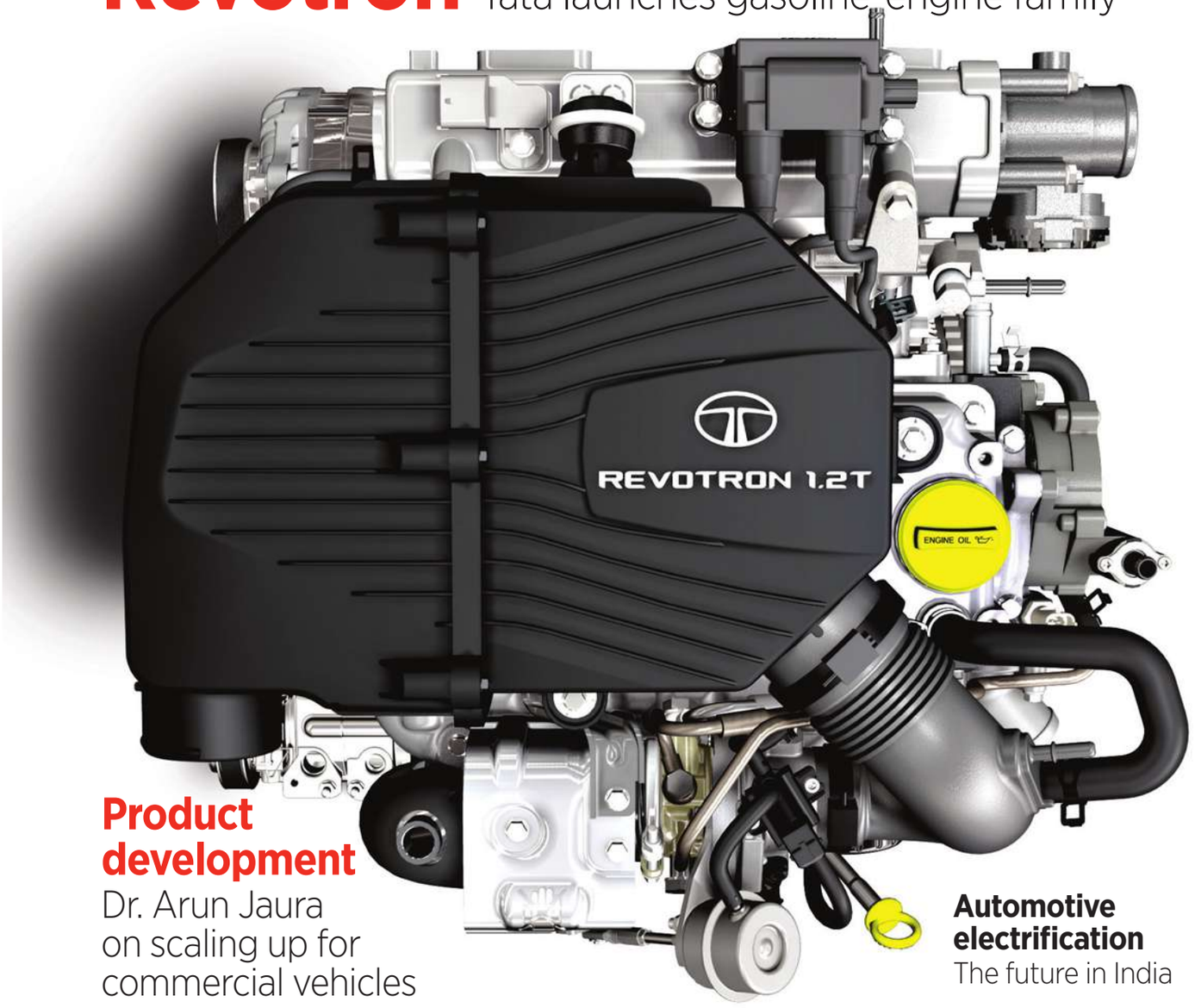
MOBILITY ENGINEERING™

AUTOMOTIVE, AEROSPACE, OFF-HIGHWAY

A quarterly publication of SAE INTERNATIONAL and SAE INDIA

Revotron
Tata launches gasoline-engine family



Product development
Dr. Arun Jaura on scaling up for commercial vehicles

Automotive electrification
The future in India

Dr. V Sumantran
Q&A with Hinduja Group's Executive Vice Chairman

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Eaton CTO assumes SAE VP post

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EDITORIAL

Advancing driver assistance

The automotive industry for years has been developing advanced driver assistance systems (ADAS) to improve the comfort and safety of passengers. These systems have hit the market with many names and acronyms, all in an effort to help burnish automaker reputations for safety and comfort.

Mercedes-Benz achieved the top ranking in **ABI Research**'s recent Competitive Assessment of the ADAS Market, with **Volvo** and **BMW** occupying second and third places, respectively.

The ABI Research survey assessed OEMs based on a number of implementation and innovation criteria. Volvo ranked first in the implementation category due mainly to the relatively high fitment of ADAS as standard equipment and the high availability of other ADAS as options across its range. Mercedes and **Audi** were second and third in the implementation category.

In July 2013, Volvo reached a landmark safety milestone of 1 million cars sold with its pioneering auto-brake technology. Its portfolio for automatic braking includes several world firsts: City Safety, which is standard and works at speeds up to 50 km/h (31 mph); Collision Warning with full auto brake; and Pedestrian and Cyclist Detection with full auto brake.

The leaders in the innovation category were Mercedes-Benz, BMW, and Audi. Mercedes scoring highest since it offers the most comprehensive range of ADAS.

The latest S-Class showcases the breadth of the Mercedes-Benz technologies. Its Distronic Plus adaptive cruise control gains Steering Assist and Stop&Go Pilot. The Brake Assist System Plus with Cross-Traffic Assist can detect crossing traffic and pedestrians, and can boost braking power applied by the driver if needed. If lane markings are broken, Active Lane Keeping Assist can detect when the adjacent lane is occupied and reduce the risk of the vehicle leaving its lane unintentionally by applying the brakes on one side. Adaptive Highbeam Assist Plus allows high-beam headlamps to be kept on permanently without dazzling traffic by masking out other vehicles in the beams' cone of light. Night View Assist Plus is supplemented by a thermal imaging camera to alert drivers to pedestrians or animals in unlit areas in front of the vehicle, and a spotlight function flashes any pedestrians detected. Attention Assist warns of inattentiveness and drowsiness and notifies drivers of their current state and the driving time since the last break and can indicate nearby rest stops through the Comand navigation system.

While luxury brands see sophisticated ADAS features as tools that burnish their "safety-conscious" brand images, "the strategy of mass-market OEMs such as **Ford** or **Volkswagen** has been to offer ADAS solutions only if there is sufficient consumer demand for them and providing the technology is affordable," said Gareth Owen, Principal Analyst at ABI Research. As a result, the penetration of ADAS systems in mass-market cars is very low; however, this is beginning to change.

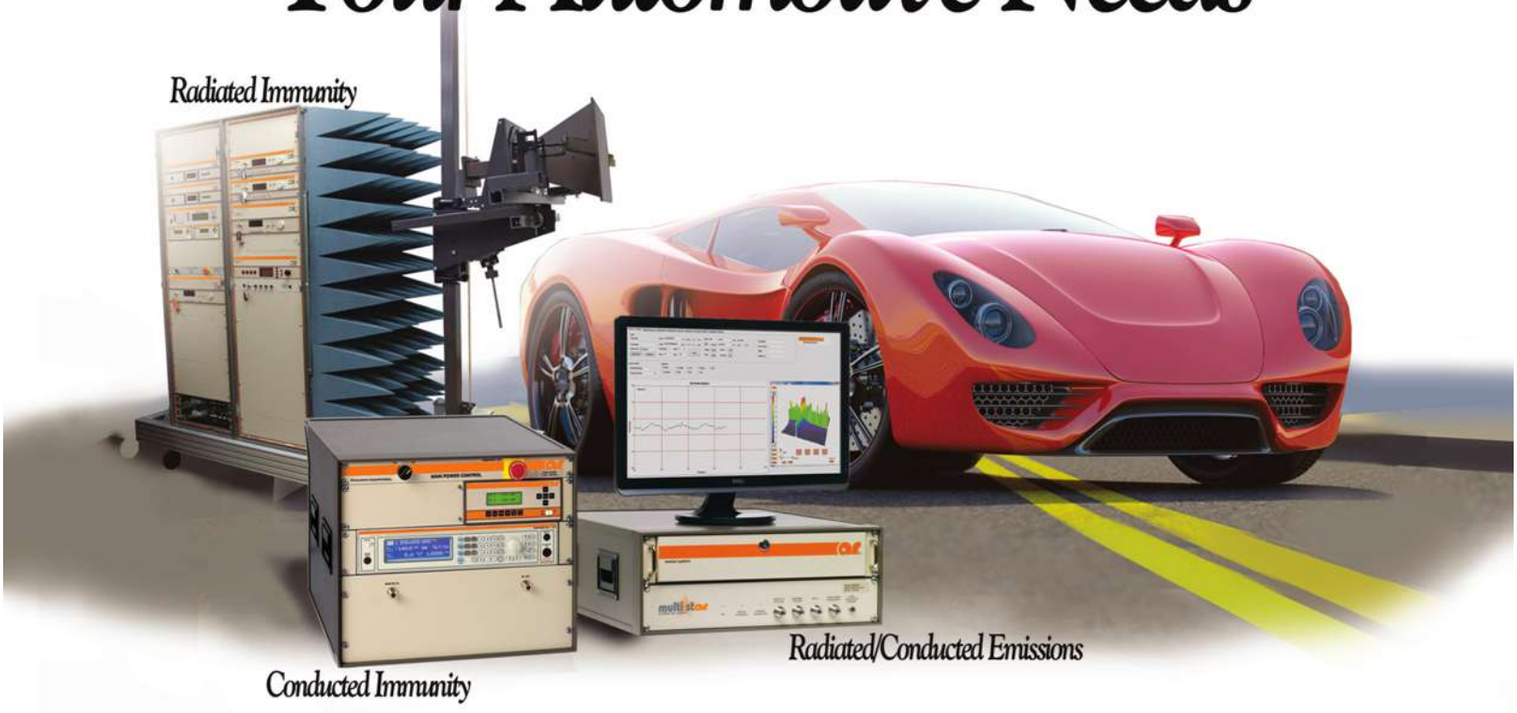
There was a steady increase last year in the number of mass-market OEMs offering ADAS, with key systems, such as front collision avoidance, beginning to be standard on select models and trim variants in advance of new and more stringent safety requirements.

ABI Research expects this trend to accelerate significantly during the next five years, said Owen. "The decision by car-safety ratings agencies to include ADAS in their ratings reflects a growing awareness of the potential of these active safety systems, and car OEMs will now be challenged to raise the availability of these systems in their new car models."

