MOBILITY ENGINEERING™

AUTOMOTIVE, AEROSPACE, OFF-HIGHWAY

A quarterly publication of SAE INTERNATIONAL and SAE INDIA

Mercedes expands production

Pune assembly plant adds GLA

Vehicle Electronics Special

- Better auto vision systems
- Autonomous agriculture and mining
- Semiconductors for EVs

Advent of stop-start

OEMs look to mainstream tech

Lithium-ion batteries

Reuse, recycle, and dispose

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September 2015

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EDITORIAL

Opportunities in electronics outsourcing

In this issue, we take a look at the increasing role that semiconductors are playing in automotive powertrain electrification. The feature "Chipping in to get more from battery packs" reveals how engineers are pushing semiconductor technologies to help extend electrified vehicle ranges and reduce battery pack weight.

Power semiconductor improvements are also helping move to higher voltages and reduce losses while managing a battery pack's nemesis—heat.

Many of the changes have occurred in specifying more insulated gate bipolar transistors and field effect transistors—central players in electrified powertrain components.

Power semiconductors represent a small portion of the total automotive electronics market and the outsourcing opportunities coming from OEMs and major suppliers.

In July, **Zinnov**, a consulting firm based in Bangalore, released results of a study on automotive electronics R&D globally and the services market in India specifically, with a focus on engineering services. The firm expects the automotive electronics market to be a $265 billion opportunity by 2018, and the overall addressable automotive-electronics market for globalization and R&D services to be $11.5 billion. The study pegged current automotive electronics outsourcing from OEMs and Tier 1 suppliers at $204 billion, with major outsourcers being top OEMs like **Daimler**, **Audi**, **Jaguar**, and **BMW**, as well as Tier 1s **Bosch**, **Denso**, **Continental**, and **Delphi**.

Apart from Europe, the study found that the availability of a large talent pool and established R&D ecosystem have made the Bay Area in California the R&D hub for automotive electronics. It also found that, while the OEMs' major R&D focus areas are concentrated around advanced transmissions, electric vehicles, and hybrid vehicle technology, the Tier 1s have focused on areas such as advanced driver assistance systems (ADAS), infotainment solutions, and autonomous-car technology.

ADAS is seen as one of the more immediate outsourcing opportunities. "Advanced driver assistance systems and infotainment systems will see increased outsourcing, and larger deals can be expected in the next two to three quarters," said Sidhant Rastogi, Partner & Practice Head, Zinnov. "The opportunities for service providers will continue to open up as we move towards a more connected world."

The study authors provided a few key observations for service providers:

• ADAS is the differentiating factor: Analysis of OEMs' spending activity shows that they will continue to increase R&D spend on emerging areas such as ADAS as they realize that moving forward it is going to be the differentiating factor among them.

• R&D investment lags product maturity curve: With driver assistance becoming a major R&D investment by OEMs, Tier 1 suppliers and consumer electronics companies will have a major presence in the product areas that lie in the emerging and growing zone of the "S-curve" of development.

• Building capability for emerging areas is the key: Service providers should focus more on building frameworks/capabilities for the products that lie in the growing and emerging zone as outsourcing will increase in these areas as they climb the S-curve.

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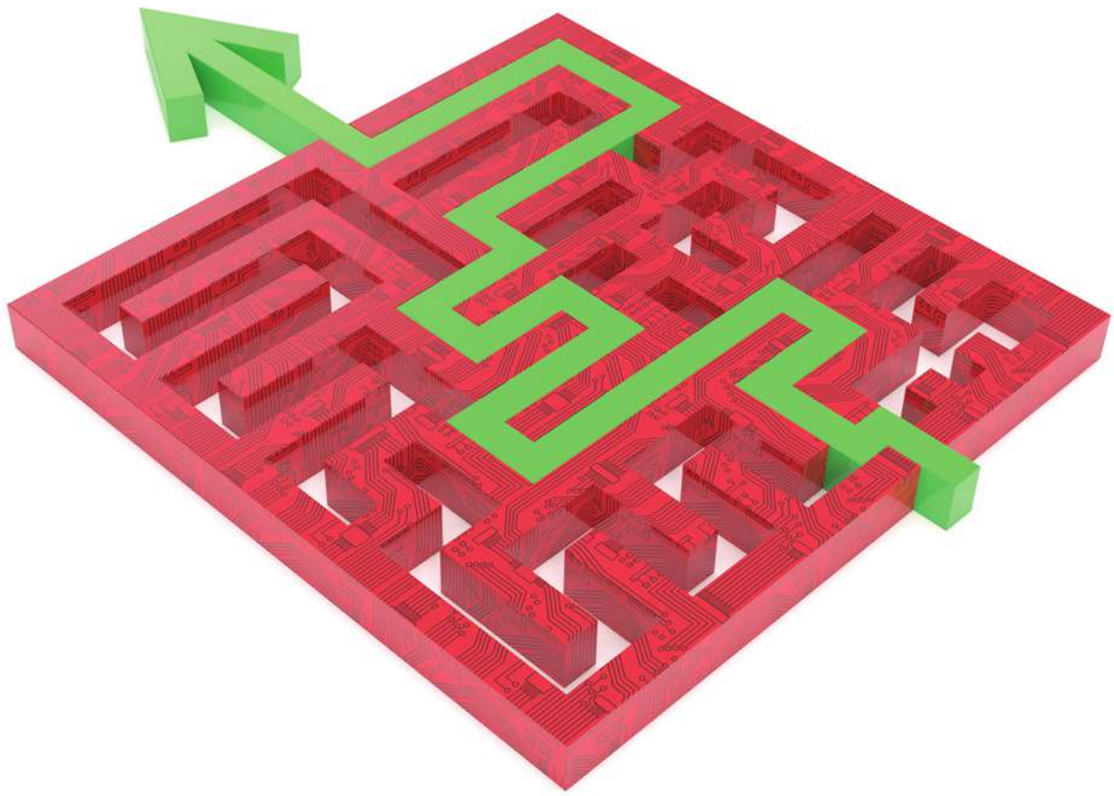
– VisSim User



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FOCUS

Fulfilling SAEINDIA's vision and mission

In the last issue of *Mobility Engineering*, I discussed building the **SAEINDIA** brand in this column.

We got a shot in the arm with the acceptance of our bid to host the **FISITA** Summit in the third quarter of 2018. This will be a true game changer as it will catapult the SAEINDIA brand to the most coveted status as a premier professional society in the comity of nations.

We were successful with APAC 16, and the FISITA Business Council Sessions in 2011

Dr. Aravind Bharadwaj
President, SAEINDIA

preceding it won wholesome praise from all quarters. The FISITA Summit will be a crowning glory for SAEINDIA in 2018.

In April, we had a symposium on "Fuels, Lubricants, Emissions & After-Treatment Devices—The Road Ahead," which was a huge success with over 200 delegates in a packed hall from industry, government, and public sector undertakings, as well as other key stakeholders. There were keynote speeches, panel discussions, and focused presentations that dealt with every critical aspect of the subject, and the road map for the future was presented to move forward.

SAEINDIA Bangalore Section celebrated Members' Day for the first time and found a rousing response from industry and academia. They had panelists and a small exposition, with industry putting up stalls and reaching out to the mobility community.

I attended the 7th edition of GMCV 2020 as Chief Guest at Coimbatore. There a cross section of major industries joined hands with SME and Micro **SME** units drawn from various parts of the country. It also witnessed many of the trade consulates from the U.K., France, and Belgium supporting the event by exploring opportunities for investment and commerce focusing on small and medium industries.

The 4th edition of SUPRA SAEINDIA 2015 took place 14-19 July at Madras Motor Race Track (where international Racing Events are regularly held) and over 98 teams vied for honors and trophies from all over the country.

Virtual BAJA SAEINDIA was held on the 10th and 11th of July at **Chitkara University**, Punjab, making inroads into another untrodden territory, spreading the message of SAEINDIA and its activities to every nook and cranny of the country.

We are also organizing a seminar on vehicle dynamics at **Amrita University**, Coimbatore, with the Engineering Education Board, which will be webcast in six different locations including remote centers like Bhubaneshwar, Hyderabad, Pune, Dindigul, and Delhi. This will be a forerunner for many more programs in the future, setting a new milestone in knowledge dissemination.

Dr. Richard Greaves visited SAEINDIA during the last week of July and first week of August, with each vertical organizing a conference, conclave, or event at Chennai, Bangalore, Pune, and Delhi with the thrust on getting the CEOs and CXOs connected to the vertical Viz. Aerospace, automotive, and off-highway sector sections are also planning new and innovative programs at Chennai, Bangalore, and Pune.

We are making slow but steady progress in organizing the first conference on International Transport Electrification in India with **IEEE** IAS (Industry Applications Society), and the involvement of the government of India in launching pilot projects and disseminating information on incentives for upfront acquisition of hybrid and electric vehicles is truly heartening. The conference will provide a strong platform to exhort users to move from conventional to hybrid and electric vehicles, saving precious fossil fuels that are imported at heavy cost to the government.

SAEINDIA is setting an exciting calendar of activities and events under all verticals and operating boards striving constantly to fulfill its vision and mission with the core objectives being achieved with a sense of satisfaction and optimism.

Allegro Power ICs in Automotive Electronics

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SAEINDIA News

Gearing up for the knowledge economy

Lighting up by conference chair Dr. M. Manickam, Executive Chair, Shakthi Groups.

Presentation of momento to Dr. Aravind S. Bharadwaj.

Bird's eye view of the conference.

The 7th Edition of the Global Manufacturing Cluster Vision 2020 (GMCV 2020) was held on the 5th of June 2015 at The Residency, Coimbatore, India with the theme "Innovation," which plays a vital role in the growth and sustainability of any manufacturing company.

Dr. Aravind S. Bharadwaj, President of SAEINDIA, was the chief guest of this GMCV conclave. This one-day conference was organized by **Texas Ventures** along with **Coimbatore District Small Industries Association** (CODISSIA) and supported by **SAEINDIA** to deliberate upon the challenges in the manufacturing industry and lay the road map for the future.

Dr. Bharadwaj said Micro, Small, and Medium Enterprises (MSMEs) need to register new ideas for products or manufacturing processes, and look at developing these to generate revenue during his speech on "Gearing up for the knowledge economy."

He also said that it is extremely critical for industries to focus on capability building and making technologies accessible to all as it helps the units gain competitive advantage. India is migrating to an advantage that will come only through knowledge. Over the last decade, we are seeing a transition to the development of products that are made in India for the Indian market. Customers need more features, specifications, and technology at an affordable price and companies have been able to provide it.

He stated that in the automobile sector, our country is today a global manufacturing hub for the small cars segment. The life cycle of several products, including automobiles, is reducing as customers want new products and industries need to deliver to meet this expectation. He added that they needed to upgrade the skills of the employees and have a well-defined structure for the process of manufacturing meeting global standards.

GMCV 2020 conclave highlights were:

- 250 CEOs as delegates from manufacturing industries forming a powerful forum.
- A forum with international content and talks from eminent personalities from the manufacturing industry.
- One-on-one interaction with industry heads.

The increasingly competitive nature of the 21st century economy is forcing manufacturers to pursue more growth opportunities to survive. One such opportunity is international markets. This conference also showcased a clear methodology to identify the emerging opportunities for Indian manufacturers globally.

GMCV 2020 has created a forum to deliberate, orient, and enable Indian manufacturing leaders in understanding the fundamental challenges that must be met to tide over the current economic challenges.

SAEISS Student Trek at Kalasalingam University

The **SAEINDIA** Southern Section (SAEISS) successfully conducted the two-day Student Trek program on the 4th and 5th of April 2015 at **Kalasalingam University**, Virudhunagar. Dr. M. Uthayakumar, KLU, welcomed the gathering and inaugurated the program. Mr. S. Selvamani facilitated the program.

The Student Trek program was conducted in two sessions. In the first, Mr. T. Kasiraja and Mr. B. Kumaran started the engineering design process, and videos were presented to the participants to have a better understanding. In session two, the participants were taken for trek to Shenbagathoppu Hills and Kattalagar Temple as per the schedule.

Session 2 – SAEISS Trek – Shenbagathoppu Hills and Kattalagar Temple.

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SAEINDIA News

Kalasalingam University also hosts Knowledge Round Table Trek

Session 2 – SAEISS Trek – Shenbagathoppu Hills and Kattalagar Temple.

Certificate distribution to participants.

The SAEINDIA Southern Section (SAEISS) successfully conducted a two-day KRT (Knowledge Round Table) Trek program on the 4th and 5th of April 2015 at **Kalasalingam University**, Virudhunagar. Dr. M. Uthayakumar, KLU, welcomed the gathering and inaugurated the program.

After the Inauguration, the program was conducted in two sessions. In the first session, there was group discussion among KRT members along with Mr. S. Selvamani and Mr. S. Shanmugam of SAEISS. The following points were discussed:

Each KRT participant (faculty and regular member) has to

• Lead and conduct the Toptech programs and be involved in the ENE program (deliver lectures).

• Launch KRT in different zones (Chennai, Mahindra City, Coimbatore, Madurai, Kerala, and Hyderabad).

• Develop activities and programs, as well as networking in their respective zones.

The following points were also discussed:

• Developing industry/institute interaction—sharing of experience and knowledge.

• A group of 10 SAE faculty advisors working in an institute should form an academic KRT.

• Value-added courses (soft skills to suit the needs of the industry) to be included in SKIP.

Bangalore Section holds Members Day

Dr. Rao Chalasani, Chairman, SAEINDIA, BS.

Mr. Dilip Chhabria, Chairman, DC Designs.

Delegates visit to SAEINDIA stall.

On 19th April 2015, **SAEINDIA** Bangalore Section (BS) organized an event for its professional & student members called "Members Day 2015" for the first time in the country.

The event was hosted by **Pes University** and the institute officially welcomed members. The dignitaries present were Dr. K. N. Balasubramanya Murthy, Vice Chancellor, PESU; Dr. K. S. Sridhar, Principal, PESIT; Mr. Damodaran Subramaniam, Event Convener; Mr. K. P. Murthy, Co-convener; Mr. Munirathnam Javaji, Vice Chair, SAEINDIA BS; followed by speakers Mr. Dilip Chhabria, **DC Designs**, Mr. Raghav Gulur, **Continental**; & Dr. Rao Chalsani, Chairman, SAEINDIA, BS. The main highlight of the event was the technical talk presented by the speakers during this occasion.

Mr. Dilip Chhabria, Chairman and Managing Director of DC Designs, spoke on his new supercar, the Avanti, followed by its technical specification. Chhabria said that it has "good design is always a great business." The Avanti is the first Indian supercar for the market.

He was followed by Mr. Raghav Gulur, Head of Technical Centre, Continental India. Gulur spoke about autonomous driving vehicles, which would be the future of all four and eight wheelers, mainly focusing on reducing the stress factors on the drivers to have more pleasurable driving experience.

One more key speaker, Dr. Rao Chalasani, Chairman, SAEINDIA Bangalore Section, spoke on an electric mobility mission plan for India and what would be the next alternative energy source to petroleum fuels. These fuels would play a significant role on clean and green energy for the country's economic growth in the coming years.

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SAEINDIA News

Symposium on fuels, lubricants, emissions and aftertreatment devices

Inauguration of the Symposium on Fuels, Lubricants, Emissions, and Aftertreatment Devices – The Road Ahead.

Panel discussion – collaborative framework between industry and policy makers.

SAEINDIA Northern Section organized a two-day symposium on fuel emissions and aftertreatment devices at the India Habitat Center (IHC), New Delhi, from 24th and 25th of April 2015. A total of seven technical sessions were held and 29 presentations were made, which were then followed by a panel discussion.

The program began with enlightening welcome notes by Mr. Ambuj Sharma, Additional Secretary, Department of Heavy Industry, **Ministry of Heavy Industries & Public Enterprises**; Dr. R. K. Malhotra, Senior VP and Chair, Finance Board, SAEINDIA; and Mr. I. V. Rao, Executive Advisor, **Maruti Suzuki** India Limited who drew the participants attention toward the current Indian auto industry and stressed the gradual improvements in vehicular emissions of steps BS4, BS5, and BS6. They also talked about the automotive mission to align Indian regulations with regulations of other developed markets and the proposal for the formulation of a working group for long-term emissions policy under the Ministry of Heavy Industries.

The first technical session focused on fuel efficiency norms with speakers Dr. Ajay Mathur, Director General, **Bureau of Energy Efficiency**; Mr. P. Panda, Vice President (Engg), Maruti Suzuki India Limited; Mr. Harjeet Singh, Vice President and Head of Global Regulatory, **Hero Moto** Corp.; and Mr. Sumant Kumar, Director and HOD (Transport), **Petroleum Conservation Research Association** who shared their valuable knowledge. The main aspects of the session were the declaration of fuel efficiency regulation for passenger cars, benefits from evolutionary technologies and emissions, future emissions regulations, and automotive mission policies necessity of synchronization.

This was followed by the next technical session on the emissions roadmap, which was headed by Mr. Bernhard Enzi, **AVL**; Dr. Lengsfeld Sven, **Bosch** India; Mr. R. Velusamy, **M&M**; Mr. P. K. Banerjee, **TML**; and Mr. M. N. Muralikrishna, **TVS**. They stressed the need for adequate development, validation time, and proper fuel quality in the market to test technologies such as diesel particulate filters (DPFs) and selective catalytic reduction (SCR) to ensure that only good performing vehicles are allowed on road.

The third technical session was on future emissions and fuel efficiency regulations. The speakers were Mr. Anoop Bhat, **MSIL**; Mr. Harald Kurz, **Horiba**; Mr. Lee Jeffcoat, **Ricardo**; Mr. Anil Kharche, **Schaeffler**; and Mr. Bernhard Mencher, **Bosch** Germany. The session focused on how worldwide regulations on emissions and fuel consumption will be a major driver for innovations in powertrain systems and vehicle design, as well as how regulations will reflect the actual road conditions.

Finally a panel discussion consisting of Mr. Vishnu Mathur, Director General, **SIAM**; Mr. I. V. Rao, Executive Advisor, **MSIL**; Mr. Rakesh Batra, **ENY**'s Automotive Sector Leader, India; Dr. M. O. Garg, Director General, **CSIR**; Mr. A. K. Jain, Advisor Energy, **NITI**, Aayog, GOI; and Dr. Leena Srivastava, Executive Director, **TERI**, focusing on the need of a collaborative framework between industry and policy makers, and regular dialog between stakeholders. They also discussed the development of infrastructure and traffic management.

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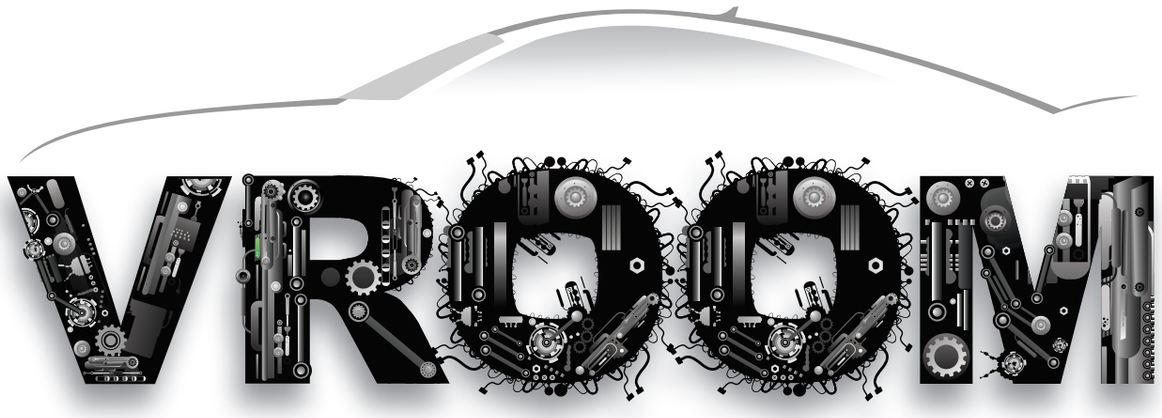

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Industry NEWS

Mercedes-Benz begins GLA production in India

Mercedes-Benz has expanded its local production portfolio at its Pune, India, assembly plant to six model series with the recent addition of the GLA compact SUV. The other models include S-, E-, and C-Class sedans as well as the GL and M-Class SUVs. Sales of the GLA in India tripled in the first quarter of 2015, justifying the move. After recently finishing an extension of the plant, Mercedes-Benz now has an installed capacity of producing 20,000 units annually there. To prepare for the new model, synchronized conveyor systems, new assembly lines, and a new roller tester were installed among other devices. Total investment at the Pune plant, which was opened in 2009, amounts to about 150 million euros.

Compact car production at the Mercedes-Benz plant in Pune.

"The start of production of the GLA in India marks the first time we are producing compact cars in our global assembly network along with sedans and SUVs. We are thus entering the next stage with our market-specific assembly, allowing us to serve local demands in a flexible and efficient manner according to highest quality standards," said Markus Schäfer, Member of the Divisional Board Mercedes-Benz Cars, Production and Supply Chain Management. Beyond the plant in India, the network comprises locations in Thailand, Vietnam, Malayasia, Indonesia, and will be joined by Brazil in 2016 where a new assembly plant is currently under construction. At these sites, the automaker produces cars for local markets with different production levels—for example, from vehicle kits (completely knocked down and semi knocked down).

Eberhard Kern, Managing Director and CEO Mercedes-Benz India, said: "Rolling out our first ever locally manufactured GLA and commencing production from India's largest installed luxury-car production facility are two very significant accomplishments for Mercedes-Benz in India. These accomplishments are a result of our long-term vision for the Indian market."

Eicher Polaris creates personal-utility-vehicle segment

Eicher Polaris Pvt. Ltd. recently launched what it claims is India's first personal utility vehicle (PUV), the Multix, creating a new category in the automotive segment. Purpose-built, specially designed, and powered by a diesel engine, Multix is available in two variants and four colors, starting at a price of $3638 US. The 50:50 joint venture between **Eicher Motors** Ltd and **Polaris Industries** Inc. has invested $55 million US in product development and setting up a manufacturing facility at Jaipur, Rajasthan. The plant has an annual capacity of 60,000 units, which can be scaled up to 120,000 units. It is equipped with robotic weld lines and an in-house paint system.

Multix can accommodate five passengers along with luggage, and can be adapted to create 1918 L (67.7 ft^3) of storage space. It is equipped with X-Port, a power-takeoff point that can generate up to 3 kW that can be used for lighting homes and powering equipment such as drilling machines and water pumps. The PUV features a tubular frame structure and roll-over protection system, Flexituff body, and Pro Ride independent suspension system. It delivers ground clearance of 225 mm (8.86 in), and fuel economy of 28.5 km/L (67.0 mpg).

Expected to launch in 30 cities starting in August, Multix has undergone more than 1.8 million km (1.1 million mi) equivalent of rigorous testing in India and the U.S. for off-road reliability, safety, and durability.

The Multix personal utility vehicle delivers ground clearance of 225 mm (8.86 in), and fuel economy of 28.5 km/L (67.0 mpg).

Jet Aviation Geneva approved to service Gulfstream, Bombardier aircraft in India

Jet Aviation Geneva recently received CAR-145 approval from the Director General Civil Aviation (DGCA) in India to provide base maintenance services to Indian-registered **Gulfstream** and **Bombardier** aircraft. The regulatory approval for Indian-registered aircraft extends to Gulfstream IV/V/200/300/350/400/450/500/550/650 and the Bombardier Global Express series. Jet Aviation Geneva provides complete maintenance, repair, and avionics support to private

and corporate operators.

"As home to a number of major multinationals, including the United Nations European headquarters, long-range business jets are regularly flying into Geneva," said Cyril Martiniere, Managing Director and Accountable Manager at Jet Aviation Geneva. "This is a significant service expansion for Indian-registered Gulfstream and Global Express series aircraft, and we look forward to welcoming these customers to our facility."

Jet Aviation Geneva will provide base maintenance services to Indian-registered Gulfstream and Bombardier aircraft.

Hindustan Aeronautics selects L-3's TACAN+ for Light Utility Helicopter program

L-3 Aviation Products announced that **Hindustan Aeronautics** Ltd (HAL) has selected its Tactical Airborne Navigation System, TACAN+, for its new Light Utility Helicopter (LUH) program. The TACAN+ transceiver is a small and light tactical airborne navigation system capable of tracking up to four ground stations simultaneously in range and two in bearing. It can be installed on rotary- and fixed-wing platforms and used for air-to-air and air-to-ground operations.

HAL developed the new LUH to meet the reconnaissance and utility rotorcraft needs of the Indian Air Force and Indian Army.

"L-3 has a long-standing relationship with HAL and we are very excited to be part of the LUH program," said Kris Ganase, President of L-3 Aviation Products & Security. "This award, coupled with the recent opening of our new Manufacturing, Repair & Overhaul facility in Bengaluru, India, reflects L-3's commitment to supporting the evolving and dynamic needs of military and commercial aviation customers and business partners in the region."

HAL developed the new LUH to meet the reconnaissance and utility rotorcraft needs of the Indian Air Force (IAF) and Indian Army. The first LUH prototype, the PT-1, is scheduled to commence test flights later this year, with initial operational clearance anticipated in 2017. Deliveries to the IAF and Indian Army are expected by the end of 2017, with production taking place near Bengaluru. HAL expects to produce about 50 helicopters annually.

L-3's TACAN+ transceiver can be used for air-to-air and air-to-ground operations.

Scania supplies 200 more trucks to Indian mining company

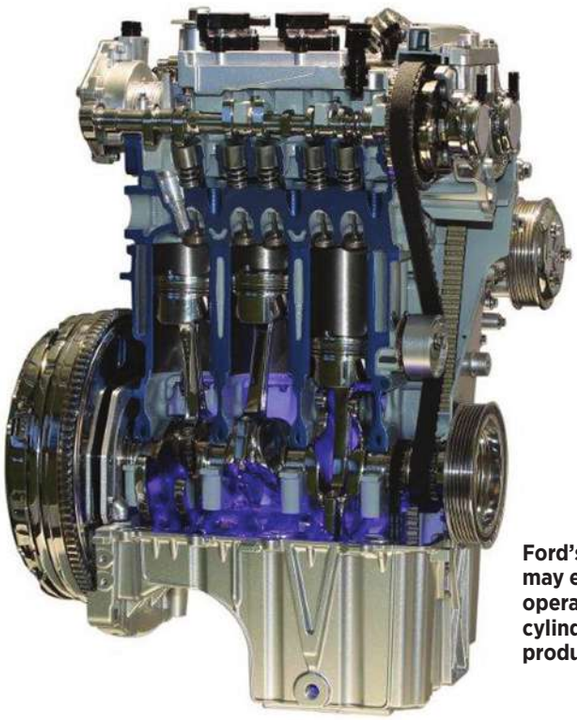
Indian mining company **BGR Mining & Infra** recently placed an order for 200 **Scania** P 410 tipper trucks, adding to the company's current fleet of 246 Scania vehicles. BGR Mining & Infra Managing Director B. Umapathi Reddy said: "Since we started using these vehicles in our mining fields, we have observed a clear increase in operational performance and efficiency. A special mention goes to the dedicated services of Scania." The mining company is headquartered in Hyderabad.

The new order for P 410 tipper trucks adds to BGR Mining & Infra's current fleet of 246 Scania vehicles.

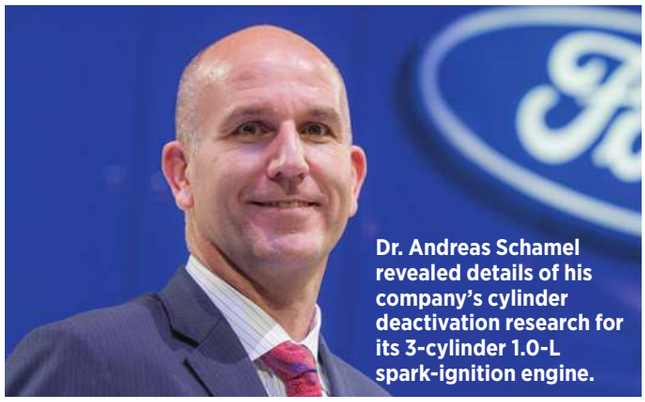
Scania has launched a range of on-road haulage truck models specially adapted for the Indian market: the R 500 6x4, the G 460 6x4, and the P 410 6x2 as well as the off-road P 410 8x4 mining tipper. The company, which has been represented in the Indian market since 2007, also has a successful partnership with **Larsen & Toubro** in the mining segment. In 2011, the company established **Scania Commercial Vehicles India** Pvt. Ltd. to strengthen its sales to additional segments of the Indian commercial vehicle market. It is currently establishing a complete service and dealer network in India.

AUTOMOTIVE POWERTRAIN

Ford tests cylinder deactivation on its 1.0-L EcoBoost triple



Ford's smallest production engine may eventually gain the ability to operate as a 666-cc twin if the cylinder deactivation system is productionized.



Dr. Andreas Schamel revealed details of his company's cylinder deactivation research for its 3-cylinder 1.0-L spark-ignition engine.

If the words "**Ford** Mondeo powered by 1.0-L 3-cylinder EcoBoost engine" sound a bit incongruent, now consider that the company is researching cylinder deactivation for its little triple.

Ford, working with European partners, has examined both single and "rolling" deactivation strategies for its smallest spark-ignited passenger car engine. After proving itself in the B- and C-segment Fiesta and Focus models, the 92-kW (69-hp), 1.0-L—smaller than many motorcycle engines—is now also available in the D-segment Mondeo in Europe.

How does this diminutive engine perform in the roomy sedan when all three cylinders are on the job? A test drive in the U.K. by this SAE Magazines editor of the production version of the Mondeo triple largely dispelled doubts of its general suitability to propel a 1455-kg (3207-lb) curb weight car. Acceleration from zero to 100 km/h takes 12 s and claimed top speed is 200 km/h (124 mph). Official economy figures for the 1.0-L Mondeo include a combined figure of 5.1 L/100 km (about 46 mpg) with CO_2 emissions of 119 g/km.

My test drive was particularly impressive regarding NVH levels both generally and in the cruise. And it is in the cruise that two-cylinder operation for the Mondeo could be viable, just as it may be for the smaller Fiesta and Focus.

Two deactivation strategies

Research into the feasibility of cylinder deactivation for a production triple has been carried out by a high-level Ford team led by Dr. Andreas Schamel, Director, Global Powertrain, Research and Advanced Engineering. He said that when installed in a Focus and dependent on various factors, a fuel consumption reduction of between 4% and 6% is achievable when operating in 666-cm^3 twin-cylinder mode.

