidance is carried out when the initial probe path is generated, when the sequence of measurements is re-ordered, and when features are added or removed. As well as preventing collisions, automatic collision checking will save significant programming time, especially when inspecting more complex items.

The user still has the option to override the path produced by the software, which might be required if any accessories not modeled in the CAD data are present, for example, any clamps or fixtures being used to hold the part.

A number of improvements to PowerINSPECT 2015 have made both data import and report generation faster. The differences will be particularly apparent when reading large CAD models, such as complete vehicle bodies, and when producing longer reports with more graphical images.

Another improvement in reporting gives users greater control over the contents of any report. For example, it is easier to produce a summary of the complete set of results as a management report. Similarly, a more concise report can be produced when greater detail is not needed, as when results are well within expected tolerances.

The 2015 release also offers improved display of results from point-cloud data, including a better shaded display of the color map, complete with the colored scale of the tolerances. The new format is more consistent with the reports produced by PowerINSPECT from data from other types of measurements making it easier to compare the results from different devices or measurement methods.



With Delcam's PowerINSPECT 2015, the software adjusts the probe path automatically if a direct move between inspection features could produce a collision. The software will calculate a new motion path that avoids the obstacle, typically by moving up and over the obstruction or around it.

In terms of usability enhancements, the representation of changes to the probe or to the probing parameters is clearer and easier to understand. These improvements will be especially useful when creating longer inspection sequences for CNC coordinate-measuring machines and for on-machine verification. They will also make it easier for CMM operators to follow measurement sequences developed by another user, for example, when the inspection routine is created by the company's metrology expert but then carried out by less experienced users.

Another usability enhancement is the addition of scale-model inspection. In this mode, the measurements from a scale model, such as a half-scale vehicle or system, are displayed as though they were the results from the full-size item. This makes the reports easier to understand at first view and makes it quicker to exchange digital measurements with the CAD system as there is no need to compensate for the scaling in the model.

It has also been made easier to handle more complex CAD data structures, with data split over a series of levels. In particular, it is easier to match the CAD view to an item contained within a history tree.

Also, a new intersection item has been added to the range of geometry that can be measured with PowerINSPECT; the intersection between a sphere and either a cone or a cylinder. This option will be useful when measuring ducting and pipework.

Its last update from the fall of 2014 featured a new interface with new icons that made the software more intuitive and easier to use. Other enhancements included the ability to create compound items, and so speed up and simplify repetitive measurements, enhancements to the measurement dialogs, and further increase the range of geometric features that can be inspected.

Jean L. Broge

AEROSPACE TESTING

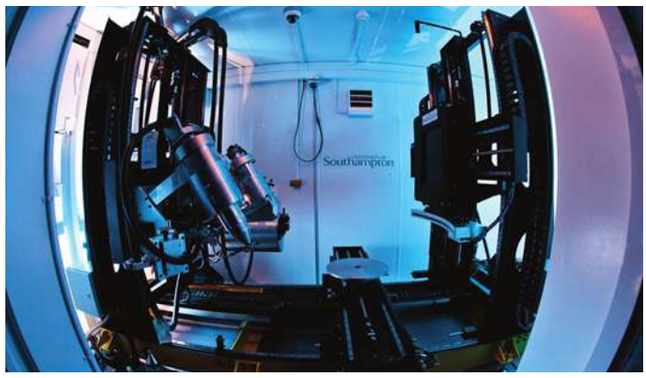
X-ray testing for large composites

Anyone who has a CT (computed tomography) scan at the hospital or medical clinic knows that fitting into the tight x-ray scanning bed is a problem for large or tall patients. The same goes for many large or bulky composite aircraft components that need x-ray inspection for tiny defects on factory floors. Long parts like wings and helicopter blades, and unwieldy ones such as fuselage assemblies, simply don't fit into most existing x-ray NDT (non-destructive testing) scanners.

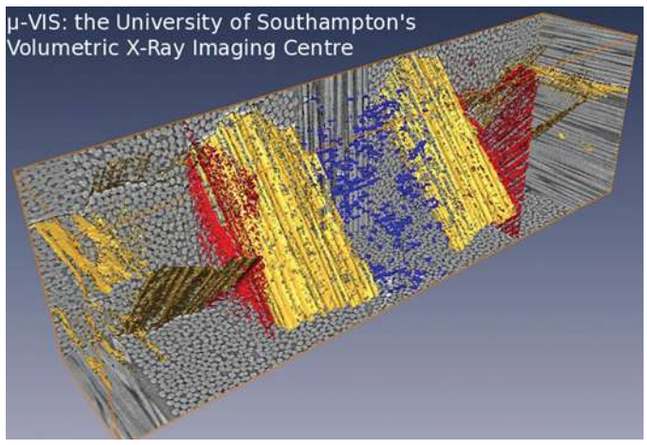
A U.K. government-supported consortium of researchers at the **University of Southampton** and **University College London** (UCL), together with British aerospace companies and x-ray equipment makers, is working to remedy that situation by developing two new x-ray imaging technologies that will be able to accommodate overlarge or ungainly parts. Meanwhile, the U.S. Defense Advanced Research Projects Agency (**DARPA**) wants to replace x-rays with neutron beams for composites NDT.

"To capture the 3D-imaging data you need for image reconstruction, you have to rotate a part in the scanner, or move the scanner around it to image it from all directions," said Thomas Blumensath, Deputy Director at the University of Southampton's μ-VIS Centre for Computed Tomography. "Many aerospace components are quite flat and extended, and you can't move them all the way through the scanner. Others are just too bulky to do so.

"These new systems will enhance our ability to find small production defects—micrometer-size voids and inclusions—in large multi-ply carbon-fiber composite parts, such as those which are increasingly used in modern aircraft," he said. "These capabilities will ultimately help in the production and maintenance processes, and will assist in the development of more environmentally friendly airplanes, as well as enhanced overall aircraft safety."



Fisheye view of the Nikon Metrology 225/450kV x-ray scanner at the University of Southampton's μ-VIS center. (Sharif Ahmed, University of Southampton)



A 3D rendering of fiber orientation and damage observed in a carbon-fiber-reinforced polymer composite. (University of Southampton)

Seeing defects better

The three-year, cost-shared R&D effort, which is being led by the British defense technology firm **QinetiQ**, has been operating for six months, with a grant of £2.1 million from the U.K. government's technology strategy board Innovate UK, and another £600,000 in private funds from the partners. The ProjectCAN consortium supports two teams that are working on two different imaging approaches: laminar tomography and backscatter x-ray.

Researchers at Southampton's imaging center and Derby-based **Nikon Metrology** UK will collaborate on scanning and visualizing the insides of large, flat components using an x-ray method called computed laminography or CL.

"We will be developing an alternative technique that applies CL techniques to overcome the limitations of conventional CT for large, flat components," Blumensath said. CL systems typically use linear translation or limited-angle rotation to scan components.

"We'll will use a laminography system and a computer algorithm to accumulate scan data and reconstruct it into a 3D volume-image," he said. The scanner will move parallel to the flat surfaces. "The hardware and software will be developed to allow laminographic imaging within the Nikon Metrology 225/450kV x-ray scanner that we have here in Southampton."

Meanwhile, researchers at **Axi-Tek** Ltd. of Nottingham and UCL will develop a new backscatter x-ray inspection technique to study large-area composite structures such as wing sections, engine cowlings, and fuselage components. Backscatter-based, or "one-side," x-ray systems, which have been used for inspecting luggage at airline security gates, have the x-ray source and the detector on the same side. They typically utilize a constant-potential x-ray source and a rotating collimator to form a flying spot that passes over the surface of the object under observation.

During the past few years, UCL researchers have worked with x-ray system maker **Rapiscan** to develop a backscatter x-ray system for cargo and vehicle security screening as part of a U.K. government-supported R&D project. Specialists there have also been developing x-ray phase contrast imaging techniques that detect changes in the phase of x-rays as they traverse a material. This method relies on materials "phase-shifting" the in-coming rays rather than

absorbing them, which can enable better detection of features that conventional x-ray systems usually cannot see.

Blumensath said that after the project is complete, a proof-of-concept system will have been designed and built. "Afterward, the technology will be developed into a marketable product in order to be made available to aircraft manufacturers," he said.

Compact neutron scanner

Getting a better view inside dense objects, like seeing corrosion in metal aircraft wings or manufacturing defects in composite ones, is just one of the applications managers at DARPA are hoping to develop in a new program called Intense and Compact Neutron Sources (ICONS).

Although x-ray imaging has proven highly useful in industrial applications, it is limited in what it can detect, DARPA stated. While x-ray radiography can highlight heavier chemical elements such as metals very well, it is not that good at imaging lighter elements such as hydrogen and carbon. That's why x-ray radiography machines are generally "blind" to elements with low atomic numbers.

By contrast, neutron radiography, which uses beams of neutrons to image objects, is very good at visualizing lighter elements that appear in composite materials, in some cases even identifying a substance's atomic makeup. But existing neutron sources are big and not nearly as portable as x-ray machines. Neutron units typically extend up to tens of meters in length and require powerful energy sources to generate the neutron beams.

"We're looking for innovative designs and construction methods to shrink a neutron accelerator from 10 meters or longer down to 1 meter or less, similar to the size of portable x-ray tubes today," said Vincent Tang, DARPA Program Manager. "Creating a high-yield, directional neutron source in a very compact package is a significant challenge. But a successful ICONS program would provide an imaging tool with significant applications, able to deliver very detailed, accurate internal imaging of objects in any setting."

Tang said that ICONS could enable non-destructive evaluation with greater fidelity than x-rays, revealing hidden corrosion or small flaws in aircraft wings, for example.

Steven Ashley

MANUFACTURING

NanoSteel powder alloys advance 3D printing of high-hardness parts

NanoSteel has expanded its additive manufacturing (AM) material capabilities to support metal 3D printing of complex high-hardness parts and the ability to customize properties layer-by-layer through "gradient material design."

The Providence, RI-based company has developed progressive generations of iron-based alloys during its 13-year history, and "within the last year has applied some of these designs in powder form specifically to additive manufacturing," according to Harald Lemke, Vice President and General Manager of Powder Metallurgy.

The tendency of high-hardness metallic parts created through additive manufacturing to develop cracks has been a major obstacle in their development path. NanoSteel leveraged its 2014 breakthrough in AM wear materials and worked with global process development partners to print a bearing and impeller using the powder bed fusion process.

NanoSteel has proven the ability to generate 99.9% dense, crack-free parts. Shown is an integrated bearing built through laser powder bed fusion.

The resultant wear parts were measured to be fully dense and crack-free, with hardness levels >1000 HV. The parts' wear resistance is comparable to conventionally manufactured M2 tool steels, according to NanoSteel, and they feature a uniform microstructure. These properties were achieved without the need for post-processing such as hot isostatic pressing (HIP) or further heat treatment, reducing production cost and lead times.

The company's powders are unique due to their chemistries and microstructure, according to Lemke. "For example, in the additive manufacturing process, some of these chemistries create a uniform metal matrix composite structure which enables isotropic properties achieved during solidification without heat treatment."

Building on the success of this wear-part demonstration, NanoSteel pursued the development of parts with a gradient design using a combination of high hardness and ductile alloys. The company worked with **Connecticut Center for Advanced Technology** within the past six months to generate part samples using freeform direct laser deposition. This single AM process achieved a seamless transition between the hard and ductile properties without subsequent heat treatment.

These gradient material designs offer the equivalent of "digital case hardening," according to NanoSteel, delivering impact resistance and overall robustness in addition to high hardness and wear resistance in a single part. This capability offers OEMs considerable design flexibility in meeting part-performance requirements, according to Lemke.

"Proprietary metal alloys that support the cost-effective 3D printing of high-quality parts will help accelerate the transition from subtractive to additive manufacturing across applications such as wear parts, bearings, and cutting tools," said Lemke. "The company's AM powder offerings make it possible to design exclusively for the function of a high-hardness part, releasing designers from the limitations of conventional production processes and opening new opportunities to improve performance."

NanoSteel is currently seeking development partnerships with OEMs on specific application development, he added. "An overall product commercialization timeline will be developed as a result of these partnerships."

Targeted markets for its AM powder portfolio include automotive and agriculture, as well as energy and tool and die.

"[Our] AM powder offering can be used for aesthetic and functional prototyping of automotive parts as well as next-generation lightweight solutions due to the higher performance compared to other carbon steels," Lemke shared. For agriculture, "parts that traditionally have required hardfacing can benefit from the process flexibility of 3D printing through the use of gradient material design."

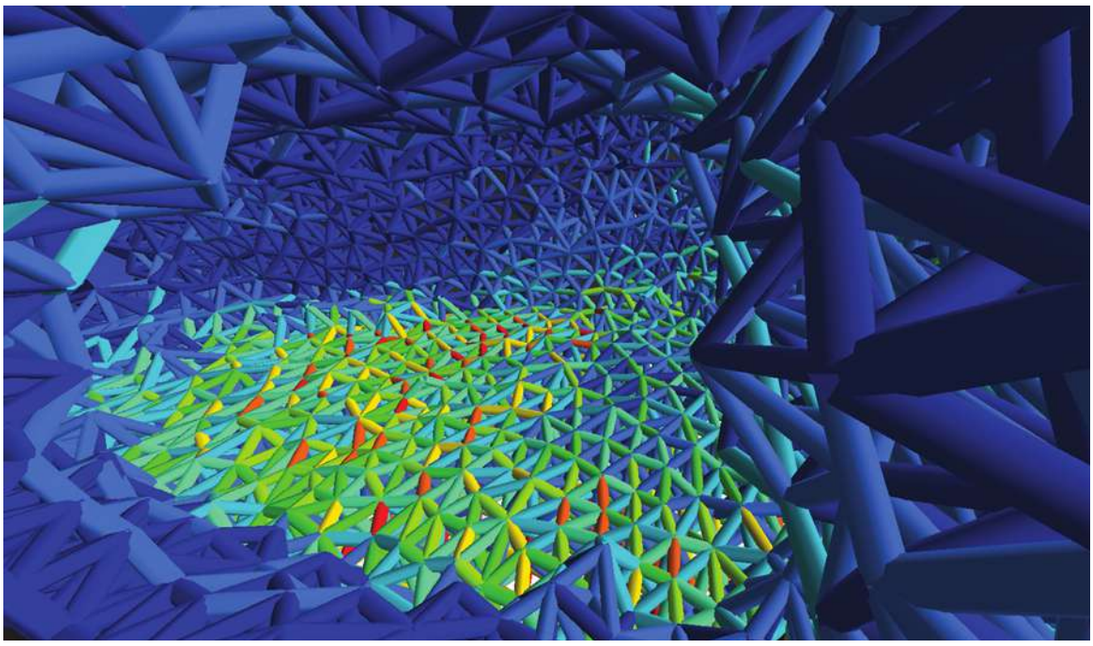
When released, the ferrous powders will be "very competitive" with other AM materials in terms of cost, he claims.

(Go to http://articles.sae.org/12968/ to read more on NanoSteel's AHSS alloys.)

Ryan Gehm

MANUFACTURING

Altair optimizes 3D-printed structures for complex, lightweight designs



Topology optimization is particularly well-suited for 3D printing because it tends to create free-form, organic structures that can be difficult to construct using traditional manufacturing methods. (Altair)

Altair expects to better support the use of additive manufacturing (AM), or 3D printing, by releasing new OptiStruct solver capabilities for topology optimization. The company claims this new technology is the first tool developed specifically for designers of lattice structures.

3D printing is capable of manufacturing hollow shapes with complex external geometry using lattice structures. OptiStruct now extends topology optimization to assist in the efficient blending of solid-lattice structures with smooth transitional material volume, according to Altair. Lattice performance can be studied under tension, compression, shear, flexion, torsion, and fatigue life. The technology provides CAE analyses for optimal and structurally efficient material distribution.

Topology optimization is particularly well-suited for 3D printing, according to Altair, because it tends to create free-form, organic structures that can be difficult or impossible to construct using traditional manufacturing methods.

"3D printing brings new structural freedom to product design, allowing more complexity in shapes and topology and the efficient production of customized products while accelerating the manufacturing process, since no tooling is needed," said Uwe Schramm, Chief Technical Officer at Altair. "Topology optimization maximizes this design freedom, enabling complex free-form structure development, seamless individual designs, a shorter design process, and optimal 3D-printed structures."