This is a positive trend. More cars having ADAS, along with connected car-to-car and -infrastruture technologies, will make the entire global fleet safer. The total integration of all these systems will eventually lead to the ultimate solution—fully autonomous driving vehicles. Volvo has a lofty goal in this regard. It aims to bring the number of people killed and seriously injured in new Volvo cars down to zero by 2020.

Kevin Jost
Editorial Director

The Total EMC Source For Your Automotive Needs



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I was extremely happy to see the fruition of our yearlong work on launching the magazine *Mobility Engineering* in India true to international standards as a joint endeavor of **SAEINDIA** and **SAE International**. The magazine has been well received by the discerning mobility professionals and practitioners and will be a valuable manual and guide to academics with the burgeoning student members of SAEINDIA from engineering and research institutions throughout the country.

SIMCOMVEC, the 8th International Mobility Conference and the first Commercial Vehicle Congress jointly hosted by SAEINDIA and SAE International, was a magnificent success in all respects, and the professional delegates touched a new height in the event with an eminent panel of speakers both from India and abroad eloquently speaking on emerging technology trends in the automotive industry. A detailed report on the event appears elsewhere in the issue with Dr. Arunkumar Sampath, Chairman, Organizing Committee of SIMCOMVEC, covering important high points of the event.

SAEINDIA has been making steady progress in all spheres of its activities. Each one of the major projects and programs has been breaking yet another record by enlisting more teams and more contestants. The Virtual SUPRA SAEINDIA was a runaway success with more than 175 teams competing this year and with more than 100 teams cleared for the final event scheduled in July 2014.

BAJA SAEINDIA is organizing the 7th edition at Pithampur near Indore Feb. 20–23, and we expect larger participation this year from the student members. The competition has taken deeper roots, with long-term plans and implementation by engineering institutions in India helped by the tremendous goodwill and support from the Management of the Colleges and local industry in different parts of the country.

The National Olympics of AWIM was held in the last week of December 2013 at Bangalore and was a tremendous success, with the young children taking keen and active part in the competition and understanding the subtle nuances with remarkable clarity and agility. It proved the fact that, given the right encouragement and training, Indian children can compete globally with ingenuity and intelligence backed by an innovative spirit.

SAEINDIA is planning to organize webinar and webcast programs on topics of relevance during 2014. The infrastructure has been geared up to handle this seamlessly across the country. The International Lecture Series, which commenced last year, will continue with greater vigor during 2014, including a program on Vehicle Dynamics by Dr. Richard Lundstorm in March. This will be followed by additional programs over the course of the year.

We are also looking at the SINE program under the Off Highway vertical and Conferences and Seminars in the Aerospace vertical, which will further reinforce the growth of the segment with focused offerings to the professional members.

Mobility Engineering will have more contributions from Indian professionals who have impeccable credentials in their areas of core competence and will cover technological advances and improvements meeting international standards on subjects such as nanotechnology, frugal engineering, and electric vehicles.

India is steadily emerging as a global research hub, with international giants including **GE**, **General Motors**, and **Hyundai** setting up tech centers in India to support their worldwide requirements. The commercial success of these hubs is spurring them to scale up their investments in research and development despite the downward market trends.

SAEINDIA, along with SAE International, should evolve as a one-stop resource for mobility technology with their continued efforts to disseminate knowledge and enhance skills through programs designed to attract, retain, and empower mobility professionals with knowledge enrichment and skills enhancement.

Please give us your constant feedback on content improvement and development of new contours to provide great value to the reading professionals.

Best wishes,
Mr. Shrikant R. Marathe
President, SAEINDIA

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SAEINDIA News

SIMCOMVEC 2013 highlights

On Dec. 4, 2013, **SAEINDIA**, the premier professional society and the largest affiliate of **SAE International**, USA, inaugurated SIMCOMVEC—8th SAEINDIA International Mobility Conference and 1st Commercial Vehicle Engineering Congress focused on "Technologies for Safe, Green and Connected Vehicles." About 850 delegates from the global and domestic automotive industry participated in the event with about 140 from **Mahindra & Mahindra** and 90 from **Ashok Leyland**.

The conference attracted delegate registrations from different organizations ranging from **Hero Motors** and **Lucas-TVS** to **TAFE** and **Fiat-Chrysler**, a first of its kind in SAEINDIA history. The conference provided a platform for exchange of ideas and knowledge to continue nurturing the growth path through solutions and opportunities for sustainable mobility technologies.

The four-day conference was inaugurated by Dr. K Rosaiah, Honorable Governor of Tamil Nadu with Vinod Dasari, Managing Director, Ashok Leyland Ltd. as the Guest of Honor. The inaugural ceremony was presided over by Srivats Ram, SIMCOMVEC Steering Committee Chairman & Managing Director, **Wheels India** Ltd. Additional dignitaries included Dr. Donald G. Hillebrand, 2013 President, SAE International; Shrikant R. Marathe, President—SAEINDIA and Director, **Automotive Research Association of India** (ARAI); Dr. David Schutt, CEO, SAE International; and Dr. Arunkumar Sampath, Chairman, Organizing Committee.

SIMCOMVEC 2013 provided an excellent opportunity for industry experts, government, and academia to be apprised of the latest technologies in the areas of enhanced safety, emissions technologies, alternative fuels and powertrain, and emerging trends in electronics and vehicle connectivity, to name a few.

In welcoming the dignitaries and the delegates, Ram said, "The Indian automotive industry is emerging as the preferred choice of destination for automotive players across the globe. The need to understand the mobility challenges of growing urban cities in the country and find safer and greener technologies will help in the integrated transportation network."

Delivering the special address was Dasari: "Commercial Vehicle manufacturers in India have consistently risen to the challenge of designing vehicles capable of withstanding harsh environments, low maintenance, and over-loading while simultaneously carrying more than 25 million passengers in their buses and transporting goods across rugged terrains in their trucks." To enable the industry to meet future emissions norms, especially in the commercial vehicle segment, he insisted on a clear-cut fuel policy and availability of low-sulfur fuel.

Said Hillebrand: "This is the first ever event being organized in India which is presenting a platform for synergy in technologies for commercial vehicles and personal mobility. India has been under the global spotlight for being a dynamic automotive market with frugal engineering at its fore. This conference will help identify best practices and standardize technologies for the future."

Conference entrance at the Chennai Trade Centre.

Chief Guest at the inaugural function of SIMCOMVEC was Dr. K Rosaiah, Honorable Governor of Tamil Nadu.

SAEINDIA's booth at the expo.

Rosaiah highlighted the continued support being provided by the government in promoting investment in the automotive industry, saying: "The automotive cluster in South India consisting of Chennai is the biggest in the country with 35% of the revenue share. I am proud to be associated with the city of Chennai—touted as the Detroit of India—as this city has been successful in attracting investment and talent pool particularly in the automotive industry with active support from the government."

In his concluding remarks at the event's inauguration ceremony, Marathe said: "We are delighted to host SIMCOMVEC as it allows us to bring global and Indian automotive leaders to showcase their technologies that address the needs of sustainable mobility solutions for today and the future. These technologies have become a competitive advantage for manufacturers and are gaining wide acceptance with customers. India is making significant contribution toward R&D for such technologies."

Rosaiah then inaugurated the exposition, which saw participation from more than 75 exhibitors who showcased their technologies and new products in addition to vehicle displays from the leading automotive OEMs. The vehicles displayed in the exposition included Ashok Leyland's ICV and Jan Bus; Mahindra's XUV 5OO bi-fuel hydrogen vehicle; ARAI's vehicle rigged with equipment for structural dynamics, **Mahindra-REVA**'s e2O, **Toyota**'s Etios, and **Hyundai**'s Grand i10.

SIMCOMVEC has set a benchmark in bringing multiple stakeholders under one roof and creating awareness on recent innovations in various technologies. It has opened up new partnership avenues for industry, academia, and government institutions, enabling healthy exchange of ideas and making this event the most sought-after by mobility practitioners.

Plenary and technical sessions

As part of the screening process of technical abstracts and manuscripts, the SIMCOMVEC Technical Committee followed the specially developed system of SAE International's "MyTechZone." The Technical Paper Review Committee comprising 35 experts from industry and academia reviewed the draft manuscripts. The conference attracted a total of 270 abstracts, which culminated in 141 manuscripts.

SIMCOMVEC brought a technical feast via 115 SAE papers presented personally on-site by authors from India and abroad who are experts in their specific domain. There were 10 international papers out of these 115. Papers were presented in four parallel sessions over four days totaling to 32 technical sessions. The details of international papers are summarized below.

The 115 papers as a group gave a 360-degree view of the following 15 technical domains (there were 10 associated keynote presentations):

- Advanced engine technology (15 papers)
- Alternative fuels (7 papers)
- Emission controls (3 papers)
- Advances in HVAC systems (3 papers)
- Simulation and modeling (32 papers)
- Automotive electronics (4 papers)
- Hybrid and electric vehicles (11 papers)
- Onboard diagnostics (4 papers)
- NVH (11 papers)
- Safety and crashworthiness (8 papers)
- Advanced materials (3 papers)
- Advanced manufacturing (4 papers)
- Braking and steering systems (4 papers)
- Suspension systems (3 papers)
- Virtual prototyping and testing (3 papers)

In addition to the technical presentations, the delegates had a wonderful opportunity to listen to the lectures from

International Papers

Topic	Number of papers	Organization(s)
Advanced engine technology	2	Achates Inc. (USA), Moscow St. Tech U. (Russia)
Safety and crashworthiness	2	Applus IDIADA (Spain), STA (Russia)
Simulation and modeling	1	Inst. of Control Sciences
Hybrid and electric vehicles	1	Applus IDIADA (Spain)
Advanced electronics	1	AVL (Austria)
NVH	1	LMS (Belgium)
Emission controls	1	Applus IDIADA (Spain)
Virtual prototyping and testing	1	China

Cutaway of the Mahindra XUV 500.

Expo attendees had a keen eye for detail.

eight plenary speakers who touched upon a wide gamut of topics such as:

- Advanced Vehicle Technology Research at U.S. National Labs—Dr. Donald G. Hillebrand of SAE International, USA
- Skill Development for Employability—Dilip Chenoy of **National Skill Development** Corp., New Delhi
- Improving Safety on Indian Roads—Technologies and Policy Changes Required—Randall B. Clark of **Michelin**, USA
- Emission Technologies in Commercial Vehicles—A Global Perspective—Tom Stover of **Eaton** Corp., USA
- Advanced Engine Technologies for Improving Commercial Vehicle Fuel Efficiency—Lukas Walter of **AVL**, Austria
- Emerging Trends in Electronics & Vehicle Connectivity—Joerg Lutzner of **Continental**, Germany
- On Board Diagnostics—Dr. Venkat Srinivas of Ashok Leyland Ltd, Chennai
- Mass Transportation Opportunities and Challenges—Vikram Kapur, IAS—Commissioner of **Chennai Corp.**

Panel discussion

The highlight of the conference was the panel discussion moderated by Dr. Arun Jaura, Managing Director of **Traktion**, with participation from leaders encompassing the entire mobility industry. The topic was rightly chosen as "Developing Tomorrow's Synergistic Solutions for Commercial & Personal Mobility in Emerging Markets." The list of panelists included:

An Ashok Leyland engine.