The general deactivation system would be complemented by further technology that Ford has now researched, including a specifically developed pendulum absorber. Integrated into the driveline, the absorber enables a broader operating range during cylinder deactivation at lower engine speed, explained Schamel in a technical paper he presented during the 2015 Vienna Motor Symposium.

The paper notes Ford's collaboration with **Schaeffler Group** (Dr. M. Scheidt), including Schaeffler's **LuK** division (Dr. H. Faust). Dipl-Ing C. Weber of Ford Cologne is also a key member of the research team.

As well as incorporating the pendulum absorber, a cylinder deactivation Focus prototype was also fitted with a

The likelihood of Ford adopting cylinder deactivation technology, a space already occupied by GM, Honda, FCA and Mercedes, was reported by this magazine in 2014, in an interview with Ford of Europe COO, Barb Samardzich: "I think it's a technology that you will see from us," she said.

The D-segment Ford Mondeo (Fusion in North America) is now available with the 1.0-L 3-cylinder EcoBoost in addition to other SI and diesel units.

Schaeffler dual-mass flywheel (DMF) and a tuned clutch disc, to achieve vibration isolation between transmission and engine.

Mandatory development targets were met and results noted no NVH deterioration compared to the standard production 1.0-L EcoBoost.

Two different cylinder-deactivation strategies were examined: deactivation of a single cylinder, and what is termed a "rolling cylinder" deactivation, which would effectively run the EcoBoost triple in a "half-engine" mode, with freedom to vary the number and sequence of deactivated cylinders.

Schamel explained that on a 3-cylinder engine, different strategies for cylinder deactivation are applicable. One "is to apply an appropriate valve deactivation mechanism to one cylinder," effectively creating a 666-cc twin but with the disadvantage of an uneven firing sequence. However, Ford has investigated other technologies which provide the freedom to vary the number and the sequence of deactivated cylinders.

Such a set-up offers the opportunity for a rolling cylinder deactivation and could be used to run the engine in half-engine mode, corresponding to a 500-cm^3 active displacement but now with the advantage of an even firing order, he noted in the paper.

The research teams found that the half-engine mode offered a greater potential of avoiding throttle losses at very low loads, but at an overall lower load limit compared to the two-thirds mode. Schamel added: "In the operating area in which the two deactivation strategies overlap, the rolling cylinder deactivation shows a bigger fuel saving potential related to the full engine operation compared to fixed cylinder activation."

The fuel economy for the 1.0-L engine during rolling cylinder deactivation would be better than that for the fixed cylinder deactivation in low load drive cycles, but the magnitude of the additional benefit would depend on vehicle application and cycle. A small car at light load would get the biggest potential benefit, with smallest achieved by a large car during mid to high load cycle. So a Fiesta with a 1.0-L engine would be able to gain another 1.2% fuel efficiency benefit in NEDC compared to the improvement already achieved with fixed cylinder deactivation. But for a Mondeo using the engine the gain would be negligible in the WLTP (Worldwide Harmonized Light Vehicles Test Procedure) cycle, considered to be more representative of real-world driving.

Conquering NVH

While fuel consumption reduction is the salient plus factor regarding the general application of cylinder deactivation, the downside can be negative NVH effect.

Schamel explained: "On the one hand, NVH requirements constrain the maximum torque at lower engine speeds and on the other, the human perception of low frequencies does not allow the operation at very low engine speeds. The NVH objective is the minimization of low engine order excitations caused by cylinder deactivation.

"The NVH limits can be moved to higher torque levels and lower engine speeds by optimization of the powertrain and introduction of new technologies," he noted.

The use of the dual-mass flywheel with tuned clutch disc counteracts the 0.5th or 0.75th engine-order excitation and the pendulum damper reduces the 1.5th engine order by more than 90%, according to Ford testing.

The baseline production DMF flywheel and clutch facilitates comfortable cruising from 1500 rpm upwards on 2nd gear and above 2000 rpm in 6th. The absorbing system allows the lower speed limit to be "significantly" reduced in all gears and maximum acceptable torque to be increased close to the mechanical design limit of the DMF, bringing a 1% NEDC fuel economy benefit. The rolling mode deactivation would see an extra 0.5% achieved.

Summing up the pros and cons of single or rolling cylinder deactivation, Schamel and his colleagues reported, "The fulfillment of the mandatory development target, no NVH deterioration, is achievable for all cylinder deactivation strategies. Without a significant compromise regarding fuel economy, the single cylinder deactivation strategy is preferred regarding complexity, controls efforts, and cost effectiveness."

Ford calculations show the ratio of total functional benefit and cost to be "advantageous" for the single cylinder deactivation strategy versus the rolling approach. A high level contemplation shows a 90% fuel economy benefit for 40% of the cost—good "bang for the buck." The research team concluded that "even highly downsized engines can benefit from a cylinder deactivation strategy, with fuel consumption reduction gained in various global drive cycles—and under real conditions."

Stuart Birch

OFF-HIGHWAY POWERTRAIN

Kohler extends its hand in off-highway diesels

The new KDI 3404 was developed by Kohler, with some help from Ricardo, to reach a standard of performance that is usually seen with higher displacement engines, with a power density of 30 kW/L.

Ricardo assisted Kohler Engines in the development of the new KDI 3404 engine from initial systems specification through design and simulation—including use of the Ricardo WAVE performance simulation and VECTIS 3D CFD tools—to final calibration and validation testing.

According to **Kohler Engines**, its new KDI 3404 model completes its platform of KDI diesel engines, which now range across three models from 30 to 100 kW (40 to 134 hp). The 3404 reaches 100 kW (134 hp) at 2200 rpm and 500 N·m (364 lb·ft) at 1400 rpm. It also reaches 412 N·m (304 lb·ft) at just 1000 rpm, enabling demanding work cycles at low rotation speeds, and reducing fuel consumption by up to 10% while significantly limiting noise levels.

The turbocharger, engine, and electronic control unit were designed together to offer an immediate response to variations in load, enabling 15% higher levels of machine productivity compared to leading competitors, claims the company. The KDI 3404 also offers efficiency in terms of the cost of ownership, with maintenance intervals of 500 hours without the need for a diesel particulate filter (DPF).

All of the models meet current emissions standards without the use of a DPF, which was made possible by the 2000-bar (29-ksi) high-pressure common-rail injection system offering clean combustion, helped at least in part by G3S solenoid-type injectors that offer precise supply of fuel during the injection process and the use of an electronically controlled EGR valve for the recirculation of the precise amount of exhaust gas. The range of KDI 3404 engines is completed by mechanical versions that are suitable for less regulated markets.

The KDI 3404 was developed by Kohler, with some help from **Ricardo**, to operate at performance levels usually seen with higher displacement engines, with a power density of 30 kW/L. As a result, OEMs can replace higher displacement engines with versions that have a considerably smaller footprint to reduce consumption without necessarily redesigning their application or, in the case of new machines, designing smaller engine housings leading to improved operator visibility and productivity.

The lack of a DPF helps to increase productivity for the end user, who no longer has to slow down the work cycle because of the regeneration process, and make installation easier as there is no longer any need to adopt expensive safety measures to counter excessive heat loss and prevent fire hazards.

The two lateral auxiliary PTOs (**SAE** A and SAE B) were engineered to deliver maximum engine power and simplify integration with the hydraulic system of the various applications, reducing the space taken up by the machines. The bedplate architecture (crankcase and sub-crankcase) used for the engine block and its counter-rotating crankshafts also contribute to reduced levels of vibration and noise.

The design of the KDI 3404 makes it the slimmest engine in its class, says the company, particularly important for agricultural applications where engines are placed on the front axle and have to be compact size with less width to give farming vehicles a better turning radius, thus making maneuvering easier.

In configurations above 56 kW (75 hp), the KDI 3404 engine complies with Stage IV/Tier 4 Final exhaust gas standards via the use of selective catalyst reduction (SCR) to reduce NOx in the exhaust. The "all-in-one" SCR system contains the DOC (diesel oxidation catalyst), the mixing pipe, and the SCR in a single piece of equipment. The compact footprint of the whole device and the possibility to fit it at any angle simplifies its integration with the machine.

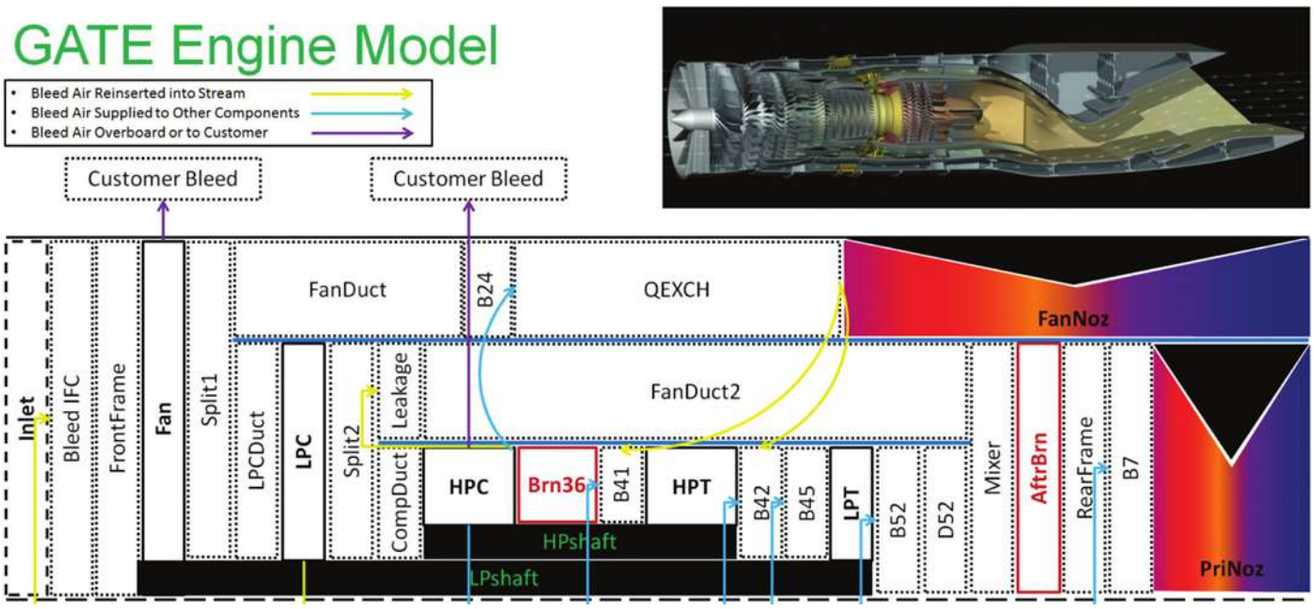
The KDI 3404 is also essentially Stage V ready, with the SCR system having been designed so it can accommodate a DPF, currently the only technical solution capable of meeting the requisites for the number of particles of particulate in the proposed law in the process of assessment by the European Commission and expected for 2019.

In the case of the 3404, it was engineered and designed such that the current all-in-one SCR module will simply have to be replaced with a new module that will be exactly the same size. The DPF used will be small and its use will benefit the already clean combustion, consequently having a lower number of regenerations than any other DPF while maintaining high levels of productivity.

Jean L. Broge

AEROSPACE PROPULSION

Propulsion performance model for efficient supersonic aircraft



NPSS is a component-based object-oriented engine cycle simulator that is designed to perform many common tasks related to a propulsion system. Shown is a three-stream variable cycle engine.

For the design process of the class of aircraft known as an efficient supersonic air vehicle (ESAV), particular attention must be paid to the propulsion system design as a whole including installation effects integrated into a vehicle performance model. The propulsion system assumed for an ESAV considered in a recent study done by **Optimal Flight Sciences** LLC and the **Air Force Research Laboratory** was a three-stream variable cycle engine (VCE).

The importance of engine performance on overall aircraft performance, even when using traditional performance methods, is hard to overstate. The ability to capture airframe-propulsion system interactions during air vehicle performance analysis promises great insights into the air vehicle design process.

Prevailing airframe-propulsion design methods involve high-fidelity, single-discipline propulsion modeling translated to a low-fidelity table format for an airframer's use in traditional performance modeling. The airframer may be required to add installation effects to this reduced engine model that are not coupled to the propulsion model that originally generated the table. This approach is not sufficient for the integrated nature of propulsion systems envisioned for future aircraft, including an ESAV class.

When information is passed from the airframer to the engine manufacturer in the early design stages, it is generally limited to net thrust and thrust specific fuel consumption (TSFC) requirements at some few points in a mission envelope. If an engine or engine core that already exists will be used to power the aircraft program, the data passed to the engine manufacturer are scale factors of the above parameters.

It can be argued that a better aircraft system could be produced if a high-fidelity interface between the engine manufacturer and the airframer existed during conceptual design stages. Without this coupling, real physical interactions that are key to the eventual design that might otherwise possibly be capitalized on through design work will be missed, and will of necessity be dealt with later on costing money and usually aircraft system performance.

In this study, a computational model was built with the Numerical Propulsion System Simulation (NPSS) software to analyze the engine. This engine model was based on the generic adaptive turbine engine model developed at the turbine engines division of the AFRL. Along with this variable cycle NPSS model, a three-ramp external compression inlet model meant for conceptual design was developed. This model was used to capture inlet installation effects, including those attributable to angle of attack changes at supersonic Mach numbers.

Those models were integrated into the Service ORiented Computing EnviRonment (SORCER), which enables parallel execution of the installed NPSS model to rapidly evaluate a full flight envelope. The SORCER-enabled NPSS model was used to produce an engine deck with an expanded selection of variable-state parameters compared to a standard conceptual level engine deck. These parameters were the inlet angle of attack, inlet flow bleed percentage, and flow holding percentage. This multiparameter engine data was used to evaluate the performance of an ESAV system model. The results of the evaluation showed that the additional nontraditional variable parameters included in the engine deck are significant and are worthwhile to consider in aircraft design work.

A conceptual design level, three ramp, external compression inlet model was constructed and integrated with the Generic Adaptive Turbine Engine (GATE) NPSS model. The inlet model was built using two-dimensional compressible flow equations, and it was verified in that it agreed well with flow results using the higher fidelity Euler

For the purposes of this study, an ESAV was defined as a lambda wing concept with two identical engines. The inlets on this ESAV concept are not two-dimensional external compression inlets, but are representative only of the ESAV configuration.

code, CART3D. This inlet model and the parameterization and wrapping of GATE to be used in a multidisciplinary design and analysis optimization (MDAO) context is collectively called the MSTC-GATE installed propulsion model. (MSTC is the Multidisciplinary Science & Technology Center with AFRL.)

The inlet code was integrated with the GATE model in NPSS for the purpose of being able to calculate the installed propulsion multiparameter performance at the conceptual design level. The inlet model enabled the calculation of spillage drag using a physics-based approach. In addition, further effects and parameters were exposed to the aircraft design space including angle of attack effects and variable engine component settings.

The MSTC-GATE model was incorporated into the SORCER environment to facilitate the coupling of physics between different aircraft disciplines and to make the MSTC-GATE model computationally tractable for MDAO applications. Therefore, changes in one discipline can propagate into the whole aircraft system so that all affected disciplinary analyses can be properly updated. In this way, the complex physical effects that occur between different aircraft subsystems can also be accounted for, and possibly exploited, during the conceptual design phase, such as coupling propulsion and aerodynamics disciplines.

This effort utilized SORCER to exercise MSTC-GATE so as to study the effect of aircraft angle of attack and varying the engine diffuser bleed percentage and the flow holding value on aircraft system performance. To understand the impact of these parameters, the engine was coupled to a supersonic-capable lambda wing planform aircraft. Different performance methods that either utilize or fix various features of the MSTC-GATE engine model were evaluated. It was found that the impact of the features explored in the study such as angle of attack linking, supersonic spillage drag, flow mismatch spillage drag, and VCE features with objective functions of TSFC minimization, spillage drag minimization, and SEP maximization all have a measureable effect.

These extra parameters, beyond the traditional Mach number and altitude mission envelopes, permit deeper insights into high-performance aircraft design by bringing more realism and physical effects earlier into the design process through multiparameter performance analysis. Conceptual design traditionally sets the majority of the eventual aircraft cost with the least amount of knowledge during the design process. This work has improved the situation by increasing the level of knowledge available at this stage of the design process, thus ideally reducing the eventual cost of the final aircraft and/or increasing the final system performance.

This investigation found that determining the optimal use of a VCE is a multiobjective optimization problem that is more complicated than the single objective problem envisioned.

Additionally, the potential to improve overall airframe-propulsion system level performance was demonstrated by showing that increasing drag improved the engine operational efficiency. This emphasized the importance of designing the propulsion system and airframe simultaneously for best performance.

Finally, researchers showed how a VCE could be used to operate the same air vehicle for either maximum specific excess power (SEP) or minimum mismatch spillage drag (only two of the many possible objectives). A standard aircraft performance analysis produces one SEP plot per air vehicle, whereas the multiparameter performance method offers designers an expanded view of many different flight envelopes based on different objectives for a complete picture of aircraft capability. These two objectives and their effect on the flight envelope were quantified as an example.

This article is based on SAE International technical paper 2014-01-2133 by Darcy Allison, Optimal Flight Sciences LLC, and Edward Alyanak, Air Force Research Laboratory.

AEROSPACE PROPULSION

Flight propulsion goes electric

NASA is using its LEAPtech blown wing to evaluate distributed electric propulsion for planes.

Somehow, the sight of an airplane wing perching incongruously atop a big-rig truck tractor that's rumbling across a dry lake bed at dawn might not seem particularly significant to the future of aviation. But when the 18 small, pinwheel-like propellers on the wing's leading-edge flash into the sun's first rays like a swarm of crimson butterflies trying to lift the wing into the still, desert air, the odd spectacle actually provides a good indication of what may become a new propulsion paradigm for next-generation aircraft.

Those morning speed runs across **Edwards Air Force Base** in California represent some of **NASA**'s first real-world tests of distributed electric aircraft propulsion technology, a budding design concept that could revolutionize everything from light planes to regional airliners within a decade or so, said Mark D. Moore, Principal Researcher for NASA's Convergent Electric Propulsion Technology Sub-Project at **Langley Research Center**.

In place of one, two, or several large propulsion engines as in conventional aircraft, the unusual "blown wing" that the Hybrid-Electric Integrated Systems Test-bed (HEIST) is evaluating features an array of small electric-powered propellers that send multiple streams of high-speed air over the upper surface of the wing to produce unprecedented lift capabilities, he said.

"If you distribute higher velocity air

NASA plans to replace the wings and engines of Tecnam light plane with an improved blown wing featuring multiple props.

NASA's Hybrid-Electric Integrated Systems Test-bed (HEIST) is now cruising across dry lake beds in the Mojave Desert.

across the entire wing, you can raise the dynamic pressure over the wing and thus increase lift substantially at low flight speeds," Moore explained. This novel arrangement allows use of a downsized wing that nonetheless generates greater lift during takeoffs and landings, which not only provides a greater safety margin for the pilot and shorter takeoff runs, but better overall ride quality as well. The design also can deliver less drag and fuel use in cruise operations and longer range, even lower noise levels.

The experimental HEIST test article, a 31-ft-span, carbon-composite wing section, is mounted on a supporting truss with load cells attached, all of which floats on a vibration-absorbing airbag, said NASA **Armstrong Flight Research Center** project engineer Sean Clark. Combined, the 18 propellers generate about 300 hp and the wing provides around 3500 lb of lift. The ground-test rig thus serves as a "mobile wind tunnel" at significantly lower cost than a large-scale wind tunnel. Testing at speeds up to 70-80 mph is providing valuable data at an affordable price.

A leap in aviation

The ground tests are part of NASA's $15-million, three-year Leading Edge Asynchronous Propeller Technology (LEAPTech) program, which aims to evaluate the premise that the tighter propulsion-airframe integration that is enabled by electric power will yield improved efficiency and safety, as well as environmental and economic benefits. To develop and build HEIST, NASA engineers at Langley and Armstrong partnered with specialists and engineers at "two small, nimble, enthusiastic firms," **Empirical Systems Aerospace** of San Luis Obisbo, CA, the prime contractor, and Santa Cruz-based **Joby Aviation**, which built the test rig, wing, motors, and propellers.

Within a few years, the NASA team hopes to develop and test a LEAPTech flight demonstrator by replacing the wings and engines of a **Tecnam** P2006T light twin airplane with an improved version of the distributed-propulsion blown wing. Using an existing airframe will allow the researchers to compare the performance of the modified vehicle with that of the standard configuration. Moore says that the researchers are applying for "X-Plane" status for the re-winged test aircraft.

New transportation solutions

The research project got its start in 2011, when Moore and his colleagues began studying the possibility of "turning the small airplane into real mid-range transportation solution instead of a mostly recreational novelty," he recalled. "An automobile works great up to about 100 miles, while a commercial airliner works great for 500 to 1000 miles, but for affordable, high-speed speed mobility between 100 to 500 miles, there's no great transportation solution.

"Our studies say that distributed electric propulsion would be cost-effective for distances less than 600 miles," Moore continued. The new technology plus improved autonomy (control/safety) systems could provide dramatically higher-speed, more affordable access than cars but with car-like ease of use, he contended. "It could create a whole new market for general aviation aircraft.

"As our analysis went forward, we realized that distributed propulsion is applicable to larger aircraft as well, even commercial transports flying stage lengths of around 600 miles. It could therefore also be a game-changer for turboprop and regional jets that the airlines fly today.

"Think of the Tecnam X-Plane as a subscale demonstrator," he noted. "We want to incubate the concept at the GA level and then scale it up."

Scale-free propulsors

The key to the entire approach is that the electric motor is "a scale-free technology," Moore asserted. "Current propulsion engines just don't scale well. A full-size turbine engine can be around 40% efficient, but if you take it down to 100 hp, it's only 24% efficient—6 hp/lb vs. 0.5 hp/lb."

In contrast, electric motors can be

very compact, very reliable, and highly efficient, he said. “They provide extremely good power-to-weight ratio—two times better than turbine engines and three times better than any reciprocating engine.”

And not only is “electric propulsion happy to scale to any size, you can place them anywhere you want, for instance, along the entire leading edge of a wing to attain synergetic benefits from close-coupled control and lift surfaces.” This innovation, he stated, offers “exciting opportunities.”

Performance benefits

A traditional light aircraft needs a large wing area to meet the low stall-speed requirement for FAA certification, but it is inefficient in cruise. The LEAPtech flight demonstrator would feature a wing that is one-third the size for reduced drag and have nearly three times the wing loading (more than 50 lb/ft^2 vs. 20 lb/ft^2 for a typical small aircraft) for improved ride quality and better response to gusts. Meanwhile, the propeller array should double the maximum lift coefficient at low speeds.

Optimized for low speed, the small-diameter propellers have low tip speeds for reduced noise. In addition, they all rotate at slightly different velocities to spread out the sound frequencies they emit, cutting community noise, it is hoped, by as much as 15 dB. All the props blow the wing for takeoff and landing operations, but some fold back to reduce drag in cruise, when wingtip propellers that are optimized for high velocities provide propulsion, operating inside the wingtip vortices to boost efficiency.

Such changes are expect to deliver a 30% reduction in operating costs, not to mention zero in-flight emissions, he said.

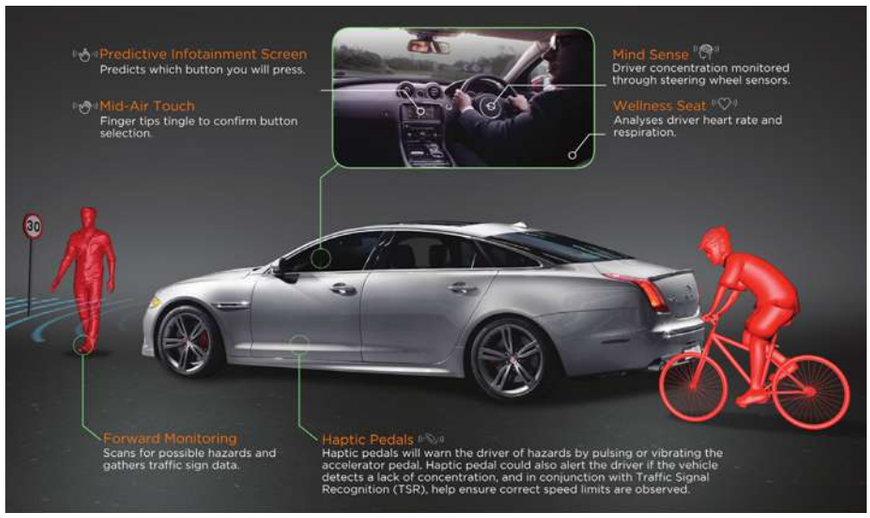
Moore concluded by noting that “the safety statistics for GA aircraft are not all that great, with most accidents happening during takeoffs and landings, when planes are flying low and slow.”

Distributed propulsion provides redundancy against engine failure and maximizes control authority. “With the blown wing, you have incredible lateral control. If one wing loses lift and stalls at low speed causing the plane to roll off to one side, you can just power out of it.”

Steven Ashley

AUTOMOTIVE ELECTRONICS

JLR reveals some R&D secrets



Major aspects of JLR’s research spending have just been revealed by the company.

Watching the alpha and beta waves of one’s brain undulating across a screen while gripping a steering wheel is one of the more bizarre experiences of automotive R&D. But that is what JLR (**Jaguar Land Rover**) is putting its mind to as it delves deep into how to eliminate the effects of driver fatigue or inattention using highly subtle techniques.

“Our project is called Mind Sense and has the ultimate goal of developing a system to detect whether a driver is concentrating, alert and focused, or distracted; we are doing so by monitoring what is going on in the brain,” said Dr. Laura Millen, Human Factors Researcher and leader of the project. “We can’t expect drivers to put on a headset carrying sensors so part of our research project is to look for non-intrusive ways to collect the same data.”

The result is what is probably the world’s most extraordinary steering wheel, which forms part of a novel test rig: “We are evaluating a prototype with four sensors on the back of the upper part of the wheel’s rim.”

Readings are presented on a large screen (this is for research only and definitely not something that would appear on a production car’s head-up display!) ahead of the rig, indicating alpha and beta brainwaves.

“The brain continuously produces four or more distinct speeds or frequencies of brain waves,” explained Millen. “Although these different brain waves are produced simultaneously and in combination, a person’s state of consciousness depends on the dominant (strongest) frequency band at each time. During sleep, the brain produces dominant slow delta waves. During daydreaming or in the twilight of sleep, the brain produces dominant theta waves that are slow but a bit faster than delta. When the brain is calm and mentally unfocused—for example, when a person relaxes with their eyes closed—the still faster alpha waves are dominant.”

To test levels of concentration, the alpha and beta waves are “scored” by an analysis system on a zero to 100% scale as the rig driver watches a screen showing a virtual drive on a winding road.

There are many questions to be resolved, including how to warn a driver (possibly steering wheel or pedal vibration), and later the project will embrace inputs from neuroscientists.

JLR R&D Director, Dr. Wolfgang Epple, said: “Even if the driver’s eyes are on the road, a lack of concentration or a daydream will mean he or she isn’t paying attention to the driving task.”

Complementing this research into a driver’s mental state is the monitoring of his or her physical health. JLR is developing a “wellness seat” that can detect stress, or some serious health issues, via heart- and respiration-rate monitoring. For research, heartbeats and breathing rates appear on displays. Again, alerting methods that don’t conflict with other

attention-getters need to be refined.

Voice alerts, such as those used in cockpits/flight decks for aircrew, would seem to be a possible solution, but JLR's researchers did not comment on this option.

JLR's R&D operation spreads very wide and not surprisingly covers the "autonomous car," a phrase Epple said the company prefers to the emotive "driverless car": "Our vision is to offer a choice of an engaged or autonomous drive. Ultimately, this means that a car could drive itself if the driver so chose, and have intelligent systems that can be adjusted for a more engaging, involved, and safer drive."

The company's Advanced Driver Assistance Systems (ADAS) will enable autonomous driving and make "real" driving safer and more enjoyable, he explained.

Supporting this, together with active cruise control, lane keeping, autonomous emergency braking and other systems will be the facility to make a multi-point 180° turnaround without driver input, and an autonomous, driver-out-of-car facility that could cope with 99% of a **Land Rover** product's off-road capability. This would enable a driver tackling very difficult situations to inch forward a vehicle remotely by use of a mobile phone with simple controls. Experiencing this at JLR's Gaydon R&D center as a Range Rover passenger with no driver aboard, progressing over an obstacle to a very high angle of attack with a front wheel in the air, proved interesting.

JLR's R&D Mind Sense project, headed by Dr. Laura Millen, monitors driver concentration and alertness via brain waves transmitted from steering wheel sensors.

Driver concentration and "wellness" monitoring systems are being developed by JLR.

Three wheels on the ground and no driver: JLR's R&D remote control off-road system.

The system could also be used by any JLR product to remotely extract a car from a hemmed-in parking slot.

Epple believes such technology will prove a major aspect of public acceptance of autonomous vehicles because it will engender trust, much as park distance controls have done. They are all part of an integrated whole and an evolution of technologies that he defines as "autonomous progression."

He sees "a degree" of autonomy entering the market soon after 2020 for use on dual-carriageways, followed progressively by lesser roads, and with a JLR fully autonomous vehicle a reality around 2025.

This development will be supported by radar, LIDAR, and stereo cameras. Epple stated that JLR required levels of cognitive ability in three components: perception, motion planning, and navigation/localization. This would give a JLR vehicle autonomous capability not only on roads without surface warning markers but also without roadside infrastructure including deserts.

Such a solution has been dubbed by JLR the Solo Car, able to take care of itself and incorporating reduced-cost LIDAR sensors (JLR has a program to achieve this) working with a range of new and different sensors. However, where possible JLR is extrapolating the capability of existing sensors, known within the company as "sweating the assets."

"Motion planning describes the vehicle's understanding of where it is at any given point, where it has to get to, and what it needs to achieve that," explained Epple. "Navigation/localization describes the vehicle's ability to navigate to the destination but also understand on which part of the journey it is currently traveling."

In handing over to a driver at completion of what may be a lengthy autonomous journey phase, a vehicle could check that the driver is awake and paying attention, which is where Mind Sense and the Wellness Seat enter the equation.

Other R&D systems to support or alert the driver include haptic accelerator pedals that will vibrate or need added torque to operate, to get attention for such things as cyclists or pedestrians entering the car's vicinity. This editor found the pedal vibration warning technique effective but added torque disconcerting; there are situations when accelerating can be as necessary as braking, and a throttle pedal requiring an extra shove in a looming potential emergency was unconvincing.

JLR has also developed a predictive touch prototype that tracks hand movements in front of an infotainment screen to predict which button a driver will press. This is to reduce "eyes out of cockpit" times by about a fifth. A static demonstration was convincing but a demonstration was required of the system in a car on a poor surface with the vehicle experiencing unpredictable body movements, particularly off road.