Altair is working with partners such as **Materialise** NV, a Belgian provider of AM software and 3D printing services, to enable more efficient data transfer. Lattice structures can contain hundreds of thousands of lattice cells, proving to be a challenge for conventional STL file transfer. Software packages like 3-MaticSTL from Materialise focus on improvements of a given lattice component to accommodate the various requirements of the 3D printing process, creating support structures where necessary.

Instead of simply applying lattice structures to existing geometry, OptiStruct enables the designer to identify the best material placement and lattice structures, according to Altair. Optimization identifies where material is needed in a design—and where it is not required—prior to placing and optimizing lattice.

OptiStruct optimizes lattices in two phases. First, it applies standard topology optimization, allowing more porous materials with intermediate densities to exist. Then, the porous zones are transformed into explicit lattice structures with varying material volume. In the second phase, the dimensions of the lattice cells are optimized. The result is a structure with solid parts plus lattice zones with varying volumes of material.

Lattice zones could enable the successful development of products that require characteristics beyond just stiffness. Some applications, for example, may need to consider buckling behavior, thermal performance, or dynamic characteristics. With OptiStruct, users can manipulate material density based upon the result of an optimization process, comparing stronger vs. weaker, or solid vs. void vs. lattice designs.

"OptiStruct's lattice capability represents the first step towards integrating smart materials with unique properties in products," said Ming Zhou, Vice President of Software Development at Altair. "Continuing research and development will explore directional behavior and smooth blending of varying lattice cell layouts to take advantage of exotic material characteristics that could bring innovation to various applications."

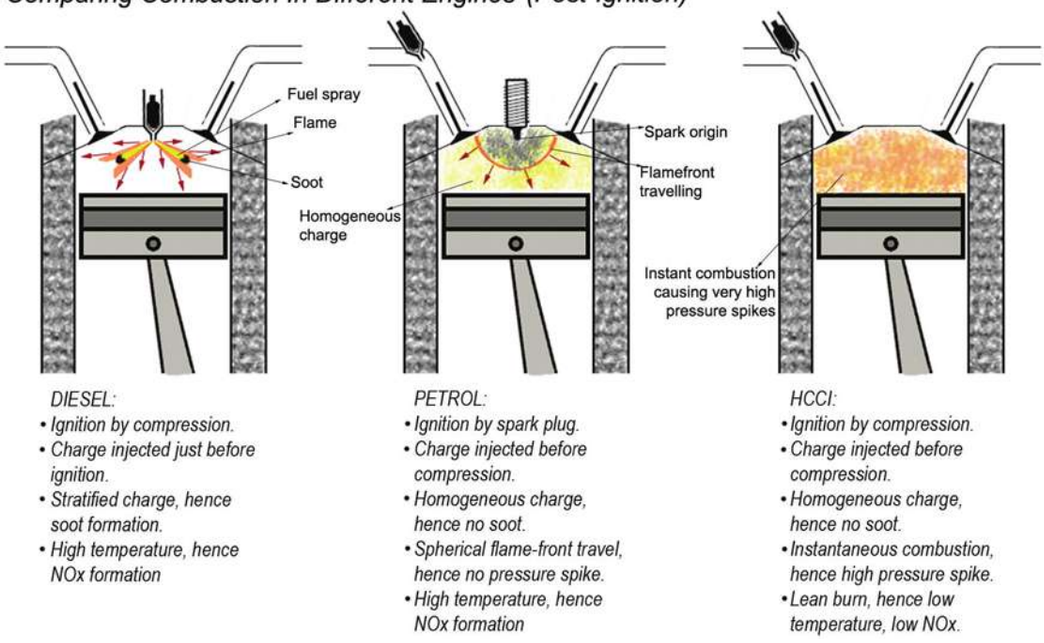
Part of the Altair HyperWorks CAE suite, OptiStruct is used for topology, topography, size, and shape optimization.

Ryan Gehm

Getting greener

To meet upcoming fuel economy and emissions regulations, the developmental homogeneous charge compression ignition (HCCI) engine shows promise, but pursuit of more conventional engine technologies may be the better path.

Comparing Combustion In Different Engines (Post-Ignition)



One of the biggest challenges for the global auto industry today is the ever-rising demand for better fuel economy and emissions. Be it the Corporate Average Fuel Economy (CAFE) target of 54.5 mpg by 2025 in the U.S. or the 95 g/km target for CO_2 emissions by the year 2020 in Europe, the major automotive markets are facing intense pressure to meet these targets. Successfully achieving these efficiency and emissions goals, along with keeping pace with the natural trajectory in performance improvements, would require nothing short of giant leaps on the technological front.

One such technology, which has been on the hot seat this decade and earlier, is the homogeneous charge compression ignition (HCCI) engine. This prototype engine technology aims to have the best of the conventional engines of today—the low emissions of a petrol engine and low consumption of a diesel engine. The petrol engine employs homogeneous charge spark ignition (HCSI) as the uniform combustion mixture is ignited by a spark plug; while the diesel has stratified charge compression ignition (SCCI) as the fuel is directly injected into the chamber and combustion occurs at the air-fuel boundary of the tiny droplets of the stratified charge.

Petrol is injected upstream of the intake valve (with port fuel injection) and the fuel-air charge becomes homogeneously mixed while getting sucked in the combustion chamber by vacuum during the intake stroke. As the charge is maintained almost always at the stoichiometric point, the combustion is of better quality and produces lower emissions. The downside is that, even during low-load conditions (which is usually the case), the petrol intake cannot be reduced as auto-ignition might occur while compressing non-stoichiometric charge. (Power is controlled by a throttle valve, which cuts the air flowing into engine.)

The diesel engine, on the other hand, can manage power by controlling the amount of fuel intake (lean burn) as fuel is injected directly into the chamber with already compressed air right before ignition. As the fuel mixture is stratified and non-stoichiometric, there is a lot of soot formation and CO generation due to incomplete burning at the air-fuel boundary. The HCCI engine theoretically produces lesser emissions, as the charge combusted is homogeneous and the overall peak temperature is lower than any of the conventional systems, hence generating less NO_x. As lean burn can be employed, a higher

compression ratio with absence of throttle improves the engine efficiency drastically.

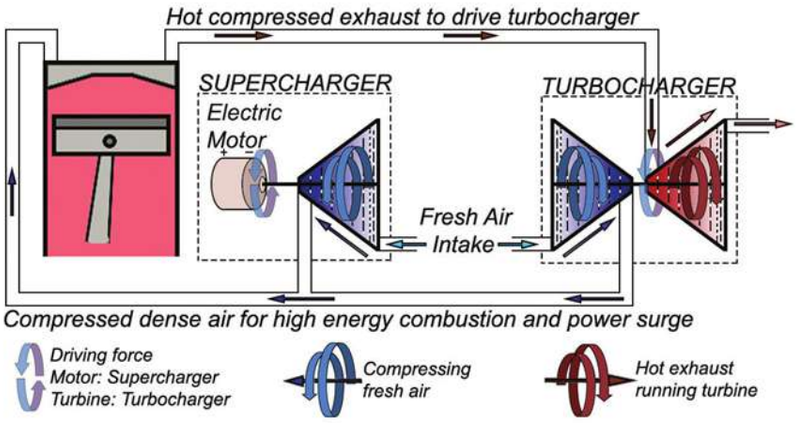
However, there are certain problems associated with this design, causing it to still be in the development phase. Both the petrol and diesel engines have explicit control over ignition timing, whereas the event of ignition can only be indirectly controlled in HCCI. Auto ignition is thus difficult to tame and knocking/pre-ignition is a problem. Secondly, instantaneous ignition of the entire compressed charge causes very high pressure spikes and heat release rate. The material technology of today structurally limits the practical HCCI engine and operation is only limited to low- or medium-load conditions.

Mercedes-Benz's prototype technology, DiesOtto operates in HCCI mode during low-load cruising conditions, reverts to normal spark-ignited operation during higher load, and employs an electric motor to ensure a smooth transition.

Another promising technology among experimental combustion systems is the pre-mixed charge compression ignition (PCCI) engine, in which a pre-mixed stoichiometric and homogeneous charge of fuel is injected during the compression stroke like in the diesel engine. **Hyundai** and **Delphi** have collaborated in the development of a new engine based on similar lines.

The gasoline direct-injected compression ignition (GDCI) engine is a cross between the HCCI prototype and the conventional diesel engine, as a partially premixed charge is directly injected into the compressed chamber and auto-ignited. The mixture is "globally stratified but locally stoichiometric," meaning that the power output is controlled by employing lean burn, and at the same time emissions are under check as combustion occurs in a homogeneous and stoichiometric fuel charge. There is also explicit control over the injection event, hence no pre-ignition. This regime employs higher compression ratios and EGR (exhaust gas recirculation) with auxiliary power from supercharger and turbocharger for low and high engine speeds, respectively. (Turbochargers and superchargers are forced-aspiration technologies meant to pump compressed air into the engine giving an instant power surge when required. A supercharger is typically direct driven from the engine, while a turbocharger typically is exhaust-driven and only effective at moderate to high engine speeds).

Chris Boer and Mike Cheiky from **Transonic Combustion** Inc. presented a truly novel



The turbocharger and supercharger working in harmony.

combustion process at the 2012 SAE High Efficiency IC Engine Symposium (the GDCI engine was also presented here, and updated in the 2014 agenda). The concept is to directly inject fuel in a supercritical state, at which it vaporizes into the compressed air very quickly to produce a cleaner and more complete burn. This supercritical state is achieved by precisely controlling the pressure and temperature of the fuel just before injection. A practically successful fuel injection design would pose minimal interference into a conventional diesel engine system with much lower emissions and higher fuel economy and performance with gasoline applications.

However, top management in the industry need to answer this one question; can the industry really afford to venture into the unknown in terms of "grass roots-level" experimenting with unique technologies, especially in a critical phase like this when steep emissions and efficiency targets are to be met within a very optimistic deadline? In fact the bigger question is: does it really need to?

Guilliaume Devauchelle from the **Valeo** Group does not think so. His department has developed an electric supercharger (originally developed by **Visteon** Technologies back in 2002) that can be "fitted" to a regular gasoline or diesel engine. The supercharger is driven by a low-inertia motor that spools it from idle to full capacity in around a third of a second (virtually eliminating turbo lag). A turbocharged diesel engine fitted with this system would demonstrate an instant surge of power upon load application at lower speeds for a few seconds until the turbo kicks in. Aggressive downsizing of engine is a very lucrative and easy option for OEMs provided auxiliary power enhancement systems like these are production ready, as this requires minimum change to existing powertrain architecture with significant improvement in economy.

The powertrain has several systems, which work together with the engine to produce the power as it is seen in the wheels. Instead of tinkering with the individual components, R&D should employ systems engineering such that every module of the complete setup is working in synergy with the other to unanimously produce the most optimized result. ■

This article was written for *Mobility Engineering* by Mr. Surojit Sen, an Analyst at EXL Service of Noida, India.

Highlights of Baja SAEINDIA

The 2015 event, the 8th edition with the theme of Beyond Boundaries, was won by the College of Engineering, Pune.

College of Engineering Pune (Team Nemesis).

Endurance round.

Baja SAE is an intercollegiate design competition run by SAE International with teams of university students from all over the world that design and build off-road vehicles that have identical engines and other specifications. The history of Baja SAEINDIA, run by SAEINDIA, can be traced back to the participation of **Delhi College of Engineering** students who participated in the SAE Mini Baja in 2002.

A tiny red buggy flanked by checkered flags, the logo for Baja SAEINDIA, has persisted since its inception in 2007, effectively conveying what the event is all about—an all-terrain, single-seat four-wheeled vehicle designed, fabricated, and raced by teams from different engineering colleges. And yet there is so much more that this little pictorial representation fails to convey.

Big winners:

The theme for this year's 2015 Baja SAEINDIA event was "Beyond Boundaries," the very title suggesting an encouragement to budding engineers to aspire higher to achieve their goals. All-terrain vehicles (ATVs), or buggies if you would like to call them that, have been known for their extreme off-roading capabilities, taking on mud-slinging, water wading, and off-road tracks that a conventional vehicle would otherwise only dream to conquer. The premise to test the capabilities of vehicles on a track leaves little room for error and a whole lot of scope for improvement. It gets interesting when teams are asked to build their own ATVs and then compete on a national level against like-minded opponents on one of the most grueling tracks developed by some of the best minds in the business. That, folks, is the 2015 Baja SAEINDIA for you, in a nutshell.

The much-awaited 8th edition of the Baja SAEINDIA came to an end on February 22, leaving behind many exhilarating moments. A total of 74 teams competed in the endurance round. The first edition of eBaja saw eight teams competing for the title on February 21.

The events took place at the NATRIP facility at Pithampur near Indore. While the **College of Engineering, Pune** was announced the winner of the 8th edition of the event, their vehicle was also the lightest, weighing only about 160 kg (353 lb). **D.Y. Patil College of Engineering, Pune** and **Vellore Institute of Technology, Vellore** were declared first and second runners-up, respectively.

The highlight of Baja SAEINDIA 2015 was the new track with natural hurdles spread over 4.5 km (2.8 mi). The track was designed in a manner to pose more challenges and test not only the success of vehicles but also of drivers.

KL University, Guntur was declared the

Winner of Endurance Round was Team Nemesis.

Bird's eye view.

Prize distribution.

"Best eBaja Team." The competition, which aims to provide a platform to leverage the push for electric mobility in India, saw participation from 12 colleges. However, only eight colleges competed in the endurance round.

About 323 teams registered for Baja SAEINDIA 2015, out of which 122 teams qualified for the final event, with 74 teams qualifying for the Endurance round. This year was remarkable, with 8000 students from different parts of the country working toward Baja SAEINDIA 2015 theme and making it a reality.

Industry accolades

Speaking at the Valedictory function, Dr. Pawan Goenka, Executive Director, **Mahindra & Mahindra** Ltd. said, "It's heartening to see thousands of students coming together once again to celebrate the spirit of Baja. The increase in participation from colleges and Baja SAEINDIA's growth since inception indicate its growing popularity and national significance. This forum gives young engineering talent an opportunity to showcase their skills, innovate, and acquire a real-life experience posed with challenges that are critical to their success in the long term. Mahindra & Mahindra is delighted to be associated with Baja SAEINDIA 2015 as the title sponsor and with Baja, we are taking forward the philosophy of Mahindra Rise to the next level."

Dr. Aravind Bharadwaj, President, SAEINDIA said, "Creation of industry-ready skilled engineers is a prerequisite to achieve the targets that have been set forth in the Automotive Mission Plan 2016 for India. Baja is one such initiative from SAEINDIA that provides an opportunity for students to get hands-on learning experience in vehicle design. The rapid increase in the number of teams from SAEINDIA clubs in colleges across the country, and the unparalleled enthusiasm of everyone involved with this event, is clear evidence that Baja SAEINDIA is making progress in the right direction."

Mr. Subodh Morye, Convener, Baja SAEINDIA said, "Baja SAEINDIA is a platform that offers students a chance to showcase their talent and skills in the presence of auto experts in addition to presenting them with an opportunity to gain hands-on experience in the industry of which they aspire to be a part. Amongst the thrill and adventure, we assess the abilities of participants by testing them on parameters such as leadership skills and theoretical and practical knowledge."

On a conclusive note he added, "Indore is a hub of industry and young talent. Its proximity to infrastructure such as the NATRIP facility makes it the ideal venue for hosting an event of this nature. The enthusiasm of the city is palpable simply from its response—Indore has shown the highest participation, closely following cities such as Pune and Chennai. I am confident that like every year, this year too will

Major Highlights: Baja SAEINDIA 2015

College of Engineering, Pune	1ST PLACE
DY Patil College of Engineering, Pune	2ND PLACE
Vellore Institute of Technology, Vellore	3RD PLACE
KL University, Guntur	EBAJA BEST TEAM AWARD

Highlights of Baja SAEINDIA

Tackling the obstacle course in the dynamic challenge.

Entrance.

showcase the most promising talent in the country."

Attending dignitaries, such as Dr. Pawan Goenka, Executive Director & President, Automotive & Farm Equipment Sectors, Mahindra & Mahindra Ltd. and Chairman Baja SAEINDIA Steering Committee; Chief Guest Mr. Anthony Je DeSa, IAS Chief Secretary Government of Madhya Pradesh State; Mr. Kamal Bali, MD, **Volvo India**; Mr. Girish Markale, Co-convener, Baja SAEINDIA; and Dr. Aravind S. Bharadwaj, President, SAEINDIA, presented numerous other awards to the teams for static events.