- Bharat Vedak—Vice President, India Technical Center & DCV, **John Deere**
- Shrikant Marathe—President, SAEINDIA and Director ARAI
- T. Sarangarajan—Vice President, Hyundai Motors
- Donald Schulte—Managing Director, **PACCAR**
- Dr. Chandan Chowdhury—Managing Director, **Dassault Systèmes**
- Dr. Aravind Bharadwaj—Head Technology, **M&M TPDS**:

Vedak touched upon the differences in cab design for off-highway vehicles between India and developed countries, as there is a tendency for people in India to use the cab as a temporary shelter/comfort zone during off-working hours; this is not the case in advanced countries. Marathe elaborated upon the homologation and vehicle-certification requirements and how his organization has been working closely with different vehicle segments toward achieving synergy. Sarangarajan exhorted the mobility engineering community to appreciate the "emotional aspect" an owner has toward his/her vehicle so that field issues are not viewed/solved from an engineering perspective only. Schulte shared his experiences of working in the USA and in the

American Axle was one of the exhibitors.

India commercial vehicle market, highlighting the expectations of these markets and how the advanced technologies have to be rightly fitted to find their place in emerging markets. Chowdhury urged the mobility practitioners to believe in the capability of their own community and challenged the automotive industry executives to move toward zero physical prototypes through enhanced virtual prototype build and simulation. Bharadwaj connected with the audience through a description of the latest technologies in alternative powertrain and advanced telematics, and also explained how Indian engineers need to leverage frugal engineering to overcome the unique challenges faced by the industry.

The finale

The SIMCOMVEC Conference was successfully concluded Dec. 7 with Dr. T. Ramasami participating as the Chief Guest and Dr. Pawan Goenka as the Guest of Honor. Additional dignitaries on the dais included Hillebrand, Schutt, Marathe, Bharadwaj, and Sampath.

In opening remarks at the closing ceremony, Marathe said: "We are delighted to have successfully conducted SIMCOMVEC for the first time in India that saw overwhelming participation from the industry in the form of sponsorships, plenary speeches, technical paper presentations, panel discussion, delegate registrations, and exposition." He urged the mobility community to continue to support SAEINDIA initiatives in organizing more such events.

Srivats Ram, MD, Wheels India Ltd., delivered the curtain-raiser.

In providing a summary of the four-day event, Sampath said: "We are extremely pleased to inform that this conference has significantly outperformed the earlier mobility conferences in terms of number of sponsors, number of technical papers, and number of technical sessions, and has been on par with the earlier conference, APAC16 2011, in terms of delegate registrations, paper presentations, and sponsorships. The event touched upon different aspects of mobility in line with the theme of the conference and also provided a forum to stress the importance of skill development for employability and also mass transportation opportunities and challenges."

Said Goenka, Patron of SIMCOMVEC: "Though the Indian market has been steadily growing to reach sixth position in personal mobility space, recent statistics on product development indicate that less than 10% of the design activities are carried out in India. The situation is a little better for the commercial vehicle segment, where about 90% of the design is carried out domestically. Automobile wars are fought in R&D and not in showrooms. Enhanced design and development activities within the country will give global recognition to India and the necessary sustainability to the industry."

The Apollo Tyres booth.

Ramasami said: "Automobile R&D is a priority sector for the government. A long-term plan document is under preparation for putting together a technology mission which includes mobility and transportation as key components. Investments in technology and development by different automotive organizations are being viewed as Corporate Social Responsibility (CSR) initiatives, which the government is willing to consider favorably for tax benefits and concessions."

Dr. K.C. Vora, Chairman, SIMCOMVEC Technical Committee, announced the awards for different categories such as Best Domestic Paper, Best International Paper, Best Student Paper, Best Oral Presentation, Best Stall, etc., which

were handed over by the dignitaries on the dais.

Said Hillebrand: "The past four days have been a wonderful experience wherein SAE International and SAEINDIA came together to successfully pull together a large event of this magnitude. This conference will help identify best practices and standardize technologies for the future."

While congratulating the team for successfully conducting the program, Schutt said: "This conference is just the beginning of joint activities planned between SAE International and SAEINDIA. Many areas of cooperation have been identified for joint efforts including professional development programs, technical magazines, and marketing of the SAE brand in India."

The Vote of Thanks was given by Sampath.

Participants of the high-profile panel discussion.

Launch of *Mobility Engineering* at the inaugural function.

Professional development programs

On Dec. 2 and 3, two professional development programs (PDPs) had been conducted. In line with the theme of the conference, one program focused on "Current and Future Safety Trends in Automotive Industry" and the second touched upon "Connected Vehicles." The PDP on safety was organized with active participation from Mahindra, **Wabco**, and **Applus IDIADA**, and the PDP on connected vehicles was organized with extensive support from Mahindra, **Microsoft**, **Ford**, and **Vodafone**.

The training programs saw about 40 registrations each from industry and academia. A live demo was arranged by Wabco for the participants who traveled to its test track in Ambattur to see first-hand the advancement of safety technologies. Ford and Microsoft showcased their development of SYNC in a vehicle while Mahindra gave the demo of Advanced Navigation System and Voice Activated Controls on its XUV5OO W8 model. ■

Dr. Pawan Goenka, Executive Director and President – AFS, M&M Ltd., addressing the audience at the valedictory function.

By Dr. Arunkumar Sampath, Chairman, Organizing Committee, SIMCOMVEC 2013.

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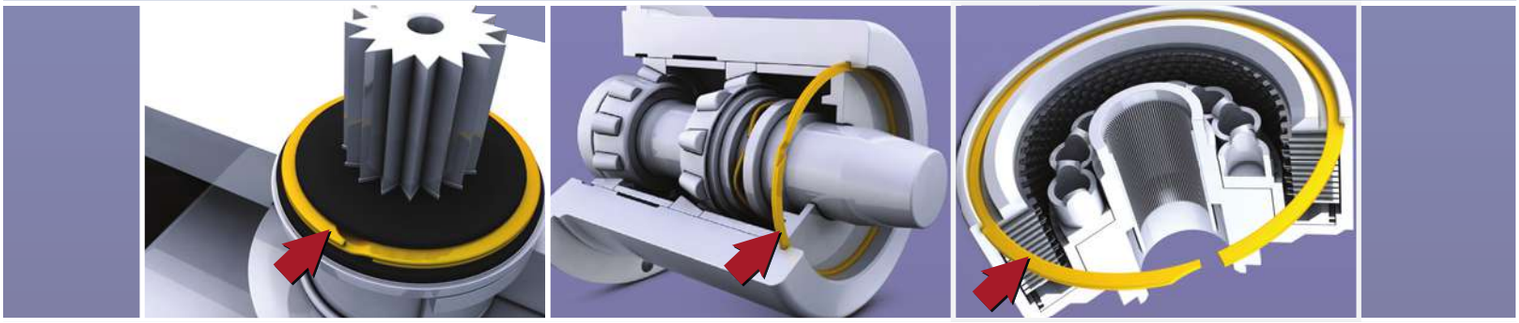

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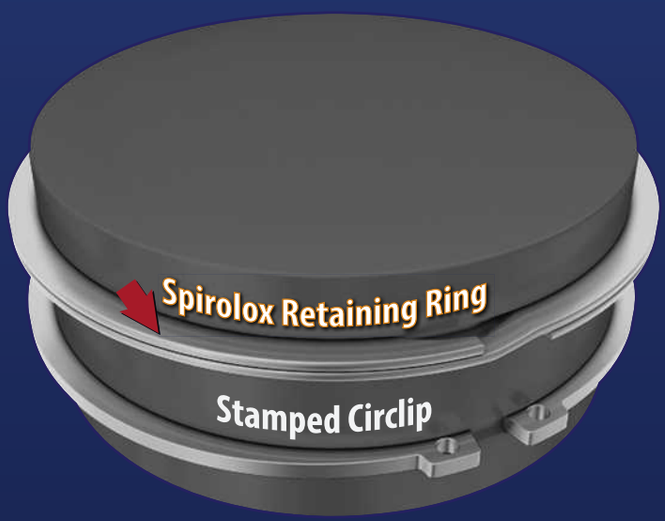

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Industry NEWS

India first to see Datsun design vision; Go en route

Nissan's **Datsun** unit Jan. 22 released a sketch of a concept car, saying it "represents a possible direction for the future expansion of Datsun's model line-up for up-and-coming young customers in high-growth markets such as India." The actual concept car was to have its world premiere Feb. 5 as part of the Delhi Auto Expo 2014, but this issue went to press prior to the announcement. Datsun already has one production car en route; called the Go, it's a five-seat hatchback with a 1.2-L engine and five-speed manual transmission. It is scheduled to go on sale in India early this year at a price below INR 400,000. The Go is built near Chennai and had its global premiere

Datsun concept.

July 15, 2103, in Delhi. Much of Go R&D and engineering was done locally. Nissan employs about 12,000 people in India and considers Chennai "a strategic hub for production, R&D, and exports" for Nissan.

Knorr-Bremse opens Indian plants and R&D center for rail and CV systems

Knorr-Bremse has expanded its production capacity in India in both the rail- and commercial-vehicle (CV) sectors with the opening of two new facilities in Palwal and Pune, as well as a new Development Center in Pune to be shared by its two divisions. These investments total around €40 million. The new Commercial Vehicle Systems plant in Hinjawadi-Pune offers 12,000 m^2 (129,000 ft^2) of production and office space for its 250 employees to manufacture a range of products, including brake cylinders, valves, pedal units, air dryers, slack adjusters, compressors, and an internally developed lift-axle system for the Indian CV market. One factor driving the company's decision to build a new Rail Vehicle Systems plant in Palwal is the planned expansion of the transport infrastructure in India, with a modernized railway network one of the main pillars. As a result, existing rail vehicles are being upgraded and orders placed for new passenger coaches and freight cars. The new plant offers around 26,000 m^2 (280,000 ft^2) of production and office space where 500 employees manufacture brake control systems, bogie equipment, compressors, and air dryers for rail vehicles primarily for the Indian market and in close collaboration with certified regional suppliers. The design of the building conforms to green building standards, helping reduce its carbon footprint.