Other JLR programs include the self-learning car (claimed as a "world first") that can "know" what radio stations are a driver's favorite when driving to and from a workplace and what level of driving seat massage is required and when.

However, though JLR works towards ever more technologically comprehensive products, it has no plans to replace the driver, quipped Epple: "The occupants of our cars will not become cargo!"

Stuart Birch

OFF-HIGHWAY ELECTRONICS

John Deere's MDT allows users to make data-driven decisions

Mobile Data Transfer is a USB-to-WiFi device that plugs into the display and transfers data quickly and conveniently using your smartphone.

John Deere has added a new tool within MyJohnDeere to make data transfer in the field easier. Mobile Data Transfer (MDT) allows customers to wirelessly transfer agronomic data to and from non-John Deere displays and from John Deere's GreenStar 3 2630 display (in older Deere equipment that is not JDLink compatible).

MDT enables users to consolidate data from multiple branded displays into one centralized location, referred to as the Operations Center, either for their use or to be shared with others to allow for impactful, data-driven decisions. It also bridges the connectivity gap as customers continue to upgrade from non-modular telematics gateway (MTG)-enabled machines to MTG-enabled machines.

"Mobile Data Transfer is the simple solution for customers who run older or mixed-fleet equipment and want immediate access of information stored in their displays. It eliminates the manual transfer of data," said Jeff Nolting, John Deere Intelligent Solutions Group (ISG). "It's a USB-to-WiFi device that plugs into the display and transfers data using a smartphone via the Mobile Data Transfer app."

The MDT app works with a variety of mobile devices to facilitate the transfer of information and it can be downloaded from either the **Apple** iTunes or **Google** Play stores.

Growers using approved competitive displays can send their production data to the Operations Center to be viewed in Field Analyzer or be used by third-party API applications. Additionally, prescription files can be pulled from the display without leaving the cab of the tractor. During the busy planting and spraying seasons, this functionality can offer time savings that translates to higher productivity and thus profitability.

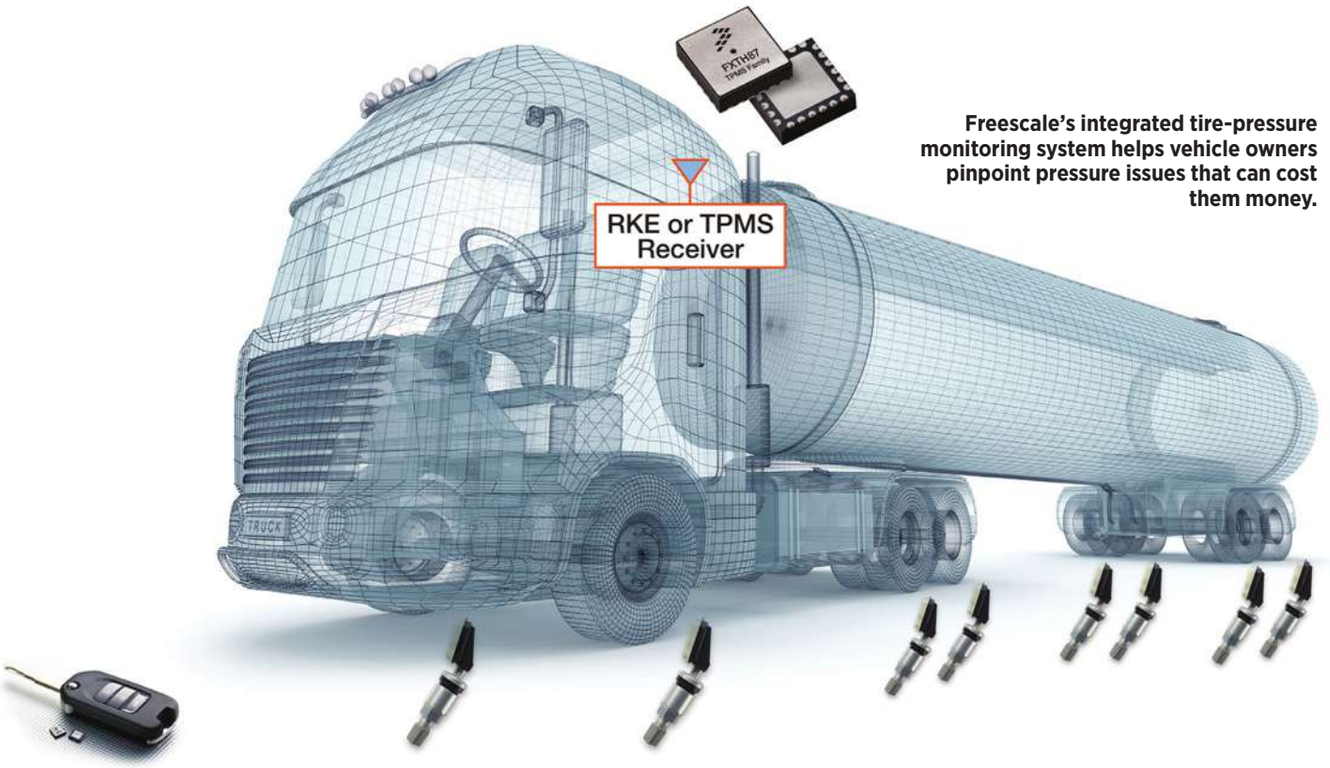
The Operations Center is where users can access the tools to start the days planning with the MyJobs app. These tools allow a manager to define a job that needs to be done, and it includes all of the specifics of that job. "Add Jobs" automatically syncs up with the "My Jobs" app on mobile devices of operators and other employees. They receive a detailed jobs order in real time vs. spending hours on the telephone or managing to-do lists.

The Operations Center and the MyJobs app also keep track of the year-to-year changes that can lead to higher efficiency and yields.

Jean L. Broge

OFF-HIGHWAY ELECTRONICS

Relieving the pressure on fleet managers, installers



Freescale's integrated tire-pressure monitoring system helps vehicle owners pinpoint pressure issues that can cost them money.

A tire pressure monitoring chipset can help fleet managers improve fuel economy and tell when vehicles are overloaded while also simplifying setup times. The **Freescale** Semiconductor device is said to be the industry's smallest sensor, yet it has a broad operating range of 100-1500 kPa, exceeding the levels normally required for heavy commercial trucks.

Though tire pressure sensors are required in passenger cars, those regulations do not apply to trucks. Freescale feels usage in trucking and off-highway applications will grow quickly since properly inflated tires are more economical and safer.

"Demand is driven by economics," said Ian Chen, Engineering Manager for Freescale's Sensor Solutions division. "When you're talking about a major trucking company's fleet, properly inflated tires can save a couple million dollars per year. Proper inflation also improves safety."

Freescale's FXTH8715 integrates a dual-axis accelerometer, motion sensor, RF transmitter, low-frequency receiver, pressure and temperature sensor, and a microcontroller in a 7- x 7-mm package. High integration simplifies installation in all markets, but the turnkey package may be especially attractive in the emerging Chinese marketplace.

"Chinese suppliers do not come from an automotive background," Chen said. "They want a faster turnaround time, so we need to provide more turnkey solutions. In China, buses and trucks are often overloaded, so the government is encouraging companies to employ tire-pressure monitoring."

The package has a maximum pressure of 1500 kPa, above the 1300-kPa level normally used in commercial trucking. That is important in off-highway markets as well as buses and trucks.

"In construction and mining, overloading is also very important," Chen said. "They're interested in under inflation."

Using a dual-axis accelerometer simplifies installation while also providing more information for users. The accelerometer provides information that can be used to pinpoint which tire each signal comes from.

"The device sends a signal at the same point in the rotation, which helps the vehicle distinguish between the number of tires on the vehicle," Chen said. "Also, the dual-axis accelerometer reconstructs where gravity is, so the installer doesn't have to align the sensor with gravity."

The technology can be used on trucks that don't have a dashboard light to display low-pressure alerts. Data can be transmitted to remote sites rather than lighting an in-vehicle alert that may be ignored or forgotten.

"The tire-pressure monitors can be tied to telematic systems that send data to the home office," Chen said. "If they decide tires are underinflated, they can send a note to the driver, telling him to properly inflate the tires when he pulls in for maintenance."

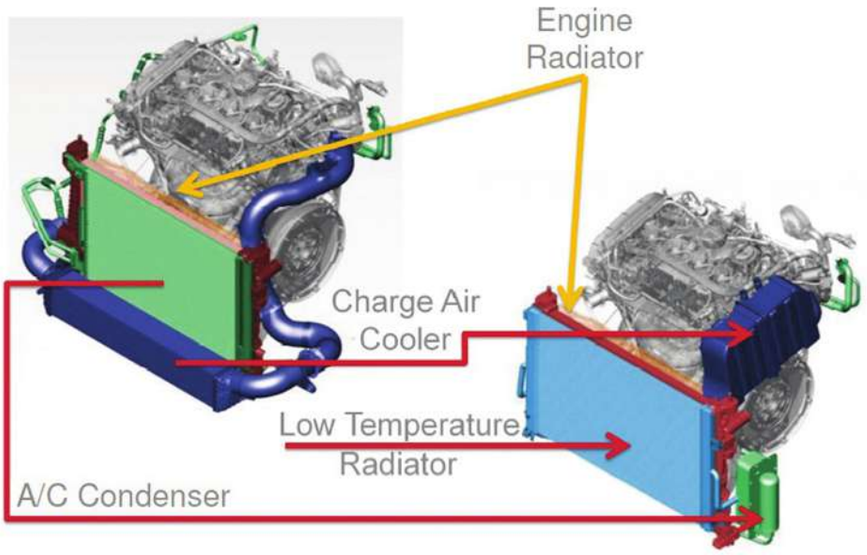
The device draws 7 mA, so it lasts 10 years on a coin cell battery, beyond the typical three-year lifetime of a truck tire, Chen noted. Packages will commonly be mounted in the air-pressure valve, but that may change over time.

"There's a trend to put the chips in the tire, where there's more information available," Chen said. "If it's in the tread, it can count the rotations of the tire, providing a better handle on tread wear, which is especially helpful in fleets where the tires may be moved from vehicle to vehicle. Sensors in the tread can also provide information on road conditions."

Terry Costlow

AUTOMOTIVE INTERIORS

Fiat demonstrates improved fuel efficiency with low-temperature liquid cooling loop



Physical layout of the prototype system as installed in a Fiat Grande Punto shows the shortened refrigerant lines which permit a reduced charge.

The concept of a second water-cooling loop—adding a low-temperature radiator (LTR) and water cooling to replace air-cooling of the A/C condenser, turbo air intercooler (charge air cooler) and other front-end heat exchangers—has been demonstrated by **Fiat Research Center** (CRF) engineers. The goal is to improve system thermal efficiency, which can translate into cost-effective improvements in fuel efficiency, with corresponding reduction in greenhouse gas emissions.

Originally indicated for A/C condenser cooling by modeling at several automakers, the second cooling loop as developed by the CRF has the LTR mounted ahead of the high-temperature radiator used for engine coolant. All individual heat exchangers on the LTR circuit are water-cooled and mounted as close as possible to the system components.

CRF estimates a 5% improvement in fuel economy during A/C operation on the New European Drive Cycle (NEDC), explained Roberto Monforte, R&D engineer in the thermal management area at CRF. He spoke with SAE Magazines at a recent meeting of the **SAE** Interior Climate Control Committee.

Amesim model to real world

The project, for **Fiat Chrysler Automobiles** (FCA), began with a modeling exercise and expanded it to real-world level. CRF was able to show very close agreement between its model, which used LMS Amesim (a mechatronics simulation suite from **Siemens**) and actual measurements. They were taken during prototype development of FCA's Grande Punto subcompact car powered by a 1.3-L Multijet diesel rated at 95 hp (71 kW) and meeting Euro5 emission standards. The results should abet FCA Group efforts to engineer the dual-loop system into a wide range of cars with differing cooling requirements and number of air-cooled heat exchangers in their present configurations.

CRF has prototypes of other vehicles including three cars (an off-road model and a heavy-duty) but showed only the data for the Grande Punto.

Outwardly, the dual-loop system seems overly complex, and its use of an additional layer of heat exchange would appear to reduce efficiency. However, water-based liquid is a more effective heat exchange fluid than air and other forms of liquid cooling used on some cars for turbo air and engine oil. The present primary alternative—airflow cooling several different fluids, including engine and transmission oils, A/C refrigerant, power steering oil and turbo air—dictates that airflow from the fan must be able to handle the worst-case requirement. So even if just one front-end heat exchanger needs it, fan speed would be excessively high to handle that single demand.

With just one LTR in front, the temperature of the water-based fluid in that radiator (55-60°C/131-140°F) becomes an average of the entire low-temperature system. The fan power draw, using an infinitely-variable pulse-width-modulated fan, reflects relatively-consistent requirements for the water-based liquids of the engine coolant radiator (90°C/194°F) and the LTR. This results in a smooth power draw that is more efficient, and may also provide better engine-off cabin heating on vehicles equipped with engine top-start. Water pump flow is electronically controlled.

The engine cooling system lends itself to accurate modeling, as heat load is a function of engine rpm and BMEP (brake mean effective pressure). So does turbocharger air, as mass-flow rate and temperature are determined from a table that includes those two heat load entries.

Refrigerant charge reduction possible

The LTR might also seem to raise packaging issues. But only the LTR is located at the front, making the front-end cooling module simpler to install. Further, specific system heat exchangers may be packaged close to the system they're cooling, reducing length of the lines for the different oils, turbocharger air intercooler and A/C refrigerant. This lowers risk of physical damage and permits a smaller refrigerant charge.

While the CRF installation was done with R-134a refrigerant, a production version might be equipped with R-1234yf, which is so costly that even a 50-g (1.7-oz) reduction in charge would be worthwhile. Water cooling in conjunction with condenser sub-cooling indicated that an internal heat exchanger was not needed on the

Grande Punto with R-134a; it would only be used in a system where considerably more sub-cooling is needed.

The Grande Punto required less than a more complex vehicle, as the only LTR loop heat exchangers are for the A/C condenser and turbocharger air intercooler, although evaporator performance also was part of the model. CRF engineers attempted to keep each of the heat exchanger models simple by using the sizing and performance data of the parts supplier.

Three condensers with sub-cool sections, from different suppliers, were evaluated. There was no specific size/configuration/performance data for the turbo intercooler or cabin heater arrangements, so the model took the NTU approach (Number of Transfer Units, a way to estimate heat transfer, particularly for counter-flow heat exchangers, when needed data from specific heat exchangers is not available).

Modeling results close to measured

Both the Amesim model and the Grande Punto were run on an NEDC, which begins with a hot start, and is run at 28°C (82°F), 50% relative humidity. The A/C is on and set for 22°C/72°F; the system is in outside air and blower speed automatically controlled.

The Amesim model for the LTR and the actual measurement were, on average, within 2°C. For the water-cooled intercooler, the model was an average of about 3°C high on the NEDC's EUDC (extra-urban section, high-speed operation) segment. The model showed greater heat rejection than measured. And although the dynamic difference in that segment will be investigated, all the temperature levels were acceptable.

The loop for the condenser showed very close agreement between the Amesim model and the measurements, both for coolant temperature and R-134a condenser outlet pressure.

CRF also modeled and tested A/C cool-down at high ambient temperatures, beginning with a hot soak at 43°C (109°F), 30% relative humidity, solar load of 900 W/m^2. The Amesim cabin temperature and A/C refrigerant pressure tracked almost exactly with actual measurements, with only minor differences at engine idle.

Paul Weissler

AUTOMOTIVE INTERIORS

Ford expands 'split-view' camera applications in SUVs, trucks

360° camera display screen in the 2015 F-150 pioneers Ford's adoption of this safety technology across its global truck and SUV ranges by 2020.

Ford's latest vehicle camera technology can help drivers see around corners. The optional "split-view" camera feature enables a view of traffic and obstacles that enter the vehicle's path from the side by displaying a 180° view ahead of or behind a vehicle.

Split view uses real-time video from 1-megapixel wide-angle-lens cameras mounted in the vehicle's grill and lift gate. A tri-panel display in the 8-in screen helps customers to perceive quickly whether an obstacle is coming from either side or straight on. Split view is activated by button and automatically shuts off when vehicle speed reaches just over 6 mph (10 km/h).

Split view will be offered on nearly all Ford SUVs globally by 2020, according to the company. A front-only system was introduced on the 2015 Ford Edge, and a front/rear system is standard on the 2016 Explorer Limited and Platinum trim levels in the U.S. and China. European Galaxy and S-Max models get front split view next year.

A small telescopic jet washer keeps the front camera clean on split-view-equipped vehicles; Explorer also uses a washer for the rear camera.

The new aluminum-intensive 2017 Super Duty pickup features up to seven cameras and all-new electrical architecture, making Ford an industry leader in advanced camera technology. The 2016 F-150 has up to five cameras available—four of them mounted in the outside mirrors, and at the rear and front of the vehicle, to enable a 360° view and backup-view functions.

A forward-looking camera mounted behind the rearview mirror is used to activate auto high beams and lane-keeping assist. While the driver never sees the image from this camera, the vehicle's computer uses the visual signal to operate the rest of the system.

Lindsay Brooke

AUTOMOTIVE INTERIORS

HMI's simple challenge: control everything possible without any difficulty

"Right now, voice is too often not an enjoyable solution," said Panasonic's Taylor.

Car buyers who select vehicles with an abundant array of features and functions have a simple request for automakers. They want a human machine interface that lets them bring in personal devices and perform all kinds of tasks whenever they want, and they don't want to have to read a manual or spend time learning how to manage their many options.

Panelists grappled with solutions to this vexing challenge during an SAE World Congress panel, "In-Car Experience—What does the Consumer Really Want?" One of the key requirements will be user interface that adapts to drivers personal preferences, and possibly even to change in response to various driving environments.

"The HMI has to be intelligent," said Charan Lota of General Manager, Electronics Systems at **Toyota** Technical Center USA. "If you're in a busy downtown area with a lot of pedestrians, the display should be dumbed down so it's less distracting. If a teen is driving and there are several people in the car, it should turn down the volume."

Simplicity is another critical trait for controls that are used extremely often. Many expect to do most of the tasks they do in homes and offices without distractions that could cause accidents. Often, they aren't thrilled with current offerings.

"Now, there's so much diversity and systems are so complex, there's a lot of dissatisfaction," said David Taylor of **Panasonic** Automotive System of America. "Developers need to make sure commonly used features are readily available. Audio and navigation are the two biggest things—84% of drivers still listen to terrestrial radio weekly, partially because it's easy."

The stakes are high because HMIs are widely seen as important product differentiators. Companies that have problems with user interfaces get plenty of negative publicity. Consumer-focused companies are trying to play a role in the rapidly-evolving HMI field.

"If we don't get it right, companies from outside the industry are smelling blood," said Andrew Hart of **SBD** North America, a research firm. "Companies like **Apple** and **Google** are already trying to move in."

Many of the techniques preferred by panelists leverage popular concepts from various consumer technologies. The ability to tailor user interfaces is an important factor for HMIs. Vehicle owners want to be able to pick personal favorites on the home page and arrange them in order of preference.

"Favorites are undervalued in vehicle HMIs," said David Lyon of **Pocketsquare**, a design partner group. "It's great to be able to make the functions you use most in a spot where they're easy to access."

The ability to further personalize icons with photos or colors will help drivers easily perform the tasks they do most often. Some drivers will want to see everything, while others want to see basic displays until they decide to access a less-used function.

"Customization is important," Lota said. "You can have a hyper user mode and a common mode. Some people want all the information available, others don't. The hyper user may not be a hyper user all the time. In a busy city environment, they may go to the basic display."

Even hyper users may become fatigued by the number of available offerings. Many owners complain that cars already have so many options that it's difficult to understand and utilize all of them. One panelist said that strategists and developers need to rein in the feature set.

"Vehicles today are overloaded with features," Lyon said. "It's difficult for someone designing a car for 2018, they don't want to leave anything out. I think companies need to set a budget for features so they don't get too many."

Determining how to control these functions remains a challenge. Manual controls ranging from knobs and buttons to touch input to mouse-like console devices are effective. While these manual techniques are effective, they draw the driver's eyes away from the road and pull a hand off the wheel.

Unfortunately, hands-free alternatives didn't get enthusiastic support. Most panelists agreed that voice recognition needs to be improved. Users don't like to learn commands for tasks, and many vehicle owners complain that systems too often don't understand instructions.

"There are some technical problems, one is that we're not yet working with natural speech," Taylor said. "Right now voice is too often not an enjoyable solution, it's easier to do things other ways."

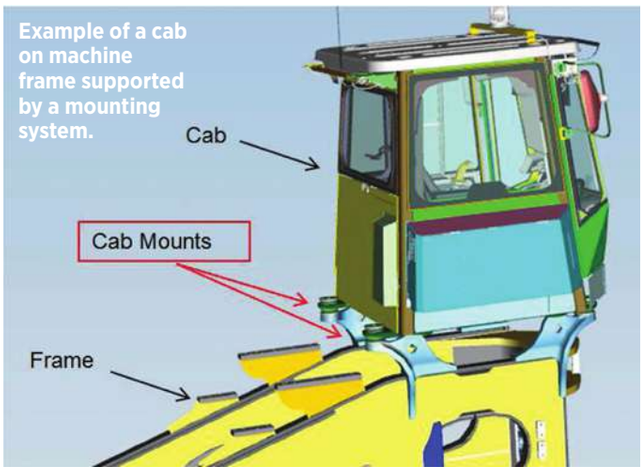
At this point, it doesn't look like gesture recognition will be one of the alternatives to voice control. Panelists described far more problems than benefits for hand motions.

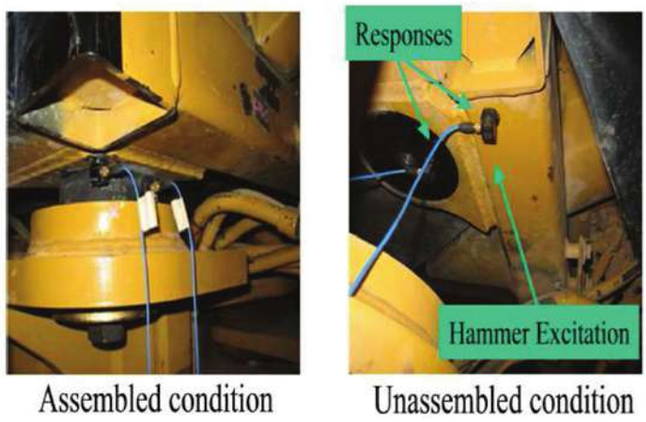
"Every supplier has brought us a gesture control system, not one has worked all the time," Lota said. "There are a lot of different techniques that are not easy to understand. Another fundamental issues is that you have to take your hand off the wheel."

Terry Costlow

OFF-HIGHWAY BODY & CHASSIS

Mounting structure stiffness critical for isolation performance on off-highway machines





Example of the vibration measurement on machine frame and cab across a mounting system.

Off-highway machine mounting systems, especially the cab mounting system, significantly affect the operator comfort in the cab by providing enough damping to the harsh inputs for a good ride, and isolating the structure-borne forces from traveling into the cab, which can cause structure-borne noise (SBN) issues.

A mounting system includes the isolation component and the adjacent mounting structures that work like two springs in series to provide isolation. Both components experience the same load and deflect inversely proportional to their relative stiffness. To properly isolate the vibrations, it is expected that the cab isolators do most of the deflection and isolation; however, the mounting-system isolation performance also relies on the stiffness of the structures to which the mount is attached, and they should be treated as a system when considering isolation performance or capability, according to experts from **Caterpillar** Inc. If the mounting structure is not optimized or stiff enough, then the mounting system will not perform no matter how well the isolation component is designed.

In the automotive world, it is generally required to have the mounting structure be 10-20 times stiffer than the isolator itself. For off-highway machines, the isolators are much stiffer due to other requirements like loads and durability, and hence require stiffer mounting structures.

Cat engineers set out to identify how the mounting structure's stiffness affects the mounting-system isolation performance, and why one wants to design the mounting structures to be at least 10 times stiffer than the isolator stiffness.

Mounting system isolation metric: transmissibility

The concept of vibration isolation can be illustrated by considering the one degree of freedom (1-DOF) system; the mounting system will isolate the vibration forces from the engine to the machine frame or from the machine frame to the cab.

In either case, transmissibility can be used as a measure of the reduction of the transmitted force or vibration through the mounts. In the first case, transmissibility is the ratio of the force amplitude of the frame to the force amplitude of the engine; in the second case, it can be defined by the ratio of the vibration amplitude of the cab to the vibration amplitude of the frame.

With the definition of transmissibility, one should do one's best to approach the lowest possible transmissibility for better mounting system isolation performance. The problem is that a mounting system will not isolate force or vibration over the entire frequency range, which is the transmissibility curve with different damping coefficients. The mounting system actually amplifies the force or vibration amplitudes in the lower frequency.

There are a few ways to look at the transmissibility; one is to describe it in terms of mobility, another is to look at it in terms of vibration.

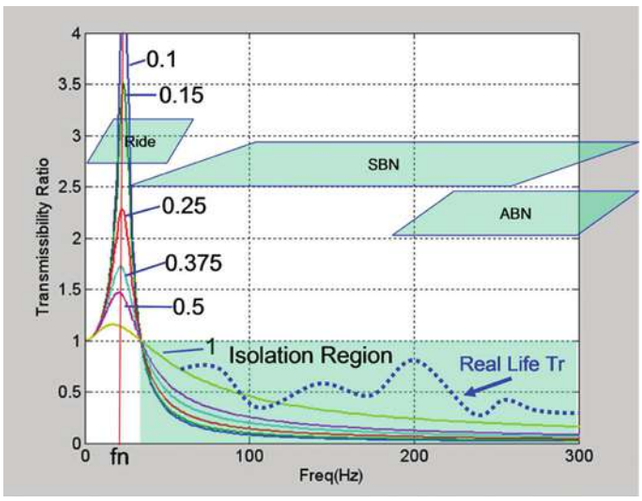
In the mobility approach, the mounting system transmissibility is defined as the force ratio at the interface point with and without mount isolation. In the vibration transfer approach, transmissibility is defined as the ratio of vibration amplitude after and before the mounting system. An example of an off-highway cab support features a mounting system with four rubber mounts.

To look at the effect of the mounting structure stiffness, Cat engineers modeled the cab mounting system in two simplified ways: 1-DOF system and 3-DOF system.

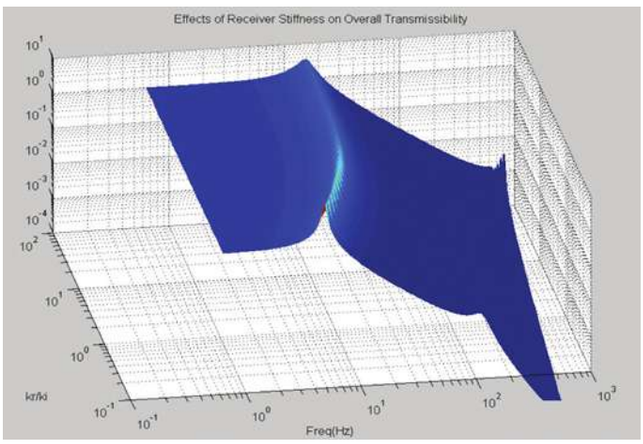
1-DOF mounting system

In a simplified 1-DOF system model of the mounting system, the mass is concentrated on the frame and cab side, the masses of the isolator and mounting brackets are neglected, but the stiffness of the brackets is considered. It was found that the transmissibility is higher when the mounting structure stiffness is low; once the mounting structure stiffness is 10 times higher than that of the isolator, the change of the transmissibility over the change of the structural stiffness is small.

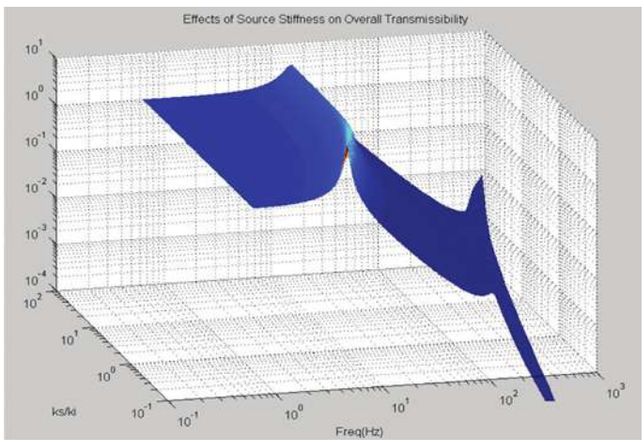
Illustrated in a few transmissibility



1-DOF mounting system transmissibility with respect to different mount damping coefficients.



Effect of receiver stiffness on the mounting system transmissibility, for 3-DOF mounting system.



Effect of source stiffness on the mounting system transmissibility, for 3-DOF mounting system.

curves due to different mounting-structure and isolator stiffness ratios, the transmissibility between stiffness ratios above 5 is really small in the isolation range above 100 Hz, but it is considerable around 20 Hz at the resonance peak, which suggests that the structural stiffness' effect on the mount transmissibility is greater for the first system resonance peak, but not for higher frequencies.

This is due to the simplification of the mounting system to 1-DOF. In the 1-DOF mounting system, the mounting structure stiffness is considered as part of the mounting stiffness, but the mounting structure masses are omitted. To address this problem further, a 3-DOF mount system model with bracket mass was considered.

3-DOF mounting system

The simplified 3-DOF mounting system considers both receiver and source side mounting bracket masses. Based on the equations of motion, the transmissibility of the isolator itself as well as the system including the brackets was calculated in **MathWorks**' Matlab.

The system transmissibility trends due to the stiffness change of the frame or cab bracket were examined. Since they are in series with the isolator, the effects are similar. The resonance peak frequency shifts with the bracket stiffness due to its effect on the overall system stiffness, and the transmissibility varies with it as well. Generally speaking, after the brackets are five times stiffer than the mount, the transmissibility change becomes slow; when the brackets are 10 times stiffer, the effect on the transmissibility is stable and does not change much even if the brackets are a lot stiffer.

The second natural frequency zone is due to the source and receiver mounting bracket stiffness. Even though the transmissibility seems low in that region compared with the first natural frequency zone, it could cause machine isolation issues that are hard to deal with.

For slices from the 3D plots, only a few stiffness ratios between the receiver and source brackets to the isolator were selected to show the trends of the transmissibility due to the mounting bracket stiffness change.