Other awards and sponsors

Rustamji Institute of Technology, Gwalior bagged the Engineering Design award, whereas **SRM University, Chennai** and **Institute of Engineering and Technology-DAVV, Indore** won the Go Green-Emissions Award. Special awards, such as the Dronacharya award, was given to the team of **Sant Longowal Institute of Engineering & Technology, Sangrur-Punjab** and **Venus International College of Technology, Gandhi Nagar**. The Endurance award, which assesses vehicles ability to operate at a speed over rough terrain, was won by College of Engineering, Pune followed by VIT University, Vellore.

The students walked away not just with the excitement and a sense of accomplishment for having competed in such a testing event, but also a fair amount of prize money as well which was about Rs 27,00,000/-.

Sponsors.

The other sponsors included **ARAI**, **Altair**, **Briggs & Stratton**, **PTC**, **AVL**, **Chevrolet**, **Volvo**, **John Deere**, **Anand Group**, **Bharat Petroleum**, **Cummins**, **GTE**, **Emitec**, **Priya Events**, **Ansys**, **iCAT**, **NATRIP**, **Endurance Landmark**, **IIST**, **Varroc**, **V productions**, **Wurth**, **Xitadel**, **ACMA**, and **Fortune Landmark**.

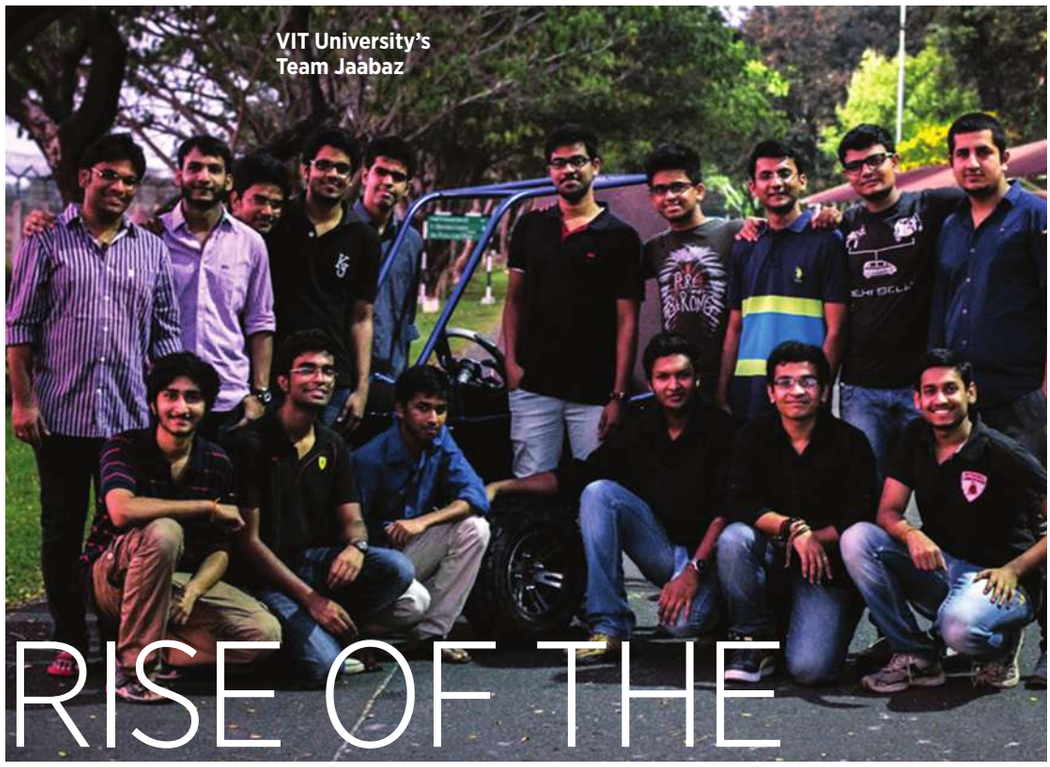
The three-day event started with the basic static evaluation round, which was comprised of design evaluation, cost evaluation, and marketing presentation. In the final round, the teams showcased their prototype of a rugged single seat off-road recreational four-wheel vehicle and were evaluated on various parameters including engineering design, cost, and technology innovation.

The objective of the competition was to simulate real-world engineering design projects and their related challenges. Each team's goal was to create a safe, easily transported, easily maintained, and fun-to-drive prototype without any direct involvement from professional fabricators. However, the teams were free to design their own transmissions with the only restriction being the speed limit to 60 km/h (37 mph).

The dynamic evaluation round tested the vehicles for acceleration, speed, hill climb, and maneuverability. The durability evaluation round saw the vehicles undergo endurance tests. The endurance event assessed each vehicle's ability to operate continuously and at a speed over rough terrain containing obstacles in any weather conditions.

Baja SAEINDIA is currently active on social networking website Facebook and has grabbed the interest of numerous individuals. Since fan base is an integral part of any event, the 8th edition of the Baja SAEINDIA has received more than 70,000 likes.

R. Srinivasa Raghavan, DY. Manager, Projects, SAEINDIA



VIT University's Team Jaabaz

RISE OF THE UNDERDOGS

Problem-plagued effort last year spurs Baja SAE team from VIT University of India to overhaul itself and its car.

This article isn't a thrilling discourse about engineering innovation and game-changing technology. It most definitely isn't a dramatic rags to riches story. Neither is it a satirical piece on the often erroneous experiments that make Baja SAE a fantastic platform for students to learn and thrive in the automotive industry.

Rather, this story is the firsthand account of how a Baja SAE team from India with international ambitions is turning its fortunes around through a complete perspective change, calculated risk-taking and, of course, a touch of luck.

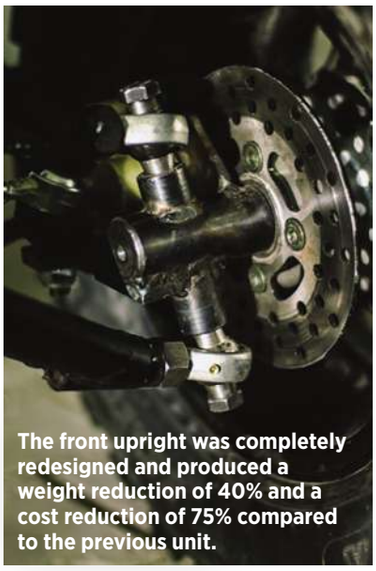
Team Jaabaz is a Baja SAE team at **VIT University** in Vellore, India. Let's jump to 2013, which is when I entered the team. Cash-starved, resource-strapped, and mismanaged, we couldn't really be called a team. We were a project group, albeit of sound technical acumen.

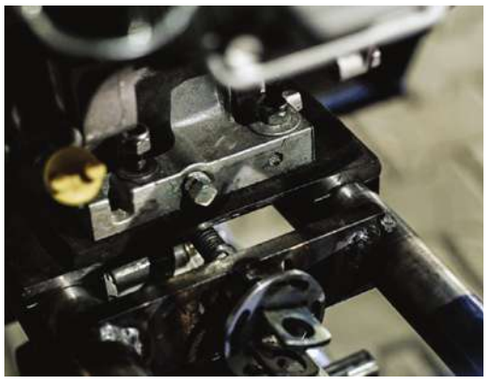
Our 2014 car weighed 595 lb (270 kg), had a manual transmission, and salvaged spring shocks. We had mismatching brake cylinders and, quite honestly, abysmal finish quality. The only reason we were even able to get our car to the track in one piece was because of the relentless support we received from **New Mexico State University**. This was the luck factor.

The wonderful student members of NMSU Baja, and their faculty advisor Kenneth Ruble, accepted our shipment from India, provided us garage space, and gave us material to fix parts that failed when we tested our car in New Mexico. They even stayed up all night during the event to help us fix a major roll-cage issue that had virtually disqualified us from technical inspection. We finished 80th overall. It was more the guilt and shame we felt from having stressed NMSU's hospitality and resources than our rank that made us realize we needed some major

RISE OF THE UNDERDOGS

Team Jaabaz's new car is 155 lb (70 kg) lighter than last year's.


The front upright was completely redesigned and produced a weight reduction of 40% and a cost reduction of 75% compared to the previous unit.


A new screw-driven adjustable engine mount is a key improvement over last year's car.

organizational and operational overhauling—immediately!

After an in-depth analysis of where improvements were needed, we realized that our technical knowledge was sound. Our Achilles' heel was lack of funds. To put things in context, we spend about $8000US purely on shipping our vehicle to the United States and back.

As soon as semester broke in July 2014, I ran an aggressive recruitment campaign at VIT purely to recruit undergraduate engineering students who were interested in marketing and management. I selected eight sophomores based on their communication skills, general awareness of the automotive industry and, most importantly, team-working ability. Then we divided the team into two focus groups, each with a single goal.

I gave each marketing group member the option to choose its own sponsorship target and deadline, within certain limits. I don't know if it was the undivided focus or the independence to choose targets and deadlines that did it, but in the next couple of months sponsor funds started to flow in consistently—and in substantial amounts.

Finally, Team Jaabaz had the freedom to innovate.

This one tremor of change in our financial strategy caused an avalanche of change in our design and manufacturing quality. We began with changing our shock absorbers from standard spring shocks to **Fox** Float 3 air shocks. This reduced the weight of our shock absorbers by about 80%, gave us an infinite range of stiffness adjustment, and eliminated bottoming out. We made the roll cage simpler by using fewer members. The wheel assembly saw many changes.

The rear upper control arm became one single member. This led to very efficient packaging of the transmission and rear suspension. The front upright was completely redesigned and produced a weight reduction of 40% and a cost reduction of 75% compared to the previous unit because the new upright was largely manufactured using lathe and vertical drill. Material was retained along axes only in amounts needed to accommodate expected force transmission levels.

We selected front and rear tires with different tread patterns. A ribbed grooving pattern for the front tires would ensure directional stability, and V-shaped deep grooves for the rear tires would ensure better traction. The front tires were made smaller than the rear to strike a balance between top speed and acceleration. Thus our vehicle dynamics were taken care of. But we weren't satisfied yet—not even close.

We switched from a roof-mounted brake assembly to a floor-mounted unit to improve the driver's field of view. Our "nonidentical twin" master cylinders from 2014 were replaced by a single tandem master cylinder that took up less space. We shifted from an open differential to a limited-slip type for ideal performance.

Heart-wrenchingly, we parted ways with our manual gearbox and brought home a gaged GX9 continuously variable transmission (CVT). Compared to our former unit, the new one more easily adjusts to power needs and increases the ease of driving.

And now the showstopper, which took our design to a whole new parallel. Taking inspiration from the movement of the apron on the lathe bed, we designed, prototyped, and repeated the same to create a power screw-driven adjustable engine mount. Boy, does it work perfectly! This system would make it very easy for us to compensate for any operational changes in the belt length over time and consequent transmission loss.

An interesting fact is that we managed to reduce the weight of our car from last year's by 155 lb (70 kg). Our car for SAE Baja Auburn on April 9-12 is track-ready. Each of the design changes and organizational changes took courage, because the biggest problem a team faces is not talent but resistance to change. We are far from perfect. We are a work in progress, and our future isn't going to be easy. Then again, the only easy day was yesterday. ■

Brejesh G. Aiyer, who is in his fourth year studying mechanical engineering at VIT University, wrote this article for SAE International.

The Solar Impulse 2 design team faced new challenges and trade-offs in designing the plane, including a new design for the fuselage and wings, and using new materials to achieve strict weight objectives. (Solar Impulse)

Testing reality in an increasingly complex DESIGN SPACE

Digital simulation tools have transformed the designing and testing of new aircraft, as well as the way they are manufactured and sustained.

by Richard Gardner

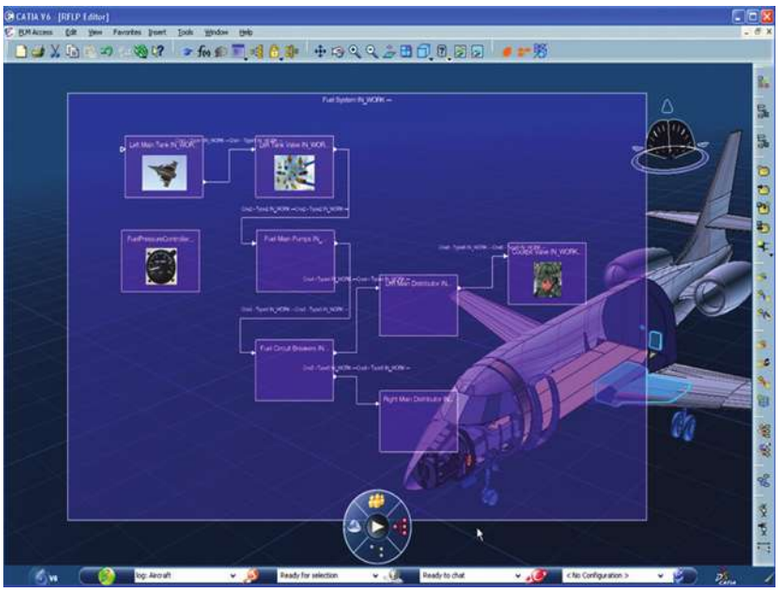
The universal adoption of digital 3D design tools has truly changed forever the way that advanced products are created, from original concept studies, development, testing, and manufacturing, right through the lifecycle to maintainability, future enhancement, and long-term support. The ability to share detailed specifications and test data between all partners worldwide, but with controlled access as required throughout the supply chain, enables large and small suppliers to work to common standards and requirements, maintaining the same data accuracy across the network. This has not only saved valuable time, helping to reduce costs, but has brought about higher standards of product quality and, importantly, more traceability, providing a clear picture for project managers who have access in real time to progress at all levels.

Such has been the rapid rate of progress in all aspects of 3D simulation technology that it is hard to believe that its widespread adoption only dates back to the 1980s. The most commercially successful pioneer of digital design tools, originally known as computer-aided design and computer-aided manufacturing (CAD/CAM), arrived in the form of the CATIA product line, from **Dassault Systèmes**. This was a significant breakthrough technology and enabled the aerospace, defense, and automotive sectors in particular to use digital tools to transform the way new products were designed and made.

Before long the obvious advantages of using CAD/CAM methodologies cascaded into every area of manufacturing, as it reduced much uncertainty in complex manufacturing programs and speeded up the process in an ever-increasing number of specialist activities. Initially it was seen as a way of eliminating the need for huge numbers of detailed design drawings, which then had to be checked before distributing, and which took more time to modify and then re-check.

CATIA Version 3 introduced a 3D design capability in 1986 and by 1994, V4 had introduced the more advanced digital mock-up capability. In 1999 V5 introduced a 3D/product-lifecycle management tool. A decade later,

Testing reality in an increasingly complex
DESIGN SPACE



CATIA Version 6 screen image showing how the operator can access the fuel system in its entirety within a 3D model of the aircraft. (Dassault)

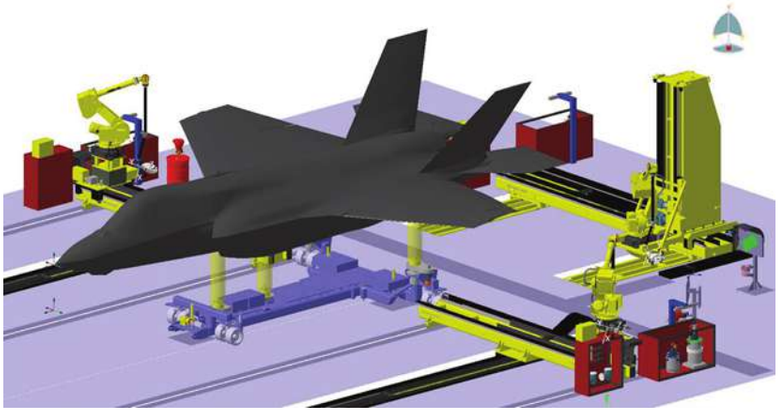


Image of how an assembly workstation or maintenance bay can be configured to support a combat aircraft using advanced 3D simulation tools to test and validate various automated activities on the aircraft line. (Dassault)

V6 introduced the Dassault Systèmes 3DEXPERIENCE platform that has gone on to power brand applications serving 12 industries and a wide portfolio of industry solutions.

Across scope and scale

At the opposite end of the scale from multi-billion dollar civil air transports and military programs is the around-the-world record-breaking solar-powered Solar Impulse airplane, which used the 3DEXPERIENCE platform for design and assembly simulation. This permitted the design team of about 50 project engineers to determine the best configuration to adopt in terms of weight and size and cockpit design, as well as how best to assemble the final design, and even how to transport it safely to the initial take-off location.