Knorr-Bremse's new Commercial Vehicle Systems plant in Hinjawadi-Pune includes a state-of-the-art technology center that serves both commercial and rail-vehicle sectors.

Tata Sikorsky JV producing fully indigenous S-92 cabins

The India joint venture established between **Tata Advanced Systems** Ltd. (TASL) and **Sikorsky Aircraft** Corp. has announced that its S-92 helicopter cabin production in India has become 100% indigenous. The India operation is not only assembling cabins but also producing all parts needed for the assembly, before shipping the cabins to the U.S. for aircraft completion and customer delivery. The S-92 helicopter cabin and more than 5000 associated precision components are made in Hyderabad, India. The Tata Sikorsky India JV also announced the Hyderabad facility of TASL completed another significant milestone by producing its 50th S-92 helicopter cabin. The TASL facility now has the capacity to produce up to four cabins a month and is responsible for future design modifications.

The Sikorsky S-92 helicopter features a cabin with a stand-up height of 6 ft.

Tata launches family of gasoline engines

Tata Motors on Jan. 20 announced the launch of a new gasoline engine family for Tata passenger vehicles called Revotron. The first to come out of the family of three- and four-cylinders is the four-cylinder Revotron 1.2T, a turbocharged unit delivering 140 N·m (103 lb·ft) from 1750-3500 rpm and 85 PS (84 hp) maximum power at 5000 rpm. Bore is 75.0 mm (2.95 in) and stroke is 69.5 mm (2.74 in). It has a single overhead camshaft (two valves per cylinder) and a compression ratio of 9:3. The injectors have eight holes and function under an "innovative calibration strategy." Tata worked closely with several companies in developing the engine, including **AVL**, **Bosch**, **Honeywell** (the turbocharger is a water-cooled unit with low-mass wheel), **Mahle**, and **INA**.

The Revotron 1.2T is a turbocharged unit delivering 140 N·m (103 lb·ft) from 1750–3500 rpm and 85 PS (84 hp) maximum power at 5000 rpm.

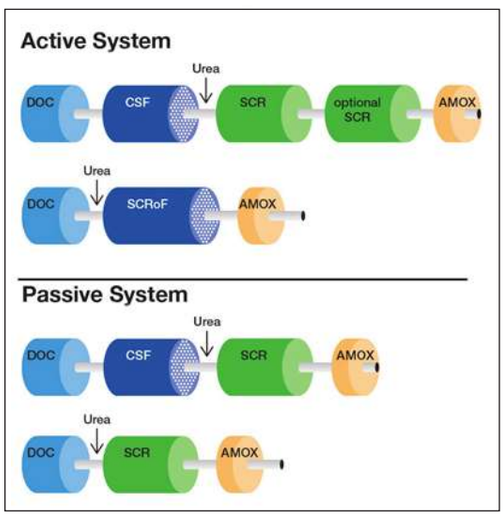
A380 receives approval for operations in India

The **Indian Ministry of Civil Aviation** has approved the operations of the **Airbus** A380 in India. A booming economy, a growing middle class, migration, urbanization, and tourism are all factors pushing India to become one of the world's fastest growing aviation markets. Larger aircraft such as the A380 combined with higher load factors make the most efficient use of limited airport slots and contribute to rising passenger numbers without additional flights to capture this growth. Previously, carriers were banned from operating aircraft larger than the **Boeing** 747.

India's Civil Aviation Minister Praful Patel tours the A380 at the India Aviation 2008 Air Show.

BASF expands catalyst production in India to support emissions regs

BASF Catalysts India Private Ltd. is expanding its mobile emissions catalysts production capacity in Chennai, India. Construction of a new 47,000-m^2 (506,000-ft^2) facility commenced in December 2013, with operations startup expected in the first quarter of 2015. Nine manufacturing lines will be housed in the new site, producing heavy-, light-duty, and motorcycle emissions control catalysts. Once operating at full capacity, the site is expected to employ about 300 people. "The pending expansion of Bharat Stage IV (Euro IV equivalent) emissions control regulations in India combined with overall vehicle production growth will drive a significant increase in demand for our advanced emissions control solutions," said Anup Kothari, Vice President, Mobile Emissions Catalysts Asia Pacific. "BASF is investing to more than double our manufacturing capacity in India to help customers meet these emerging needs." In addition to existing catalyst technologies such as the three-way catalyst, diesel oxidation catalyst (DOC), and catalyzed soot filter (CSF), the advanced SCR (selective catalytic reduction) system also will be locally manufactured, ensuring "world-class heavy-duty diesel production capabilities in the region," the company claims.



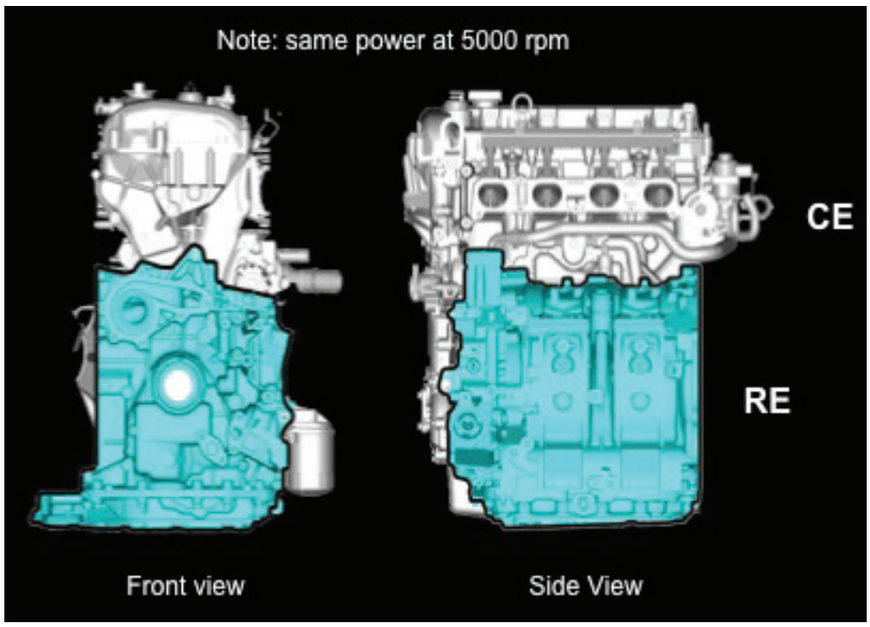
BASF manufactures various catalyst solutions to help control heavy-duty diesel emissions. The company plans to produce such technologies in its new India facility.

AUTOMOTIVE POWERTRAIN

Mazda plots Wankel-powered range extenders, HCCI mild hybrids

The problem with electric drive systems is that they are too electrified. That's **Mazda**'s view, judging from the company's plans to fortify internal-combustion technology so that hybrids and EVs can carry smaller electric motors and batteries, making them lighter and cheaper.

For mainstream products, that means piston engines that feature homogeneous-charge compression ignition (HCCI) and adiabatic design. For EVs, Mazda is eyeing a compact, quiet, and smooth range extender using the company's signature Wankel rotary engine to power a small onboard generator.



Mazda illustrates how its compact 330-cc single-rotor rotary engine (shaded blue here) compares in size to a piston engine of equivalent power.

HCCI and adiabatic development

Today's Mazda SkyActiv engines employ non-typical compression ratios—14:1 for gasoline engines and the same CR for diesel. This focus on optimal combustion lays the groundwork to move into HCCI, according to Takahisa Sori, Managing Executive Officer for research and development at Mazda Motor Corp.

These engines and their successors will be normally aspirated rather than turbocharged, because normally aspirated engines' quicker response is better suited to Mazda's focus on fun-to-drive cars, he explained. And while reduced-displacement turbo engines can achieve high efficiency on standardized tests, such engines commonly disappoint customers with their real-world fuel economy, he pointed out.

Hence Mazda's continued refinement of normally aspirated internal-combustion engines. Because IC engines still waste most of their energy in the form of heat, converting more of that to useful energy is Mazda's focus for future engines, Sori said.

A lean-burning HCCI engine will help achieve that using a compression ratio that is even higher than today's SkyActiv 14:1 ratio. Diesel-like throttleless intake reduces pumping losses, and the company aims to trim friction losses by 20%. Together these changes will boost fuel economy by 30% over today's engines.

HCCI engines are limited in the load range in which they can run in HCCI mode, but Mazda expects to expand that range with improvements to the fuel injection system. Meanwhile, matching the HCCI engine to a hybrid-electric drivetrain will let the HCCI gas engine run in its most efficient operating range, letting the electric motor assist as needed.

In this de-emphasized role, the electric motor and battery need not be as large as in conventional hybrids, reducing their cost.

These improvements to the engine reduce the energy loss through the exhaust but increase the heat loss to the cooling system. For SkyActiv 3, Mazda is pursuing adiabatic combustion, using insulation and possibly ceramic materials to minimize cooling-related efficiency losses, Sori said. He did not offer a timetable for the delivery of these technologies.

Rotary redux?

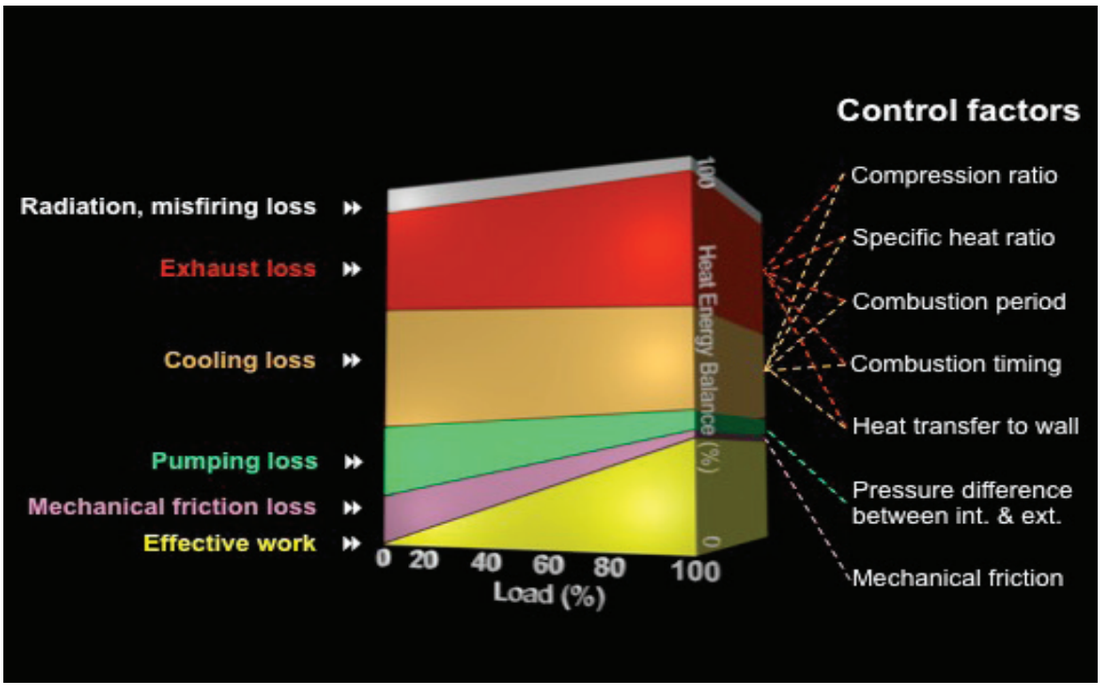
Meanwhile, Mazda is pursuing a new way to preserve the relevance of its signature rotary engine, which was dropped from production in late 2011 due to steadily decreasing volumes (in the RX-8 sports car). The rotary has struggled since the 1990s to meet increasingly stringent emission regulations.