To match the analysis closer to realistic cases, the frame and cab brackets were assumed to be the same stiffness as the isolator, five times stiffer than the isolator, as well as 10 times stiffer than the isolator. It is apparent that when both the frame and cab bracket are at the same stiffness level of the isolator, the mounting system will have problems isolating at around 100 Hz, which is close to typical major engine excitation frequencies. When the brackets get stiffer, the resonance frequency is then shifted to a higher frequency. Specifically, when the ratios of the structure stiffness is five times more than that of the isolator, the resonance is shifted to above 200 Hz, which could still be around some major engine orders and cause SBN if the excitation is high. But when this ratio is 10 or more,

the resonance frequency is shifted to above 300 Hz where no major structural-borne excitations exist in most cases.

As it is shown, the receiver and the source brackets have the same effect on the first peak of the transmissibility since they are in series in the overall mounting stiffness look, but they have different effects on the secondary natural frequency depending on where they are in the link. The source stiffness apparently affects the system more than the receiver stiffness, which indicates it is important to have rigid enough machine frame mounting brackets.

Note that the transmissibility is calculated based on a set of stiffness and damping values that are not relevant to a specific isolator; they were only used in this model for illustration purposes.

Looking at the mounting system transmissibility, it's seen how important the mounting brackets are to the mounting system isolation. As the isolator is supposed to be the component deflecting the most when the mounting system is loaded dynamically, the bracket stiffness affects the isolator component's transmissibility more than the overall system transmissibility. The mounting bracket stiffness has less effect on the isolator performance when it is 10 times stiffer than the isolator.

The isolator is not isolating when the brackets are not stiff enough. From the view of just the isolator component, its isolation effectiveness varies greatly with the mounting bracket stiffness. When the bracket is five times stiffer than the isolator, the resonance is driven to above 200 Hz where there could still be some major engine order excitations, but when the bracket is 10 times stiffer than the mount, the resonance is shifted above 300 Hz, which is well above the major structure-borne excitations for off-highway machines.

A real mounting system case study confirmed these results.

This article is based on SAE International technical paper 2015-01-2350 written by Jiantie Zhen and Scott Fredrickson of Caterpillar Inc., in conjunction with the SAE 2015 Noise and Vibration Conference & Exhibition.

TRUCK CHASSIS

Aluminum frame rails, new alloy castings from Alcoa help cut 2500 lb from tractor-trailers

An aluminum truck frame developed by Alcoa and Metalsa, and employed in the SuperTruck program, is 40% lighter than steel frames of the same size. (Images by Ryan Gehm)

A custom tractor-trailer technology demonstrator built by **Alcoa** is outfitted with various current and "soon-to-be-available" aluminum solutions that altogether can reduce the weight of a tractor-trailer by up to 2500 lb (1135 kg) compared to traditional steel components, according to Victor Marquez, Vice President and General Manager Americas, Alcoa Wheel Products.

The "centerpiece" of the technical display, according to Marquez, is a new roll-formed aluminum frame rail that engineers at Alcoa Technical Center developed with counterparts at structural-component manufacturer **Metalsa**.

"As the central attachment point for the truck's major components, an aluminum frame rail can save almost 900 lb (410 kg) over a traditional steel frame rail—that's game-changing weight savings," Marquez said.

The companies developed the new frame over the past two years as part of the **U.S. Department of Energy** SuperTruck program, according to Russell Long, Chief Design Engineer, Ground Transportation, Alcoa Technical Center.

"The challenges are not as great as one would expect because we've been working with Metalsa, who makes steel frame rails, and they were able to use their current tooling on their current roll-forming line with the material change. So it's mainly just design differences," Long told SAE Magazines at the 2015 Mid-America Trucking Show (MATS).

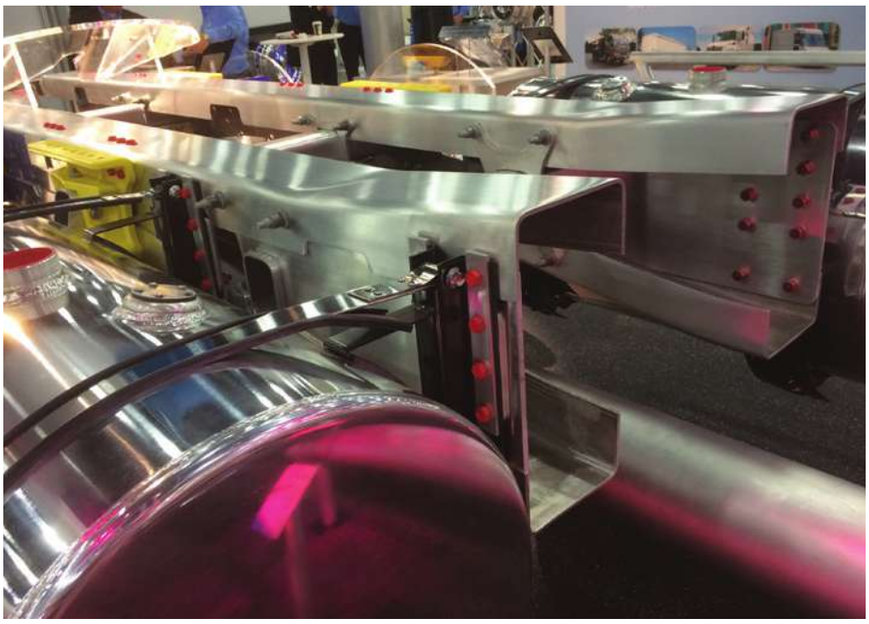
Long noted that Alcoa had previous conversations with truck manufacturers regarding the use of its flat-rolled product for aluminum frame rails, "but it really accelerated with the SuperTruck programs...Once we get through that testing phase, we'll be ready to move forward" with production plans. He declined to share on which SuperTruck program(s) the technology is employed.

The rails are around 9 mm (0.35 in) thick and made of high-strength 6000 series aluminum, Long said. Alcoa expects the frame to be available in 2018.

In addition to fuel efficiency and payload-increase benefits, the lightweight rails offer enhanced strength and corrosion-resistance performance compared to steel, said Kurt Johnson, Central Region Sales Manager, Global Aerospace, Transportation and Industrial Rolled Products.

"Durability is one [area] that we get challenged on—aluminum vs. steel," Johnson explained. "So one of the data points that we have on this [new frame rail] is that from a durability standpoint it's equal to or greater than that of steel—actually two times the rigidity, which would lead to a more comfortable ride."

Corrosion testing was not finalized yet when Johnson spoke with SAE Magazines, but he said that early results



Existing equipment and tooling can be used to produce the frame, which is made of high-strength 6000 series aluminum.

indicated that aluminum is the "superior product" in this measure.

"That corrosion benefit has been there all along—wheels and fuel tanks have benefitted for many years. It's just moving on to the next bigger item," added Long. "None of it's that new; aluminum's been used for major structures all over the place. It just takes time for acceptance."

Regarding pricing when the technology becomes available, Marquez said that "it's going to be a premium. Again, you're talking about almost 900 lb of weight savings—how much is that worth to a fleet? What we see is different fleets value it differently. Those that cube out before they weigh out, probably not so much—but for reefers and fuel tankers, that's big bucks right there."

Another new technology showcased in the demonstrator was Alcoa VersaCast aluminum alloy castings that are stronger and simpler to cast while lowering vehicle weight and improving suspension rigidity, according to Marquez.

The new alloy outperforms cast iron by up to 94% and typical aluminum alloy alternatives by at least 40%, according to Alcoa. That enables it to be used for critical structural parts in commercial trucks, such as mounting brackets for suspension systems.

Alcoa has validated the benefits of the new alloy with help from aluminum casting supplier **Eck Industries**.

"VersaCast enables commercial truck manufacturers to lightweight new and legacy structures traditionally made of iron, such as hanger brackets that attach the truck's suspension system to the vehicle frame," said Christine Keener, Vice President, Commercial, Alcoa Casting. "It outperforms alternatives in the key areas of strength, corrosion resistance, thermal fatigue resistance, and ease of casting across applications."

VersaCast has two times less density than iron and can be produced in high-volume applications. The alloy is currently in customer trials.

Many other solutions contributed to the 2500-lb (1135-kg) weight savings claimed for the technology demonstrator. Alcoa Ultra One wheels with MagnaForce alloy, launched at the 2014 MATS, are employed. Each wheel weighs 40 lb (18 kg), which Marquez claims is "the lightest in the industry." The proprietary MagnaForce alloy offers a 17% increase in strength compared to existing alloys, according to Alcoa.

Structural sheet is used for the doors, which reduces the weight of a typical cab by about 60 lb (27 kg), Marquez said. "Underneath our chassis is an aluminum propshaft tube, which can lower the mass of a typical shaft up to 100 lb (45 kg). And our aluminum fifth wheel, marketed through **SAF-Holland**, can save 100 lb" compared to a steel one, he added.

Ryan Gehm

AERO | AUTO MATERIALS

High-strength aluminum powder developed for additive manufacturing

Metal laser melting has made a successful leap from rapid prototyping to an approved manufacturing technology, and the method is increasingly becoming an option for companies in high-tech industries, according to **Toolcraft**. And now the German manufacturer has teamed with **Airbus APWorks** to offer another option for additive manufacturing—the Airbus subsidiary's Scalmalloy high-performance aluminum powder.

"The cooperation between Toolcraft and Airbus APWorks has existed since the beginning of this year and as of now we process Scalmalloy," Christoph Hauck, Managing Director at Toolcraft, shared with SAE Magazines. Regarding challenges using the material, Hauck noted that Scalmalloy is a completely new alloy, so "the components need a fully new development of parameters."

Toolcraft also uses nickel and titanium alloys, stainless and tool steels, as well as aluminum-silicon alloys in its metal laser melting process. Any mate-

Scalmalloy from Airbus APWorks is a corrosion-resistant material with the specific strength of titanium at a simultaneously high ductility. It is more than twice as strong as the aluminum-silicon powder currently in use.

The new alloy's properties make it ideally suited for high-performance applications in the aerospace, aviation, and automotive industries.

rial that is weldable can be processed.

Scalmalloy is described as a corrosion-resistant material with the specific strength of titanium at a simultaneously high ductility. It is more than twice as strong as the aluminum-silicon powder currently in use, according to Toolcraft. These properties make the new alloy ideally suited for high-performance applications in the aerospace, aviation, and automotive industries, as well as for special machinery manufacturing: "For example, highly durable parts with extraordinary high-strength properties," Hauck added.

Toolcraft continuously seeks to improve its procedures and to expand its material base, Hauck noted, so materials-procurement partners are essential. "The Airbus Group has produced a type of powder that not only exhibits the positive properties of aluminum, but also very high strength with good elongation at break. Scalmalloy is therefore unique in the market," he said.

Scalmalloy is more expensive than standard aluminum alloys, according to Hauck: "There is no serial production of the material yet. The costs can be compared with titanium powder."

In the field of metal laser melting, Toolcraft provides a range of processes from engineering to additive manufacturing and heat treatment to finishing by turning or milling, as well as final tactical or optical measuring. It also uses a system for nondestructive surface testing and meets the requirements of the EN 9100 certificate for aerospace applications.

The cooperation with Airbus APWorks—the technical consulting firm and production operation for additive metal components at the Airbus Group—strengthens the process chain through enhanced topology optimization of the design data. Components can be evaluated in advance, taking advantage of the possibilities provided by additive manufacturing for potential redesigns, parts consolidation, and weight reduction.

"The additive manufacturing process builds up a workpiece layer by layer, as the laser melts the material concerned in powdered form," Hauck explained. "The material is checked for different properties by different analytic tools. The design data for the manufacture of the piece is divided into cross sections and then formed on top of one another during the melting process. The piece is thus literally built up in a '3D' way."

Four laser melting machines from **Concept Laser** are in use. The machines offer a workspace of 250 x 250 x 280 mm in the x, y, and z directions. They melt down layers measuring 20-80 µm in thickness at a speed of 2-20 cm^3/h depending on the material. The laser has an output of 400 W.

The new Scalmalloy material is now ready for production applications, Hauck said.

Ryan Gehm

AEROSPACE MATERIALS

Freudenberg-NOK develops lightweight, fireproof materials for engine nacelles

Freudenberg-NOK Sealing Technologies is currently developing two new materials that reportedly will help aircraft manufacturers save weight and production costs while exceeding fire resistance and fireproof requirements for engine nacelles.

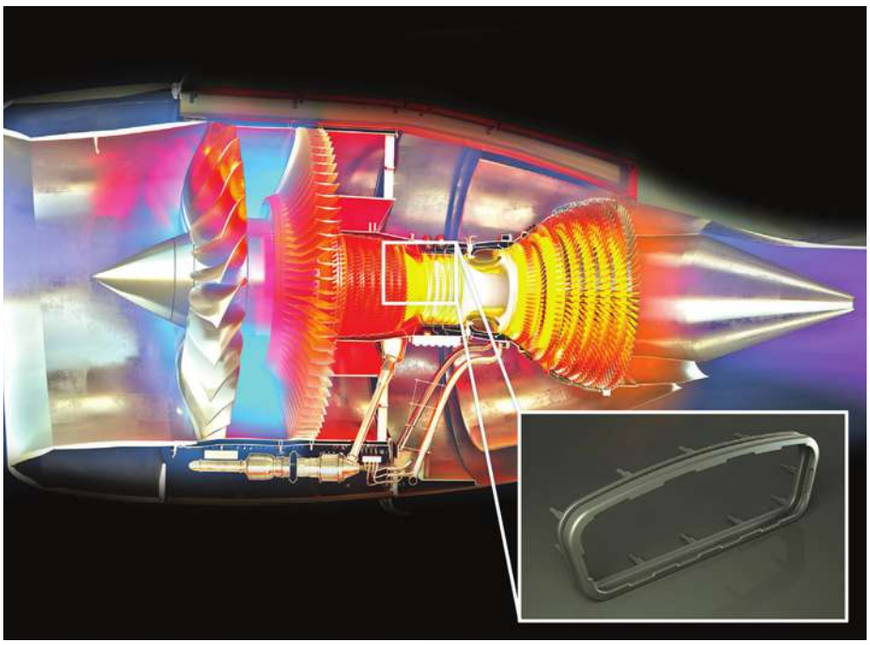
Seals in engine nacelles must withstand fire of more than 1832°F (1000°C) for 15 min per ISO 2685 and AC 20-135. Special, fabric-reinforced materials traditionally have been used in these applications. Freudenberg-NOK is developing a new silicone material that will meet fireproof requirements in traditional fabric-reinforced constructions but offers a 15-20% weight savings over other existing elastomers. The company has also developed a lower-cost alternative material and construction for fire seals.

To conserve fuel, modern engines have been employing increasingly high combustion chamber temperatures that expose seals to higher thermal stresses. For example, the inner side of the engine casing is exposed to temperatures of up to nearly 600°F (315°C) while the air flowing on the outside can be as low as -85°F (-65°C).

"Freudenberg-NOK is continuously engaged in research on materials that offer the required temperature/fire resistance on one hand, and are as light as possible to maximize the payload on the other hand," said Todd Blair, Business and Development Manager at the Tillsonburg, Ontario, facility where the components are developed and manufactured.

Engineers at the sealing specialist are testing the new silicone material that it expects to replace traditional fire-resistant/proof aviation elastomers.

"A similar material technology was previously developed by Freudenberg-NOK for non-fire applications and is currently in use on commercial aircraft providing customers tremendous weight savings," Blair said. "We are now taking this technology into fire applications by developing a lower density



This illustration of an engine nacelle indicates where a seal made of the new material from Freudenberg-NOK would be placed.

elastomer that can meet fireproof requirements when properly constructed with fabric reinforcement."

Adapting the existing material for fire applications is not without its challenges, according to Dr. Paul Hochgesang, Fellow, Technology, Freudenberg-NOK. "Challenges are still being verified. We do not anticipate that adjusting usage from current materials to the new materials will pose significant challenges; however, the materials are still in validation. Each individual application needs to be evaluated as to whether or not the new material is appropriate and applicable for use," he shared with SAE Magazines.

The other material under development is an elastomer that can meet fire resistance and fireproof standards with reduced fabric layers and in some cases no fabric at all.

"The material 'ceramitizes' upon exposure to heat and fire," Hochgesang explained. "Although 'ceramitizing' materials have existed in industry for years, we believe applying this material to engine nacelle seals is a new innovation."

When the surface of the silicone is exposed to direct flame contact, the surface takes on characteristics similar to ceramic material and becomes a fireproof barrier. According to Freudenberg-NOK, this surface barrier slows the progress of elastomer degradation underneath. This material change enables the elastomer to withstand direct contact with fire much longer than traditional elastomers. Since the seal construction can be simplified and the amount of expensive ceramic and aramid fabric layers can be reduced and potentially eliminated, the manufacturing process is simplified and costs reduced, the company claims.

Specialists at Freudenberg-NOK in Tillsonburg work closely with engine manufacturers on material selection and design, since the seal's geometry affects the airflow within the engine and plays a key part in its ability to meet fire requirements. This is even more critical today, according to the company, as industry authorities convert from propane to Jet A burners for testing fireproof capabilities, which can be "much more challenging."

Asked if the two new materials could find use in other transportation sectors such as automotive and commercial vehicle, Hochgesang replied: "All transportation industries are concerned with fuel economy, lower fuel consumption, and lightweighting challenges. We see these developments potentially having applications across many industries and areas."

Freudenberg-NOK anticipates the materials will be available later this year.

Ryan Gehm

AEROSPACE SIMULATION

Dassault Systèmes on everyone's side with 3D visualization for cabin design

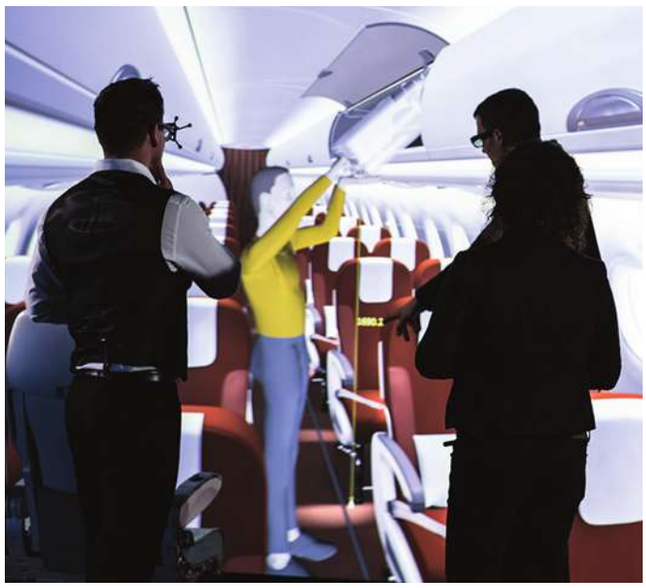
Dassault Systèmes announced just prior to the Paris Air Show the launch of "Passenger Experience," what it describes as a new aerospace and defense industry solution experience that featuring high-end 3D visualization technology for customized aircraft cabins.

As Pierre Marchadier, Vice President, Public Relations, Corporate Communications, and Global Events, Dassault Systèmes, told SAE Magazines at the Paris Air Show, "The passenger is the last bastion to conquer in the aerospace industry."

And he meant it in the best way. Indeed, throughout the show the talk to the press conferences seats, if not the talk on the street, was very focused on the passenger, and not just stretching versions of planes already flying like the A380 to fit more of them in. Instead, it's about connecting them and, if possible, making it seem like they're the only ones of the plane through a customized experience, such as allowing them to preorder food, or starting off a movie on flight B exactly where they left off on flight A. It's also about comforting them.

There have been many technological advances in the industry since nearly every plane flying today went into production, and "there are still lots of planes to produce," said Marchadier. And if not finally, then at least intently, passengers have become part of the conversation as aircraft modernization and the retirement of thousands of aircraft over the next decade have led to a strong build cycle in the industry. That fact in particular has is spurred innovation in cabin personalization and passenger comfort as "an effective tool" for OEMs, completion centers, suppliers, and airlines to differentiate themselves and bring back flyers.

Based on Dassault Systèmes' 3DEXPERIENCE platform, Passenger Experience uses 3D visualization technology and interactive content to transform engineering data into visual 3D design, marketing, and sales applications that address all aspects of the cabin design experience—from initial



Based on Dassault Systèmes' 3DEXPERIENCE platform, Passenger Experience uses 3D visualization technology and interactive content to transform engineering data into visual 3D design, marketing, and sales applications that address all aspects of the cabin design experience.

Real-time cabin configuration and immersive cabin validation capabilities enable quick turnaround time on design configurations, reduce engineering changes, and ensure that the final product meets expectations before a physical prototype is created.

customer interaction and design validation and verification, through to marketing campaigns. "We think of ourselves as strategy partners as opposed to software suppliers," said Marchadier.

Passenger Experience automates cabin completion processes with essential intelligent "building blocks" capturing rules, regulations, and manufacturing knowledge to automate cabin interior design, development, and delivery.

Real-time cabin configuration and immersive cabin validation capabilities enable quick turnaround time on design configurations, reduce engineering changes, and ensure that the final product meets expectations before a physical prototype is created.

Different forms of training and visualization content, including Web-based courseware, interactive game-based training and fully immersive 3D visualization, increase training efficiency and minimize time out of the field for cabin crews and aircraft on the ground.

"Allowing aircraft customers to experience their choices as they make them, to appreciate the beauty, effect, practicality, feasibility, cost, and benefit in real time as they make these choices, is a key goal for Passenger Experience," said Michel Tellier, Vice President Aerospace & Defense Industry, Dassault Systèmes. "There is a competitive advantage in bringing maximum harmony between the interior while it is being specified and what will be delivered, and ultimately marketed, to the private or commercial passenger."

Jean L. Broge

AUTOMOTIVE SIMULATION

Accelerated testing of embedded software code leverages AUTOSAR and virtual validation

The use of the AUTOSAR standard is well known for its business benefits, but it also presents many improvements for the software engineering side of the integrated development process. These include maximum code reuse, employment of off-the-shelf software stacks, and the creation of hardware-independent applications.

The standard also introduces numerous opportunities to improve embedded electronic systems in vehicles including the early testing of software code. Testing earlier in the development process, using virtual validation without expensive physical electronic control unit (ECU) prototypes, can speed up the development cycle, save time, and increase the potential for a functional design.

With growing system complexity, testing code earlier in the development phase is an ongoing issue for engineers. That testing process is usually split into two segments: component and system-level testing. It is usually difficult to perform system-level functional testing without hardware components. That's because the code often contains calls to low-level drivers that won't work without ECU hardware, or the code needs an operating system to trigger calls to the function to be tested.

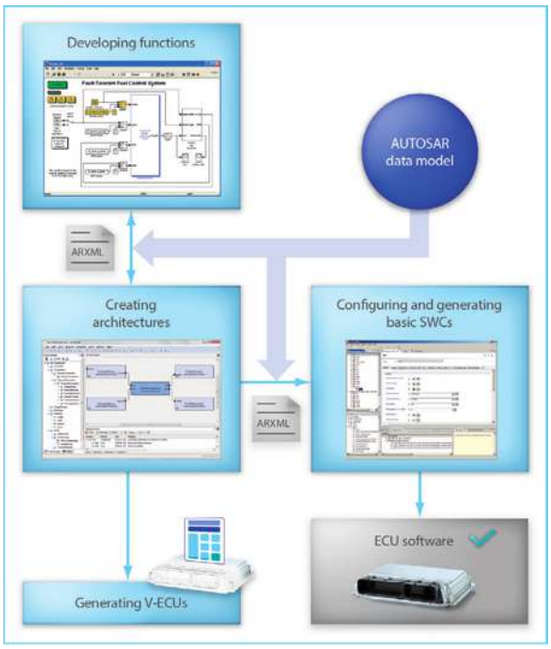
Today, development time constraints and ongoing functional sophistication requirements dictate that component integration tests are performed in realistic scenarios to get useful simulation data early in development. Virtual function validation of AUTOSAR application software modules, using commercially available tools, can help meet these requirements.

There are two key features of AUTOSAR that enable virtual validation.

The first is the standardization of interfaces. This means that any function call, memory access, or hardware driver action that accesses a feature external to the current application component will do so in a standardized way.

The second is the meta model for

Product developers can test a system's overall behavior with the PC-based simulation platform called dSPACE VEOS.



Testing and virtual electronic control units can be performed with dSPACE VEOS.

system architecture modeling. This allows use of XML (or an off-the-shelf tool) to specify information about existing code such as which data are input or output by the code, or what triggering behavior activates it, etc. Using AUTOSAR, developers can be aware of everything going into and coming out of each of piece of an application in a standardized format.

Having a standardized way to access production-intent code in a hardware-dependent way has led to the creation of new tools and execution environments that can run simulations with realistic ECU behavior. It has also led to the extension of existing platforms such as rapid control prototyping devices and hardware-in-the-loop (HIL) systems by applying the use of "virtual ECUs" to in-vehicle prototyping and mixed networks of real and virtual ECUs during HIL testing.

In addition to the standardization of application code through AUTOSAR, standards such as FMI (Functional Mock-up Interface), ASAM (Association for Standardization of Automation and Measuring Systems) XCP (Universal Measurement and Calibration Protocol), and ASAM HIL API (application programming interface) are used by virtual validation execution platforms to connect to plant models and interface with tools already in use during hardware testing. This enables a developer to validate the AUTOSAR software components under development, in a closed loop, and connect to a powerful suite of functional test tools already employed in the HIL area including complex and realistic plant, environmental, visualization, or test automation models.

So regardless of where you are along the path to using AUTOSAR, there is a new light at the end of the testing tunnel in the form of virtual validation.

Joe Fairchild of dSPACE Inc. wrote this article for SAE Magazines.

AEROSPACE MANUFACTURING

3D-printed parts fly on Airbus A350 XWB and ULA rockets

Additive manufacturing (AM) is making significant headway in aerospace production programs, as evidenced by recent announcements that **Airbus** and rocket manufacturer **United Launch Alliance** (ULA) both are—or soon will be—flying aircraft that incorporate 3D-printed parts enabled by **Stratasys**.

The AM solutions provider announced in May that Airbus has produced more than 1000 flight parts on its Stratasys FDM (Fused Deposition Modeling) 3D Production Systems for use in the A350 XWB aircraft, delivered in December 2014. Airbus chose to replace certain traditionally manufactured parts—lightly- or non-loaded interior components, according to a Stratasys spokesperson—with the 3D-printed ones in an effort to increase supply chain flexibility, which the company achieved while meeting its delivery commitment.

Airbus initiated development and certification of 3D printing with Stratasys in 2013 as a schedule risk reduction activity.

"With a digital file as the basis for automated production, wherever you have the appropriate, qualified machine to produce the part, you can," Scott Sevcik, Stratasys' Aerospace & Defense Business Development Manager, shared with SAE Magazines. "This shifts the make-buy decision out of the development phase, and can be a decision made based on the needs of the specific procurement rather than a design choice for the life of the program...Also, because you are producing a part without tooling, changes to the part can occur without involving a change to tooling, which can take weeks or months out of the procurement cycle. So you have more flexibility in where and how you produce the parts, and the shorter change cycle enables flexibility to improve designs over time with less impact."

The parts are 3D-printed using ULTEM 9085 resin for FDM, which is certified to an Airbus material specification. ULTEM 9085 thermoplastic provides

high strength-to-weight ratio and is FST (flame, smoke, and toxicity) compliant for aircraft interior applications. The process enables Airbus to manufacture lighter weight parts while "substantially reducing" production time and manufacturing costs.

"Additive manufacturing also greatly improves the buy-to-fly ratio as significantly less material is wasted than with conventional manufacturing methods," said Dan Yalon, Executive Vice President, Business Development, Marketing & Vertical Solutions for Stratasys. "Stratasys is looking forward to bringing these and other advantages to its collaboration with Airbus and to being part of Airbus' Factory of the Future initiative."

Airbus provides insight into how additive manufacturing, in general, will impact its business in the coming years in this video: https://www.youtube.com/watch?v=Cy3V3KR1LWc&feature=youtu.be. The narrator states in the video that "in the long term, 3D printing could reduce weight on each aircraft by more than a ton."

ULA uses 3D printing to produce flight-ready parts for its launch vehicles, which cost at the lower end about $165 million and are used to propel into space satellites that can weigh more than 60,000 lb. The company makes launch vehicles for **NASA**, the **U.S. Air Force**, and commercial satellites.

ULA progressed its use of 3D printing technology from prototyping to tooling and then to flight hardware production. After acquiring two Fortus 900mc 3D Production Systems from Stratasys, the company began updating the environmental control system (ECS) duct on the Atlas V, which is expected to launch with the new 3D component in 2016. The ECS duct delivers nitrogen to electronic components within the rocket booster.

Engineers consolidated the number of parts for the ECS duct assembly from 140 to 16 parts by using FDM technology to modify the design. This "significantly reduces" installation time and results in a 57% part-cost reduction, the company claims.

"ULTEM 9085 has great strength properties over a wide temperature range," said Greg Arend, Program Manager for Additive Manufacturing at ULA. "We have done testing to show that it is very capable of withstanding temperatures from cryogenic all the way up to extreme heat. And it's tough enough to handle the vibration and stress of lift off and flight."

Airbus has produced more than 1000 flight parts on its Stratasys FDM 3D Production Systems for use in the first-of-type A350 XWB aircraft.

United Launch Alliance will 3D print flight-ready components, including an environmental control system (ECS) duct for the Atlas V, which is expected to launch with the new 3D component in 2016. (ULA)

ULA plans to increase the quantity of 3D-printed parts to more than 100 on the next-generation rocket.

"In a lot of cases, because we do have the ability to use this high-strength thermoplastic, we're actually replacing a lot of metallic applications with plastic applications because it's substantially less expensive," said Andrea Casias, Materials Process Engineer at ULA.

"We see somewhat of an exponential growth in the utility of 3D printing for flight applications on our current vehicles," added Arend. "And we intend to use it heavily with our Vulcan rocket."

The lower volume, higher complexity nature of the aerospace industry is an ideal fit for additive manufacturing, according to Stratasys' Sevcik. "In early 2014, we were in discussion with two companies on certifying material for flight applications; today we're talking to more than 10.

"The type of parts that can be printed will be driven by the type of materials we can offer," he continued. "Right now, we're limited to certain applications that aren't heavily load bearing, but we are working with key customers in the aerospace industry to advance the technology even further. As we continue to improve the material and process offerings, we will be able to address more and more applications," including structural and flight-critical content throughout the aircraft and engines.

Ryan Gehm

AUTOMOTIVE MANUFACTURING

Additive manufacturing startup added to Ford's research roster

Ford is jumping on the additive manufacturing bandwagon, teaming up with a startup that claims its 3D manufacturing system makes parts 25 to 100 times faster than conventional 3D printing systems. The automaker is using additive processes to make tooling and may eventually use them to make production parts.