This project was very complex, involving a combination of new energy and propulsion systems, with a new lightweight airframe. Each element was designed and tested using simulation techniques, with no physical mock-ups. CATIA was used for designing all the individual parts and for evaluating the assembly before manufacturing took place. Even the plies of the carbon fiber structure were defined and optimized in virtual reality, as were the machined tools used to produce the carbon fiber parts.

All the design, test, and manufacturing data was tracked using the 3DEXPERIENCE platform and thus was easy to validate for total part traceability and certification. Without the ability to design and test the Solar Impulse in this simulated format it would have been impossible to develop the project in an affordable way.

In contrast, the design, development, test, and manufacture of the new **Airbus** A350XWB wide-body jetliner involved around 4000 people on a daily basis, of which 85% were in the supply chain. By adopting the 3DEXPERIENCE platform, and the ENOVIA tool, employees and suppliers were able to collaborate in real time using a unique digital mock up as a common reference. This integrated all necessary data requirements globally and represented a considerable advance over previous digital simulation solutions that comprised many separate elements.

Changes made by the design office were immediately communicated to those in manufacturing, which dramatically reduced the time needed to prepare the tooling for production. A completely new approach to designing the electrical harness installation was just one example of how the overall assembly process and design quality was improved. Engineers were able to perform realistic non-linear analyses using SIMULIA to predict the strength and behavior of the aircraft's structure.

The optimized industrialization of the design for the manufacturing and assembly stage was created using DELMIA. As a result of fully exploiting all these digital tools on the whole A350XWB, it is claimed that the assembly process was reduced by 30%.

Minimizing risk

The task of designing, building, testing, and introducing into service new airplanes has always been a risky business at almost every stage, but especially when introducing new advanced features, as has been seen in recent times with **Boeing**'s 787, Airbus's A380, and **Bombardier**'s C-Series. Attempting to rectify the late discovery of unexpected faults has cost manufacturers dearly in bad publicity, loss of customer confidence, and goodwill, and has also devalued the share price of major partners and their suppliers during the recovery stages.

Cut-away image of an aircraft interior showing how CATIA tools can be used for detailed design. (Dassault)

When problems arise as full-scale production is ramping up, the impact on delivery flow patterns can be enormous. Even using advanced digital design tools does not eliminate all program exposure, especially if the management team underestimates risk factors at key stages during the development and test phases.

The desire to avoid early delays and cost increases by enhancing visibility and traceability through all stages of testing led Dassault to develop Test to Perform, which aims to improve overall integration, verification, and qualification using a single platform that connects all disciplines across the program. Realistic and accurate simulations allow for increased virtual testing throughout the development process, lowering costs compared to physical tests.

A key requirement in keeping a new program on track is the ability to make decisions in a timely manner based on a complete understanding of test results and a correct interpretation of the available data. The Test to Perform solution enables managers to visualize test results in context through a functional digital mock-up that incorporates system behavior and thus tests how functions work with the aid of a more complete, true-to-life design definition. This encourages closer integrated activity between test teams and those in engineering and it gives the whole test community a greater understanding of the test results on which informed decisions can be made.

The overall real-time view of the test activity is comprehensive and performance measures are shared by all. Users automate and execute simulations using high-performance computing systems and manage both the simulations and resulting test data. Using a common collaborative platform reduces the prospect of errors and allows improved performance-based decisions while specifications and compliance with regulations can be met with confidence. The testing of new design concepts at an early stage improves the firmed-up design and shortens the test-cycle process and this in turn speeds up validation.

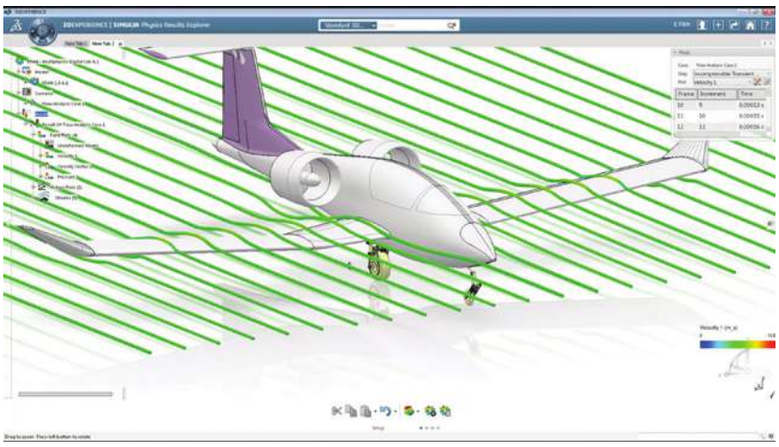
Another advantage of using this solution is that virtual testing can exceed physical test limitations, producing valid data, but at much lower costs and quicker. Using robust digital modelling tools, the likelihood of premature failure is minimized and unforeseen issues can be identified early and corrective changes made and re-tested.

Defending against increasing complexity

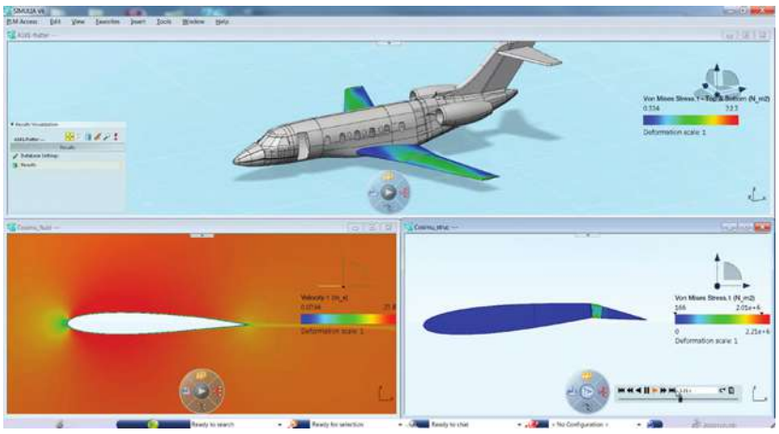
One of the main causes of cost escalation is growing complexity as programs progress. Often this is a reflection of launch customer indecision—requirements and subsequent demands can change as other factors evolve, such as market competition or the availability of new technologies and features on rival designs. If customer suggestions are accepted at an early stage it can enhance the marketability of the product, but further down the design path it becomes more of a challenge to adapt the design without introducing unacceptable extra delays and cost.

New military air programs are even more prone to customer interference during the development stage. Electronic systems develop faster than the airframes in which they are carried, and typically can offer major improvements in performance every five years, compared

Testing reality in an increasingly complex DESIGN SPACE



3DEXPERIENCE/SIMULIA physics results explorer showing virtual tests being undertaken on the Airbus E-Fan electrically powered light aircraft design. (Dassault)



A computer screen image showing flutter simulation multiphysics representation with Fluid Structure Interaction on a computer model of a business jet. (Dassault)

to aircraft enhancements improving perhaps only marginally, every 10-15 years.

As an all-new military air platform can take up to 20 years to reach service, it has become essential to incorporate a systems architecture that will allow for capabilities to be upgraded at regular intervals. Combat air programs are prime examples of where cost escalation due to underestimated system complexity can threaten termination, or procurement reductions, and so the need to break this damaging spiral is more important than ever if future programs are to remain affordable and deliverable within a realistic timescale.

Dassault has identified reducing complexity in program management as an important goal in helping companies lower both non-recurring and recurring program costs. The required efficiencies include shortening the design time and introducing simplified manufacturing with, for example, fewer component and structural parts. But cutting a swath through the labyrinth of conventional multi-level design reviews and audits and replacing these arrangements with a coordinated enabling, transparent, integrated digital solution represents a very necessary measure to retain a firm grip on the wider program.

In conjunction with Dassault's 3DEXPERIENCE platform and Co-Design to Target solution, stakeholders can stay appraised of a program's status in real time so that any emerging issues can be seen and addressed at the earliest possible stage. This solution integrates all the engineering works-in-progress with contracts management, program controls, systems engineering, design engineering, configuration management, data management, and subcontracts administration.

The view into the program is always current, promoting a smoother manufacturing ramp up and more efficient production.

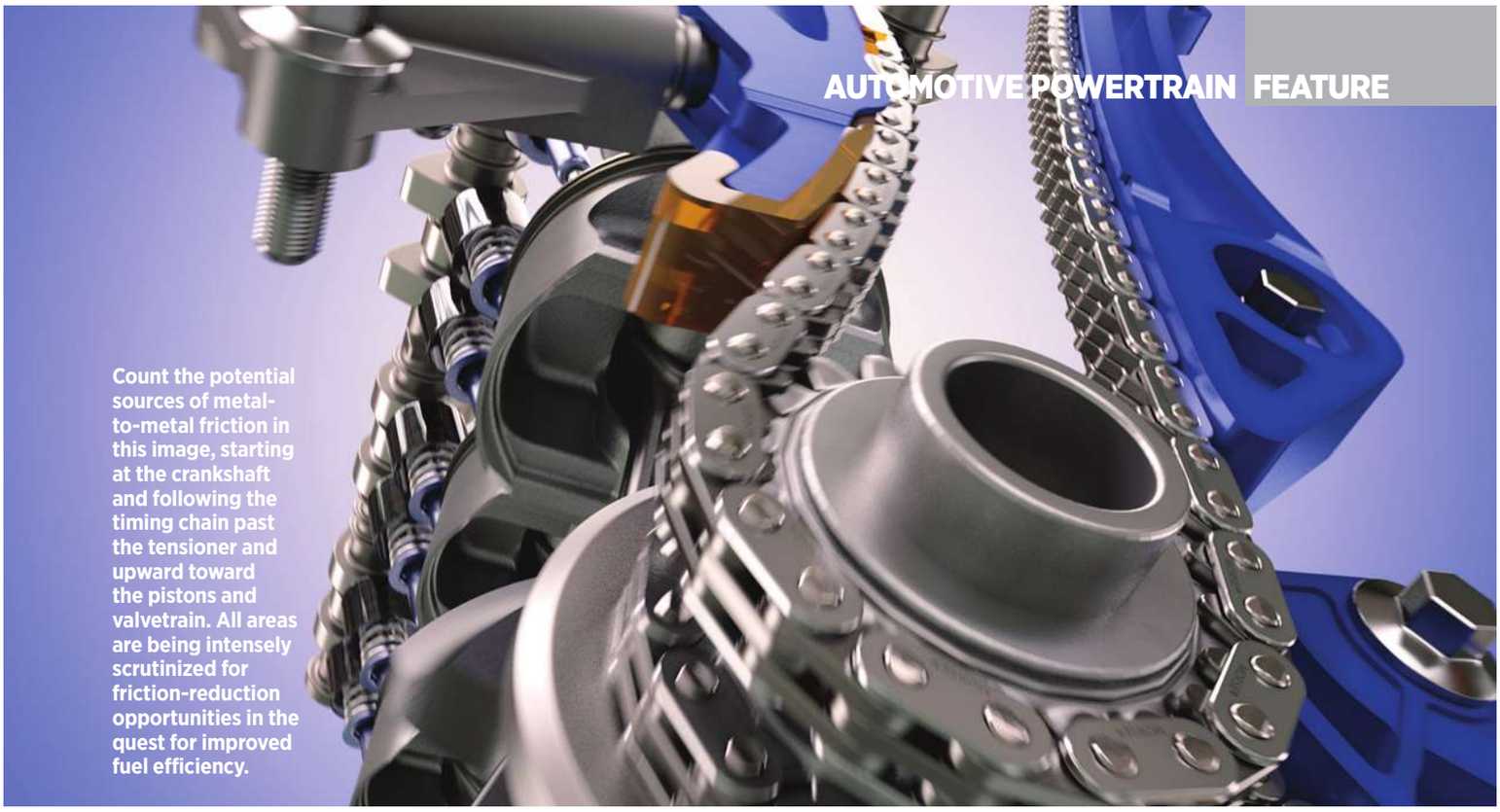
Optimized excellence

There is no reason today why optimized excellence can't be designed into an aircraft, minimizing the need for re-designs and ensuring the platform will stay on schedule and then have a lengthy lifespan. Co-Design to Target integrates "value streams" to help reduce complexity in the product-development process. This has been needed ever since programs, notably international ones, started to draw in more and more people, at many different locations, in product definition leading to detailed design.

The process involves many thousands of specifications being cascaded through the supply chain covering systems, sub-systems, and components, as well as the activity in the primes. By adopting a leaner development approach, teams collaborate and converge quicker on detailed definition at every level. By using a behavioral digital mock-up, engineering architects can define systems installation and then exhaustively validate the associated installation architecture early on.

Using requirements-based 3D design can ensure that any installation conflicts are avoided completely and can be used for early system and network checks. Multi-disciplinary simulations help reach performance targets and bring forward product maturity to specification. This can make a real difference to keeping delays and cost increases at bay during the early stages of a program, which reduces the likelihood of having to make penalty payments to delayed customers.

Delivering promised product performance and high reliability is still at the heart of customer expectations. Minimizing development risks and maximizing profitability by seeking ever-greater efficiencies requires companies throughout the aerospace sector to embrace new processes and methodologies enabled by new transformational technologies. Exploiting the latest advanced digital simulation products and services shows a better way of achieving these goals. ■



Count the potential sources of metal-to-metal friction in this image, starting at the crankshaft and following the timing chain past the tensioner and upward toward the pistons and valvetrain. All areas are being intensely scrutinized for friction-reduction opportunities in the quest for improved fuel efficiency.

SLICK SOLUTIONS FOR friction reduction

Suppliers and engine designers are attacking every potential source of internal friction—no longer a "low-hanging fruit"—as the battle to squeeze more mechanical work from less fuel intensifies.

by Lindsay Brooke

Reducing internal friction has always been a priority of powertrain designers, but recently the subject has taken on greater urgency in the crunch to meet tough new global CO_2 regulations. In piston engines, friction loss rises with the square of rpm, which is one reason OEMs are "downspeeding" their new engine families. And with their key suppliers, they're digging deeper to find cost-effective solutions to this century-old challenge—from "rollerizing" camshafts to optimizing lubrication schemes, to new gas-cushion shaft seals, to decoupling front-end drive systems. New materials and surface coatings are also enablers.

"We looked across the entire propulsion system to find places we could reduce spin and drag losses and minimize internal friction," said Tim Grewe, **GM**'s General Director of Vehicle Electrification, speaking to *Automotive Engineering* about the 2016 **Chevrolet** Volt. "This is a major area of focus in vehicle development at GM and the industry going forward."

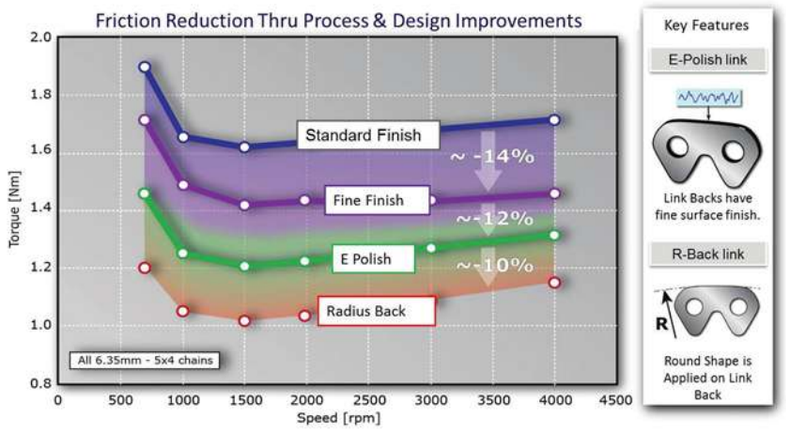
Noted Dave Kehr, Manager of Valvetrain Systems at **Schaeffler Group**: "We've seen a big increase in the OEMs' scrutiny of parasitic losses, particularly on the engine side. What used to be accepted as normal wear between contact surfaces is now seen as opportunity to reduce parasitic loss due to friction. So we're getting into the minutiae of where that wear is coming from."

Much of the "low-hanging fruit" in this area has been picked in recent years, Kehr said: "Now we're reaching higher to find solutions for increasing internal efficiencies." His boss Don Haefner, who leads Schaeffler's U.S. valvetrain development group, explained that the most significant reductions in engine friction begin with the base architecture.

"There's been a move away from the higher-friction valvetrains," Haefner noted, "such as the so-called Type 1 direct-acting bucket tappet system. It used to be popular due to its superior high-rpm dynamics. We still sell a lot of Type 1 tappet systems, but they also tend to be pretty high in friction. So the industry has been moving to the end-pivoted, roller-finger-follower Type 2 system" that he said offers reduced friction.