"We engineers at Mazda are very proud of the rotary engine," Sori said. "Therefore, we have been continuing research and development of the rotary."

One benefit of Mazda's six decades of experience with the technology that yields benefits for today's piston-engine programs is a thorough understanding of combustion. But rather than viewing the engine in romantic terms, Mazda is taking a hard-eyed approach to its potential return to production. "If it will become profitable, we will use it," Sori said.

One potential application would be to address driver concerns about EV range. Mazda2 EV customers list driving range as a top concern, and using a rotary-powered range extender would alleviate that, according to Takashi Suzuki, program manager in Mazda's powertrain development division.

Aside from Mazda's desire to find a 21st-century role for the rotary engine, the design carries other benefits in com-



So much energy from burned gasoline is wasted as heat that recovering lost heat energy is the most promising source of increased efficiency, said Mazda engineers.

parison to a piston engine of equivalent power. For example, radiated noise, measured from 50 cm (19.7 in) with the engine running at 3000 rpm while producing 25 kW, is 87 dB for a rotary, compared to 92 dB for a gas engine and 96 dB for a diesel, noted Suzuki.

A chart of vehicle road and wind noise at speed closely tracks one showing the noise produced by a rotary range extender while making enough power to propel a car at those speeds. This means that an EV can use a pistonless rotary-powered range extender without the driver ever hearing it run, unlike range-extender hybrids such as the **Chevrolet** Volt and **Cadillac** ELR that use reciprocating engines to extend their EV range.

A 330-cm^3 single-rotor Wankel can produce 22 kW (29.5 hp) at 4500 rpm or 28 kW (37.5 hp) at 6000 rpm, according to the company. Its compact size means it fits easily beneath the rear load floor of a subcompact Mazda2.

Audi touted a similar solution in its A1 e-tron concept of 2011, which used a 15-kW (20-hp) 254-cc engine. The company never developed the concept for production, however, saying it wasn't cost-effective. Engineering-services companies **AVL** and **FEV** also have shown Wankel-based range-extended EV proposals that are under development.

Mazda's design makes a key change. Aside from the slightly larger displacement, Mazda's approach installs the gas engine and generator side by side, with a belt drive geared to double the speed of the generator. Audi's design stacked the generator atop the rotary engine, with a direct connection driving the generator at engine speed. The faster-spinning generator is 5% more efficient than one turning at engine speed, and Mazda's generator produces a continuous 20 kW (27 hp), according to Suzuki.

Takahisa Sori, Managing Executive Officer for Mazda R&D, says he is leading Mazda's powertrain focus toward naturally aspirated solutions because they are more efficient in real-world driving.

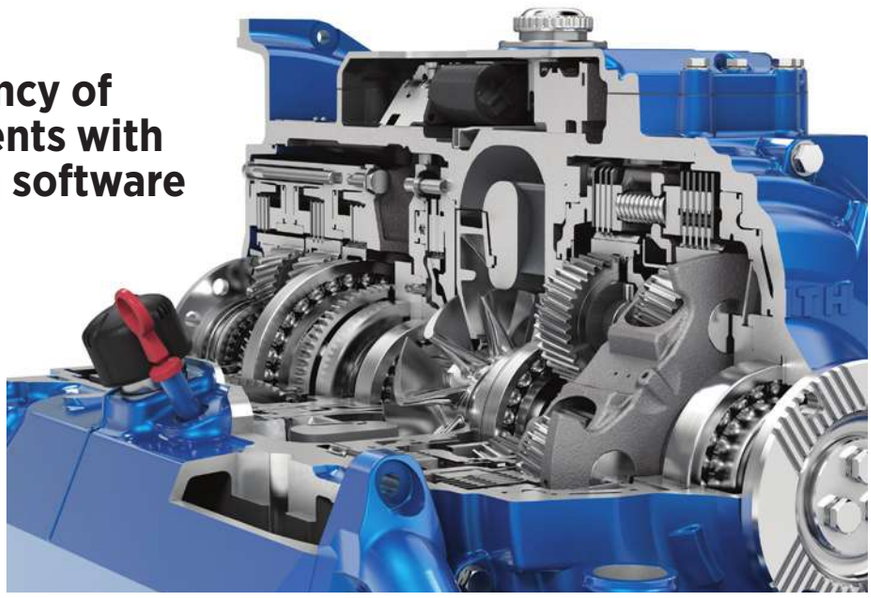
A rotary-powered range extender is an ideal EV solution because of its compact size and multi-fuel capability, explained Takashi Suzuki, Program Manager for Mazda's powertrain development division.

Mazda has survived in a market dominated by much larger rivals thanks to its unconventional approaches to design and engineering, so the company has an established track record of bringing unorthodox solutions like these to market.

Dan Carney

AUTOMOTIVE SIMULATION

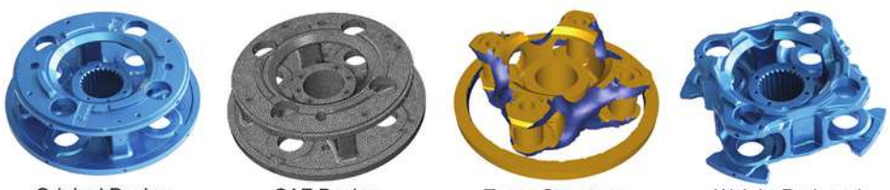
Voith improves efficiency of transmission components with structure optimization software



Voith uses SIMULIA's Tosca Structure topology optimization software to reduce the weight of components such as the planet carrier in its DIWA automatic transmissions, one of which is seen in cross-section here.

As environmental standards become stricter and consumer demands for vehicles with greater fuel efficiency rise, automotive suppliers need to support their customers with lighter components that will help meet the push for lower emissions and better gas mileage. **Voith Turbo**—a division of **Voith** GmbH that specializes in hydrodynamic drive, coupling, and braking systems for road, rail, and industrial applications and ship propulsion systems—determined that one way to help meet these challenges was to enhance the efficiency of its transmissions.

Voith targeted weight reduction through material savings as a primary route to increase efficiency. Although its engineers had already manually optimized their transmission designs, they felt more savings could still be identified. To find the optimum geometry of automatic transmission components, Voith turned to topology optimization with Tosca Structure software from **FE-DESIGN**—now part of the **Dassault Systèmes** 3DEXPERIENCE technology portfolio under the **SIMULIA** application.



The updated design of the planet carrier maintained the required stiffness and lifetime, achieved considerable material and weight savings, and resulted in more economical production.

Tosca Structure is a flexible, modular software system for non-parametric structural optimization, e.g., topology, shape, and/or bead, using FEA. Voith Turbo used Tosca Structure to optimize a planet carrier component, part of the gearing system in its DIWA automatic transmission. Planetary gearing systems consist of one or more outer, or planetary, gears that revolve around a central "sun" gear. The outer gears are mounted on the planet carrier, which is a moveable arm that itself rotates around the sun gear.

Starting with CAD data of the carrier, the engineers first used Tosca Structure to define the available design space by subtracting functional areas and joint spaces to connecting areas. Restrictions placed on the optimization ensured that any design or manufacturing requirements are kept. In this case, the functional stiffness of the planet carrier—required to guarantee bearing durability and equal load on the tooth flanks—was maintained.

Tosca Structure then automatically identified areas that did not contribute to the force flux and removed the materials within these areas that were not essential. Because requirements for the manufacturing process were taken directly into account during optimization, the design proposal could then be easily transferred to Voith Turbo's own CAD system where modifications were made to meet further casting parameters.

"By using Tosca Structure we found the best solution to realize material savings and increase efficiency in the product development process of our automatic transmissions," said Bernd Wöhrle, Technical Calculations Commercial Vehicles, Voith Turbo.

The new design of the planet carrier generated significant savings in material, with a weight reduction of more than 30%. The more compact size of the revised planet carrier permits an additional component to be placed in the molding box, allowing the same number of castings to be produced with fewer casting processes. Voith's experience with Tosca Structure shows that even designs that have already been manually optimized still contain significant optimization potential. The updated design of the planet carrier maintained the required stiffness and lifetime, achieved considerable material and weight savings, and resulted in more economical production.

"The topology optimization of our planet carrier resulted in a lighter and more robust design as well as significantly higher production efficiency," Wöhrle said.

Sumanth Kumar, VP SIMULIA Portfolio Experience at Dassault Systèmes, wrote this article for SAE Magazines.

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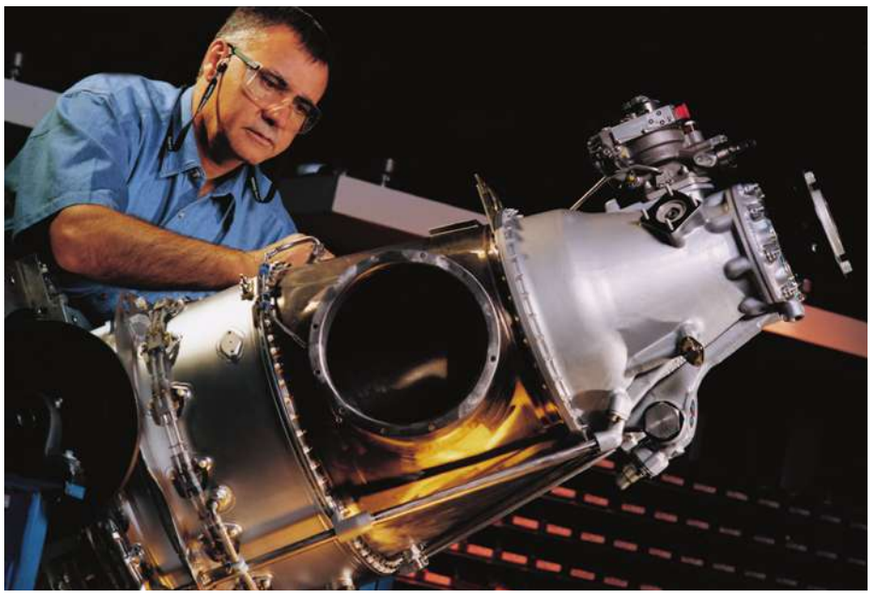
AEROSPACE PROPULSION | MANUFACTURING

Pratt & Whitney Canada streamlining design, manufacturing processes

Pratt & Whitney Canada is transforming its design and manufacturing processes, streamlining operations by eliminating steps, and improving connectivity and compatibility. The moves are being made to help the company improve and maintain its engines while also setting the stage for a move into 3-D manufacturing.