Ford recently disclosed that it began working with **Carbon3D** late last year. The Redwood City, CA, company is working on an additive manufacturing system that creates polymer parts, with production equipment set to emerge next year. Carbon3D's Continuous Liquid Interface Production (CLIP) technology builds components without pausing, unlike conventional additive processes that build parts by processing one layer at a time.

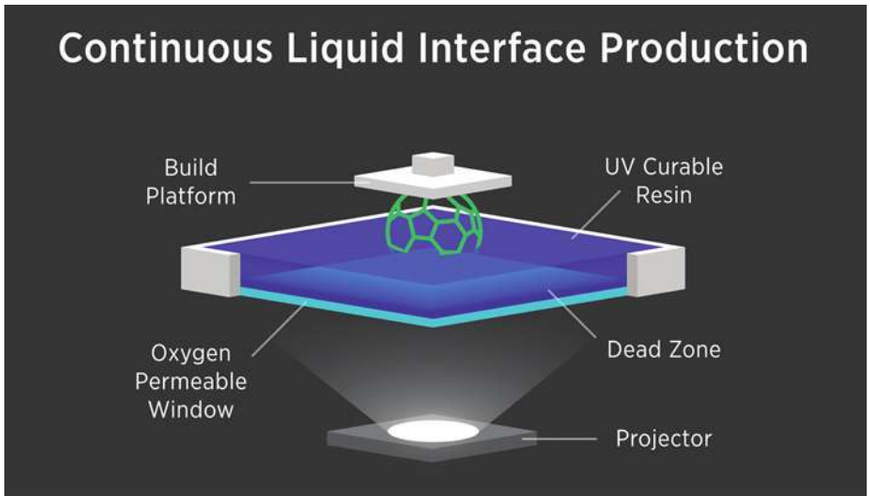
"CLIP builds parts up continuously instead of going step by step," said Kirk Phelps, Vice President of Product Management at Carbon3D. "Oxygen diffuses through the bottom of the tooling, limiting the reaction caused by the UV light. As the oxygen level gets less dense, the light does its job."

Ford hopes to expand its use of 3D printing, which is seeing rapid market acceptance in many fields. Additive processes are particularly well suited for quick builds such as prototypes, since there's no need to wait for tooling development. Ford's also interested in creating tooling with 3D equipment.

"3D printing is ideal for prototypes; we've used it for a long time," said Ellen Lee, Team Leader for Ford's additive manufacturing research. "Now we're using it to make tooling, to shorten development time. We also use it to check ergonomics for people building assemblies, using printed parts to see if workers are able to make all the necessary connections in limited spaces."

Ford may eventually use Carbon3D's high-speed system to make limited production pieces. Automotive's high volumes often make it more effective to produce parts with conventional manufacturing techniques. However, 3D parts can be built into many unusual shapes and sizes. That could make additive processes viable for production parts that are dramatically different than those made with conventional processes.

Ford is working with startup Carbon3D to quickly create components using additive processes.



Carbon3D's additive manufacturing technology adds oxygen so parts can be built up continuously.

"We're interested in it for structures that can't be made with traditional technologies," Lee said. "Sometimes, a solid part can be made lighter by opening up space inside, for example using honeycomb patterns that can't be produced with other technologies. Another possibility for production parts is to combine many parts into one, which reduces shipping and assembly costs among other benefits."

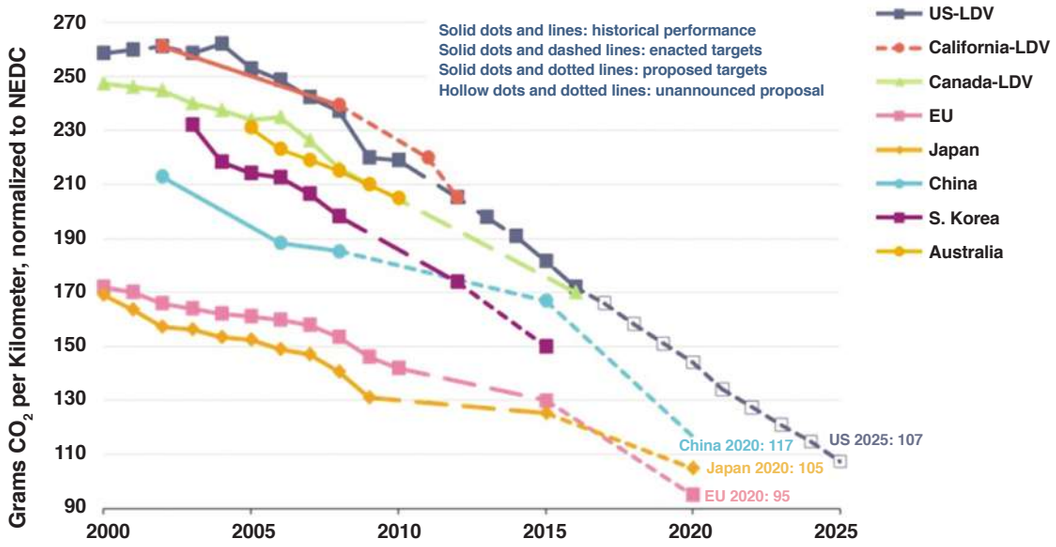
The project with Carbon3D, founded in 2013, highlights Ford's growing interest in working with startups. That can be challenging, since young firms find it difficult to wait for a return on investment given the auto industry's long development time frames.

"In general, startups are very short-term focused, looking at six to 12 months," said James Buczkowski, Director of Global Electrical and Electronics Systems Engineering at Ford. "We can help them raise capital. If Ford is involved, that can often help when they go out for venture capital."

Terry Costlow

The advent of stop-start technology

As environmental concerns grow for R&D teams, OEMs look to bring the strategy further into the mainstream.



[1] China's target reflects gasoline fleet scenario. If including other fuel types, the target will be lower.
[2] US and Canada light-duty vehicles include light-commercial vehicles.

Source: *http://www.acea.be/industry-topics/tag/category/c02-from-cars-and-vans*

CO_2 graph.

Remark: Recalculation in ICCT July 2012 report indicates level of 93g for passenger cars only for the US in 2025. EU's targets are comparitively more stringent. Vehicle definitions are different in the US and EU, and not directly comparable.

Environmental issues have become a primary concern for research and development teams globally. Euro VI, mandated in all new cars sold in the European Union from September 2014, is stricter than ever. Bharat Stage IV, a prevalent emissions standard in NCR and 13 major cities in India, is proposed to be replaced by Stage V in 2017 nationwide.

In fact, the deplorable air quality in Indian metropolitan cities has driven the **Ministry of Environment and Forests** to file an affidavit in the Supreme Court urging to leapfrog to Stage VI by 2020. The **European Automobile Manufacturers Association**, which accounts for roughly 85% of all cars sold in the European Union, has voluntarily agreed to limit their average CO_2 emissions to 95 g/km by 2020. To put things in perspective, the average CO_2 emissions for the passenger fleet was about 125 g/km in Europe in 2013. There is currently no regulation on CO_2 emissions in India, but that is soon to change.

All of this pressure has gotten the major Indian OEMs frantically searching for solutions, resulting in several "prototype-only" innovations trickling down to mainstream applications. One such technology is the stop-start system.

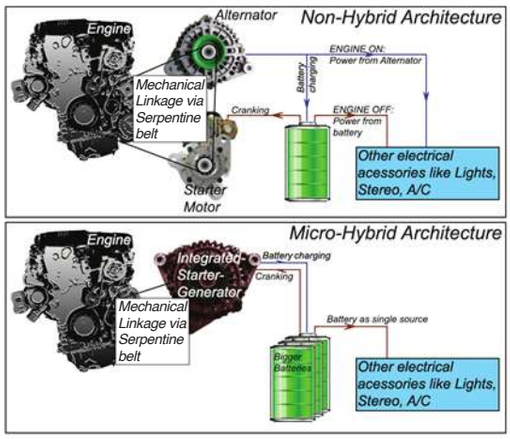
Drivers often stop several times while driving in the city due to unavoidable road conditions such as a red light, slow traffic, a herd of buffalos trying to cross the road, etc., while the engine keeps running idly. If the driver would switch off the engine during a halt of 8 s or longer (this figure is lesser in newer engines), that would save fuel.

A stop-start system in modern cars does it for a driver; it automatically shuts the engine down whenever the car halts and the driver puts the car to neutral. As soon as the driver releases the brake and depresses clutch, the engine automatically roars to life. Recent reports suggest that in normal city traffic, a car equipped with a stop-start system may benefit 10-15% in fuel economy.

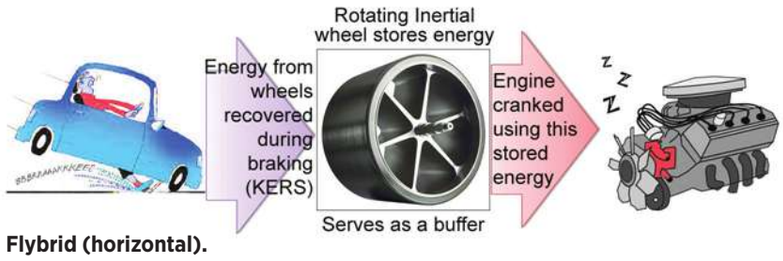
A more robust and advanced version of this micro-hybrid technology extends the auto stop-start function of engines to "coasting" or "gliding" as well. The engine need not run when the driver has released the accelerator pedal and the vehicle is coasting, but as soon as the driver depresses the pedal (say, for a quick overtaking), the engine restarts. **Bosch**'s second-gen system is still in the testing phase and is slated to reach the European market in 2016 and the U.S. market in 2017. Bosch claims that with stop-start coasting functionality, fuel economy in real-world driving may increase 20-25%.

This added functionality is not just an extra microchip with an intelligent algorithm controlling the starter motor and engine cut-off switch, as under the hood there are several changes to the hardware.

A normal car cranks roughly 50,000 times on average during its lifetime. This increases ten-fold in a hybrid, something that a conventional starter cannot bear. **BMW** uses an



Hybrid comparison.



Flybrid (horizontal).

enhanced starter that can withstand a higher number of engine starts in its lifetime.

Another widely adopted approach is replacing the starter and alternator with the integrated starter/generator (ISG). This high-capacity reversible electric device works as a rapid starter during cranking and as a generator (alternator) when the engine is running to recharge the battery system. A "mild-hybrid" system (a step above micro-hybrid, but not fully hybrid as it has electric-assist but no electric-only propulsion) also uses the ISG to recover energy during braking in a kinetic energy recovery system and works as a power assist to the engine during heavy load/instant accelerations.

Just like any other new technology making its way into industry, stop-start is also not without its share of technical shortcomings.

One natural concern is the transition period while switching. We have seen that during switching, the lights flicker and all electrical equipment momentarily stops before restarting. This happens because, while the engine is running, the auxiliaries run on power generated by the alternator (which is coupled to the engine). Whereas when the engine is not running, the only electrical source is the battery. Therefore, whenever there is a switching, there is a change in the power source. In a stop-start enabled car, all electrical accessories are prone to damage due to frequent restarts. Moreover, the air-conditioner runs only when the engine is running. An auto-stop-restart must be unobtrusive to the driver.

BMW employs a simple strategy to tackle this issue, decoupling all electrical devices from the alternator and maintaining a single power source, i.e. the battery, while the alternator only recharges the battery when required. However, this leads to irregular charge/discharge cycles and frequent deep discharges, and hence reduces the life of the battery.

The conventional lead-acid battery may take up to 10 minutes to recover from a single cranking, which is a grave impediment to multiple stop-starts in slow moving traffic. Advanced lead-acid batteries such as the absorbent glass mat (AGM) solves the problem to some extent, while lithium-ion technology is still too costly for mass application. **Volvo** resolves this issue by including a secondary battery just for engine cranking to make the transition as seamless as possible.

Another major cause of concern is the limited battery technology to support frequent stop-starts. The engine should successfully start at all times without fail, which requires not only a good battery, but also foolproof monitoring technologies. A lead-acid battery does not recharge very quickly, and hence might need some engine-on time after about 15 back-to-back stop-starts in a very slow traffic, before it resumes normal functioning. Furthermore, the charge-level of the battery is also related to external conditions like temperature and humidity. An airtight monitoring system must be able to accurately determine the current battery capacity and also synchronize with the stop-start module to prevent the engine from shutting down when the battery is not enough charged.

What if these constraints are bypassed and the battery is retained as a failsafe for emergencies only? Enter **Flybrid** technology. Flybrid, or Flywheel-Hybrid, is a smart technology wherein energy is stored in the form of kinetic energy in a rotating disc called the flywheel instead of chemical energy in battery. A negligible amount of parasitic energy from the engine is used to keep the flywheel in high-speed rotation (up to 60,000 rpm), which can later be recovered to start the engine or even provide mechanical assist during acceleration.

Mechanical energy storage theoretically overcomes all the challenges faced in electrical storage systems. A flywheel can spool to full capacity within seconds and can perform an infinite number of cycles, while a battery deteriorates with every discharge-recharge. A Flybrid system would weigh and cost significantly less than an equivalent electric hybrid system. Volvo has been testing the system in its S60 sedan on public roads, and is seeing promising boosts to the economy and performance parameters.

Lux Research had projected that by the end of this year, the stop-start technology would capture 37% of the global new vehicle market. The U.S. **Environmental Protection Agency** and **National Highway Traffic Safety Administration** predicted that micro-hybrids will account for 42% of global sales of new passenger vehicles by 2016. We have been seeing optional micro-hybrid versions of **Mahindra** Scorpio and XUV500 for many years and recently several international manufacturers like **Hyundai** have started providing this as an option.

From the looks of it, stop-start technology is already rooted in the market and is growing with further improvements. ■

This article was written for *Mobility Engineering* by Surojit Sen.

Recycling opportunities for hybrid/electric vehicle lithium-ion batteries

With limited reserves and strict environmental regulations, recyclers look to established extraction means to reuse, recycle, and dispose of the used batteries.

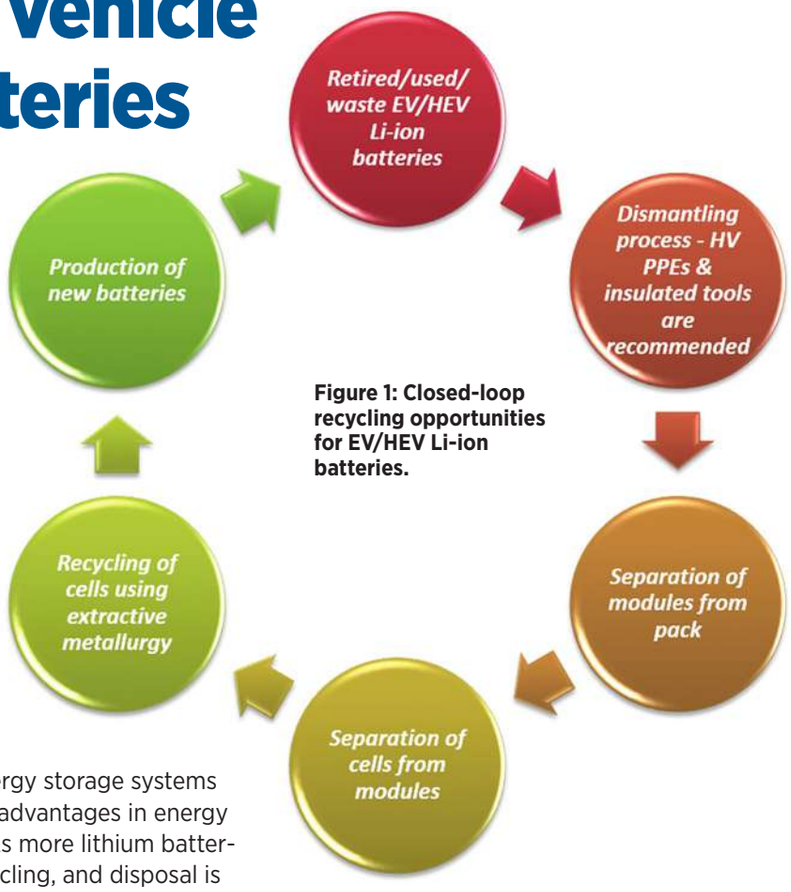


Figure 1: Closed-loop recycling opportunities for EV/HEV Li-ion batteries.

Lithium-ion batteries are the preferred energy storage systems for electric vehicles due to their inherent advantages in energy and their power density characteristics. As more lithium batteries are generated, the topic of reuse, recycling, and disposal is critical to comply with the disposal norms of waste batteries. As lithium reserves are also limited, proper recycling methods would be of use to extract the same energy out of used batteries.

Extractive metallurgy offers an excellent path for selective extraction and refining of a variety of metals from various sources, including naturally occurring ores, minerals, man-made products, etc. In a broader sense, it allows recyclers to selectively separate and refine the metals from various sources irrespective of their nature. However, the extraction process may vary with respect to the nature of metal source and aim of separation.

The subject of extractive metallurgy is multidisciplinary in nature and involves a complete understanding of metallurgy principles in terms of thermodynamics, kinetics, material and energy flow/balance, transport phenomena, reactor and reactor engineering, instrumentation and process control, environment, waste management, etc. to deal with the extraction and refining of metals from various sources.

Pyro, hydro, and electrometallurgy are the three main branches of extractive metallurgy. Pyrometallurgy is carried out at high temperatures, hydrometallurgy is carried out at room temperature in aqueous media, and electrometallurgy involves electrolysis for separation of metals at room temperature. Depending on the aim of separation, the processes are also classified into ferrous extractive metallurgy (deals with the extraction and refining of iron and steels) and nonferrous extractive metallurgy (deals with all other metals other than iron and steel—e.g., base metals, light metals, precious metals, rare earth, nuclear metals, etc.).

The sequences followed during extraction and refining of metals from ferrous-based compounds might not be equal to the sequences followed during separation of nonferrous-based compounds. In that sense, extractive metallurgy allows recyclers to select their own sequences for extraction and refining of a particular metal irrespective of their source. Similarly, hybrid/electric vehicle lithium-ion batteries could also be recycled using existing technologies of extractive metallurgy irrespective of battery size, chemistry, etc., and the resultant (extracted) metals could be used as a raw material for various applications including production of fresh batteries (see Figure 1).

Currently, mobile phone and laptop batteries are widely recycled either by pyro or hydrometallurgical processes.

In pyrometallurgy, the scrapped batteries are smelted at very high temperatures and

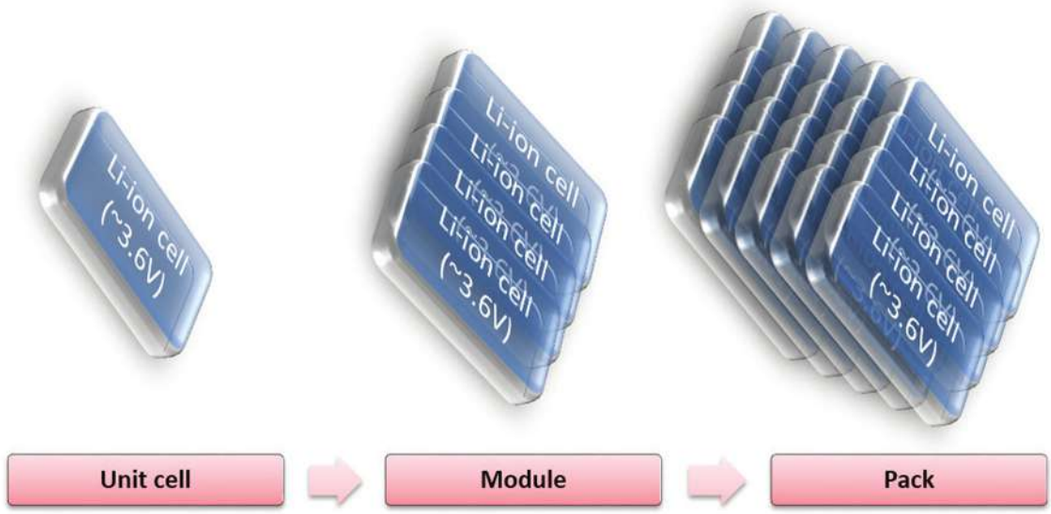


Figure 2: Unit cell to pack level construction of EV/HEV Li-ion batteries.

hence requires a large amount of energy to produce metallic fraction, slag, and gaseous products. It is a dry process. Here the subsequences like alkali fusion, calcination, roasting, reduction, and chlorine metallurgy are used to separate metals from its various sources.

Hydrometallurgy involves treatments on aqueous solution using suitable solvents to take the metals into solution; hence it is a wet process. Metals get extracted out of solution with highest purity with the help of subsequences like leaching, precipitation, ion exchange, solvent extraction, electro winning techniques, etc.

It is not mandatory that the above-mentioned subsequences (under hydro and pyrometallurgy) should strictly be followed during extraction process.

Depending on the aim of separation, addition and deletion of sequences are also allowed in extractive metallurgy due to the difference in chemical reactions required for separation of different metals from source material. Similarly, it is not mandatory that either pyro or hydrometallurgy must always be used alone for separation process, the combination of both is also allowed depending on the aim of separation. For instance, the major recyclers like **Recupy** uses hydrometallurgy for the extraction of lithium and cobalt. Similarly **Umicore** uses a pyrometallurgical process followed by hydrometallurgical for extraction of nickel, cobalt, and lithium from waste battery scrap.

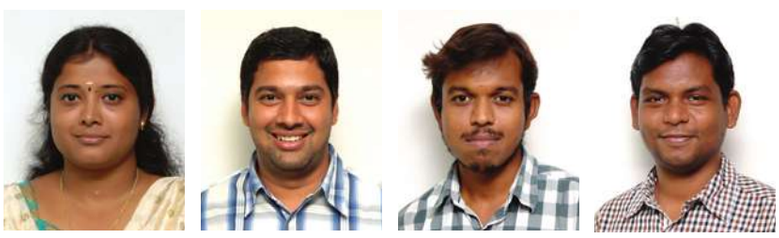
Automobile lithium-ion batteries are different from other small batteries of similar chemistries used in portable devices in terms of their size, design, application, etc. However, their fundamental unit, a lithium-ion cell, is the same for all types of batteries.

Figure 2 explains the cell to pack level construction of hybrid/electric vehicle Li-ion batteries and the reversal of the same results in separation of unit cell from battery pack. During this reversal (dismantling) process, use of high-voltage personal protective equipment (PPE) and insulated tools are highly recommended due to the presence of high-voltage shock hazards. Hence, currently available recycling technologies of mobile phones and laptop batteries could also be used for the recycling of automotive lithium-ion batteries. However, to facilitate this process, a dedicated dismantling process is required to de-energize the battery pack from pack to cell level and to reduce the size and electric hazard of the vehicle battery pack.

As the laws of the Pollution Control Board govern collection, storage, transportation, and disposal of lithium-ion batteries, safe disposal/recycling of lithium-ion batteries is the sole responsibility of electric/hybrid-electric vehicle manufacturers. However, to comply with the norms, both vehicle manufacturers and recyclers must have a valid authorization for said activities in accordance with central/state regulations.

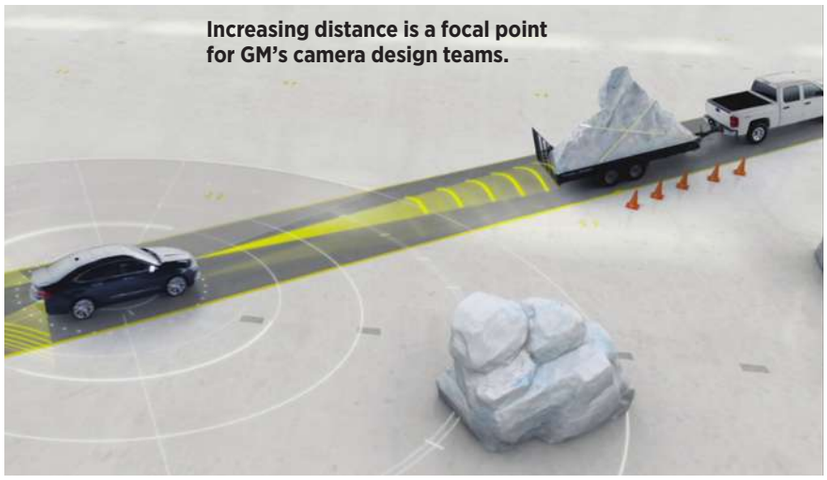
If the unit cell chemistry of an automotive lithium-ion battery is the same as laptop and mobile phone batteries, it could be recycled using existing technologies for laptop and mobile phone batteries.

If the unit cell chemistry is different, the recycler could design their own subsequences under the branches of extractive metallurgy to extract the required metals from battery scrap. This is because this technique is nothing but an extraction of metals and minerals from its ores and here the difference is a material source, which is a retired/used battery pack instead of a naturally occurring ore. ■



This article was written for *Mobility Engineering* by (left-right) Mahindra & Mahindra's Mani Vijayalakshmi, B.Sc. (Chemistry), M. Sc (Applied Chemistry), Deputy Manager; Kannan Subramanian, BE (Hons.), MS (Mechanical Engineering), Manager; Ganesh Kumar Ramakrishnan, M.E (Power Electronics & Drives), Manager; and V. S. S. Naga Karthik T, BE (Electrical Engineering), ME (Power Electronics & Drives), Deputy Manager.

CAMERAS LOOK TO GO THE DISTANCE



Increasing distance is a focal point for GM's camera design teams.

Automakers seek vision systems with greater distances, improved reliability, and more functionality, thanks to ruggedized complementary metal-oxide semiconductor technologies.

by Terry Costlow

TRW is using higher resolution cameras to increase distance detection.

Forward-looking cameras are quickly becoming standard features on cars, improving safety and convenience. Engineering teams are burning the midnight oil to improve distance capabilities and safety while adding more functions and improving performance by leveraging advances in cameras, processors, and software.

The CMOS (complementary metal-oxide semiconductor) imagers used in consumer products are helping make it more cost effective for automakers to add ruggedized cameras. Relatively few cars had cameras at the start of the decade, but most will have them by its end.

"The camera market will go from around 30 million units in 2014 to nearly 100 million by 2019," said Ian Riches, Global Automotive Practice Director at **Strategy Analytics**. "By 2021 there will be one or more cameras on every car."

Faraway look

When cameras are compared to other forward-looking sensors, distance is a weakness. Cameras have displaced radar in some applications, but radar still offers far better distance capabilities.

"Camera technologies are not as good as radar," said John Capp, Director, Global Vehicle Safety at **General Motors**. "Cameras can see about 50-60 yards, radar's range is about two to three times that. That's why higher-end systems pushing the envelope for autonomous driving combine radar and cameras."

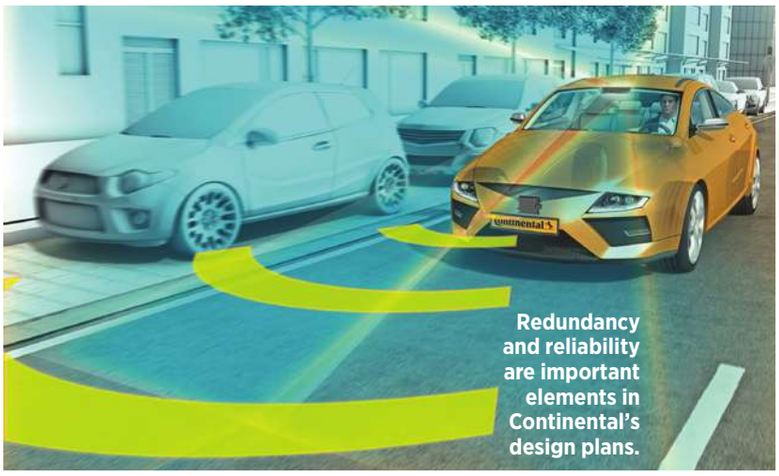
Automotive-grade CMOS imagers are being improved to close that gap. The drive to higher resolution in consumer products is helping automakers collect information before objects get too close.

"Higher resolution imagers are going from 752 x 480 pixel formats to HD imaging at 1280 x 960," said Andy Whydell, Product Planning Director for Global Electronics at **TRW Automotive**. "That improves range by about 50%."

Once cameras are added, developers want to make them do more. The combination of higher resolutions and faster processors lets these cameras perform more functions.

"Traffic-light recognition is now available in the U.S., and there's a

CAMERAS LOOK TO GO THE DISTANCE



Redundancy and reliability are important elements in Continental's design plans.

Packaging inside camera modules helps TRW remove heat, which is a major issue for automakers.

move to get to 1000 road signs that can be detected," said Martin Duncan, Business Unit Director at **STMicroelectronics**. "Cameras are also looking at the road profile so the active suspension can adjust for potholes. Cameras can also see if something's on the road, detecting an object that measures 10 cm at a distance of 40 meters."

Changes will be made

As imagers and lenses improve, other system components such as microcontrollers are also advancing. There's also a lot of work on algorithms and software, where refinements help systems understand what they're seeing.

"The use of cameras is currently limited by the ability of the algorithm to detect objects in the image," said Ron Schubert, Director of **Denso** International America's Body Components Group. "This is impacted by both the detail available in the image (resolution) and the ability of the algorithm to decide if an object falls into a specific category (identification)."

Going forward, it's likely that the processing architectures for cameras will move from dedicated processors in the camera module to a centralized sensor fusion box. These centralized boxes will combine data from radars and other sensors.

This ECU will include processors that decide whether or not to activate brakes or steering, among other tasks. As these boxes get more complex, some are likely to use real-time operating systems.

"Cameras have been kind of dumb systems that could be handled with a home-grown operating system, but when you get into ADAS, you need hard real-time

Don't be afraid of the dark

Night-vision systems have gotten a lot of attention, but sales chart levels have never gotten larger than a sliver. Improving CMOS imagers may make it a bit safer to drive after dark.

Interest in night-vision systems may rise as automakers add safety features and cater to aging drivers. The **National Safety Council** says nighttime traffic death rates are triple daytime rates. Drivers aged 15 to 24 have 33% of their crashes after dark, according to **NHTSA**. That falls to 12% for drivers between 65 and 74, partially because some older drivers don't like to drive after dark.

Infrared cameras have been used for night vision by **Cadillac**, **BMW**, **Audi**, and others, but most automakers don't think the cost of IR sensors makes them viable in the mainstream. However, advances in the CMOS cameras used on a rapidly growing number of vehicles are improving their ability to see in low light. Distance is a major difference between pure IR devices and CMOS technology, which has some IR capabilities.

"If you want to see up to 300 meters, far infrared is viable," said Martin Duncan, Business Unit Director at **STMicroelectronics**. "If you want to see an object that's 100 meters or less, CMOS that goes into near IR is a better solution."