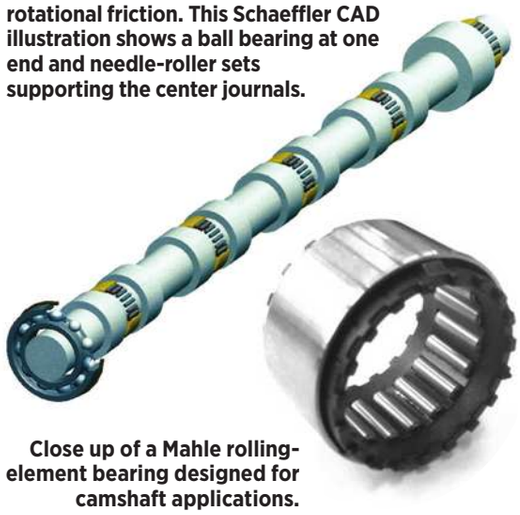
SLICK SOLUTIONS FOR

friction reduction



Improving drive chain efficiency is a science at BorgWarner (source of this chart) as well as other suppliers of timing and transmission-drive systems.

Camshaft suppliers have been receiving heightened interest from OEMs for cams supported by needle-roller and ball bearings, as they seek to reduce rotational friction. This Schaeffler CAD illustration shows a ball bearing at one end and needle-roller sets supporting the center journals.



Close up of a Mahle rolling-element bearing designed for camshaft applications.

Improved surface finishing such as superpolishing can further decrease valvetrain friction by as much as 20% compared with a Type-1 system with ground contact faces, engineers report. "And when a coating is added to a polished bucket tappet, valvetrain friction can be reduced at certain operating conditions by up to 50% vs. the standard unit," added Allen Hale, Schaeffler's Senior Product Development Engineer for Valvetrains and Engine Bearings.

New coating technologies represent a more significant potential improvement going forward, Hale said, compared with the incremental gains of new surface-finish processes. The challenge, of course, is to make them cost effective at automotive volumes. "The customer drives those decisions, to determine if there's enough bang for the buck," Hale explained.

Cutting chain friction link by link

To spin a pair of overhead camshafts requires drive systems whose increasingly sophisticated designs help wage war on friction. "The sprockets, chain, and tensioner are a complete system and if you do not optimize all components equally you'll have a less efficient engine in the end," explained Tim White, Senior Development Engineer, Chain Products, at **BorgWarner.**

White's team is focused on producing improved link geometries that will reduce friction on contact surfaces across the powertrain chain-drive landscape, including engine timing, CVT transmissions, and the MorseTEC chains used in 4WD transfer cases.

"We're reducing the number of [chain] pitches that actually make contact with the friction surfaces," he said. His team uses proprietary tools to simulate and analyze not only tooth profiles and the link-to-tooth and link-to-link mechanical friction, but also that which occurs within the pin, rocker, and sideplate interfaces.

"By reducing the mass we reduce the size of the system while maintaining the same strength—the result is not only lighter but also gives a better torque-to-turn product," he said.

Keeping pace with the OEMs' shorter and faster development cycles pushes innovation. White noted introduction of a new hydraulic-tensioner technology that he claimed improves timing-drive efficiency by up to 25%. Surface coatings also are playing a greater role at BorgWarner which recently introduced into production a stainless-steel nitride finish that was designed to reduce wear but also could help improve system efficiency.

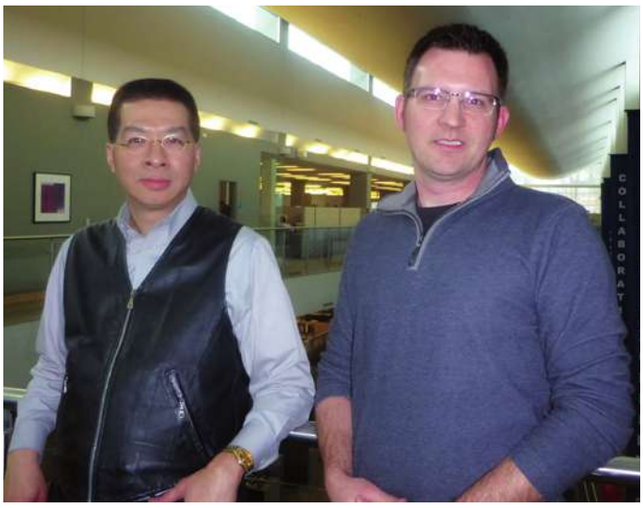
"We think it could potentially allow us to retune the [timing drive] system so it doesn't have to accommodate such a large range of chain wear," White noted, "therefore improving the initial efficiency over the life of the product."

On the transmission side, "it's not just reducing friction losses but balancing it with high torque capacity and heat resistance for durability and lower oil flow for internal efficiency," explained Robert Lam, Director of Friction Products. "We talk about the temperature at the interface; once you improve the friction loss at the friction interface the temperatures get higher and higher, so how do you survive? That's the main challenge for us."

Lam outlined a new friction-materials family called BW6900 based on a nanofiber blend that is designed to complement the industry's use of "smart" oil pumps that deliver specific quantities of lubrication when and where it's needed, for the purpose of reducing fluid drag. The patented design is called Active Friction Plate Separation, which uses two types of friction material bonded on one friction plate. One material is more elastic than the other and sits 0.05 mm (0.0019 in) higher on the plate.

"This allows us to control how much oil can go in at one time because the applied pressure is occurring at different times," Lam explained. "The two materials differ in their compressibility, so that under a certain pressure only one material is in contact with the plate. That enables us to control how much oil is on the surface."

The two step lining concept uses both a basic friction material and a second very elastic material, bonded to a different height. When the clutch is open the elastic lining element with the additional height of 0.05 mm (0.0019 in) causes an "active separation" process that prevents any suction between the friction and separator surfaces. This reduces



Engineers Robert Lam (left) and Tim White are on an anti-friction mission at BorgWarner. Lam's in Friction Materials and White's a Chain Systems expert. (Image by Erika Neilsen)

the hydrodynamic peak in height and width.

The BW6910 material is designed for wet-starting clutches, torque-converter lock up, torque-transfer units and hybrid disconnecting clutches. "We used CFD models to simulate viscous or drag losses which is related to friction losses," he noted. "We incorporated the various geometries, the friction material, and operating conditions and run the CFD to get an idea how the oil is distributed and dissipated and how it affects drag loss. Of course we also had to do experiments to verify it case by case, but our working CFD model guides us for the theoretical basis of our designs."

Boring in on piston ring stress

Piston rings are responsible for most (up to 24%) of an ICE's internal friction, experts noted, with the oil-scraper ring contributing up to 70% of the total ring-pack friction. Reducing ring-to-bore friction while maintaining sealing and durability performance, and scaling the other components to the new operating-rpm parameters, is an ongoing strategy to reduce fuel consumption.

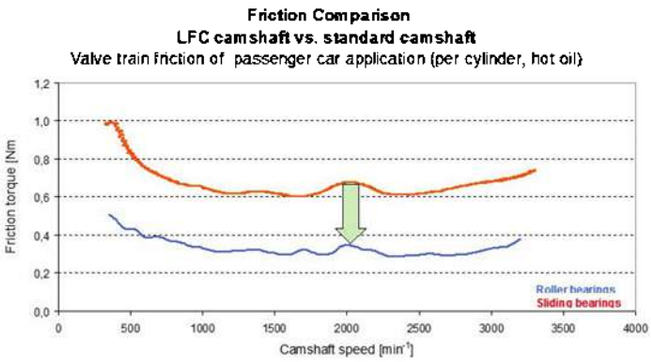
Friction reduction focus for June webcast

Facing the super-stringent U.S. CO_2 emission requirements for 2020 to 2025, powertrain engineers need to squeeze every last fraction of a gram of CO_2 per kilometer (and mile-per-gallon) of efficiency out of new engines, transmissions, and drivelines. Reducing internal friction on rotating and reciprocating components, and across systems, is no longer an exercise in plucking low-hanging fruit. Rather, it's now a major design and engineering focus. New technology solutions are appearing as a result.

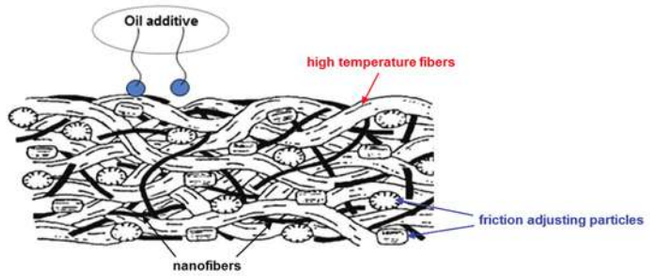
On June 11 the editors of *Automotive Engineering* will host a special technical webcast on the topic of "Friction Reduction." During this free 60-min webcast, participants will hear representatives from key technology supplier companies discuss the latest in low-friction mechanical components including bearings and seals, coatings, lubricants, and other advances. They'll provide insights into development challenges, systems engineering, as well as application opportunities for the future.

Webcast attendees will be invited to interact with the experts during a Q&A segment.

Visit www.sae.org/webcasts for more information and to register.



Mahle-supplied data showing low-friction (roller bearing) camshaft friction versus that of a plain-bearing cam.



BorgWarner's new family of friction material for clutches features a blend of nanofibers.

"Our testing has shown that by optimizing the piston structure and skirt profile can be worth about 0.5 g CO_2/km reduction on the NEDC cycle; and optimizing the entire ring pack could add up to a 2% fuel-consumption reduction, depending on the baseline," Mahle piston technology expert Steve Sytsma told *Automotive Engineering*.

Ring stress is the load that the ring exerts against the cylinder wall to seal it during the combustion cycle and scrape off the oil. It has a significant effect on total engine friction. Sytsma noted that while the latest downsized gasoline engines have a total ring stress of about 0.6 to 0.7 N/mm, **Mahle** offers a new, two-piece "X-taper" oil control ring that reduces load on the scraper ring by about 50% (and on the ring pack by up to 0.25 N/mm), while maintaining its scraping effectiveness.

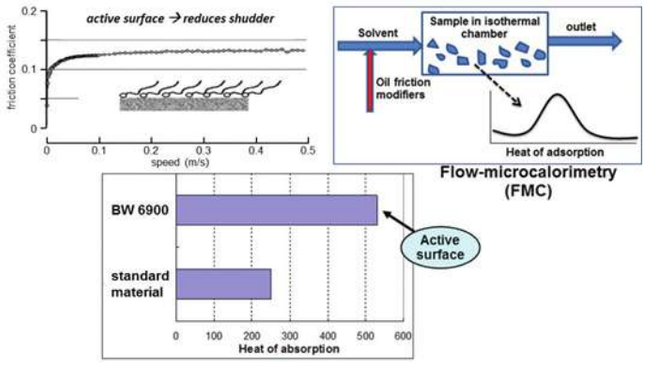
What remains of the increasingly abbreviated piston skirts going forward will feature embedded low-friction coatings; **Hyundai** has developed a new type of PTFE (polytetrafluoroethylene) coating that includes nano-sized composite. Mahle now uses a chromium-nitride PVD (physical vapor deposition) coating on the oil control ring, which also increases service life, engineers claim.

Roller-bearing promises

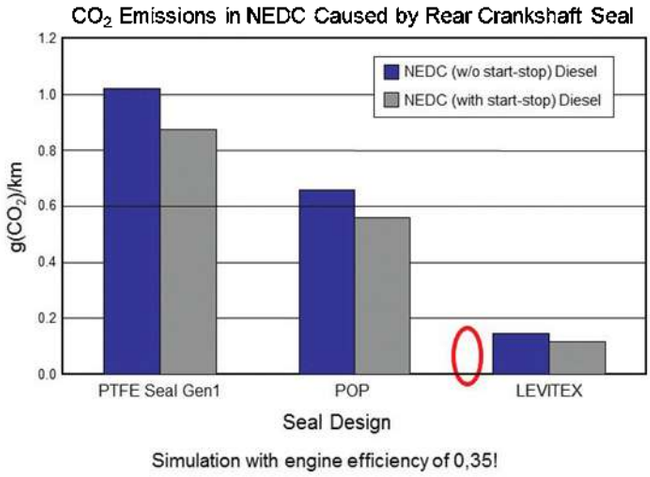
Plain bearings have handled the lion's share of engine bearing applications for decades, their low cost and durability proven up to and beyond the 3000 hours that automobile engines typically run.

But bearing suppliers such as **INA** and **FAG** (part of Schaeffler Group) are seeing "a lot of interest in 'rollerizing' the camshaft"—supporting it with needle and or ball bearings in the cylinder head, noted Hale. Roller bearings don't

SLICK SOLUTIONS FOR
friction reduction



Performance details of BorgWarner's new BW6900 nanofiber-based friction material family.



Freudenberg-NOK's new Levitex seal technology is currently under evaluation at three OEMs with production planned for 2017-2020.

require a pressurized oil feed, allowing engineers to downsize the oil pump and reduce parasitic losses.

Recently **Volvo** and **Jaguar Land Rover** have adopted rolling-element bearings for the camshafts in their latest turbocharged gasoline engine families (see http://articles.sae.org/13353/). GM quietly adopted roller-bearing cams in its 2.0-L DOHC diesel introduced by **Opel** in 2011. Others are expected to follow.

"For just the components themselves, swapping out plain bearings for roller bearings can yield up to a 50% improvement in valvetrain friction," Hale explained. "A lot of that greater efficiency occurs at colder temps which is important because the industry's switching to stop-start systems."

Powertrain engineers across the industry have told *Automotive Engineering* that they're investigating rollerized camshafts. But they also note a caveat: increased operating noise.

The Opel diesel wasn't in production long before customers and media testers complained about excessive mechanical noise. A GM engineer familiar with the program said the engine was replaced in late 2014 with a new 2.0-L unit featuring a plain-bearing camshaft.

Some OEMs are converting just the No. 1 camshaft bearing (which handles most of the load) to ball bearings, which provide good radial and axial load capacity.

Schaeffler engineers (from left) Allen Hale, Dave Kehr, and Don Haeffner see numerous opportunities to reduce friction in valvetrain systems via architecture changes, coatings, superfinishing processes, and rolling-element bearings.

Sublime sealing solutions

Engine seals such as those used at the crankshaft-to-block and front cover interfaces, have the dual responsibility of ensuring lubricant remains on the inside of the engine, while minimizing friction on the shaft ends as they spin.

A broad array of PTFE and elastomeric lay-down lip-type seals are featured in the **Freudenberg-NOK** product portfolio known as LESS—low-emission sealing solutions. But the technology that has Senior VP of Technology Luis Lorenzo excited the most is currently being evaluated by OEMs.

"It's a new gas-lubricated seal we call Levitex," Lorenzo said. "The concept has two metallic races. When the two parts don't rotate—that is, the axle doesn't rotate in respect to the bore—the two faces are in contact when the rotation starts and when it passes through a critical rotational speed, one of the races moves away from the other race. This creates an air cushion that establishes itself between the two races. And you don't have anything but the friction of the races with the air."

He said the technology originated at Freudenberg's **Eagle Burgmann** affiliate that specializes in seals for high velocity turbines and other high-precision industrial applications. "Because of that, they're very high cost," Lorenzo admits. "What we've done is look at the technology, understand how it works, and translate that into lower cost manufacturing options that allow us to replicate the functionality but at a fraction of the total cost."