P&WC is taking a corporate-wide approach designed to make it simpler for employees in different groups to work together. Product life-cycle management (PLM) tools will be a critical element in that transformation, providing an overarching structure for communication and data sharing.



Pratt & Whitney Canada is transforming its design and manufacturing processes to streamline operations.

Many of the design and manufacturing processes at P&WC have evolved to meet the needs of disparate groups. That's made it difficult to share information as remote sites and outsourcing have become more prevalent. These design and manufacturing trends, coupled with a number of business issues, prompted the company to revamp its processes.

"There's been a lot of pressure on our industry since the '08 downturn," said John Wyzykowski, Director of Productivity, P&WC. "We've got 50,000 engines operating now, and we think we'll be at 70,000 by 2020. We'd like to service them with the same number of people. At the same time, about 20% of our employees will be eligible for retirement in the next few years, so we need to capture their knowledge so we can continue to innovate."

"Early in 2013, we began a transformational change that's being implemented across the enterprise," Wyzykowski said. "Our designs go through 5101 hand-offs today. We want to get that down to 1551, which is a 70% reduction. We have 160 applications. We hope to reduce that by 50% to 80. And now we have 25 bills of materials. We want to reduce that to one."

Wyzykowski noted that when the company tracked the design process by following all parts of the design from end to end, each component had many touch points when data files were accessed. Often, no benefits were gained by the hand-offs that occurred when engineers passed these files along.

"Our philosophy going forward is that people won't touch a file unless they're going to improve it," Wyzykowski said. "We don't want intermediaries to take value out. For example, someone might take some data and alter a tiny portion and the original intent of the data can be lost."

A central aspect of the program is to let all P&WC employees share design data. Many companies have acquired hardware and software that fit their requirements but are not compatible with other equipment. PLM tools from **Dassault Systèmes** will be a central component of this evolving strategy.

"A lot of systems don't talk to each other. We need all of them to be connected," said Wyzykowski. "In the next phase, we'll link the multiple organizations that now have their own systems. In the following phase, we'll go to select outside suppliers and set up a different class of contractors that are compatible with our systems."

This compatibility will also ensure that all P&WC employees are working from what's called a single version of the truth. Data will be stored on servers that can be accessed by any authorized employee, ensuring that employees are always working with up-to-date files.

The transformation will also help P&WC adopt the newest technology in manufacturing, ramping up its additive manufacturing capabilities rapidly. 3-D manufacturing can be quite helpful in engine designs, since unusually shaped parts can be built up in far less time than comparable parts made with conventional subtractive processes such as milling. Additive processes can also create complex designs as a single component, simplifying manufacturing.

Part of a $275 million investment over five years will go toward 3-D manufacturing. The Quebec government recently contributed $19 million to this project. Wyzykowski noted that the transition to 3-D PLM will be a major step for this move to additive manufacturing, eliminating the transitions that now occur when 2-D designs are transformed to 3-D parts.

"PLM is an enabler for many things," he said. "The source for additive manufacturing is data in 3-D, so having 3-D PLM data will help us input data in 3-D and realize the output with a final part ready for production."

Terry Costlow

AUTOMOTIVE ELECTRONICS

Wireless connectivity comes with major security threats

Preventing outsiders from hacking into electronic systems is becoming a greater concern as wireless technologies become the norm for vehicles. Automakers are employing different techniques to reduce vulnerability, often by teaming up with partners that specialize in security.

To date, automakers have spent more time worrying about protecting data from hackers who plug into vehicle buses. But as more vehicles have onboard telematics and advanced links to smart phones, the soaring volumes are likely to attract malware developers. Companies throughout the supply chain are viewing the threat with concern.

"Ultimately, wireless hacking will become the biggest threat," said Richard Soja, Distinguished Member of the Technical Staff at **Freescale Semiconductor**. "There are a variety of methods for maintaining data confidentiality on the chip."

Wireless hacking has not yet emerged as a critical threat, but several research projects have shown the potential danger and dramatically increased concern levels. Component suppliers and subsystem developers alike are devising techniques that ensure that outsiders can't send messages over vehicle networks. These approaches must work within the limitations of vehicle networks.

"One step to protect critical systems is to digitally sign safety-critical messages that travel on the CAN bus so that the system only acts on messages that are verified as authentic," said Bjoern Steurich, Cross Functional Team Lead at **Infineon Technologies** AG. "This is practical, versus trying to encrypt all CAN traffic, which cannot be done due to bandwidth issues."

Smart phones, which have already attracted the interest of hackers, will become one of the biggest threats once they start interacting closely with vehicle infotainment systems. As more users connect their phones to the vehicles and run apps that are tightly linked to the infotainment systems, the surge in data transfer is increasing the number of potential threats to vehicle electronics.

"There has been a shift by automakers to enable the secure installation of trusted apps via an OEM-owned, cloud-based system," said Bas Mevissen, Lead Security Software Architect at **Visteon**. "The use cases of trusted apps must be understood and the access rights must be clearly defined and enforced to help mitigate the security challenges."

As automakers expand their engineering programs to include security, they're leveraging knowledge gained in other fields. Many are linking up with security specialists from fields where security has been needed for years. For example, Visteon has worked closely with **Secunet**, a German information technology company that focuses on security.

"We work with a security consultancy partner that assists us in determining and assessing possible risks/threats and advises us of possible security measures that can be taken," Mevissen said.

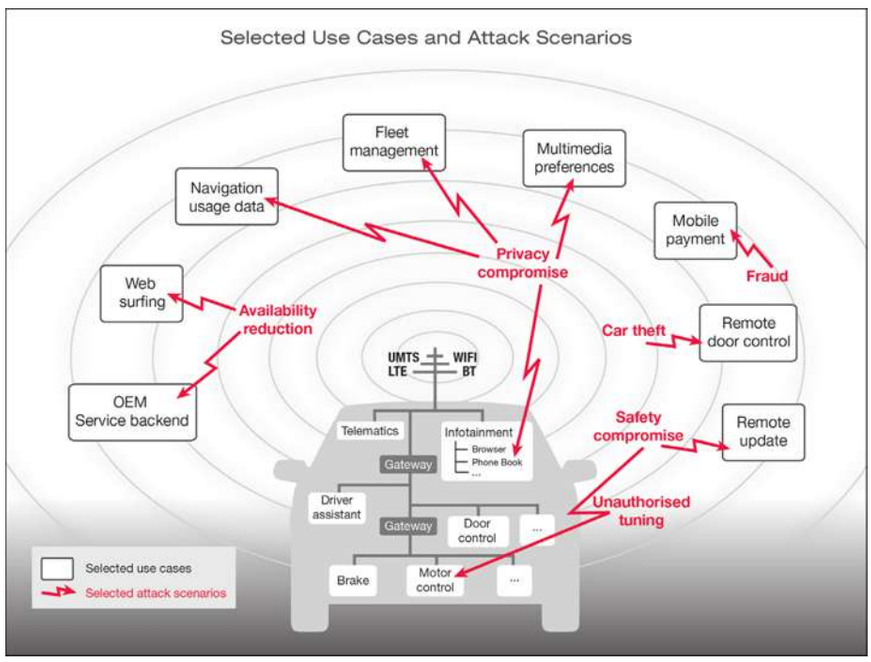
Some OEMs, Tier 1s, and component suppliers are altering their development teams to reduce vulnerabilities. For example, Infineon has altered some of its teams while noting that its customers are taking a similar tack.

"We are seeing that OEMs are forming dedicated teams to work on this at a system level," Steurich said. "Where there used to be separate groups looking at security, body protection, and powertrain issues like tuning and intellectual property protection, there are now more cross-functional groups."

Observers note that an expected increase in communications may drive expanded interest in security. Many predict that regulators will require vehicle-to-vehicle/-infrastructure communications. When cars send messages to each other and communicate with roadside beacons, there's potential that hackers can cause accidents or jam up traffic.

"When you start getting into vehicle-to-vehicle communications, there's a lot of concern that a malicious attack on a large basis, like someone sending out malicious emergency braking commands could gridlock an entire city," said Gary Miller, Staff Product Marketing Manager, Body and Powertrain, Automotive Marketing Unit at **Renesas**. "To stay ahead of this when every car on the road is talking requires handling a lot of messages, so vehicles will need even more processing capability."

Terry Costlow



Visteon has teamed up with Secunet to address the many ways that hackers can attack vehicle systems. (Secunet)

OFF-HIGHWAY HYDRAULICS

Identifying operating states for equipment and system diagnostics

Machinery diagnostics require analysis of the time series of sensor and control signals. To analyze the time series data, different operating states that describe the transients of the measured variables need first be detected. After that, some higher level description should be used to further analyze these operating states.

Finding operating states from the measured time series data requires segmentation of the time series data. Segmentation is a method that allows the dividing of time series data into smaller groups of data sets that describe the patterns of the measured variables. In segmentation, the time series data are transformed into piecewise representation. A segment is a contiguous subset of a time series.

Time series segmentation is often used as a preprocessing step in time series analysis applications. Time series segmentation is exploited in a wide range of applications such as medical diagnostics, analysis of financial time series, speech processing, or sensor signal analysis.

Typically, in modern machinery there is already a lot of information available about the operation of the machine, e.g., process and control data through communication buses, which can be used in analysis. In addition to this, condition monitoring specific sensors can also be added to the system.

When all this information from communication busses and additional sensors is recorded, it leads to the generation of a huge amount of data. High dimensionality complicates the processing of time series data, especially from the pattern recognition point of view. After segmentation, the segments have to be organized into groups of similar members so that data can be classified against these groups. This grouping process is often referred to as clustering.

A cluster is a collection of objects that are similar between them and are dissimilar to the objects belonging to other clusters. These clusters are then interpreted to be operating states. Diagnostics can now be focused on these operating states or even a single interesting operating state. Most information in regard to the detection of anomalies is usually obtained from operating states that have the biggest changes in the analyzed variables.

Researchers from **Tempere University of Technology** studied the operating states of a wheel loader for diagnostics purposes using a real-time simulation model of an articulated-frame-steered wheel loader.

The wheel loader, referred to as a GIM machine, was designed to serve as a platform for different types of research. The frame of the machine is original, but the control system, electronics, and hydraulics had been changed for a variety of research purposes.