CMOS image developers are improving near IR, but at present it doesn't look likely to match the distances of IR sensors. Companies that focus on military, security, and other environments that require long-distance night vision are also pushing technology that could migrate into autos.

CMOS imagers from STMicroelectronics offer some infrared capabilities, helping them see in lower light.

"Many sensors today are already capable of near IR, so for short-range night vision, the problem resolves into a day camera development," said Davide Santo, ADAS Microcontroller Product Line Manager at **Freescale**. "For far IR, there are notable technologies from companies like **Raytheon** that can be leveraged effectively today."

Even when automakers employ conventional cameras that have some IR capabilities, it remains difficult to use that information. Displaying information on center stacks pulls the driver's eyes from the road, which can be dangerous if it's not extremely simple to understand whether images on the screen require action or not. Using head-up displays reduces distraction, but it's challenging to direct the driver's eyes to pedestrians or other potential danger points.

"Showing only the images from a night-vision system can potentially lead to more driver distraction and not add value because the driver has to look to two different views and correlate the images to determine if there is any potential danger," said Tejas Desai, Head of Interior Electronic Solutions at **Continental** North America. "It would be necessary to have a highlight, for example, of a pedestrian onto the night-vision image to give the driver information that they can act upon. This level of image processing has only recently become practical in automotive applications."

Terry Costlow

Vehicles are using multiple cameras for safety, so Continental is putting more emphasis on safety integrity levels.

As cameras perform more tasks, TRW is moving to advanced networks and control architectures.

responses to process graphics and understand what's going on," said Andrew Poliak, Global Director, Business Development for **QNX Software Systems**. "Some of those smart ADAS cameras will start appearing around model year 2018. When you get to a central sensor fusion box, you definitely need real-time capabilities."

While various forms of software will play a major role in engineering efforts, old-time mechanical issues must still be dealt with. Removing heat is an important factor for rooftop-area cameras. The packages that house electronics must be very compact while providing high levels of protection and heat removal. Chipmakers play a major role in cooling.

"We use expensive packaging, with copper fillers and metal lids," STMicroelectronics' Duncan said. "We need to get as much heat out as possible."

When semiconductors remove heat, they transfer it to the system package. The Tier 1s that integrate these components are also improving their cooling techniques.

"We're always working to advance packaging," TRW's Whydell said. "For camera modules, we use more expensive materials like magnesium, which is lightweight and has good thermal characteristics."

Safe and reliable

When ECUs decide to steer or hit the brakes, safety and reliability requirements climb beyond automotive's already-stringent demands. Single points of failure aren't acceptable. Engineers are revising architectures to provide high reliability while living within cost guidelines.

"As ADAS functions move from informing and warning the driver to autonomous functions such as automated braking and steering, the need for higher safety levels and redundancy increases," said Dean McConnell, ADAS Business Unit Director at **Continental** Automotive. "This is driving certain function integration into the sensors, but also system integration of multiple sensor inputs, and fusion, which sometimes happens in the sensors, sometimes in a separate ECU."

Every element in the system must meet performance demands. Engineers striving to meet safety requirements are also being pushed to alter networks to provide more bandwidth. Security is a factor that's seeing increased interest.

"Cameras are becoming more highly-developed safety products that are generally rated to higher automotive safety integrity levels," Whydell said. "The architecture of electronics, software design and testing are changing. Many companies are also moving to higher speed buses, going from CAN to Ethernet. Cybersecurity is also on the drawing boards."

The magic of semiconductor pricing is helping engineers meet the combined challenges of enhancing performance and improving reliability. CMOS imagers are becoming far more affordable, making it practical to use a few cameras to gain different benefits.

"With camera prices coming down, some companies are using three cameras mounted in the one box," Duncan said. "They can be a wide angle, a conventional camera, and a medium camera, which help you see different objects. That also gives you some redundancy." ■

Getting it RIGHT with composites

With composites now a mainstay in most new aircraft designs, the engineering emphasis has switched from understanding if they work to thinking through the most efficient way to manufacture them, such as using design-for-manufacturing software.

by Bruce Morey

A composite wing spar undergoing inspection at GKN Aerospace. CAE and DFM simulation techniques are aimed at increasing the speed of manufacturing such components.

"Composite design and analysis is a highly integrated activity," said Chris Gear, Chief Technology Officer & Senior Technical Fellow for **GKN Aerospace**. He noted that how composite material is placed, how it moves, how it cures, and the quality and conformance of the product are all inter-related. All of these factors are considered in the final release of the data for manufacturing, he said, aided by design-for-manufacturing (DFM).

Complicating manufacturing optimization is the very nature of advanced composites, requiring a unique design process, unlike isotropic, homogenous metal. Controlling fiber orientation and number of layers of fiber embedded in a plastic matrix is vital for its performance. Initial CAD definitions that specify the outer and/or inner mold lines of the part require further definition of material type, fiber orientation, stack-up order, balance, symmetry, drop-offs, splices, and darts.

"DFM is a very important aspect on any composite design, where the manufacturing process and materials used will drive the final design solution and are key to meeting our internal requirements on weight, costs, and robustness of product," said Gear.

He explained that in the early stages of a design, GKN will use its own or a customer's design methods for composites within GKN's own CAE toolset. This is to ensure they characterize and simulate how the material will lay down into GKN's double curvature tools, identifying "hot spots where extra care is needed in manufacturing and pinpoint where we need to validate an area that is beyond the limitations of our existing methods," he said.

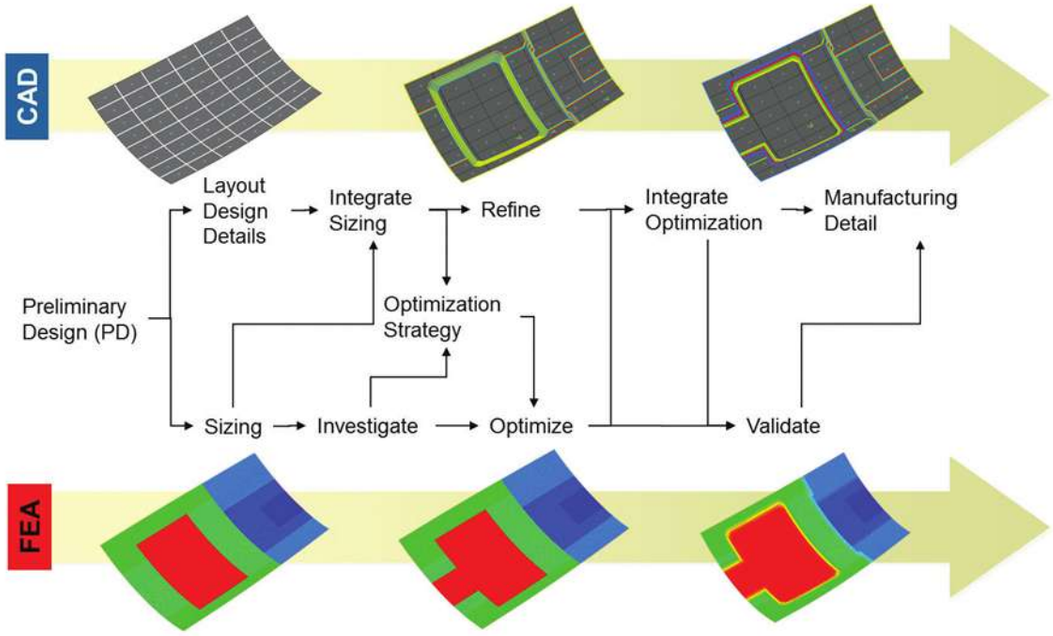
Composites design, composite constraints

John O'Connor, Director, Product and Market Strategy for **Siemens PLM**, provider of the Fibersim tool for design with composites, noted that there are three areas where engineers can improve production rates for composites. One is to improve at the point of production itself, with faster machines or better tools. The second is asking how to modify a design for faster manufacturing.

"The third step is the furthest upstream and that is how to optimize the design for both its purpose, for example least weight and maximum strength, while incorporating manufacturing constraints to produce it as quickly as possible," he said.

An important element in this design process, according to O'Connor, is to incorporate in the process the automated tool used to make the part, for example automated fiber placement (AFP) versus automated tape laying (ATL).

Optimizing material also reduces weight. That was a goal of the new Multi-ply design



The unique workflow for advanced composites parts is different from metals, yet the end result must remain the same—a part that meets the specification for the lowest cost. (Siemens PLM)

feature in their latest Fibersim release. Unlike traditional ply-, zone-, or grid-based methods, the engineer places independent reinforcement regions on top of other regions, eliminating tedious zone or grid redefinition. With this Multi-ply approach, the design is updatable between geometry and associated ply definitions, eliminating rework.

"Multi-ply makes it easier and quicker to define a design, maintaining communication between analysis and redesign," he said.

According to O'Connor, the Multi-ply function was developed through working with Siemens' automotive customers. "The traditional zone- or grid-based design approaches were more than automotive needed. But once our aerospace customers saw [this feature], they knew they could use it to their advantage." He predicts more automotive to aerospace spillover as the industry continues to emphasize rate.

"We need to ensure there is no disconnect between the design engineer, the manufacturing engineer, and the shop floor," said Rani Richardson, Composites Consultant for **Dassault Systèmes**, providers of a full suite of Product Lifecycle Management (PLM) software as well as the Composite Workbench set of tools for designing and analyzing composite structures.

She agrees that when it comes to helping aerospace increase production rates, lessons learned from automotive will be a powerful tool. "One example of that is our new CATIA Composites Braiding Designer tool," she said, developed with a major European automotive OEM.

"With this, we simulate the actual braiding machine," including parameters like mandrel speed, carrier rotation, and orientation. "We can do this all in the design phase before we pass it to CAE simulation. We are designing properly right from the start rather than having to go through that iteration loop," she said. While developed for the automotive market, it provides a useful tool to aerospace users as well.

In fact, there are plenty of synergy opportunities as composites and advanced composites become more popular in many applications. For example, Richardson expects government funding of institutes such as the **Institute for Advanced Composites Manufacturing Innovation** (IACMI), of which Dassault Systèmes is a charter member, to also advance tools for better design for manufacture.

"Industries such as automotive, wind energy, or compressed gas storage have the same goal [as aerospace]—develop tools for building quality, robust composite parts faster and cheaper," she said. The materials and resins may be a little different, and certainly crashworthiness means different things between autos and airplanes, but the basic tools will be the same.

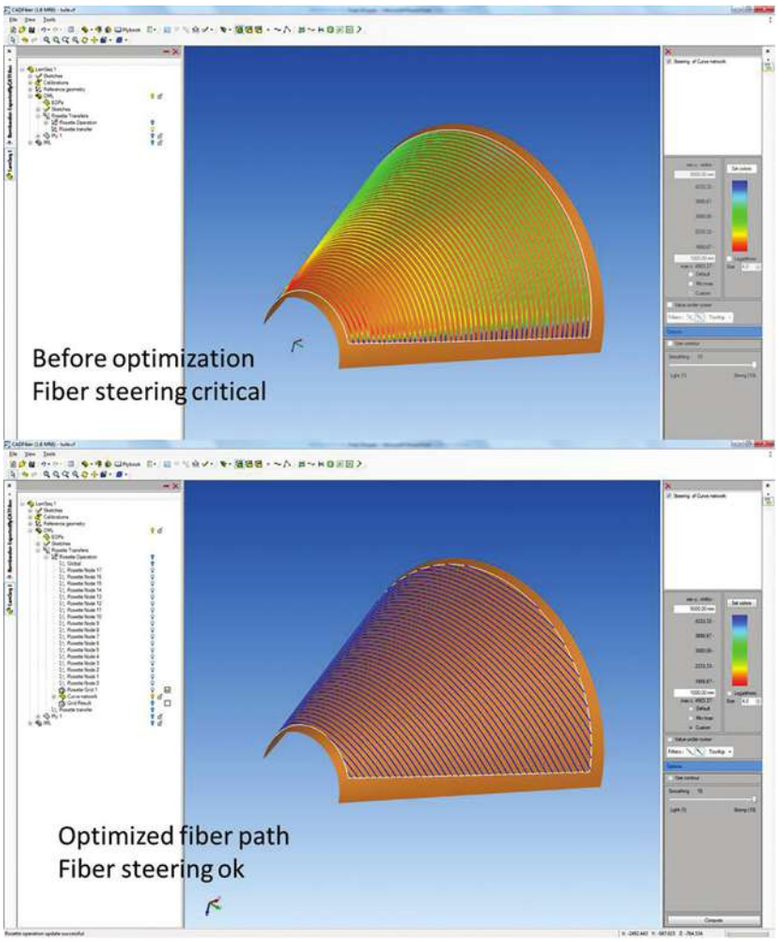
An especially interesting new development in CAE simulation is Dassault Systèmes 2014 acquisition of **Accelrys**, now known as the Biovia brand within Dassault Systèmes. This software models molecular formation of resins and the resin curing cycle through chemical kinetics simulation. Optimizing the chemistry through design of the plastics used to bind composites could mean stronger materials, and faster curing cycles and manufacturing efficiencies.

"That brings a whole new element to our design for manufacturing that we are starting to incorporate," said Richardson. "We can predict delamination or lack of chemical bonding that will affect the lifecycle performance."

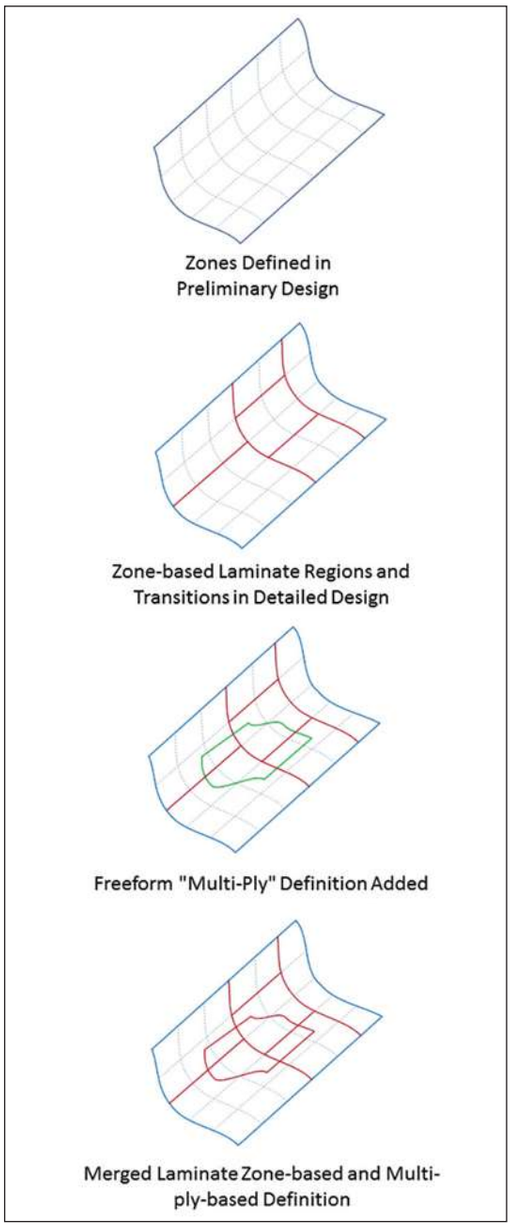
Machines and design

Richardson also noted that, with the increased emphasis in aerospace on DFM, a number of machine tool builders are working more closely with software providers like Dassault Systèmes. Current partners include

Getting it **RIGHT** with composites



Using software to tweak designs for best manufacturing is the goal of software like this from Coriolis. In this case, it adjusts ply contours to fill material strips most efficiently, creating faster, lighter designs as shown in this before and after picture.



Siemens Fibersim Multi-ply combines a ply-based methodology with a zone-based methodology to assure a robust workflow accommodates changes in design more easily.

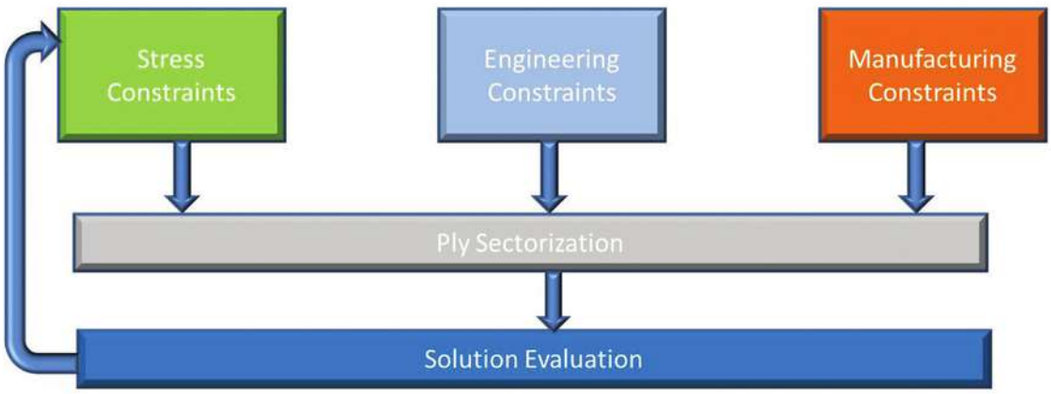
Fives, **Ingersoll Machine Tool**, **Mtorres**, and **Coriolis**. This is important because how a machine operates is best incorporated in the design for maximum manufacturing efficiency.

The final product of a design process involves using an advanced composites machine, such as an ATL or AFP, to make the part. Fives makes a number of such devices and provides software—the Advanced Composites Environment Suite—that takes input such as CAD models and ply contours from the CATIA Composites Designer or Siemens Fibersim and produces machine instructions that are used to build the part.

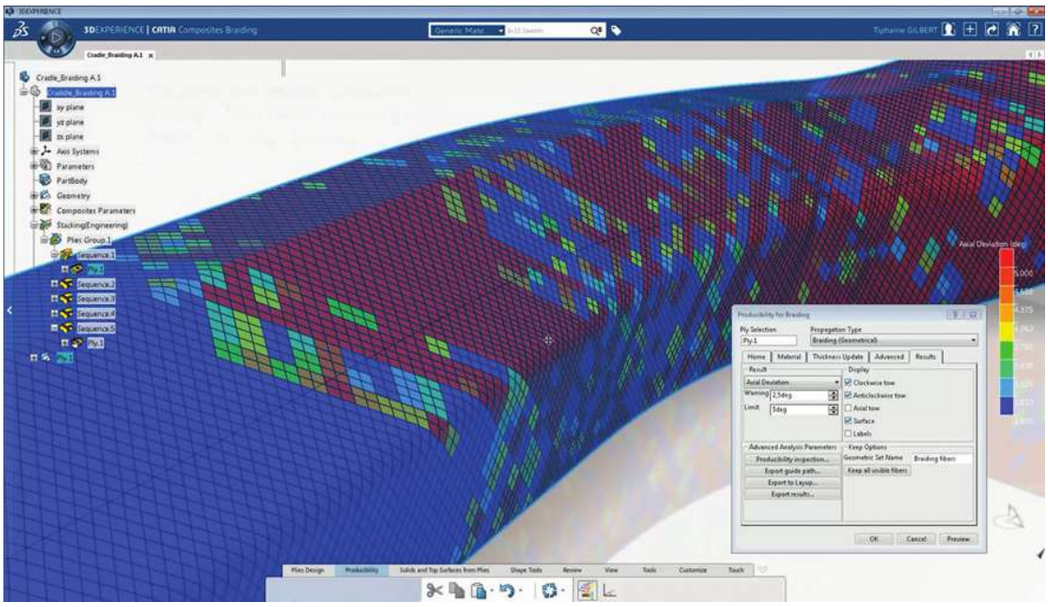
"The engineer designing the part needs to know something about how the machine will make the part," said Robert Harper, Director, Technical Sales, Fives Cincinnati. Parameters include material width, minimum steering radius for that width, material thickness, and the number of layers the machine can place. "They need to know these and limitations, such as minimum coarse length in an AFP and minimum cut length of the material, so when the engineer creates the design the machine is capable of creating that part. They need to know the machine's capabilities in localized contours as well."

He said that they supply data to companies like Dassault Systèmes, such as minimum tow length, so that the designer has access to that in the CATIA Composites Workbench. While having access to such data is useful, educating design engineers directly is just as important. "Making parts using advanced composites is fairly new, especially compared with the 100 years of experience in metal cutting."

Coriolis Software also provides software packages that specialize in composites design and offline programming solutions for various machines. The parent, Coriolis Composites, specializes in building AFP based on 6-axis robots for manufacturing composite parts. To program their own



Companies like Coriolis Software are advancing the use of automatic design optimization to balance the competing objectives of stress, engineering, and manufacturing constraints. The Coriolis optimization framework captures design constraints, priorities, and rates solutions using criteria from the user.



CATIA Composites Braiding Designer is a role-based application, providing advanced braiding fiber simulation. (Dassault Systèmes)

robots, they needed to develop software that could produce an optimized design for the system and produce a program off-line for the robot itself. The now independent Coriolis Software extended its capabilities to generalized CNC composite machines.

The output from the company's software is a design of the part optimized for manufacturing and a machine program that produces that part. They use FEM modeling to ensure the final model meets strength requirements. They offer a package integrated into CATIA Composites Designer, or a standalone package that can import data from either CATIA Composites Designer or Siemens Fibersim.

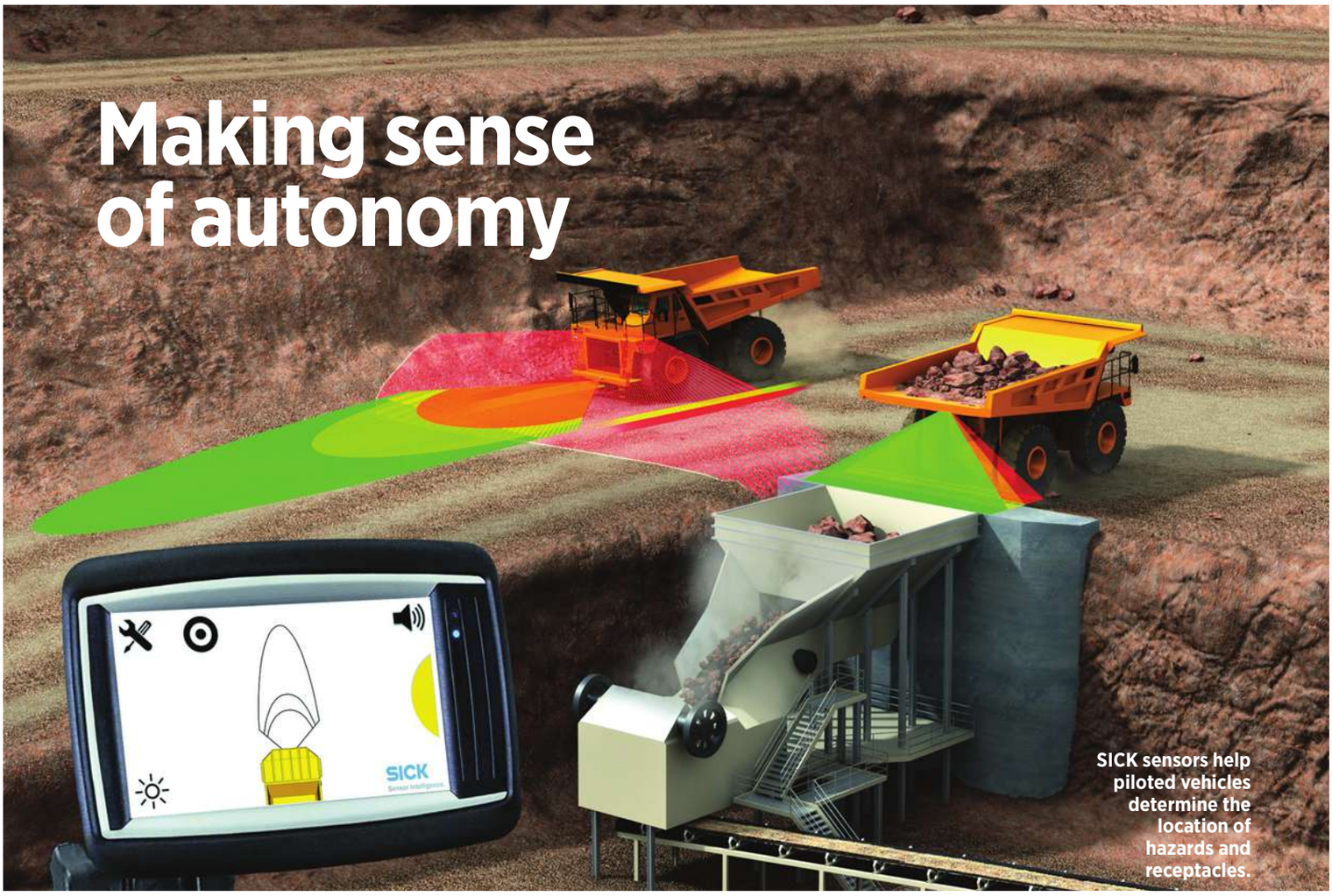
"The objective of our software is to fill the ply contours with material strips in the most efficient way," said Olivier Munaux, Software Manager, Coriolis Software. "An enriched data model serves the basis for running fast simulations at an early stage in the design process, giving engineers the opportunity to get feedback from the 'as built' as soon as possible."

This is a multi-objective optimization problem when accounting for all of the design drivers including cost, weight, and cycle time. Coriolis employs a genetic algorithm as an optimization engine, embedded in a framework to automate the process. Munaux believes his customers want built-in tools that are easy to use, that incorporate requirements and geometry, and compute a solution that is the best compromise between all of the competing requirements.

"The aircraft industry recognizes both the benefits and the need [of simulation optimization] as aircraft production rates have increased," said GKN's Gear. He believes the challenge relates to over-reliance on testing to validate solutions as opposed to using the full potential of simulation techniques available today. "As more automation of manufacturing is being brought into our factories, we need better methods to simulate and define our products in shorter lead times."

Using a DFM approach is helping GKN establish how to do this more effectively. "[It] is assisting us in gaining a comprehensive understanding of our products before we enter full scale production," he said. "More importantly, DFM has significantly reduced non-conformances and lowered waste in our manufacturing processes."

Making sense of autonomy



SICK sensors help piloted vehicles determine the location of hazards and receptacles.

Industry offers a range of sensors that will free humans from many tasks while also improving reliability, though devising strategies that meet demanding requirements without breaking the bank is no easy challenge.

by Terry Costlow

Fully autonomous vehicles are just a sliver of the industry, but semi-autonomous technologies are paving the way for mainstream adoption. Strategies for sensing the vehicle's surroundings will play an important role in the advance of piloted and driverless vehicles.

A range of sensors are being used to feed the controllers that make driving decisions. These sensors must provide enough information to ensure that automated braking and steering decisions are always perfect.

Devising strategies that meet this demanding requirement without breaking the bank is no easy challenge. Many design teams are moving forward incrementally, coming up with semi-autonomous systems that lighten the workload for drivers.

"Collision awareness provides a level of automated functionality that helps avoid collisions, but at a lower cost than a fully automated system," said Jeff Wuendry, Industry Applications Specialist at **SICK**. "Damaging a single tire on a mining vehicle can cost more than $30k and this doesn't include the losses in vehicle productivity, repair time, and safety reviews. Collision-awareness systems prevent costly accidents without the premium for fully automated solutions."

Sensitive and smart

Sensor counts are spiraling upward as autonomous controls strive to collect enough information to identify objects with 100% certainty. Processing all this information similarly requires more computing horsepower. System developers need to meet demands with architectures that are cost effective yet still make good decisions that maximize safety.

One aspect of this challenge is to determine whether to package small, inexpensive processors into sensors or embed more powerful CPUs in sensor packages. That impacts networking requirements as well as overall computing needs.

"The computation power of sensors or sensor systems will increase," said Carola Pfeifle, spokeswoman for **Daimler** AG's Mercedes-Benz Trucks. "The challenge with raw data is the total amount of information that has to be processed and transferred into ECUs. A good system architecture helps to provide the optimal detail level of information to the features."

Sensor makers are responding with multiple packages, letting users match their processing and pricing goals. This diversity is being augmented by declining prices, making it easier for system designers to get to market quickly with products that meet specific user requirements.

"The computing capability of sensors is either reducing the price of sensor manufacturing and

development or increasing the sensor's functionality," Wuendry said. "From a sensor manufacturer's perspective, the market is asking for both and the sensor manufacturers are able to provide more sensor options because development cycles continue to shrink."

Leveraging the strengths of different types of sensors is becoming more common. Using a camera's ability to discern shapes and radar's proficiency in any weather or lighting conditions helps avoid false positives. Synchronizing these inputs can reduce sensor counts, but it requires more intelligence.

"Fusing data from multiple sensors takes a lot of computing power and memory," said Don Remboski, Vice President of R&D and Innovation at **Dana** Holding. "Microcontrollers are getting cheaper by the day, so today it's plausible to do things that were impossible a few years ago."

Software obviously plays a critical role in system capabilities. Programmers continue to devise more ways to reduce the operator's workload. Some feel that artificial intelligence can help systems adapt as workers perform repetitive tasks.

"There's some machine learning," said Mark Versteyhe, Manager, Advanced Powertrain, at Dana Corporate Research. "When a human uses a joystick to execute a difficult task, the machine recognizes patterns and can repeat them, the system can even improve efficiency."

Frugal is the watchword

When OEMs increase the level of autonomy, they usually increase the number of devices that tell digital controllers about the vehicle's surroundings. That move isn't made without a major effort to ensure that cost and reliability don't rise.

Reliability is more of a concern than with other semiconductor devices since sensors must interact with the real world. Microelectromechanical devices have small moving parts that can be damaged in harsh environments.

"We assume that the total amount of sensors for autonomous features will rise," Pfeifle said. "We will introduce new sensors or sensor principles if the overall failure rate will decrease and not increase anymore."

Drivers can do other tasks when sensors guide Daimler vehicles along their chosen paths.

One way to control this growth is to make sensors perform multiple tasks. That's already being done, but engineers want to use sensors to see even more deeply into vehicle operations, using safety sensors to monitor mechanical components.

"You want to get dual use from the sensors," Remboski said. "Antilock brake sensors now feed information to braking and traction-control systems. You can also understand component performance by analyzing vibration. Similarly, you can analyze problems in drivelines by analyzing vibration when you use the sensors' maximum capabilities."

Design teams are also looking at sensors that augment or replace the cameras and radar

Many communications technologies augment sensors

Communications will be one of the central technologies as vehicles become more autonomous. Self-piloted vehicles will need more functionality from on-vehicle networks, while wireless links to the outside world will help them operate with minimal or no human intervention.

A growing number of sensors will send copious volumes of data to multiple controllers, sending bandwidth demands skyward. Some vendors feel this bandwidth can be provided by multiple CAN buses, leveraging the existing **SAE** J1939 technology used throughout the industry. Others feel that it may be wiser to switch to FlexRay, which was developed for deterministic transportation systems, or to leverage Ethernet, which has proven its durability in industrial applications.