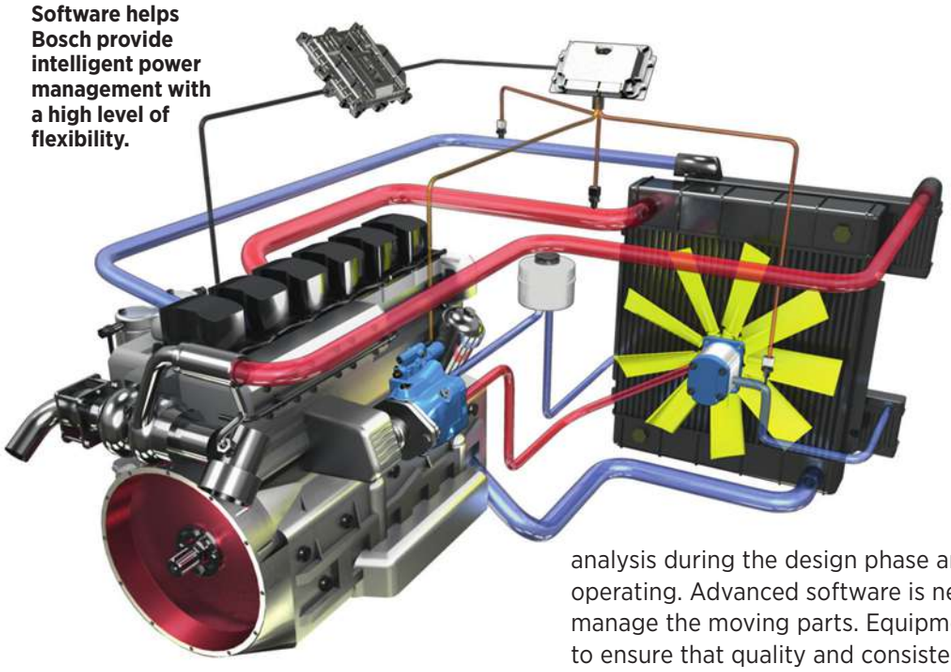
Freudenberg currently has Levitex seals in evaluation at three OEMs. Compared with optimized PTFE seals the Levitex items can save 0.5 g of CO_2 per seal—offering up to 90% friction reduction per engine compared with current production seals, Lorenzo claimed. First applications will likely be on the crankshaft. The seal is designed as a system with the rear engine cover including the [crank-angle] sensor encoder. Lorenzo revealed that Freudenberg is quoting three engines at three different OEMs, with SOP targeted for 2017 to 2020.

"The company that ran the simulations for us was so surprised at how low-friction the Levitex seals are," he said. "They ran the engine with no seals—no friction between the bore and the shaft—and found the friction in the Levitex seals is just a fraction greater than that of an engine using no seals at all. It's truly significant." ■

HYDRAULICS still in control of off-highway needs

Engineers continue to master electronic controllers and software to help systems manage engine speeds and boost efficiency to the ultimate benefit of both OEMs and end users.

by Terry Costlow



Software helps Bosch provide intelligent power management with a high level of flexibility.

Electrohydraulic controls continue to evolve rapidly, helping OEMS improve fuel efficiency and performance while also enhancing safety. Developers are tightening integration with engines, altering pump, valve, and networking schemes while also designing systems that meet functional safety requirements.

Forging tighter links between the engine and hydraulics is a dominant trend. More electrohydraulic controllers are communicating with engines to increase efficiency and meet Tier 4 emissions and fuel consumption requirements.

"We're seeing more powerful onboard controllers and more I/Os that let the ECU more closely control power management, anticipating stalls and communicating with the engine and hydrostatic transmissions to ensure that everything's operating at the highest efficiency level," said Kevin Lingenfelter, Senior Advanced Systems Engineer at **Danfoss Power Solutions**.

There are benefits beyond increased efficiency. However, the gains require plenty of analysis during the design phase and lots of communication while operating. Advanced software is needed to analyze conditions and manage the moving parts. Equipment suppliers try to reuse software to ensure that quality and consistency are maintained.

"Depending on the design of the equipment and its operation, IPM (intelligent power management) may be realized in a myriad of ways, which requires flexibility," said David Eckerd, Product Management Director for Mobile Electronics, **Bosch Rexroth**. "This is realized by special software developed for the electrohydraulic ECU, which is easily configurable for the equipment to which it is applied."

Engines typically have an optimal operating spot, so coordinating hydraulics and engines can ensure the best system performance. Hitting this sweet spot can be easier when engine suppliers and hydraulic developers work closely together.

"This can be a delicate balance, protecting sensitive intellectual property of the components while sharing enough information to optimize system operation," said Steve Zumbusch, Advanced Platform Systems Engineering Director, Hydraulics, **Eaton**. "One example where we are seeing success is where Eaton is collaborating with an engine manufacturer on a mechanical transmission to develop improved shifting and driving capabilities."

Developers are also revising the designs of pumps to help maximize the joint efforts of electrohydraulic and engine controllers. When there's a valve command, the pump has to produce a certain flow to meet that demand. If that demand can be met at a lower engine speed, the engine can be slowed down.

"If the pump operates at a slower speed, it needs a higher angle to meet that demand request, which also lets the pump run more efficiently," Lingenfelter said. "We added an angle sensor to the pump so the ECU knows the exact displacement of the pump."

HYDRAULICS
still in control of
off-highway needs

Bus loading is one of the concerns for Parker Hannifin.

When Danfoss controllers communicate with engines, both stalls and fuel consumption are less common.

Network news

Though engine and hydraulic controllers work together, there's little interest in merging them into a single controller. Integration isn't a huge goal for off-highway developers, who mostly use separate controllers for engines and transmissions. Gaining the flexibly offered by dedicated controllers highlights the need for an overall system view.

"Complete hydraulic system solutions can often be better accomplished with their own controllers, but all the controllers on the machine need to communicate with the engine and supervisory controllers," Zumbusch said. "Machines can have two, three, or even more controllers, but they need to work well together to provide the needed machine control, productivity and efficiency."

SAE J1939, a specialized version of CAN, is widely used by engine and electrohydraulic controller manufacturers, simplifying integration. However, the volume of data being sent by increasingly sophisticated controllers is forcing engineers to devise ways to boost bandwidth.

"The use of CAN data has driven up the amount of data on the CAN bus, resulting in more concern about bus loading," said Kirk Lola, Business Development Manager at **Parker Hannifin**'s Electronic Controls Division. "One approach to help manage this bus loading is to use gateways and multi-master systems. This allows the control system designer to support multiple CAN buses on the vehicle and limit the amount of data that is sent on each bus. Multi-master systems can be much more complex than single master systems, so more design thought has to be put into how the control logic is split between the various masters on the system."

This additional bandwidth makes it easier

Hydraulics expands its scope

Hydraulic technologies are broadening their role, cooling engines, shifting gears, and challenging electric hybrid systems. Advanced controls and sensors are key elements of systems designed to improve productivity and fuel efficiency.

Dana recently started supplying field test versions of its Spicer PowerBoost hydraulic-hybrid system, noting that it can yield fuel savings of over 20% for a front-end loader and over 25% on a telescopic boom handler.

"The PowerBoost hub has a very specific hydraulic design and control electronics," said Giulio Ornella, Advanced Engineering Manager for Dana Off-Highway Driveline Technologies. "Its unique mechatronic design is capable of providing high-flow, high-pressure dynamic performance through an integrated design that is engineered to reduce packaging on the vehicle. The integration of the hydraulic system and ECU then becomes the key for optimizing performance."

Eaton is offering an alternative to electric hybrids, contending that hydraulics can be more efficient given the power levels needed in many off-highway applications.

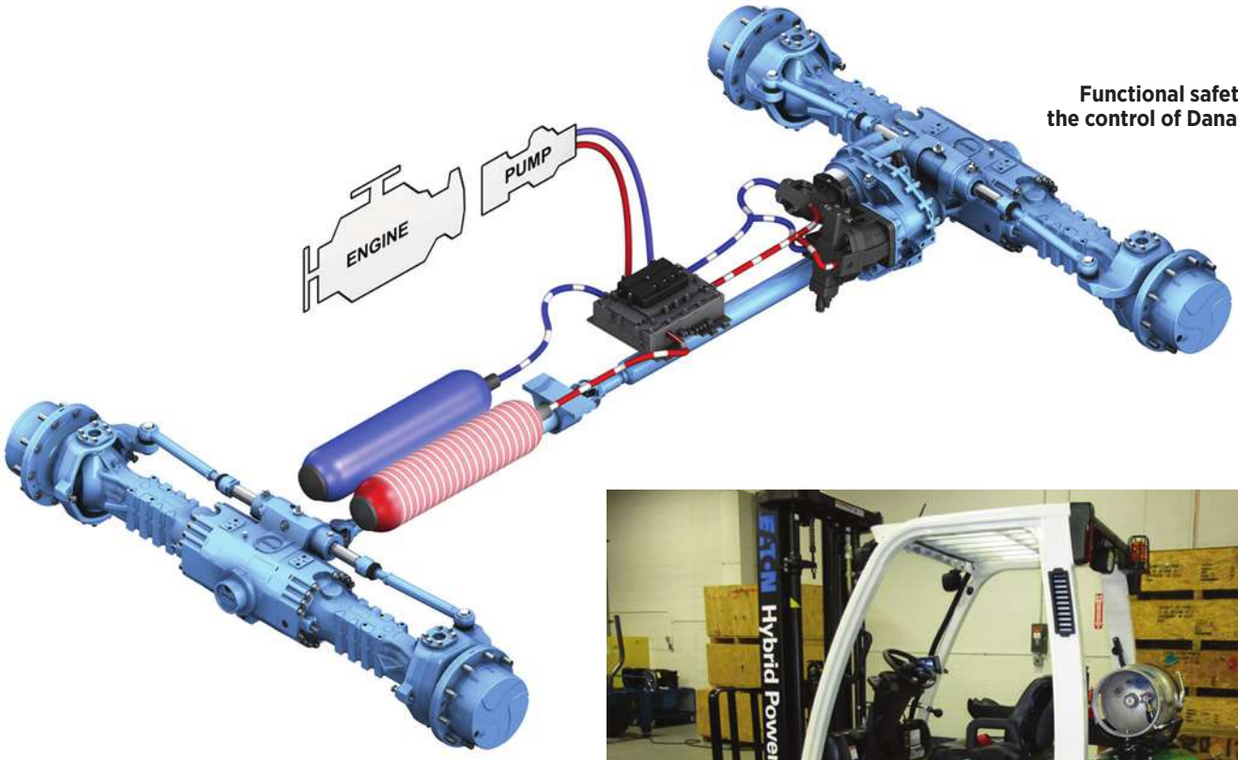
"Our testing has shown fuel efficiency increases of 20-40% with hydraulic hybrid technology, significant savings that can help pay for large machines," said Steve Zumbusch, Advanced Platform Systems Engineering Director, Hydraulics, at Eaton "In excavator testing, fuel efficiency can be improved by 20% and productivity improved by 12% using hydraulic hybrid technologies. On a lift truck, tests have shown fuel efficiency increases of up to 45%."

Hydraulics are also saving fuel by improving fan efficiency. Unlike constant-speed belt driven fans, hydraulic fans can run at variable speeds in response to engine cooling needs. That's helping some equipment makers meet Tier 4 requirements.

Parker's hydraulic fan controller adjusts speed for temperature conditions, conserving energy.

"Since the cooling load is most likely different from the engine load, the ability to drive the fan independent of engine speed is crucial to maintaining the correct engine coolant temperatures," said Kirk Lola, Business Development Manager at **Parker** Hannifin's Electronic Controls Division. "Parker's CM0711 controller has been used as an effective fan drive controller as it provides two CAN ports for J1939 data, as well as analog inputs for temperature sensors and PWM outputs to drive the hydraulic valves in the fan drive system."

Terry Costlow



Functional safety is critical for the control of Dana's PowerBoost transmission.

to link all the controllers scattered around the vehicle. That's becoming more important as microcontrollers are embedded into more pumps and valves.

"All the valves can communicate with all of the controllers and other valves, as well as the engine, transmission, and any other components on the bus," Lingenfelter said. "It's helpful for advanced machine management and control to be able to get the same data to multiple controllers. As equipment uses more networking, it opens the doors to letting systems do exactly what the operator wants, nothing more, nothing less."

Safe and sane

Safety is becoming one of the foremost challenges for controls developers. Functional safety requirements are transforming design programs, especially for machines built for European markets. Engineers are devising techniques that let hydraulic functions fail in ways that don't put people in danger or damage the machine. Meeting those requirements is no simple task.

"The impact of functional safety requirements can be significant," said Giulio Ornella, Advanced Engineering Manager for **Dana** Off-Highway Driveline Technologies. "These include hardware requirements like redundant I/O, ECU quality mean-time-to-failure assessment, and software development with respect to safety

Using Eaton's hydraulic hybrid technology can increase lift truck fuel consumption nearly 50%.

functions development. Moreover, a second watchdog controller also needs to be present nowadays to achieve the required safety integrity level for numerous safety-relevant applications."

One bright spot is that the safety requirements are driven by standards such as ISO 13849 and IEC 61508. These specifications set varying safety integrity levels (SIL) for systems based on the potential for causing injury or severe damage. When electrohydraulic suppliers certify controls, OEMs can more easily merge them into their design plans.

"Machine designers can use the certification and reliability data for our IQAN MC3 controller to help them design a SIL-compliant machine," Lola said. "This also allows the machine designer to consider not only the probability of a failure, but also what fault conditions need to be monitored, and in some cases redundancy needs to be designed in."

Redundancy is a central aspect of functional safety. Eliminating single points of failure is an important requirement that can often be met with fault-tolerant designs.

"SIL-compliant architectures ensure that components continue to function, even if part of the machine or component is damaged," Zumbusch said. "These redundancies are seen on sensors and control architectures—and as they become more advanced, there is increasing need for machine OEMs and component suppliers to work together to ensure optimal machine builds." ■

Global VEHICLES

Next-gen NSX: a twin-turbo, multi-material Ferrari-fighter

Development of the next-generation Acura NSX involved three years of intensive effort by a global design and engineering team led by engineers at Honda's development center in Raymond, OH.

Three years removed from its concept-design debut, the **Acura** NSX supercar took to the 2015 North American International Auto Show (NAIAS) stage once more, this time in its production form. While recognizable as that concept's progeny, the next-generation 2016 NSX revealed this January in Detroit has evolved over its 36-month development program.

The Ohio-based, American-led R&D team for the new NSX, with Ted Klaus, Chief Engineer and Global Development Leader, at the helm, has made design and engineering decisions both big and small—but none insignificant—every step of the way.

Perhaps the biggest of these decisions, inevitably making exterior design changes necessary as well, was to abandon the initially planned naturally aspirated V6 engine for a power plant with more "growl." Which is something the new $150,000+ supercar will need plenty of to compete against what Klaus considers its key competitors: the **Porsche** 911 Turbo, **Audi** R8 V10, and "looking up toward" the **Ferrari** 458 Italia.

Revising the powertrain on the fly

"Some of you may recall [the] blue NSX Concept that lapped Mid-Ohio before the start of the Indy Car race in August of 2013. This prototype was powered by a transverse-mounted, normally aspirated V6. It was a good powertrain, but for NSX good is not good enough," Klaus explained after the production NSX rolled onto the Detroit stage.

"So, in the middle of development, we made a bold decision to create an all-new longitudinally mounted, twin-turbocharged V6. Changing the powertrain design and layout was *not* an easy task—it was like undergoing a heart transplant while running a marathon. But 10 seconds behind the wheel, and you will understand how this new power unit is one of the keys to delivering a 'new sports experience.'"

The mid-mounted, 75° DOHC V6 engine (Klaus would not reveal the displacement) employs a "race-inspired" compact valvetrain and dry-sump lubrication system to help lower the center of gravity. It is paired with a new nine-speed dual clutch transmission (DCT) "of our own design," stated Klaus. The unit houses an electric motor that helps directly drive the rear wheels, to support acceleration, braking, and transmission shifting performance. Twin electric motors in front provide instantaneous torque delivery and dynamic torque vectoring. The Sport Hybrid system is said to generate "north of 550 hp."

"It will run on electric alone for short periods of time," said Klaus. "It is not a heavy plug-in hybrid...We have just the right amount of electric capacity to support the driver when they're demanding it but also to quickly recover energy from the brakes. It's a very lightweight, high-performance [system]—much closer to an F1 type."

While vehicle development was led by **Honda** R&D Americas, engineering of the sport-hybrid power unit was executed in Japan, Klaus shared. "We were interdependent; we're a global team," he said. "The engine will be built in America at Anna [Ohio]. It's all about leveraging our global capabilities—certainly in Japan, in Europe just refining the product, and in America, we've integrated everything. And also working with our global suppliers and bringing on new suppliers." (Supplier information will be released at a later date, Klaus said.)

Key powertrain components including the Sport Hybrid battery pack and power control unit were optimally placed to concentrate vehicle mass low and toward the center of the vehicle.

"The combination of its lightweight chassis and low-mounted Sport Hybrid power unit, give the NSX the lowest center of gravity in its class," Klaus claims.

The NSX features a fully independent, all-aluminum front and rear suspension, riding on **Continental** ContiSportContact high-performance tires—245/35Z R19 front and 295/30Z R20 rear—with 19- x 8.5-in front and 20- x 11-in rear aluminum alloy wheels. Six-piston front and four-piston rear monoblock calipers and carbon-ceramic brake discs bring the supercar to a stop.