In this case, a hydrostatic transmission was implemented with an electronically actuated variable displacement pump and fixed displacement motors. Steering was executed by a hydraulic cylinder. The stroke of the steering cylinder was controlled by means of an electronically actuated proportional valve as well as other cylinders (boom, telescope, and bucket) in the working hydraulics.

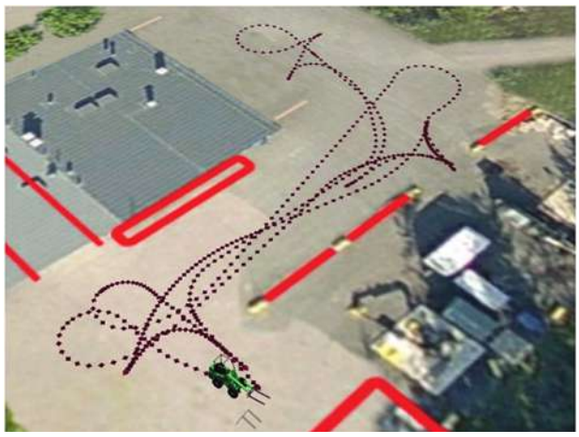
The GIM research platform for the recognition of operating states of a wheel loader for diagnostic purposes. The telescope and the bucket have been left off the figure for purposes of clarity.

Separate fixed displacement pumps were used for the steering and for the working hydraulics. A real-time hardware-in-the-loop (HIL) simulation model for the GIM machine had been developed using the Matlab/Simulink environment for the GIM research project (www.gim.tkk.fi). It is used mainly in the development of the control and the hydraulic systems of future autonomous mobile machines. The model and its submodels, such as the hydraulic component models, were verified by laboratory measurements, and the model has proved its capability to even tune the control parameters of the control system. From this perspective, it is also very well suited for fault diagnostic research.

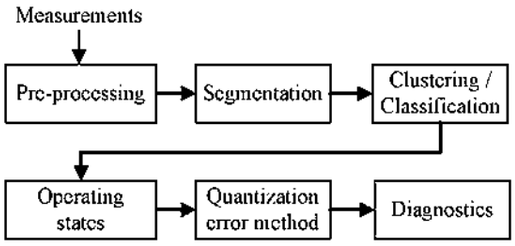
Altogether, 20 test-drives were carried out to obtain measurement data for analysis purposes. The measured data comprised two different data sets: hydrostatic transmission and working hydraulics.

Forty-one different operating states were found from the measurement data using the sliding window method with piecewise linear regression for time series segmentation and the k-means algorithm for the clustering and classification of the pre-processed segments.

The recognized operating states were further analyzed using the quantization error method to detect anomalies. Simulated leakages in the main hydraulic components (HST pump and control valve) of the hydrostatic transmission and working hydraulics were used as anomalies. One operating state from both data sets were selected as examples. One state was from the situation where the



Example of the machine's drive path on a test field with simulation.



Time series analysis and state recognition.

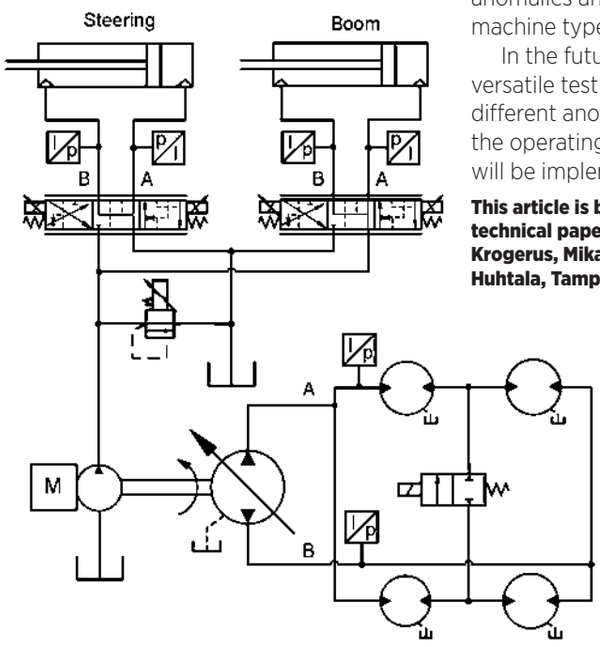
machine was reversed and the other in which the boom was lifted up. Overall, the quantization error was higher in case of internal leakage. From the mean of the quantization error, the anomalies can be seen even more clearly.

Data-driven methods can be implemented in different kinds of machines. Insufficient sensor information may limit the number of applications, but the analysis methods in general are not restricted to a specific machine type. The thresholds in segmentation and anomaly detection need be defined based on specific applications and need specific knowledge about the operation of the system.

The selection of critical measurement signals describing the operation of the machine also requires knowledge about the machine. The operating state recognition method enables the detection of sudden critical faults as well as slowly evolving faults like internal leakages, which were studied to demonstrate the functionality of this proposed method. The simultaneous examination of several variables and data sets enabled a more generic method of detecting several different anomalies and applying it to different machine types.

In the future, longer and more versatile test runs will be performed, different anomalies will be tested, and the operating state recognition method will be implemented in a real machine.

This article is based on SAE International technical paper 2013-01-2409 by Tomi Krogerus, Mika Hyvönen, and Kalevi Huhtala, Tampere University of Technology.



Depiction of a simplified hydraulic circuit of the hydrostatic transmission (HST) and the working hydraulics of this research platform.

AUTOMOTIVE INTERIORS | ELECTRONICS

Module blocks texts to reduce distractions

As telecom suppliers and insurance companies strive to leverage connected-car technology and increase revenues from autos, they're also attempting to reduce the dangers of distracted driving. **Sprint** has focused on texting while driving, coming out with a tool that will block texting functions when the vehicle is in motion.

Sprint's technology blocks texting and prevents football fans and others from checking websites while vehicles are moving.

Sprint has unveiled a text-disablement module that plugs into the vehicle's onboard diagnostic (OBD II) port. It blocks the driver's cell phone from sending and receiving text messages and surfing the Web when the vehicle is moving. Incoming messages are stored for later viewing, and users have the option of responding with a message that says they're currently driving.

To underscore the benefits of text disablement, Sprint cited a **Virginia Tech** Transportation Institute study that said drivers are 23 times more likely to crash if they're texting while driving.

"Other studies show that it's more dangerous to text while driving than driving drunk," said Nathan George, Vice President of Technology at **Modus**, a service provider for telematics companies.

Modus is a Sprint partner that developed the text-disablement software. Some of Modus' other work was in tools that let fleet managers monitor acceleration and speed. That system yielded a 20-60% decrease in rear-end collisions, George said.

George said the critical factor for the Sprint system is that it plugs into the

OBD II port, which eliminates some concerns about cell-phone apps that prevent texting while driving. The Sprint system will always be active, unlike cell-phone apps that can be disabled by users. It also removes a key concern for cell-phone users—battery life.

"A half dozen or so companies have similar apps for smart phones, but they require turning on the GPS to block the screen above a certain speed," George said. "The problem with that is that keeping the GPS on burns the battery quickly."

Sprint hopes to expand its role in the usage-based insurance market, which is expected to grow at a compounded annual growth rate of 81% from 5.5 million at the end of 2013 to 107 million in 2018, according to **ABI Research**. One facet of Sprint's strategy is to make it easy for insurance companies to roll out new features.

"Text disablement enables auto insurance carriers and self-insured organizations to improve driver risk assessment and encourage good driving behavior," said Ben Vos, Vice President of Emerging Solutions Group at Sprint.

George noted that the system creates a limited zone so passengers' phones won't be blocked. Though Sprint and Modus have been working with a number of cell-phone providers for a while, George said that not all of them let users easily access the Modus app that links phones to the module.

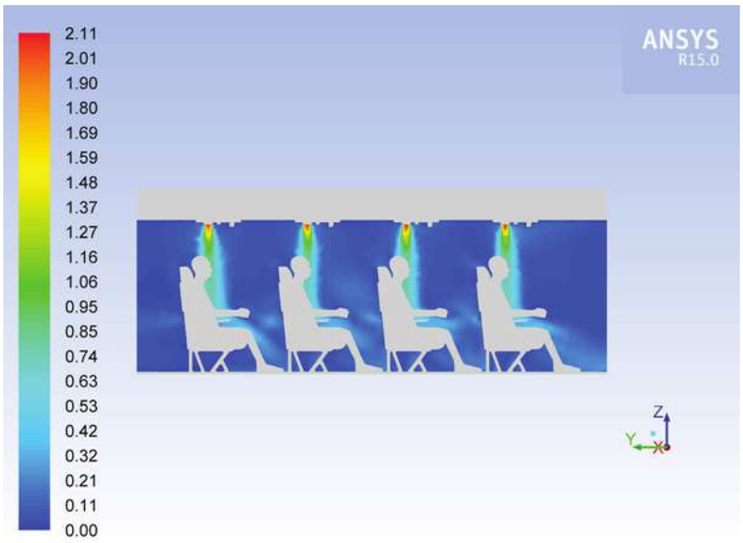
"**Apple** refuses to let us block texting while driving. They won't let us in their app store," George said.

Terry Costlow

AEROSPACE INTERIORS | SIMULATION

Design software targets germs, dry air

Concerns about airborne diseases and flu pandemics coupled with increasing passenger concerns about environmental conditions are prompting some aircraft designers to take a closer look at ventilation systems. In many instances, improvements in air quality and cleanliness are being expedited by using design tools such as computational fluid dynamics (CFD).



Product designers can analyze nozzle shapes and size to determine the best airflow patterns. (Ansys)

Ansys is responding to this increased interest by upgrading its CFD tools to let aircraft engineers look at 3-D environments as well as 2-D technologies such as electronics and ductwork simultaneously. Ansys 15, unveiled late last year, also claims to handle larger problems and complete analysis runs in short times. That could help ventilation experts improve air quality.

"With CFD software, you can look not just at airflow, but also at temperature distribution and humidity," said Rob Harwood, Aerospace and Defense Industry Director at Ansys. "Our new tool lets users track particulates like viruses to see how they move and how they can be removed. Users can also look at deliberate threats to see what happens if someone releases contaminants on a plane."

The need to combine 2-D and 3-D files highlights the complex nature of airflow management. Air quality is impacted by the efficiency of motors, ductwork design, and the capabilities of electronic controllers that manage air movement, as well as the number and position of passengers.

"Engineers can look at different ductwork designs to see how they can eliminate losses," Harwood said. "Nozzles also play a major role when designers are trying to develop more efficient systems that draw less power. Designers want to reduce the amount of power drawn from engines."

Electronic controls are central components, since they determine when fans will cycle on and off while also managing temperature and humidity levels. Ansys has expanded its software capabilities to improve efficiency of these controls.