"We do not see the possibility to provide such features only with CAN communication," said Carola Pfeifle, spokeswoman for **Daimler** AG's Mercedes-Benz Trucks. "We're currently analyzing other communication protocols like Ethernet or FlexRay."

Moving to a new networking architecture is a major decision. Some design teams feel it's better to make investments in wireless technologies rather than to jettison CAN for a new on-vehicle network.

"The physical layer will probably remain CAN, though there will be redundant network connections," said Steve Wesolowski, Senior Director of Global Engineering at **Dana**. "There will be an emerging area of communication with the rest of the world, with vehicle-to-vehicle and vehicle-to-infrastructure and telematics. Network connections outside the vehicle will have a big impact on improving performance. When you see parameters moving the wrong way, you can sniff out the causes."

Autonomous vehicle developers don't have to rely solely on data collected by onboard sensors. Global positioning satellite data is being used to augment the database. When vehicles are charting their own path, it's important to know what's around the vehicle.

"GPS enhances vehicle functionality and is always beneficial because the location of stationary features may change the vehicle's autonomous behavior," said Jeff Wuendry, Industry Applications Specialist at **SICK**. "SICK integrates GPS functionality within the sensor."

Developers can save time by leveraging the expertise gained in other fields that use these sensing technologies. Programmers can also borrow concepts that help them create pathways and avoid obstacles.

"Improved 3D sensors (stereo cameras, LIDAR) now enable engineers to create terrain and 3D scene maps with the fidelity required to safely perceive a vehicle's environment and navigate through it in off-highway scenarios," said Avi Nehemiah, Product Marketing Manager, Computer Vision, at **MathWorks**. "In addition to improved 3D sensors, algorithms and methods developed by the robotics community—such as point cloud processing, simultaneous localization and mapping, and obstacle detection and avoidance—are becoming critical."

Terry Costlow

Making sense of autonomy

Daimler employed a range of sensors when it recently demonstrated a self-driving truck.

When drivers aren't monitoring vehicles closely, remote technicians will have to watch for low tires and other problems. (Dana)

now used on many off-highway vehicles. Radar can see through the dust and fog common in many environments, but it doesn't have good resolution and can't identify objects. Cameras meet those requirements, but have trouble in dirty and dusty environments.

Lidar uses lasers to overcome many of the obstacles that hinder radar and cameras. It can provide range, depth, and resolution while peering through rain, snow, and fog. It's been used in a range of high-end defense and mining vehicles and is being examined for more mainstream applications.

"An important application is looking for objects in non-ideal situations in industrial off-highway applications, for example, in the mining, agriculture, and construction industries," Wuendry said. "While camera systems can be overwhelmed by particulates in the air like dust, lidar is not easily hampered by these conditions."

However, cost is currently lidar's Achilles heel. It's been difficult to justify this expense except in very demanding applications. However, suppliers are racing to bring costs in line for off-highway equipment, partially because it will help them address the large passenger-car market.

Startups are also eyeing this arena. For example, three-year-old **Quanergy** is working with **Joy Global Mining**, which is using Quanergy's mechanical technology as the startup moves toward a digital system.

"Our first-generation system, which is mechanical, broke the $1000 barrier when most Lidar systems went for between $30,000 and $80,000," said Louay Eldada, Quanergy's CEO. "Our solid-state systems will be at $250 when we start sampling at the start of 2016. The third-generation system will only cost $100."

Diagnostic data

Adding sensors and processing power has benefits beyond driving vehicles along their chosen path. They can be combined to give operators and maintenance technicians more information. When drivers aren't constantly controlling the vehicle, they'll probably pay less attention to its performance.

"We focus on creating vehicles reliable enough to take on the mission when the driver isn't totally in the loop minute to minute," Remboski said. "Vehicles need to do more self-diagnosis and even self-healing. If there's no driver, how do you detect a flat tire or a sticky brake?"

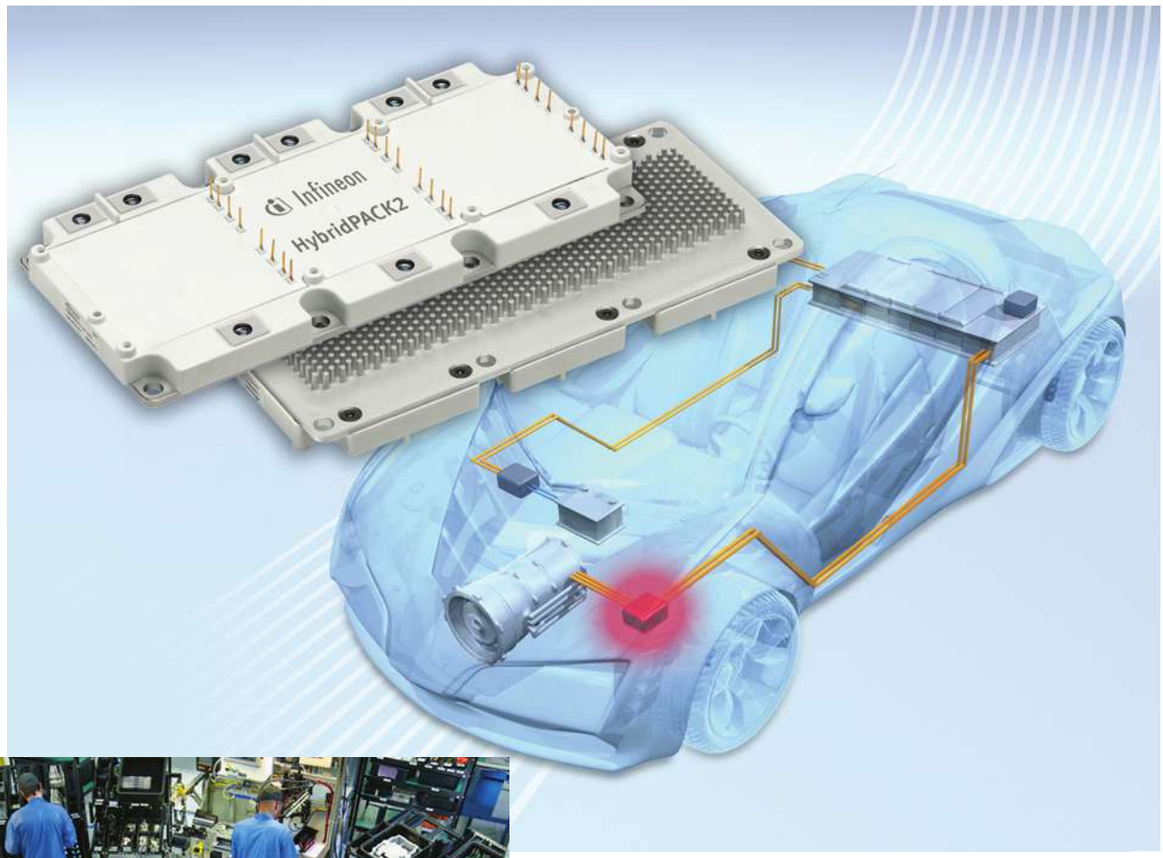
Sometimes, information about potential problems will be displayed on operator screens, other times it will be sent to remote maintenance staffs. It's more challenging to send data remotely, since components, on-vehicle networks, and wireless links are all potential failure points.

"Our OEM customers are demanding higher levels of communication reliability and immediate notification if the communication may be compromised," Wuendry said. "The difficulty in these situations is the inability of the sensor or the controller to know which device is at fault and then communicate that information through a different path."

Chipping in to get more from BATTERY PACKS

Power semiconductors help extend range, keeping their cool while improving efficiency at higher voltages.

by Terry Costlow



Infineon's high-voltage HybridPACK devices for full hybrid electrical vehicles are based on IGBT trench-field-stop technology that offers low conduction and switching losses.

Handling higher voltages succumbing to the effects of heat are among the goals for Magna's power semiconductor designers.

Electrified vehicle designers are pushing semiconductor technologies to help them extend ranges and reduce the weight of battery packs. Power semiconductor improvements are helping powertrain designers move to higher voltages and reduce losses while managing a battery pack's nemesis, heat.

Falling oil prices curtailed electrified vehicle sales during 2014. Hybrid volumes dropped, with market share of just 2.8%, according to a survey by HybridCars.com and **Baum & Associates**. In the U.S., plug-in vehicle sales soared by 23% in 2014, yet still barely cracked 120,000, according to **InsideEVs**.

The ardor of early buyers also seems to be cooling. Only 45% of last year's hybrid and EV trade-ins went toward buying another alternative fuel vehicle, down from around 60% in 2012, according to **Edmunds**.com.

Power rangers

Power semiconductor advances are helping developers improve efficiency and increase range with fewer batteries. Improvements are

Chipping in to get more from
BATTERY PACKS

Silicon carbide MOSFETs from STMicro provide higher switching frequencies than silicon-based IGBTs.

making it more cost effective to use higher voltage systems while still meeting lifetime requirements.

"Semiconductors for higher voltage levels can transfer more power at less losses, [and] power semiconductors for higher voltage levels (1200 V) will help to increase mileage," said Markus Schermann, Director New Product Area Electrification at **Magna** Powertrain. "Those that can bear more amps are able to provide more power. Semiconductors that can withstand higher temperatures allow higher continuous power output."

Many of the changes occur in insulated gate bipolar transistors (IGBTs) and field effect transistors (FETs), central players in electrified powertrain components. **Infineon** recently introduced a line of automotive IGBTs with a breakdown voltage of 750 V, up from 650 V for the preceding generation. That simplifies designs for powertrain developers who opt to increase battery-pack voltages while providing other benefits.

"We have faster switching, which everyone wants because they get lower losses," said Carl Bonfiglio, Senior Segment Marketing Manager, Powertrain and Electric Vehicle, at Infineon Technologies North America. "In the past, people often had to slow down so they would not surpass the breakdown voltage."

Keep your cool

As voltages rise, cooling challenges follow suit. Chipmakers are trimming resistance factors such as RDS(on), which helps determine both maximum current ratings and loss.

"Lower RDS(on) and reduced switching losses are reducing thermal losses in the FET or IGBT," said Antonio Leone, Product Marketing Manager at **Freescale** Automotive Battery Management. "This leads to reduced requirements regarding cooling as well as

Inverter modules from Magna convert stored electric energy to meet powertrain demands.

increased efficiency of the drivetrain."

Metal oxide semiconductor FETs and IGBTs are competing in many instances, creating competition that drives innovation. Early this year, **STMicroelectronics** rolled out a silicon-carbide power MOSFET with RDS(on) better than 290 mΩ at the 200°C (392°F) maximum operating junction temperature. That facilitates switching frequencies up to three times higher than similar-rated silicon IGBTs offer, letting designers employ smaller external components to trim size and simplify cooling-system design.

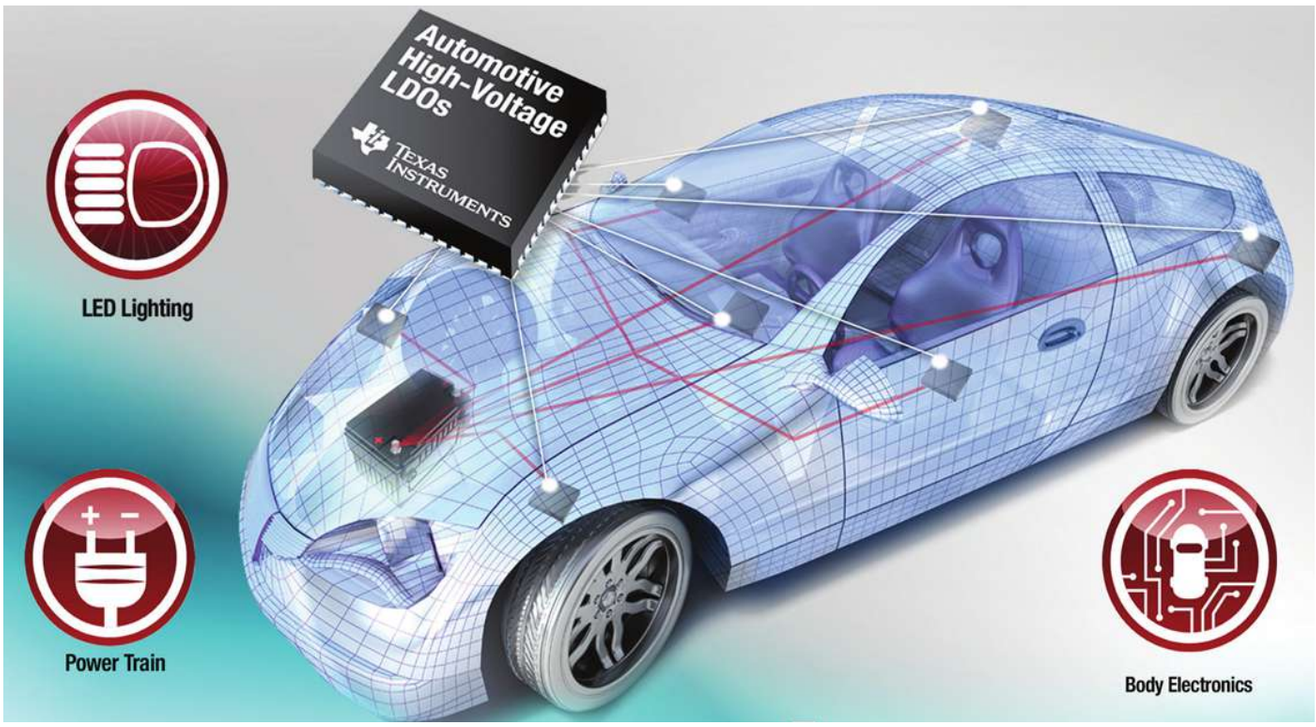
On the other hand, **Fairchild** trimmed energy loss by 30% in its latest IGBTs. An advanced high-density-pitch self-balancing cell uses a self-aligned contact technology for extremely high current densities and improved dynamic switching features.

Packaging is a major factor in all power devices. Component housings and heat sinks can help system designers improve efficiency while meeting temperature goals.

"The IGBT chip is soldered to a ceramic substrate that's soldered to copper fins that are immersed in liquid," Bonfiglio said. "That increases the power cycling capability of the package, letting you run more current through, around 20% more."

While power semiconductors play a central role in electrified powertrains, other digital devices can't be overlooked. The electronic control units that oversee powertrains constantly make adjustments to maximize overall efficiency.

"A big role is going to be played by a central ECU, which controls the ICE, the transmission, and the electric propulsion," Schermann said. "This ECU can choose the optimum setup of the entire powertrain for every operating condition. Ideally also the vehicle dynamics are controlled by this central ECU."



Texas Instruments and other suppliers are reducing power consumption on automotive parts to help reduce the drain on batteries.

Look everywhere

While there's a major focus on semiconductors in the powertrain, chipmakers are looking at all aspects of vehicle power requirements. Power saved in the instrument cluster can drive the powertrain.

For example, **Texas Instruments** trimmed the quiescent current of its low drop-out regulators to 10 µA in standby mode, cutting power consumption in infotainment systems, clusters, and other applications. Other vendors are focusing on sleep modes and networking.

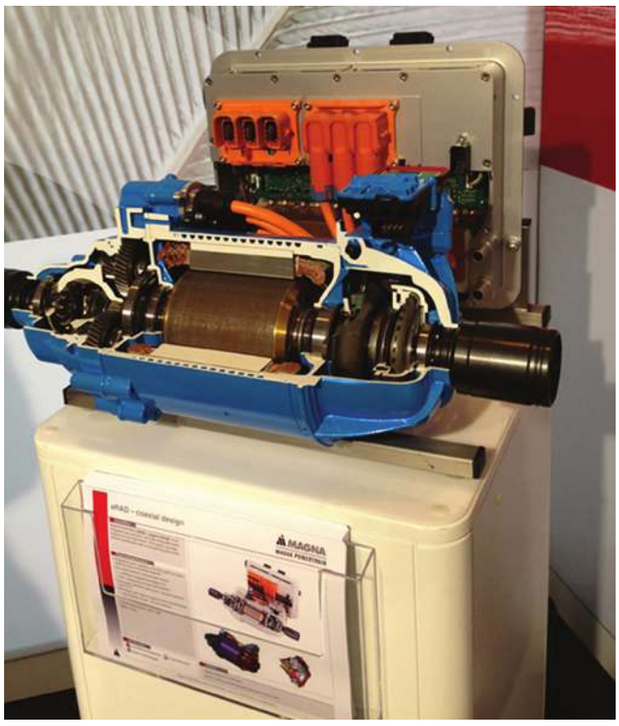
"Amps equal 'miles per gallon,' especially in hybrids," said Paul Kanan, Senior Manager, Automotive Controls Solutions Marketing at **Renesas** Electronics America's Automotive Marketing Unit. "Instead of having door or sunroof modules alive during operations, they go to sleep and wake up only when needed. That's done using partial networking."

The focus on communications extends into the battery pack. A lot of data is moved when controllers and chargers interact to power vehicle components and recharge batteries. Simplifying data links can trim costs without sacrificing efficiency.

"Significant advancements are made in the battery internal communication between the individual cell monitoring ICs and the battery-management system," Leone said. "Cheaper daisy chain and bus communication systems are available, eliminating costly isolated CAN communication."

Electronics can also help vehicle owners improve mileage. Clusters and infotainment systems display mileage and find energy-saving routes. Navigation software is being tweaked to find routes that conserve power requirements by minimizing hills, among other tricks.

"There is also a big impact caused by the driver; the driver determines the route and the dynamics," Schermann said. "Thus, control units can assist the driver. Navigation units can select the route with the minimum energy consumption; the vehicle controller can determine the optimum acceleration and cruise speed." ■



Magna technology helps OEMs combine internal-combustion engines with electric traction drives, reducing complexity.

Audi chooses high technology but cautious design evolution for new A4

The fifth-generation Audi A4's road presence is about evolution and aero efficiency with a best Cd of 0.23. Compared to the previous generation, all panels have been changed and the grille redesigned.

Audi's just-revealed 2016MY A4 is a classic example of automotive evolutionary design. Its aesthetics are not quite ripe for a game of "spot the difference" between the new fifth and previous fourth generation of this hugely successful model line, but they are close to it, even though every panel has been changed.

What this car is about, is evolution, technology, and systems' development; development of practically every aspect of its being (including new engine technology), without risking the sort of image step-change that **Mercedes-Benz** took in 2014 with the rival C-Class, a decision that has paid huge dividends in terms of sales and brand appreciation.

The new A4's reveal (sedan and Avant) in Germany ahead of its public unveiling at September's Frankfurt Motor Show was not accompanied by any official public comment by Audi's main Board members, who presumably are allowing the car to "speak" for itself.

In a sense it does so: check out the interior space and it has increased; try the headlights and (optional) matrix LEDs, developed in conjunction with **Hella**, will illuminate; interrogate the MMI and natural language voice control will respond; and the car gets Audi's virtual cockpit technology that it is rolling out to embrace its wider model range.

The A4's suspension has a redesigned five-link system front and rear to provide improved levels of ride comfort and sharper handling; one of its transmission options incorporates freewheeling; engine choice includes units providing exceptionally low fuel consumption and CO_2 figures; and the A4 sedan is highly aerodynamically efficient, with a Cd of only 0.23.

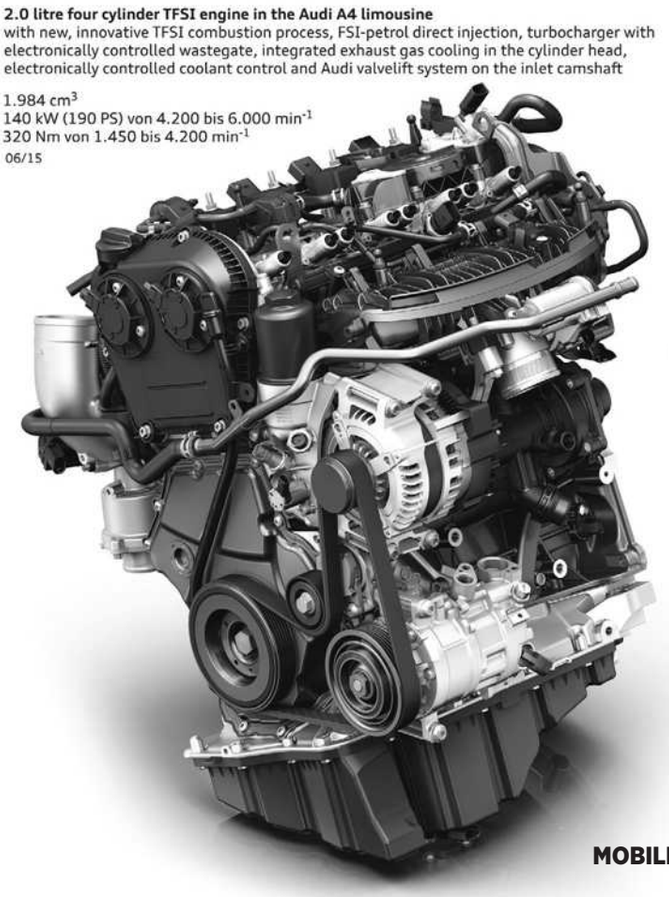
Perhaps Audi reckons it has a classic design signature (such as the 911, Beetle, Mini) that can just be massaged every few years as technology is updated and efficiency improved. But it is what is inside the wrapper, rather than the wrapper itself, that really distinguishes the A4's advance.

While the A4, using the MLB (modular longitudinal) EVO platform, gets a plethora of advanced electronic infotainment and connected systems, the fundamentals of improving a vehicle remain vital, with weight reduction still a salient issue; the 120-kg (265-lb) improvement against the fourth-generation car is significant.

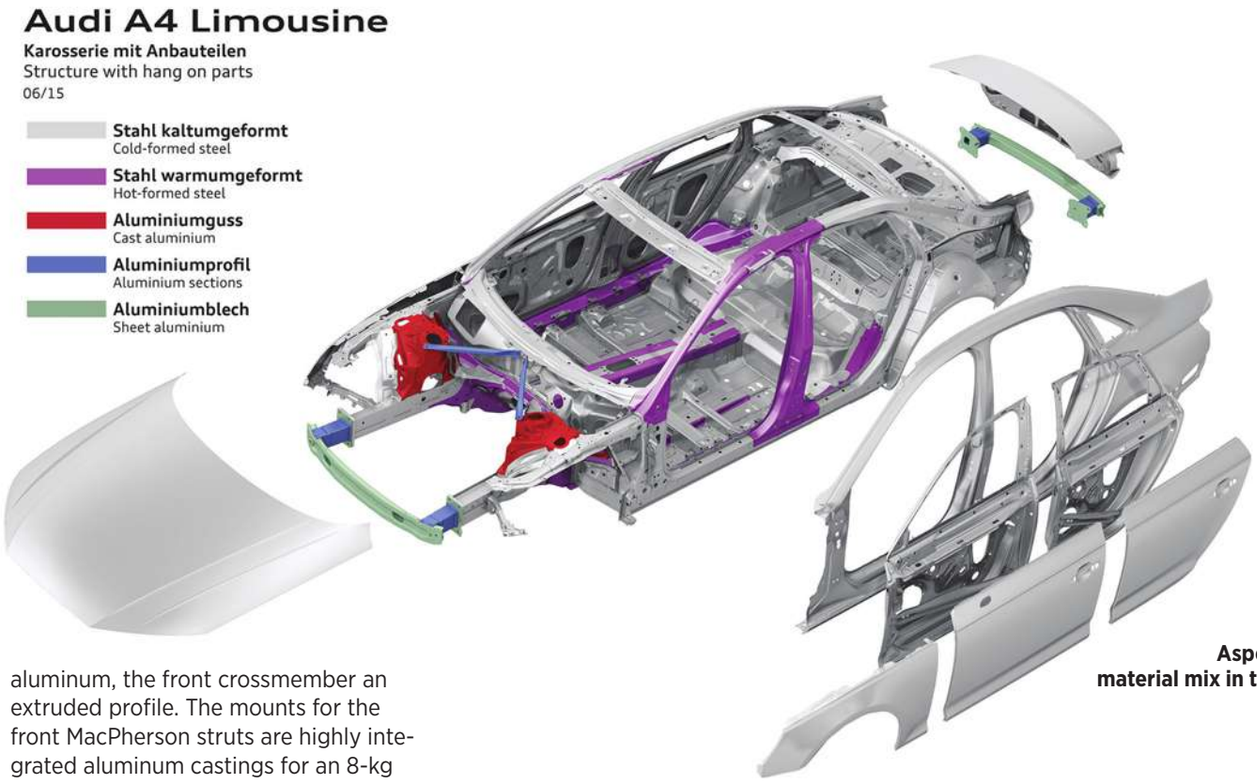
Intelligent materials

The 1.4 TFSI gasoline base sedan has a 1320-kg (2910-lb) mass empty and without driver. The car's body is 15 kg (33 lb) lighter than its predecessor thanks to "geometrical lightweight construction and an intelligent combination of materials"—mainly aluminum and high-strength steels.

The module crossmember under the dashboard is now of extruded and sheet



Rightsize, not downsize, is Audi's philosophy for increased efficiency powertrains.



Aspects of material mix in the A4.

aluminum, the front crossmember an extruded profile. The mounts for the front MacPherson struts are highly integrated aluminum castings for an 8-kg (18-lb) savings. The construction is said to allow a very stiff connection between the upper ends of the struts and the car body for optimal driving dynamics.

Hot-stamped components form the high-strength, crash-proof backbone of the passenger compartment. They strengthen the transition from the front of the car to the interior, the frontal area of the roof frame, the B-pillars, the doorsills, and parts of the floor—and constitute 17% of the body structure. Interior weight watching includes lightweight seats.

The A4 sedan's length is 4726 mm (186.1 in), 25 mm (1 in) longer than the previous model. Width expands 16 mm (0.6 in) to 1842 mm (72.5 in). Height remains 1427 mm (56.2 in). Wheelbase is stretched 12 mm (0.5 in) to 2820 mm (111.0 in). The Avant is 1 mm (0.04 in) shorter and 7 mm (0.3 in) taller than the sedan but all other dimensions are the same.

Audi claims up to a 21% fuel consumption improvement for its latest engine range. Initially it spans from four-cylinder 1.4-L gasoline to six-cylinder 3.0-L diesels; power output spreads from 110 to 200 kW (148 to 268 hp).

The A4 2.0-L TDI (diesel) ultra (efficiency) sedan delivers a very frugal fuel consumption of 3.7 L/100 km, with CO_2 emissions of 95 g/km. But gasoline technology developments are also bringing impressive results.

Design and engineering focus on aerodynamics has given the new A4 Avant a Cd figure of 0.26.

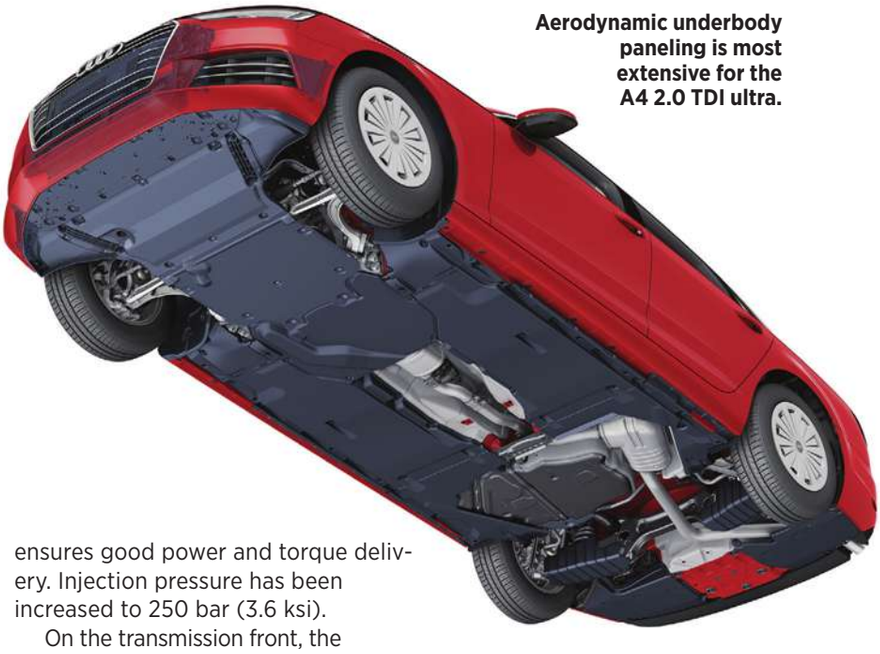
Ultra solution

Audi's gasoline 2.0-L TFSI ultra model produces 140 kW (188 hp) and maximum torque of 320 N·m (236 lb·ft) from 1450 to 4200 rpm. Performance figures include 0-100 km/h (0-62 mph) in 7.3 s and a top speed of 240 km/h (149 mph) for the sedan with an S tronic transmission. NEDC (New European Driving Cycle) fuel consumption is a very good 4.8 L/100 km and CO_2 emissions are 109 g/km.

Audi reveals that new technology is contributing to this efficiency. The 2.0 TFSI employs a new combustion method with shorter compression and longer expansion phases, and raised compression is designed especially for partial load, the intake valves closing much earlier than usual. Together with increased pressure in the intake manifold, this reduces throttling losses.

Because of the shortened compression phase, the compression ratio is upped from 9.6:1 to a heady 11.7:1. So in the compression phase, the engine has only to compress as much gas as a 1.4 TFSI. In the expansion phase, it gains from the high compression ratio, the resulting higher level of pressure during combustion further increasing the engine's efficiency.

For the 2.0 TFSI air/fuel mixture to swirl sufficiently despite the short intake time, the combustion chambers, piston recesses, intake ducts, and turbocharging are specially adapted. Under higher loads, the Audi valvelift system opens the intake valves later, resulting in a higher charge, which



Aerodynamic underbody paneling is most extensive for the A4 2.0 TDI ultra.

ensures good power and torque delivery. Injection pressure has been increased to 250 bar (3.6 ksi).

On the transmission front, the Multitronic CVT system has been dropped and choices now embrace a redeveloped six-speed manual, seven-speed dual-clutch S tronic, and eight-speed Tiptronic conventional automatic.

Playing the Cd game

While weight reduction and advanced powertrains are at the epicenter of Audi's efficiency, aerodynamics have taken a very significant step with the new car, as Audi shows Mercedes-Benz what it, too, can do in that discipline. The sedan's 0.23 Cd is complemented by the Avant's 0.26.

Audi explains how some of it is accomplished by attention to fine detail.