Sport Hybrid Super-Handling All Wheel Drive (Sport Hybrid SH-AWD) enhances stability, control, and launch performance while providing quicker response to driver inputs for steering, braking, and throttle. Agile Handling Assist (AHA) subtly applies brake torque to further enhance yaw response and dynamic stability.

The NSX's dial-operated Integrated Dynamic System (IDS) features four modes—Quiet, Sport, Sport+, and Track—plus a "launch" function. The system

Outward visibility and straightforward interfaces were priorities for the interior design team.

"The first NSX meant this, and the new NSX means this—the product to unleash the passion, the talents of our entire company. So inside of this [car] you have dreams realized in a very concrete way," said the man who led global development of the supercar, Ted Klaus. (Ryan Gehm)

adjusts engine, motor, transmission, and chassis response accordingly, as well as the engine sound level. Quiet mode enables electric-only driving at lower speeds. Dynamic vehicle responses become "increasingly sharp" moving from Sport to Sport+ to Track.

"These guys are real time developing the car," Michelle Christensen, NSX Exterior Design Project Leader, said at NAIAS in January. "We're still taking it on the track, but can get rid of that camo a little bit now."

Aerodynamic sans active elements

To accommodate the new longitudinally mounted twin-turbo V6 and nine-speed DCT, the production NSX is longer—by 3.2 in (80 mm)—and wider—by 1 in (25 mm)—than the NSX Concept shown in 2012. (See table for dimensions comparison between new NSX, the concept, and 2005 NSX.)

A slightly more cab-forward package also stems from the powertrain change, according to Christensen, who is based in the Torrance, CA, Acura design studio.

"Closely. Daily," Christensen said when asked how closely she worked with engineering on the exterior design of the vehicle. "I'm in the Torrance office and our engineers are in Ohio, but [we had] daily communication and I would fly out to Ohio for a week at a time."

The exterior body design was sculpted with "total airflow management" in mind, for optimum downforce and vehicle systems cooling—all with no active aerodynamic elements "because we wanted it to be pure and not add any extra gear and weight that we didn't really need," Christensen said. She gave *Automotive Engineering* a vehicle walk-around on the Detroit show floor, pointing out the many aero features and design changes.

"Compared to the 2012 show car, the biggest difference on the exterior is all the cooling and airflow elements. So that's really the pivotal styling change for us," she said. "When we changed from the transverse engine that we had earlier to the longitudinal twin-turbo, obviously now we need a lot more air intake. And as much air that's going in we need that to go out, so we took it to the wind tunnel [in Raymond, OH] and started exploring."

The NSX has three radiators in the front. Explaining the modifications made to the hood vents from concept to final body design, Christensen said, "They were further back on the original show car, and by doubling the size and pulling them forward, we were able to strategically get the air to land on the windshield and provide downforce; downforce is obviously critical for this car."

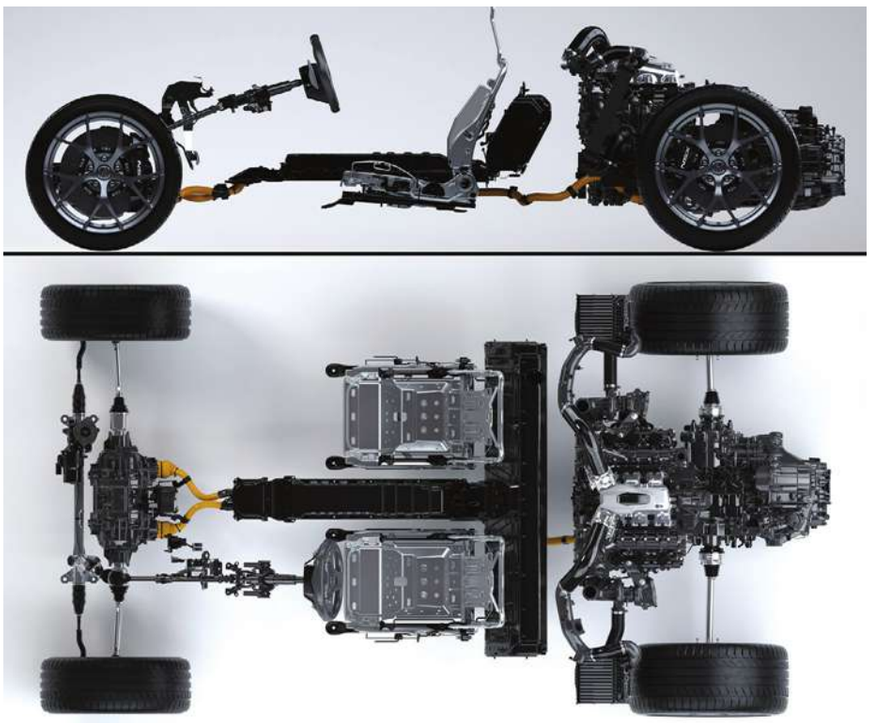
Other significant changes to the production car include new front fender vents, modified side air intakes, and an optimized deck spoiler.

"In the wind tunnel, we have a string test—it's kind of like the paint blot test, where you can see the direction of the airflow," Christensen said, discussing the efficacy of the fender vents. "We stuck the string in the wheel well just to make sure it was in fact exiting out that side vent. As we put the string in there, it kind of wiggled its way out of that vent, stuck down the body side, and shot right into the side intake, which is awesome—that's right where we need all the air to go at high velocity."

The side intake and floating C-pillar collect air to feed the intercoolers and mid-mounted engine, and direct airflow over the rear deck to increase downforce.

"As the air comes out onto the decklid, it meets up with the air coming off the roof," she continued at the rear of the car. "So we were getting a lot of lift back here. We extended the spoiler a great deal from the original show car, and we also adjusted all these surfaces on the decklid to help guide the air; we had slightly different surfacing before." A small vent was also added to duct air out of the wheel well to reduce lift.

"This whole relationship is creating a lot of downforce, with the diffuser and the air coming out of the rear. It's all a very delicate balance," Christensen said. "All the updates that we did in the wind tunnel, I think it changed the styling for the better, made it a little more aggressive, more exotic."



An all-new longitudinally mounted, twin-turbocharged V6 engine is mated to a nine-speed DCT. The unit houses an electric motor that helps directly drive the rear wheels; twin electric motors in front provide instantaneous torque delivery and dynamic torque vectoring.

The NSX features "world-first" casting technology for aluminum frame components that combines the design and manufacturing flexibility of a casting process with the strength and elongation properties of a forged material.

An interior that 'disappears'

While the exterior surely will attract attention, the interior of the new NSX—with its "human support cockpit" design theme—is meant to not be noticed. "We didn't want to create a glitzy, elaborate interior. We wanted to make sure that the interior almost disappeared when you drove," John Norman, NSX Interior Design Project Leader, shared with *Automotive Engineering*.

"I had this excellent experience when we did the original ride-and-drive for the car during the development," he continued. "We had all of our competitors; we had a **Lamborghini** there, a Ferrari, Porsche, the **Nissan** GT-R, a [**Chevrolet**] Corvette, we had all these fantastic cars. But we also had an original NSX to drive. Now while the performance benchmark had gotten much more modern and much faster, I read about driving the original NSX, how it was like the invisible car, and I actually experienced that. We were driving through the canyon roads of Malibu and I had this transcendent driving experience where everything just went away, the car went away, and it was just me and the road. And I said, 'Wow! We really need to keep this [with the next-gen NSX].'"

To that end, designers focused on providing great forward visibility; simple, intuitive controls; and "class-leading" ergonomics—most notably with the seats, which feature "top-class" holding performance thanks to suede inserts and offer easy ingress/egress.

"We really focused on pushing the IP [instrument panel] down as low as we could, making the pillars as thin as possible, prioritizing outward visibility. Even though it's a very low, wide, very sexy car, when you sit in it, it doesn't feel completely like you're inside the space shuttle or some really compromised seating position."

The NSX's instrument cluster features a dynamic thin-film-transistor display that responds to changes in the driver-selectable IDS with pertinent graphics and information. The Power button resides in the center of the new IDS dial control.

"The interface is relatively straightforward," Norman said. "In some of our other Acura cars we have the high screen, but from a package standpoint we wanted to really prioritize outward visibility, so we have a low-mounted touchscreen. Also on our current cars, the IDS control function is just a small button behind the shifter that you cycle through the modes; this one, we turned it into this large rotary knob and placed it kind of high in the center panel...We made it big enough that it can function at track speed—you can just grab it with a gloved hand and select your mode."

Below the handcrafted leather dash panel is an exposed mid-frame—a functioning chassis structural member—made of a structural polymer with metal plating, according to Norman. "We didn't want to put some giant metal casting in there; that'd just be ridiculous [in terms of weight]," he said, noting that parts consolidation and weight reduction were major goals of the interior development program.

Manufacturing—a materials technology-enabler

After stating that there "absolutely" will be a right-hand-drive version of the NSX since it's a global project, Klaus gave a "shout-out" to the new Performance Manufacturing Center (PMC) in Marysville, OH, where the supercar will be exclusively manufactured, as well as to the man leading the creation of the plant, Clement DeSouza.

"We would not have been able to deliver this product without this new factory," Klaus said. "To achieve that styling, to achieve our performance, the story of the factory enabling new technologies is a very exciting [one]."

The multi-material chassis comprises an aluminum-intensive space frame complemented by the "strategic use" of ultra-high-strength steel (UHSS) and carbon fiber. UHSS is used for the thin A-pillar, which is a continuous member, while carbon fiber is placed at the central floor, "close to the spine of the car," Klaus said,

2016 NSX development team leaders (l to r): Michelle Christensen, exterior design; John Norman, interior design; and Clement DeSouza, manufacturing. (Ryan Gehm)

to enhance torsional and bending stiffness.

"I know ultra-high-strength steel maybe isn't as sexy as carbon fiber or aluminum, but if it's the most effective way to meet your overall design concept, that's what you should be doing," said Klaus. "[Plus] it's lighter than if we tried to use aluminum [for the A-pillar] and it's not as strong but way more robust than using carbon fiber."

Body panels are composed of aluminum and sheet molding composite.

The NSX features "world-first" casting technology that combines the design and manufacturing flexibility of a casting process with the strength and elongation properties of a forged material, enabling significant weight reduction, according to DeSouza.

"One of the big reasons we picked Ohio [for manufacturing] was because of proximity to R&D and our ability to work with them on a daily basis to realize this model," he told *Automotive Engineering*. Development of the casting technology provides "one of our biggest material differences and also biggest challenges on this project."

The casting is employed for aluminum frame parts, but the process will be carried out at the Anna engine plant. "We had to leverage our casting experience at Anna engine, so we decided to do it there," DeSouza shared.

SAE technical paper 2015-01-0512, "Cast body nodes for 2016 NSX," was presented as part of the "Advances in Lightweight Materials" session on April 22 at the SAE World Congress in Detroit. The paper details ablation casting, described as "an emerging technology which combines traditional sand molding techniques with rapid cooling due to the use of a water soluble binder." Six different body node castings have been manufactured for the aluminum space frame using ablation. These castings are integrated into the crash structure.

Full body construction, paint, and final assembly will be conducted at PMC, where about 100 associates will help support and perform those tasks. And DeSouza noted that it's not your typical small-volume operation.

"It's a blend of craftsmanship and technology," he explained. "Usually when you go to a small-volume facility, you see a lot of hands-on work, but…keeping quality in mind and the demands of this vehicle, we realized we could use technology. Looking at each process and determining, 'Do we have a robot do it or have a person do it?'—that was our big driver in figuring out what we would devise."

The body shop is one area that benefits from the deployment of technology. "If you look at most of the other supercars, a lot of them are hand-MIG welded, but we're going to 100% robotic welding for the body," DeSouza said. "That helps guarantee the quality, the heat distribution, the accuracy of the body, and torsional rigidity. [With] aluminum, the biggest challenge is heat distortion…It gives us so much more flexibility by using a robot."

The company will begin accepting custom orders for the new NSX starting this summer. "There will be more than one spec because we know this customer wants to be able to configure, customize, and build their own vehicle," said Mike Accavitti, Senior Vice President and General Manager, Acura Division.

Klaus acknowledges that the supply-and-demand equation may cause some disappointment. "We are conscious that allocating the products globally is going to be a challenge," he said. "Especially if we choose to not satisfy demand…We have not given production figures and will not, but there is only so much we can do."

Production is expected to commence at PMC in the fall, with first deliveries planned for later in the year. Klaus and his team are quite certain those customers driving away in the new NSX will *not* be disappointed.

Ryan Gehm

Acura NSX – Dimensions Comparison

	New 2016 NSX	2013 NSX Concept	Difference	2005 NSX	Difference
Length, in (mm)	176 (4470)	172.8 (4390)	+3.2 (80)	174.2 (4425)	+1.8 (45)
Width, in (mm)	76.4 (1940)	75.4 (1915)	+1.0 (25)	71.3 (1810)	+5.1 (130)
Height, in (mm)	47.8 (1215)	47.2 (1200)	+0.6 (15)	46.1 (1170)	+1.7 (45)
Wheelbase, in (mm)	103.5 (2630)	102.8 (2610)	+0.7 (20)	99.6 (2530)	+3.9 (100)
Front track, in (mm)	65.2 (1655)	---	---	59.5 (1510)	+5.7 (145)
Rear track, in (mm)	63.6 (1615)	---	---	60.7 (1540)	+2.9 (75)

Cabin key to Komatsu America's new T4F hydraulic excavator

With an operating weight between 87,388 lb (39,638 kg) and 89,248 lb (40,579 kg), **Komatsu America**'s PC390LC-11 hydraulic excavator has upgraded cab features and an enhanced power mode for greater productivity and lower cost per ton, according to the company.

In addition to improved productivity and upgraded cab features, the PC390LC-11 maintains the same lifting performance and stability of the previous model. The PC390LC-11 continues to feature PC450 class heavy-duty undercarriage components to maintain the same high lift capacity and lateral stability as its predecessor. The larger undercarriage has a 6% wider track gauge and offers up to 18% greater over-the-side lift capacity than the PC360LC-11.

The excavator is equipped with the latest KOMTRAX technology, Komatsu's standard telematics system, which relays data such as fuel levels, diesel exhaust fluid (DEF) levels, operating hours, location, cautions, and maintenance alerts. A new Operator Identification System reports key operating information for multiple operators, and the new Auto Idle Shutdown function helps reduce idle time as well as operating costs.

With 257 hp (192 kW) net, the excavator is powered by a Komatsu Tier 4 Final SAA6D114E-6 engine. Komatsu's Tier 4 Interim foundation integrates a selective catalyst reduction (SCR) system. The engine uses an electronic control system to manage the air-flow rate, fuel injection, combustion parameters, and aftertreatment functions to optimize performance, reduce emissions, and provide advanced diagnostic capability. The powertrain system continues to use Komatsu's variable geometry turbocharger (VGT) and an exhaust gas recirculation (EGR) valve for temperature and air management control.

Komatsu developed the entire system, including the control software that is critical to the effective operation of the aftertreatment system. Additionally, the control system is integrated into the machine's onboard diagnostics systems and KOMTRAX.

All major components on the new PC390LC-11 including the engine, hydraulic pumps, motors, and valves are exclusively designed and produced by Komatsu. This integrated design uses an efficient closed center load-sensing hydraulic system and features a new enhanced power mode for improved performance and reduced cycle times.

In addition to improved productivity and upgraded cab features, Komatsu America's PC390LC-11 hydraulic excavator maintains the same lifting performance and stability of the previous model.

The PC390LC-11's ISO 12117-2 ROPS certified cab, specifically designed for hydraulic excavators, gains strength from a reinforced box structure framework. The cab is mounted on viscous isolation dampers that provide low vibration levels.

A standard heated air suspension high-back seat with new fully adjustable armrests provides improved comfort. In addition to the standard AM/FM stereo radio, a remote located auxiliary input for connecting external devices is provided to play music through the cab speakers. Additionally there are two 12-volt power ports incorporated into the cab, and optional joysticks are available with proportional controls for attachment operation.

The high-resolution 7-in LCD color monitor features enhanced capabilities and displays information in 33 languages. The operator can easily select up to six working modes to match machine performance to the application. The monitor panel provides information on DEF fluid level, Eco guidance, operational records, fuel consumption history, and utilization information. A new display interface combines vehicle information with a wide landscape view from the standard rearview camera so the operator can easily view the working area directly behind the machine.