The outer lines of the air inlets integrate additional openings, guiding some of the air stream over the wheel well, where it flows past wheels which have also been aerodynamically optimized.

The Avant gets a roof edge spoiler with a positive downward slant, and narrow trim on both sides of the back window aid airflow.

The underside of the engine compartment of both A4 versions is sealed from the road, and broad trim under the passenger cell and the luggage compartments protects the metal. The wishbones on the rear axle are enclosed and small spoilers guide the airflow at various areas of the car.

The A4 TDI ultra gets a controllable cool-air inlet. A frame installed behind the radiator grille houses two blinds that can be activated independently. They are closed as the car starts so that air resistance stays as low as possible; when air is needed to cool the engine, first the lower and then the upper blind opens.

The accent on aerodynamic efficiency has also been aimed at providing the A4 with a notably quiet cabin, particularly at high cruising speeds.

Electronic upgrade

However, it is the level of cabin and electronic driver support technology that increasingly establishes a new car's status.

For the A4 it includes, depending on version and trim level, the Audi virtual cockpit with 12.3-in LCD screen with high resolution graphics; predictive efficiency assistant; traffic jam assist; rear cross-traffic assist; collision avoidance assist; and turn assist. There is an Audi smartphone interface, Audi Drive Select, and a second-generation modular infotainment platform with a 7-in color MMI (Multi Media Interface) monitor.

The infotainment system includes MMI Navigation Plus, MMI Touch, and Virtual Cockpit developed with **Harman** and **Bosch**. The modular infotainment system processor, called MIB II, is a **Nvidia** quadcore Tegra 30 chip.

An optional Audi tablet, available as a rear-seat entertainment device that's portable, employs a **Google** Android operating system and Nvidia Tegra 40 processor.

Stuart Birch

Alternative drive system for Wacker Neuson's smallest excavator

At this year's Intermat, Dieter Freisler, Regional President, **Wacker Neuson**, emphasized that the company plans in the future to "always have double digit growth," and that "technology development will be the basis of our growth," not that mergers and acquisitions are completely off the table.

Part of that technology development is characterized by the company's smallest excavator, the 803, which is now available with a dual-power option. In fact, the 803 this year won the Intermat Innovation Award in Gold.

With the dual power option, the Wacker Neuson 803 can—in addition to the standard diesel engine—be connected to the HPU8, an external electro-hydraulic drive unit that allows the excavator to be operated electrically. Thus, 803 dual power contractors have a machine that offers the features of a conventional diesel excavator, but at the same time, if necessary, also replaces equipment for completely emissions-free applications. This saves costs,

The HPU8 unit designed specifically for excavator operation is characterized by its compact and sturdy design and the cooling capacity specially tailored for the 803 compact excavator.

If Wacker Neuson's 803 is required for demolition/renovation work or interior restorations, the operator can drive it in conventional mode to the site of operation. Two openings are embedded in the excavator's dozer blade in which the HPU8 can be suspended for transport.

With the dual power option, the Wacker Neuson 803 can—in addition to the standard diesel engine—be connected to the HPU8, an external electrohydraulic drive unit that allows the excavator to be operated electrically.

ensures a higher machine utilization, and expands the application areas of the mini-excavator, opening up indoor use potential.

Simple handling is particularly relevant for end users. If, for example, the excavator 803 is required for demolition/renovation work or interior restorations, the operator drives it in conventional mode to the site of operation. Two openings are embedded in the excavator's dozer blade in which the HPU8 can be suspended for transport. In this way, the operator brings along the generator via this transport support.

The dimensions of the excavator 803 and the unit HPU8 are matched to each other so that the end user can easily drive through narrow door openings with the set. Once on site, the operator simply connects the external unit to the excavator's undercarriage and can then continue to work completely free of emissions.

Hydraulic power for the excavator is supplied via the undercarriage. In this way, the tail swing radius and possibility of a 360° rotation also remain unrestricted in electrical operation, which means complete freedom of movement for the operator. The operating weight, stability, and dimensions of the excavator do not change with the option and the output also remains constant in operation with the generator. For the operator, the sequence of operations thus remain completely unchanged after the connection of the generator.

Operators of the 803 dual power excavator have a machine that offers the features of a conventional diesel excavator, but at the same time also could use the HPU8 generator emissions-free applications.

The HPU8 unit designed specifically for excavator operation is characterized by its compact and sturdy design and the cooling capacity specially tailored for the 803. The electrohydraulic unit saves space, is easy to transport, and is designed for work under full load at up to 45°C ambient temperature as well as at low temperatures.

With their indoor/outdoor possibilities, the 803 dual power excavator and the generator HPU8 are of particular interest for rental yard operators: A high machine utilization is ensured due to the versatile applications. The generator is connected to the excavator's undercarriage via plug & play and is said to be problem-free for less experienced operators. With a weight of 190 kg (419 lb) and compact dimensions, the unit can be stored and transported easily. The HPU8 is also very maintenance friendly: The simple design and easy-to-remove casing parts provide for good maintenance access.

Jean L. Broge

Sierra Nevada breathes life into D328, determined to make it fly again, and evolve

Some 10 years since being out of production (some might say even nearly 15 years if one considers the demise of the plane's originator), the **Dornier** 328, known for its ability to function on "unimproved runways" and "being easy to maintain in third-world countries," is going back into production under at least the partial guidance of Sierra Nevada Corp. (SNC), which at the Paris Air Show announced the formation of its newest wholly owned subsidiary, TRJet Havacilik Teknolojileri Anonim Şirketi (**TRJet**, for short). The announcement follows SNC's May 2015 signing of a Memorandum of Understanding involving the Savunma Teknolojileri Mühendislik ve Ticaret A.S. (**STM**) in support of the Turkish Ministry of Transport, Maritime Affairs & Communications to produce the country's first regional jet as part of its Regional Aircraft Project.

A Turkish corporation, TRJet will be based in Ankara, Turkey—chosen over Istanbul mainly due to existing infrastructure, SNC President Eren Ozmen said—and will serve the Regional Aircraft Project as well as the commercial aviation sector. TRJet will combine the legacy of SNC and 328 Support Services GmbH (**328 SSG**), to create "an aviation and aerospace company that merges modern-edge German aircraft engineering and the latest industry modification standards."

The newly launched Regional Aircraft Project will use the TRJ328 aircraft, a modernized version of the 32-seat D328, as a first-step toward production of Turkey's first domestically built passenger aircraft, the 50-70 seat TRJ628. The 328's reputation not only lies in the commercial arena, but special ops as well for civil and military applications, and the 628 may earn that reputation as well, but it is first anticipated as an entry into the commercial market.

"We believe that the combination of technology, research, collaboration, and decades of experience is the right recipe for TRJet's future success in Turkey and around the globe," said Ozmen. "We are confident that the commitment and support of those involved in the Turkish Regional Aircraft Project, will be successful in producing aircraft that changes the face of transportation in Turkey."

The TRJ328 is currently certified in 85 countries around the world. TRJet believes there is an increasing demand around the world for such an aircraft, which has a normal seating capacity of 32 passengers with the possibility of a turboprop or jet engine. The maximum range of the standard Jet aircraft is approximately 1500 nmi with a typical range of 900 nmi with a full passenger load. (Lorbi)

328 SSG has held the type certificate on the high-wing 328 since 2006, but has not resumed production, focusing instead on MRO for the 328JET and 328 turboprop. On the re-launch of production, Dave Jackson, Managing Director, 328 SSG, emphasized that the company is "not looking to create cutting-edge technologies. Instead, the re-launch of the 328 is designed to be a stepping stone to familiarize Turkish engineers with the aircraft's workings prior to design of the 628."

To start, Jackson said two to three 328s will be manufactured in Germany for recertification and then their production will move to Turkey, with most of the original suppliers for continuity, though some contracts may be re-assessed and/or reassigned.

At various times in Paris, Jackson referred to the 328 as a "stepping stone," a "training vehicle," and as a "learning curve" toward the ultimate 628 goal. That said, by no accounts do the jet and turboprop 328 versions seem to be the ugly duckling sibling of the same versions for the 628, but, instead, strong shoulders upon which to technologically advance and provide Turkish engineers the ultimate in professional development, and while the aircraft engineers may not "create" cutting-edge technologies, that is not to say that they won't make the best of cutting-edge technologies already in the marketplace.

For example in terms of the 328JET, it is expected to include a glass cockpit and updated systems suitable both for today's and future ATM environments, an upgraded modern interior with LED lighting and new seats, and a full-height cabin.

It is estimated that up to 500 people are needed to work in the factory to build the aircraft, which will also employ significant numbers of the Turkish population via indirect employment opportunities. The 328 is currently certified in 85 countries around the world, and is in use in many countries including the U.S., Switzerland, Germany, U.K., and Denmark. TRJet believes that there is an increasing demand around the world for an aircraft such as the 328 with this passenger capacity.

"The [328] fills a niche market for direct and frequent flights between small cities in the country that is currently not feasible using larger airplanes," said Ozmen. "According to market analysis, the aircraft is expected to meet a large demand for both domestic and international [needs]."

TRJet will ultimately produce and sell the TRJ328 and "will play an essential role in making Turkey's first indigenous passenger aircraft [the TRJ628] a reality," said Jackson. "The TRJ628 will be built on the DNA of the 328." And, ultimately, the 628 will be locally designed, engineered, and manufactured in Turkey, and it is expected that engineers will be able to leverage the built-in supply chain of the 328, even though it hasn't been in production for some years.

Launch funding was enabled by the Turkish government ordering 50 planes, but ultimately, TRJet is fully commercial and "will have to live or die by selling airplanes," said Jackson.

Jean L. Broge

2016 Chevrolet Cruze is larger, longer, and sheds 250 lb

General Motors' best-selling global product, the **Chevrolet** Cruze, gains an all-new platform for 2016 that helps make the C-segment model longer, roomier, more aerodynamic, and lighter—shedding 250 lb (113 kg)—while gaining the new 1.4-L direct-injected turbocharged gasoline engine with stop-start and a suite of available connected-vehicle technologies.

A 1.6-L turbodiesel sourced from GM's Szentgotthárd, Hungary, plant currently offered in **Opel** models is scheduled to debut in North American Cruze models in early 2017.

To be sold in over 40 countries, the new Cruze shifts to GM's D2XX compact platform which succeeds the current Delta II that is shared with **Buick** Verano, Chevy Equinox, Opel Astra, and others. The four-door notchback body style is expected to be joined by a five-door hatch. A slight increase in wheelbase, to 106.3 in (2700 mm) from the current 105.7 in (2685 mm), along with 2.7 in (69 mm) longer overall length, makes the new Cruze larger than competitors **Honda** Civic, **Ford** Focus, **Dodge** Dart, **Mazda**3, **Hyundai** Elantra, **Nissan** Sentra, and **Volkswagen** Jetta.

Inside, the car is roomier than its predecessor and boasts more rear legroom—36.1 in (917 mm)—and 2 in (51 mm) more rear knee room than Focus and Elantra, according to GM. Front and rear tracks carry over from the current Cruze, at 60.8 in (1544 mm) and 61.3 in (1557 mm), respectively.

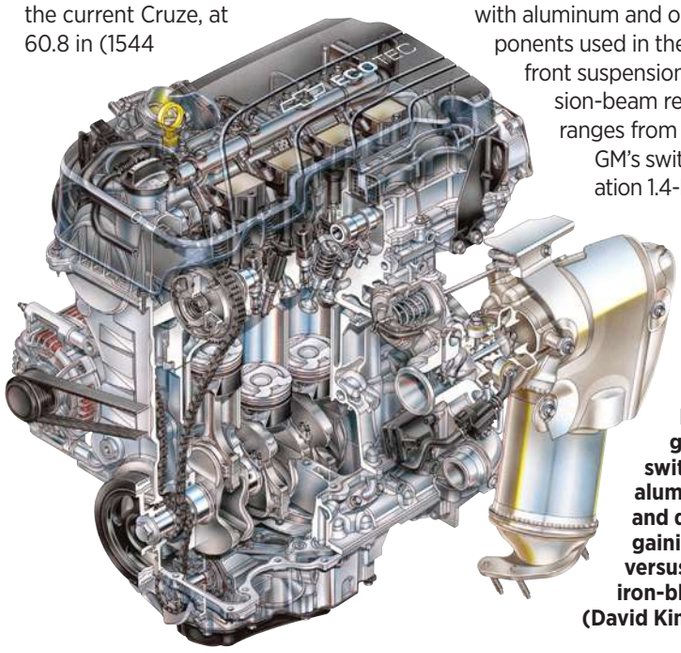
Overall height on the 2016 Cruze has been reduced by nearly an inch versus the 2015 car, which helps enable a 0.29 Cd.

Like the 2016 Chevrolet Volt, the new Cruze's overall height has been reduced—by nearly 1 in (25 mm), giving it a sleeker look and enabling a 0.29 coefficient of drag (Cd)—a factor in the car achieving the estimated 40-mpg highway fuel efficiency, engineers noted. **EPA** fuel efficiency testing was not yet completed at the car's June 24 reveal.

The new body architecture, claimed to be 27% stiffer overall than the 2015 model, is expected to help further decrease cabin noise as well as improve vehicle dynamic performance and occupant safety. The body shell uses about 8% hot-stamped/high-strength steel alloys that help reduce mass by 53 lb (24 kg) versus the incumbent Cruze's.

Executive Chief Engineer Ron Arnesen calls the Cruze's chassis system "perhaps the most mass-efficient in the segment," with aluminum and optimized steel components used in the MacPherson strut front suspension and in the torsion-beam rear setup. Wheel size ranges from 15 to 18 in.

GM's switch to its new-generation 1.4-L turbocharged engine for Cruze contributes to the car's interior quiet. Measured noise levels are up to 50% quieter—6 dB(A)—than the benchmark VW 1.4-L TSI, Small Ecotec Gas Engines Chief Engineer Tom Sutter told *Automotive Engineering*. The engine's open-deck, die-cast aluminum cylinder block features a bedplate architecture that stiffens up the lower end, also contributing to inherently better NVH attenuation.



GM's new 1.6-L Ecotec turbo gasoline engine switches to a die-cast aluminum cylinder block and direct fuel injection, gaining 14 hp (10 kW) versus the incumbent iron-block 1.4-L turbo. (David Kimble illustration)

The aluminum block is also 20 lb (9 kg) lighter than the grey iron block in the current-gen Family Zero 1.4-L turbo engine. Still a long-stroke design, the new engine also gains direct injection that, along with a 10:1 compression ratio, helps boost its **SAE**-certified power rating to 153 hp (114 kW) at 5600 rpm—up from 138 hp (103 kW) on the previous port-injected unit. SAE rated torque is 177 lb·ft (240 N·m). Low-friction piston rings, camshaft drive, and oil pump are used. Transaxles are a standard M32 six-speed manual and available 6T35 six-speed automatic.

Inside Cruze, customers will find the Chevy-signature dual cockpit layout with vast safety capability and infotainment connectivity. The 7-in MyLink screen in the center stack is compatible with **Google** Android Auto and **Apple** CarPlay—the latter available with an 8-in screen, and offers wireless phone charging. Android Auto requires a phone running the Android Lollipop 5.0 operating system or above, while Apple CarPlay requires an iPhone 5 or later. There's standard **OnStar** 4G LTE with Wi-Fi hotspot. Available safety features include side blind-zone alert, rear cross-traffic alert, lane-keep assist, and forward collision alert.

Cruzes sold in North America are being built at GM's Lordstown, OH, complex, which received a $50-million upgrade for the 2016 program.

Lindsay Brooke

Cat designs its 336F L XE Hybrid excavator with building-block technologies

Caterpillar says its 336F L XE Hybrid delivers an estimated fuel savings of up to 20% compared with its standard 336 counterpart with no compromise in performance and no added maintenance costs.

The 308-hp (230-kW) C9.3 engine meets **U.S. EPA** Tier 4 Final emissions regulations via proven electronic, fuel, air, and aftertreatment components. The inherent fuel efficiency of the C9.3 is further enhanced with automatic engine speed control, a programmable engine idle shutdown feature, and an ECO mode that allows operators to tailor machine performance to the application. The engine also runs efficiently on biodiesel blends up to B20.

Three building-block technologies enable the 336F XE to deliver fuel savings and enhance performance. The Cat ESP (electronic standardized programmable) pump "smoothly transitions" between the hydraulic hybrid power sources, the engine, and the accumulator to conserve fuel. The Cat ACS (adaptive control system) valve optimizes performance by intelligently managing restrictions and flows to control machine motion. Instead of wasting kinetic energy during swing braking, the Cat Hydraulic Hybrid Swing System pressurizes the accumulator to stop the machine and then uses that pressure when needed to accelerate the machine later.

That said, Caterpillar considers the key ingredient the ACS valve, which it says "is exclusive to Cat brand." It is the "brain" of the system—one that independently controls machine functions and directs hydraulic energy where operators need it precisely when they need it.

Because the ACS valve is fully integrated with the pump and hybrid system, operators will experience the same control, hydraulic power, and lift capacity as from traditional Cat machines, with the added benefit of reduced fuel consumption. That's one reason why the valve is also now standard on larger machines like the 374F and 390F.

Caterpillar offers several connected technologies as standard on the 336F L XE. Grade technologies provide real-time bucket tip elevation guidance to help operators stay on grade and finish work more quickly, accurately, and productively. The latest technology addition is payload, and it provides real-time weighing as the boom swings for fast, efficient loading, and optimum payloads.

Operators can view load weights on the in-cab display and know when target payload is achieved, maximizing the productivity of the entire fleet. Productivity can be tracked from the cab—with quick access to payload weights, load and cycle counts, and daily totals. Site managers can wirelessly access payload data and machine operating data such as location, hours, idle time, fuel usage, and events via Link technologies through the VisionLink web portal to measure production, monitor efficiency, and optimize performance.

The 336F L XE's massive frame, heavy-duty extended-length undercarriage, and standard and heavy counterweight options combine to form an exceptionally strong, stable work platform for digging, lifting, or attachment use. The heavy-duty reach boom can be paired with either a 10.5-ft (3.2-m) 12.8-ft (3.9-m) stick. A mass boom and 8.4-ft (2.55-m) stick combination are also available. So are multiple Cat Work Tools and a state-of-the-art tool control system.

The 336F L XE also provides the ultimate in operator comfort and convenience. Cat says it didn't go short on the operator's environment, boasting an in-cab sound level of only 73 dB(A). Air suspension and heated and cooled seat options are available as well as joystick controls adjustable to suit operator preferences and an automatic climate control system that continually maintains a stable, comfortable environment.

Three building-block technologies enable the Caterpillar 336F XE to provide improved performance and fuel-consumption numbers over its predecessors: the electronic standardized programmable pump, which smoothly transitions between the hydraulic hybrid power sources, the engine, and the accumulator to conserve fuel; an adaptive control system valve that optimizes performance by intelligently managing restrictions and flows to control machine motion; and the hydraulic hybrid swing system, which pressurizes the accumulator to stop the machine and then uses that pressure when needed to accelerate the machine later.

Serviceability features include ground-level access to major maintenance points, an electric fuel system priming pump, remote fuel tank drain, and a fuel level indicator to help avoid overfilling. Safety features include a ROPS (roll-over protective structure) cab, anti-skid surfaces, programmable halogen working lights, easily stored upper and lower windows, and large skylight that can be removed for an emergency exit.

It is also augmented with the new Cat Production Measurement system, which enables operators to load trucks with just the right weight while allowing managers to remotely monitor the machine's productivity.

Jean L. Broge

COMPANIES MENTIONED

AD INDEX

Q&A

Cybersecurity is a continuous process, said SwRI's Mark Brooks, especially for vehicles and equipment with their long life spans.

Cybersecurity for commercial vehicles

As a Senior Research Engineer at **Southwest Research Institute** (SwRI) in the Automation and Data Systems Division's Cooperative Systems Section, Mark Brooks' primary focus is on automotive (meaning any self-propelled vehicle or machine). He became involved in cybersecurity and embedded systems more than 10 years ago when an off-highway client wanted to add security capabilities to its new ECU (electronic control unit) platforms. "We assisted them in the design of that product, and ever since then we've maintained a presence in embedded systems security—everything from penetration testing of existing products, helping to design and develop products, and researching brand-new security technologies," he said. Brooks recently spoke with SAE Magazines about "attribute-based encryption," a topic he discussed at last year's **SAE** Commercial Vehicle Engineering Congress, and other cybersecurity issues. For the full transcript, visit http://articles.sae.org/14229/.

In your SAE presentation you discussed an "alternative" encryption method that's attribute-based. Can you explain what this is?
Attribute-based encryption is a subset of functional encryption. This is based on some research we've been doing with one of our clients. They are trying to commercialize attribute-based encryption. The nice thing about this method is that it encrypts data based on a policy. For example, you can set a policy saying that this data could be viewed if you are the automotive manufacturer, or if you're a mechanic. If you satisfy either of those policy attributes, then you're able to view the data. And this is from an encrypt-once type of situation. In symmetric encryption, you'd have to encrypt the same data at least twice, for anybody that you would want to be able to protect it from. Same thing with asymmetric encryption, you'd have to be able to use the public key from each of those entities to be able to protect it. So the nice thing about attribute-based encryption is that it allows you to do role-based access control or even content-based access control, where based upon what the contents of the data are is who's allowed to view it. And you don't have to do a lot of the additional key management, or the separate encryptions, to be able to protect the data as in asymmetric or symmetric key technologies.

Where does this technology stand in terms of development?
Our client is working closely with the government on cloud-based computing, and for protecting data in the Cloud. You can see how the idea of protecting data with attribute-based encryption might be beneficial for the Cloud. What we're looking to do is to bring it into automotive [including commercial vehicles]. We saw some synergy with what's needed in the automotive sector, both possibly within a vehicle and also external to a vehicle—somebody trying to hack the data in and out, or even communications between vehicles. So at this research stage we want to be able to see, does it make sense for the automotive sector? Does it make sense based upon requirements for computation times, how intensive is it, can it fit on the boards on a vehicle? Those are questions we want to answer, so that's what we're investigating.

Are there unique challenges in protecting passenger vehicles vs. commercial vehicles?
Off-road vehicles are adding a lot of autonomy, which provides a potential impact if a vulnerability or if an attack occurs. They're also adding a lot of connectivity for communication, to be able to update things that are in the field and remote locations, so that's another "attack surface" that a hacker might be able to exploit. So these are things that they're working toward protecting, and before they deploy they put solutions in place to build or protect firewalling and systems using various intrusion-detection systems, segregating different components, and things like that.

Each of these [industries] is going to have unique challenges as we get connected, and the regulations are going to be different, safety concerns are going to be different. Passenger cars focused a lot on infotainment driver experience, and that of course is not as much of a concern on the off-road side; it's more about getting the job done and those capabilities, and those are going to have some differences in attack surfaces and the potential vulnerabilities.

How do you protect increasingly connected/automated vehicles?
These are complex systems and there are going to be issues that arise, especially in the field, and things that just get missed; it's a very complex problem. Fortunately, software is modifiable and can be patched after it's delivered. But unfortunately, that software modifiability is another area that attackers might take advantage of, so there needs to be protective mechanisms in place to combat that, and there are. But we need to keep abreast of what security issues might be out there.

One of the key things that I think would be most beneficial in protecting too, is information sharing—for example, [industry-specific] information-sharing assurance centers (ISACs) that are being set up are a good way to help share information. That way within an industry, if there's a particular attack discovered, that information can be shared so that others might be able to work toward protecting themselves...Also having in place internal security test teams, setting up the organization so that security is designed from the ground up for a product, making sure that you test, that you keep active on what's going on with threats so that you can keep updating your software and updating the patches.

Ryan Gehm

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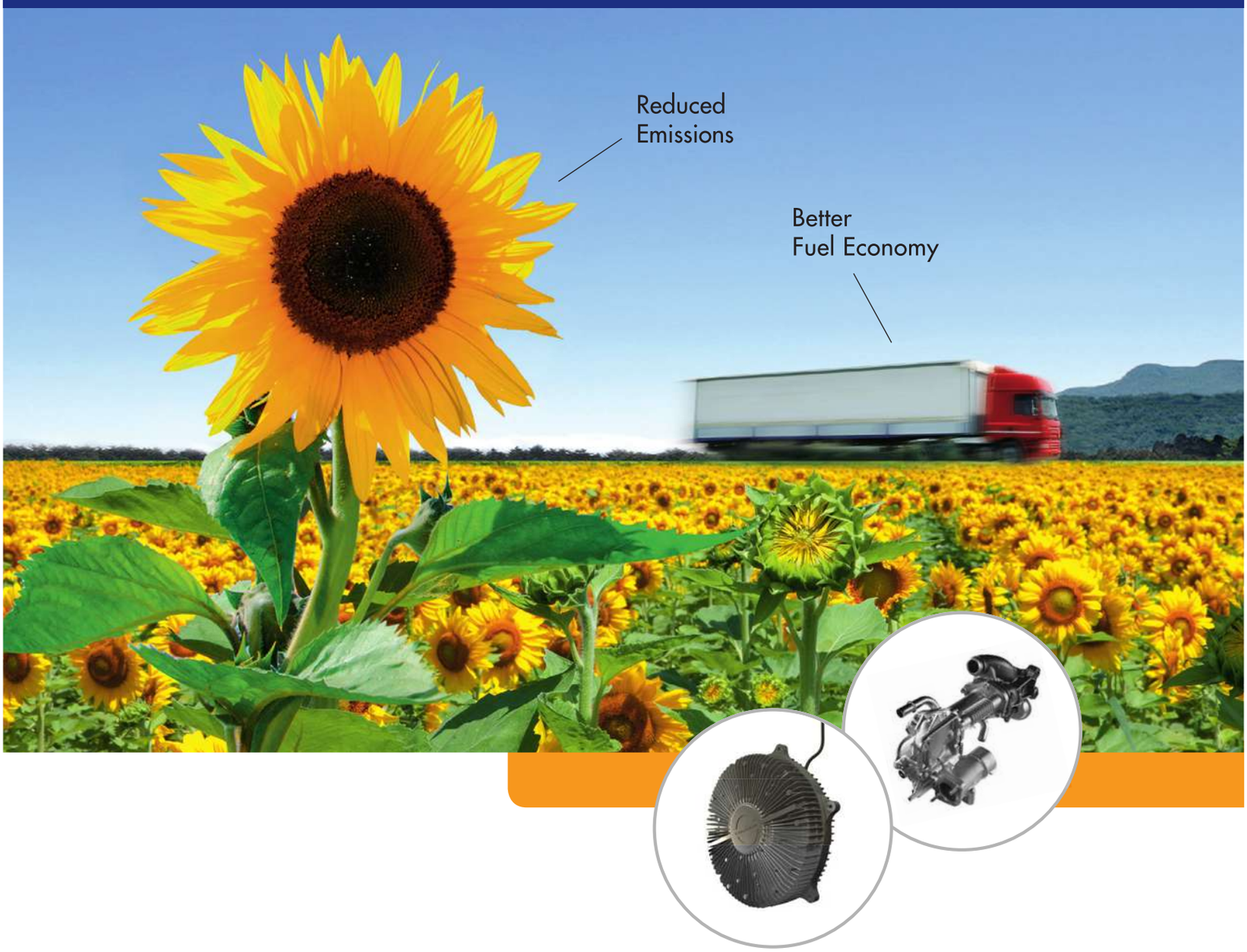

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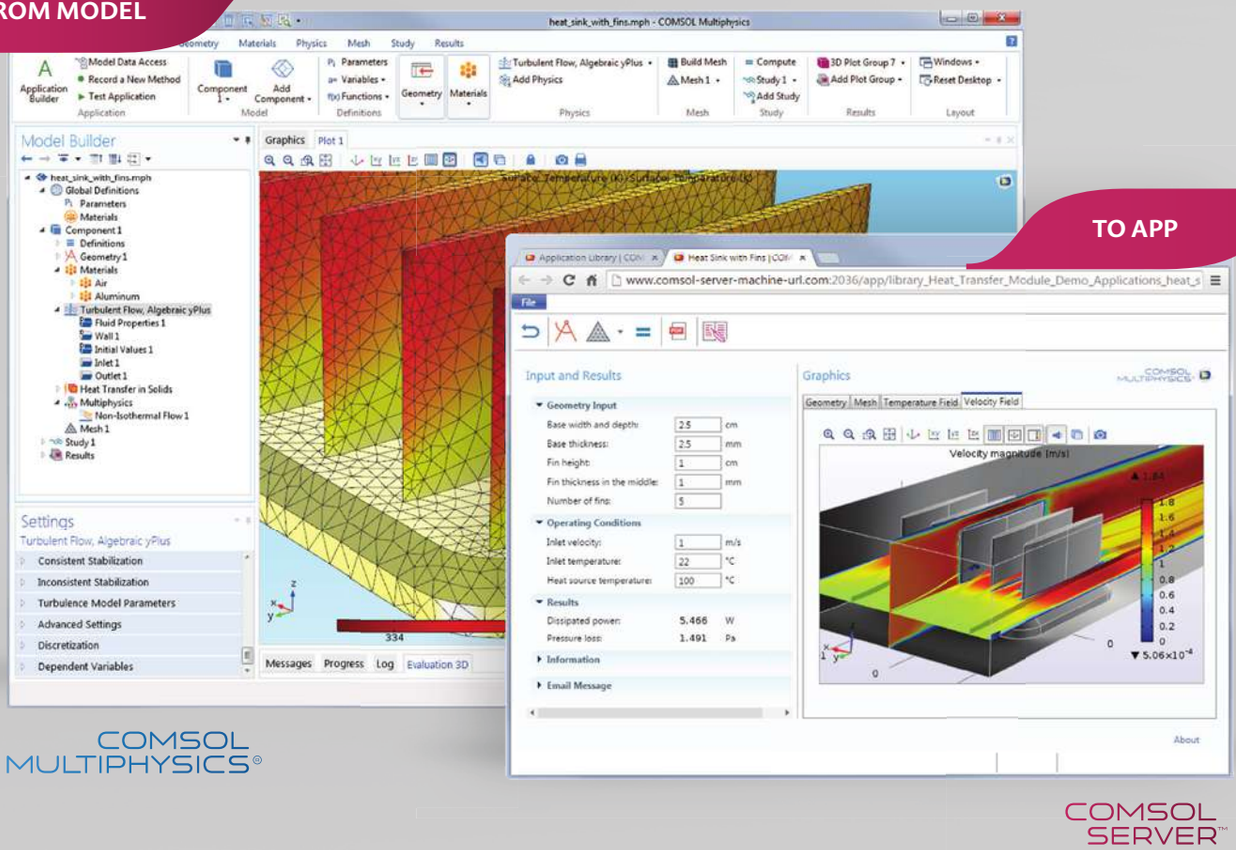

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