The PC390LC-11 has handrails on both sides of the upper structure for easy accessibility and service access. A large 10.3-gal (39-L) refill capacity DEF tank is located in a lockable compartment directly behind the right side toolbox, and is sized to provide a 2:1 diesel to DEF refill ratio. Side-by-side radiator and hydraulic oil coolers make it easy to maintain and service the machine.

The excavator is equipped with Komatsu's EMMS (Equipment Management Monitoring System), which has enhanced diagnostic features to give the operator and technicians greater monitoring and troubleshooting capabilities for preventative maintenance, minimizing diagnostic and repair time.

Jean L. Broge

New XF moves to Jaguar's aluminum architecture

Jaguar's best-selling model, the XF, is moving from a steel body to the aluminum-intensive monocoque architecture used on the XE and XJ. It's one of the latest steps the luxury car maker has taken to meet regulatory and emissions demands in Europe and the U.S. The new car, scheduled for introduction in winter, was debuted to the public at the 2015 New York Auto Show. It's a midsize-plus model, fitting between the full-size XJ and the mid-size XE.

The car has a body-in-white that is some 75% aluminum, and much of that aluminum is RC5754, which is primarily scrap recycled with a small percent of new material. The recycled aluminum, which comes from Jaguar's press shops, constitutes much of the 5000 series wrought alloy (aluminum and magnesium) that is used on the XF, where specified to add stiffness (as for underbody reinforcements).

Jaguar XF moves to aluminum body, with a coupe-like look, but with increased rear passenger room, including up to 1.1 in greater headroom.

Magnesium is used for XF hood crush beam, as shown, and dashboard cross-car beam.

Steel used for weight distribution

Where steel is used, such as for the rear underbody, in the decklid, and rear-seat-area pan, it serves a number of specific engineering requirements, and it also contributes to a balanced front-rear weight distribution. The end result is a projected 51% front, 49% rear balance.

The steel applications pose an obvious galvanic-corrosion-protection requirement and Jaguar employs a five layer process based on aerospace techniques. First a zinc coating is applied to the steel. Then the joints are made with structural adhesive. Next, the entire body is electrocoated. Following that, seam sealer is applied, and finally the body is painted. There are no body welds, although self-piercing rivets are used.

The bodyside panels are stamped from single sheets of high-strength 6000-series aluminum alloy, which is a wrought alloy that contains magnesium and silicon. A panel weighs less than 6 kg (13 lb).

Jaguar uses specific high-strength aluminum alloys for front and rear crash structures and the A- and B-pillars. The front structure joint with the A-pillar is a large section shaped to distribute crash energy. The B-pillar also gets an ultra-high-strength (boron) steel reinforcement and is filled with high-density foam. The front suspension towers are high-pressure die-cast aluminum for added stiffness in that area.

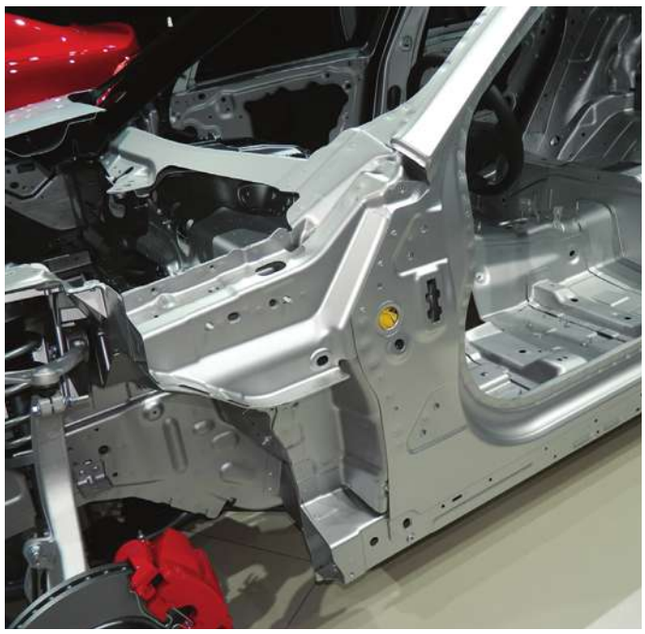
Both the dashboard's cross-car beam and the hood crush beam are made of magnesium.

Precise riveting boosts rigidity

Assembling the side panels to the remainder of the body structure starts with precise locating of the rivets, so the overall result is a more torsionally rigid package. Jaguar claims up to 28% improvement, with the 2016 model specification at 21.7 kN·m (16,000 lb·ft) per degree.

Naturally a Jaguar has to be quiet and the best way is to ensure that is to design noise out. The crash structure behind the front bulkhead, for example, consists of sealed double-wall sections. Foam fillers are placed inside boxed aluminum sections, and when the body goes through the electrocoating ovens, the foam expands to fill. In other locations, sound deadening is a spray-on type that can perform the needed sound reduction with less added weight than mastic sheeting.

Rear-seat panel is steel, in part for XF weight distribution, and requires multi-step joint to prevent galvanic corrosion with aluminum body.



XF front structure ties into beefed-up A-pillar for optimum distribution of crash energy.

The XF is some 80 kg (176 lb) lighter than comparable competition, Jaguar claims, and 190 kg (419 lb) below the previous model with the steel body. Vehicle weight is 3902 lb (1770 kg) for the rear wheel drive model, 4145 lb (1880 kg) for the AWD.

Coefficient of drag was reduced from 0.29 to 0.26. An assist comes from vents in the front bumper that direct airflow smoothly over the front wheels, instead of becoming turbulent around the wheels and creating drag.

The new model is shorter than its predecessor at 195.1 in (4956 mm) long overall, on a 116.6-in (2962-mm) wheelbase. The wheelbase actually is 2.0 in (51 mm) longer, but overall length is 3.3 in (84 mm) shorter. Rear legroom is slightly greater, up 15 mm (0.6 in) to 951 mm (37.4 in). Despite the coupe look, headroom is greater by 1.1 in (28 mm).

There are two 3.0-L supercharged gasoline engines for the U.S. market, both using the same **Eaton** Roots-type supercharger. One is rated at 340 hp (254 kW) and 332 lb·ft (450 N·m), the other at 380 hp (283 kW) and 339 lb·ft (460 N·m). Both are bolted to the eight-speed automatic, which is required for pairing with all-wheel drive.

A six-speed manual is listed for rear-wheel-drive models and the 340-hp V6, but is not available at launch. A supercharged version of the 5.0-L V8 rated at 550 hp (410 kW) and 502 lb·ft (681 N·m) will be available with a forthcoming Type R performance model.

The electric power steering has been upgraded with improved sensing inputs, better damping steering response to both road irregularities and road camber. The AWD system transfer case is new, with a chain drive for lighter weight and smoother torque transfer vs. the previous gear-drive type.

Standard, optional suspension variants

The standard shock absorbers contain a second valve to provide velocity- and frequency-dependent damping. During moderate driving conditions, that valve is open and some hydraulic fluid passes through. This additional flow path reduces damping for a smoother ride. At increasing speed, the valve closes and all the fluid has to go through the piston valve, which firms up the ride for better control.

In addition, there's Jaguar's optional active damping system, which senses body movements 100 times/s and wheel movement 500 times/s. This electronic system has been improved for better control of damping at all speeds, and incorporates advanced algorithms for road texture detection to provide better traction. Like the F-Type, it can now be driver-configured at the control stack touch-screen.

The XF incorporates a standard advanced traction control system (All Surface Progress Control) that improves drive away on both rear-drive and AWD models in ice and snow. Also included with AWD is torque vectoring by braking, for which the vehicle's electronic stability control modulates torque-on-demand for varying weather conditions.

Integrated with AWD and the active damping system is Jaguar's Adaptive Surface Response. ASR employs algorithms for road-surface-texture detection and uses the information to modify steering response, transmission shifting, throttle response, and stability control operation.

The front suspension is an upgraded double-wishbone design modeled after the F-Type to improve cornering. The rear suspension drops the double-wishbone for a multi-link with an integral link that connects the toe link to the control arm. This separates vertical from lateral forces, so each can be tuned separately, for a better ride.

The XF has a full suite of optional safety features, including automatic emergency braking. For connectivity, it offers the 10.2-in corporate capacitive touch screen with Incontrol Apps for a smartphone. This touch screen and the 12.3-in configurable TFT (thin film transistor) instrument cluster also are available on the **Land Rover** Range Rover.

Paul Weissler

COMPANIES MENTIONED

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Aerojet Rocketdyne 18
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Q&A

Michael Tinskey said Ford will soon announce new projects aimed at furthering vehicle electrification in China's EV market.

Green-lighting Ford's 'clean' technologies

As **Ford** Motor Co.'s Global Director of Vehicle Electrification and Infrastructure, Michael Tinskey eats, sleeps, and breathes sustainable mobility. His small group of "clean technologists" are linked with industry and academic partners on several fronts, including smart mobility experiments. Since electrification and infrastructure first grabbed Tinskey's work duties in 2009, Ford has launched two plug-in hybrid electric vehicles and an all-electric car. Tinskey recently sat down with SAE Magazines for an interview.

What is the most challenging global region for vehicle electrification?

Each region has a unique set of challenges. China is really promoting electrification, and one of the reasons is energy security. Their gross domestic product continues to grow. And that means their automotive market is continuing to grow, and their thirst for oil is continuing to grow. China is one of the world's largest oil importers, so access to reliable crude is really challenging. The other side of the challenge with China is their strong reliance on coal to produce their electricity.

If you put a lot of electrified vehicles on the grid and that grid is using coal, then the air quality goes in the wrong direction. We have some really neat projects that we're going to be announcing soon to help China embrace electrification and air quality at the same time.

What is Ford's strategy in China for electrified vehicles?

When we look at a market, we have to have a few things. We need to make sure there's charging infrastructure—both public and for homes—and that there are policies in place that allow us to get the needed infrastructure. We look for favorable policies, so that electrified vehicles are affordable. And we look at other incentives, like discounted electric vehicle registration fees. When all those pieces come together at both a central and a regional level, that's when we believe electrification is likely to take off. Those things haven't come together yet in China.

In China, there's still a lot of uncertainty around some of the policies and how the policies will be implemented. And infrastructure plans are still being finalized both in terms of standards and rolling out the charging stations. In 2014, China sold around 23 million passenger vehicles with about 75,000 of those being electric vehicles. Ford isn't selling plug-in vehicles in China yet, and that's because the market is in the very early days of being electrification-ready.

Why are smart mobility experiments important to the progression of electrified vehicles?

The smart mobility experiments we're doing really address the issues surrounding sustainability. And sustainability transcends all forms of mobility, including electrified vehicles. My group was involved in four experiments, including the antiquated exercise of finding a parking spot. We found that 12% of drivers find a parking spot immediately, while 88% of drivers take up to 30 minutes to locate a parking spot. We think it's much more effective to use ultrasonic sensors on vehicles to create a real-time parking database in the cloud rather than spending billions of dollars putting sensors on the infrastructure. Using ultrasonic sensors on vehicles is a smart way to eliminate or mitigate the traffic congestion caused by a distracted driver looking for a parking spot, especially street parking.

In another experiment, we're using LTE 4G networks to re-position a vehicle from a remote location. We're working at very low speeds, mostly 10 mph, but we're getting better at the video-compression and getting as much as possible from the bandwidth. What we'd like to do next is see if it's possible to perform the vehicle re-positioning at street speeds from a remote location. Our original goal for this experiment was to re-position a vehicle during night-time hours to get it ready for a daytime rental or car sharing reservation.

How will connected vehicle initiatives impact vehicle electrification?

There is a tremendous amount of information that can go back and forth between the vehicle and the cloud. We have embedded modems in every one of our plug-in products. When a customer enables the MyFord Mobile app, the driver can access all sorts of information, like locating the nearest charge stations and determining the amount of electricity needed to get from point A to point B. If a user opts to share data with Ford, we get the analytics that show how our customers are using plug-in vehicles, like how far they're driving on a charge and how often the vehicle is being charged. That data has been tremendously powerful in shaping our next-generation product.

What are the high-points of vehicle electrification so far?

The very end of 2011/beginning of 2012 marked the first sales of Ford's first-generation plug-in vehicles. During the past two and half to three years, Ford has sold approximately 40,000 plug-in vehicles. Other manufacturers are also growing their electrified vehicle portfolio. I'm very bullish on vehicle electrification. It's not going to be as quick as flipping a light switch, but there is going to be a migration toward electrification.

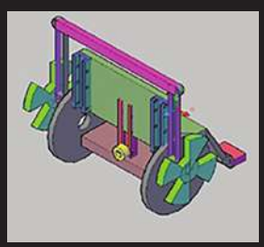
One of the proof-points is the amount of all-electric miles. Just for Ford vehicles, the data shows that more than 600,000 miles a day are driven in electric mode. So every two days that's 1.2 million all-electric miles being driven in Focus Electric cars and our two plug-in hybrids, the C-MAX Energi and the Fusion Energi. In the U.S., Ford sold about 22,000 plug-in hybrid and battery-electric vehicles in 2014. The year before it was probably 60% of that figure, and the year before that it was probably 50% of that figure. So you can start to see the progression.

Kami Buchholz

He's Creating the Future

Lakshman Murugesan
Student
PSG College of Technology,
Coimbatore, India

Lakshman Murugesan is currently a student at PSG College of Technology, Coimbatore, India and was an entrant in the 2014 Create the Future Design Contest. Studying to be an engineer has inspired him to help society by designing products that will help the disabled.



A Staircase Climbing Mechanical System for a Wheelchair is a low-cost design that will enable a wheelchair to climb the stairs using a simple mechanical system with the help of only one assistant to control the wheelchair.

"I would like to thank the Create the Future Design Contest team for providing an opportunity to participate in this contest," says Lakshman Murugesan, student at PSG College of Technology. "Soon after my project was open for public viewing and voting, I received valuable suggestions from many people as to how to make the project more efficient. This platform was really helpful and the project was a complete success."

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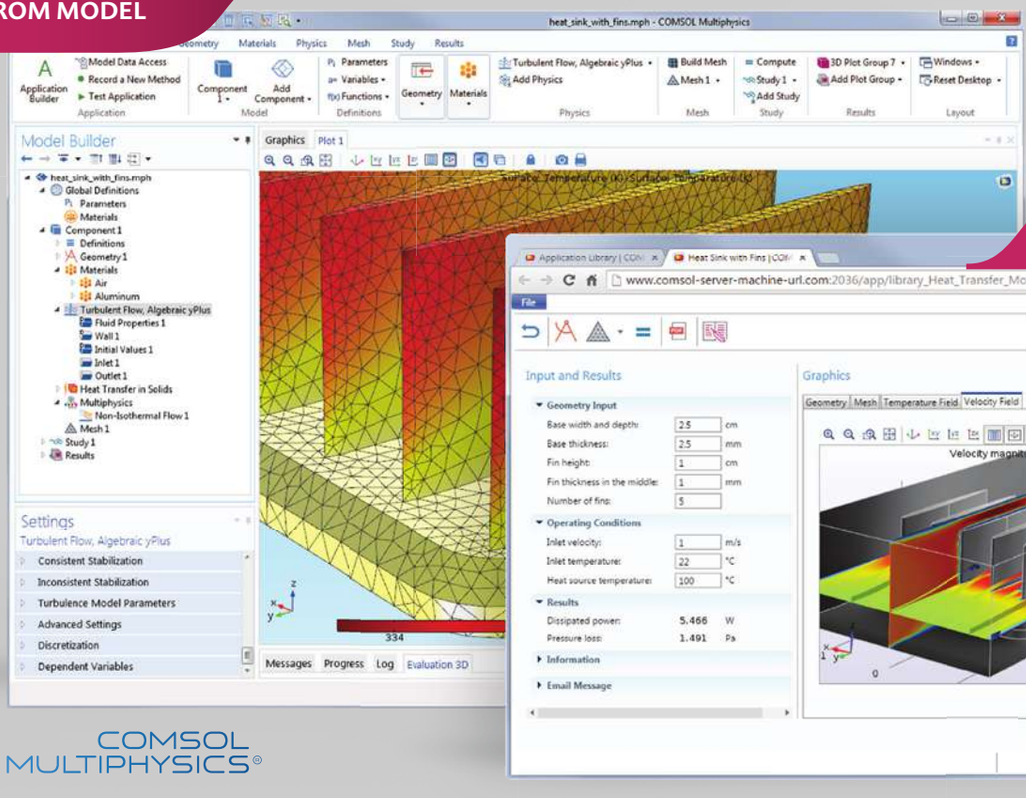

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