"We're doing more with automatic code generation," Harwood said. "Users can describe their requirements at the functional level and the system generates code that meets **FAA** standards."

Harwood noted that increased use of CFD tools highlights the trend for aircraft design to increasingly rely on modeling and simulation.

"We're going into an era when designs can be optimized throughout the process," he said. "Engineers can run simulations at any stage to see how minor tweaks impact complex designs."

Terry Costlow

Allegro LED Driver ICs for Automotive Lighting Applications

Allegro's portfolio of LED driver ICs is designed to address the emerging requirements of lighting applications within the automotive market.

The family of linear programmable LED current regulators, A6260/1/2/3/4/9, can drive single to multiple LED strings over a wide range of currents. Features like wide input voltage range, precision string matching, short protection, and full/stop current are industry-leading.

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Additionally, the A6213 integrated MOSFET buck LED driver is capable of compactly and efficiently driving an LED string up to 3 A.

Allegro continues to add to the automotive LED driver IC portfolio with products in packages to meet high density, manufacturing and AEC-Q100 stress requirements.

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Key automotive applications include:

- **Brake and tail**
- **Turn**
- **Rear combination lights (RCL)**
- **Front/rear fog**
- **Daytime running lights (DRL)**
- **Headlights**
- **Position**
- **Rear "applique" lighting**
- **Dome, map, reading**
- **Footwell**
- **Door "puddle" lighting**

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OFF-HIGHWAY INTERIORS

Displays add color to simplify operator tasks

Capacitive touch input allows operators to wear gloves.

For decades, off-highway vehicles typically had one paint color outside and monochromatic displays or gauges inside. Color displays are now transforming operator environments as human-machine interfaces make it easier for operators to understand complex tasks and diagnostic information.

"Color displays (HMIs) have brought complex functions like advanced fault detection, predictive maintenance, and data logging to life," said Eddie Phillips, Marketing Manager, Electronic Controls and Software, for **Eaton**'s Hydraulics Business. "Machine operators have a simpler operator interface, allowing them to focus on the task at hand. Displays can provide real-time graphical feedback on the operating status of a machine, making it easier for the operator to make changes to improve the overall performance and efficiency of the machine."

The graphical information data on liquid crystal displays improves efficiency for maintenance technicians as well as operators. These screens can provide diagnostic data, directing attention to the parts that have failed. That's especially helpful when technicians must carry parts into the field. Operators and technicians continually want more data, causing a spiraling trend for designers.

"As the amount of information on the display rises, higher resolution displays are required," said Kirk Lola, Business Development Manager at **Parker Hannifin** Corp.'s Electronic Controls Division. "This allows more information and graphical images to be displayed. In addition, using a display that shows operating condition along with error and status messages greatly reduces operator confusion."

As equipment makers employ more LCDs, they're also working to help operators interact with the information on those screens. Touch input has become fairly common. Initially, resistive technology was used in applications where gloves are not required.

But as capacitive sensing technology advanced, equipment makers utilized it to make it possible for users to interact with touch screens while wearing gloves. Capacitive sensors are evolving so operators can touch multiple points while wearing gloves. Many of these systems also sense proximity, so operators don't actually have to touch the screen.

"The major trend in touch screen technology, driven by the consumer applications, is the increased adoption of Projective Capacitive (PCap) technology," Phillips said. "PCap technology, which is found in the Eaton VFX displays, has considerable advantages over resistive technology. It has better optical clarity and the support of gestures."

Along with improved efficiency, the combination of touch input and LCDs is lowering overall costs. Touch screens can replace a number of buttons and knobs, cleaning up interiors while improving efficiency.

"Touch screens allow a simpler and often lower-cost instrument cluster by removing many physical buttons and input devices and replacing them with virtual touch buttons on the display," Lola said. "In addition to the cost saving, the virtual buttons can have different text and styles based on user preferences, languages, and the operating mode of the machine. Parker's IQAN MD4 display can be programmed in a wide variety of languages, including Cantonese and Russian. This dynamic configurability would be impossible with physical buttons.

Terry Costlow

AUTOMOTIVE BODY

Volvo's new scalable architecture puts emphasis on safety

Scalable architecture is commonly associated with chassis adaption for track or wheelbase dimensions and suspension characteristics, plus other facets including electronics and hydraulics, to meet the needs of a variety of model types. **Volvo**'s new SPA (Scalable Product Architecture) is all of that but it will also make a major contribution to the company's aim that by 2020, no one should be killed or seriously injured in a new Volvo.

The super-safety-conscious company will use the SPA to support environmental integration, which even includes developing technology to make the interaction between its cars and cyclists safer.

Jan Ivarsson, Senior Manager, Safety Strategy and Requirements, reveals that some 40% of the safety cage of the next-generation XC90 (to be launched later this year) using the SPA will incorporate hot-formed boron steel for "significantly improved" strength but without adding mass or weight. The outgoing car used about 7% of the material.

Jan Ivarsson is playing a key role in supporting Volvo's aim that by 2020, no one should be killed or seriously injured in a new Volvo.

"This means that the SPA architecture provides significantly improved protection in worst-case scenarios. But it also facilitates innovative features that support the driver in avoiding accidents," said Ivarsson.

The need to develop preventative safety systems alongside technology to make accidents survivable when they do occur, is exercising the minds of most OEMs and has long been part of Volvo's R&D work.

Intelligence systems are central to that and during the last decade microprocessor development has demonstrated rapid strides, particularly when integrated with radar and vision technology

Peter Mertens, Volvo's Senior Vice President for Research and Development,

Volvo's next-generation XC90, due later this year, will include significantly increased safety-cage strength without a weight penalty.

Volvo's pedestrian and animal safety alert systems will be expanded to provide improved interaction between its cars and cyclists.

explains that it is this speed of evolution that the new SPA has been designed to assimilate, with a network incorporating what he describes as having four domain masters: vehicle dynamics, safety, car body, and infotainment, each of them linked into salient aspects of the whole vehicle architecture.

Mertens says this has created a single "nerve system," and he adds that it will provide full control over all the connections in the vehicle: "This is unique in the industry."

Vehicles built off the SPA will benefit from the next step in smart seatbelt pre-tensioning to enhance the security of their occupants. Rear-facing radar is used to detect an impact and trigger pre-event tightening.

The SPA will also carry technology to help prevent unintentional road departures, by using autonomous steering intervention in critical situations, says Ivarsson.

The SPA is also designed to accommodate the implementation of autonomous technologies "all the way to self-driving cars," he said. Car2Car and Car2Infrastructure technology will be a central part of the program.

Ivarsson is convinced of the need to develop autonomous vehicle operation in the pursuit of safety beyond crashworthiness and into the realm of a "crashless" environment. "Allowing the car to act automatically is crucial when moving towards the vision that future cars will not crash at all," he said. "The technologies enabled by our new SPA will bring us significantly closer to this ultimate goal."

Volvo is planning to widen its programs to enhance safety issues concerning other road users. As well as pedestrians and animals, cyclists will receive special attention.

In a world where pedal cycles represent an increasingly large element of individual transport, Volvo is focusing on a further aspect of its safety technology.

Said Ivarsson: "Communication with cyclists around the car is a possible extension of our groundbreaking Pedestrian and Cyclist Detection technology. Providing the cyclist with confirmation that he or she is seen by the vehicle can make interaction between cars and cyclists smoother and safer in urban areas."

Volvo is working with Swedish company **POC** on the project. POC develops high-tech protective gear for extreme sports' athletes. The two companies will exchange knowledge to explore new ideas within safety and design, Ivarsson said.

A lot of safety technology will be riding on the SPA.

Stuart Birch

AEROSPACE BODY

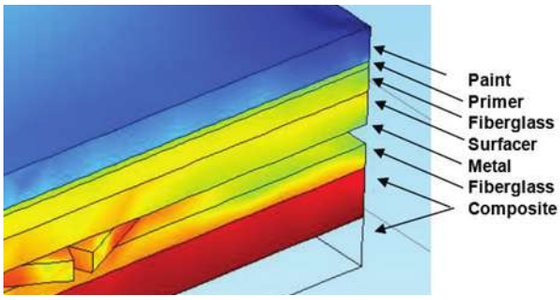
Boeing examines expanded metal foils for lightning protection of composite structures

With the implementation of major aircraft structures fabricated from carbon-fiber-reinforced plastic (CFRP) materials, lightning protection has become a more complicated issue to solve. One widely used material for lightning strike protection of CFRP structures within the aerospace industry is expanded metal foil (EMF). EMF is currently used in both military and commercial passenger aircraft.

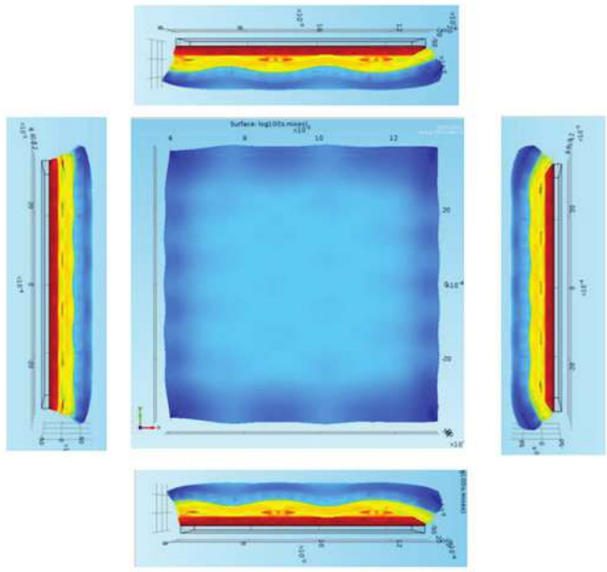
An issue that has historically been an area of concern with EMF is micro cracking of paint on the composite structure, which can result in corrosion of the metal foil and subsequent loss of conductivity. Researchers from **Boeing Research and Technology** (BR&T) examined the issues of stress and displacement in the composite structure layup, which contribute to paint cracking caused by aircraft thermal cycling (i.e., ground-to-air-to-ground flight cycle).

Parameter	Paint	Primer	Fiberglass	Surfacer	Aluminum	Copper	Composite
CTE (1/K)	8.14e-5 T<Tg 24.4e-5 T>Tg	4.0e-5	12.6e-6	5.5e-5	23e-6	17e-6	3.20e-5
Heat Capacity (J/kgmK)	1260	1050	921.1	1050	900	385	770
Density (kgm/m3)	1630	1840	2460	1980	2700	8700	1600
Thermal Conductivity (W/mK)	0.419	0.837	0.668	0.837	160	400	11.8
Young's Modulus (Pa)	1.8e8	5.5e9	1.68e10	5.9e9	70e9	110e9	9.5e10
Poisson's Ratio	0.42	0.16	0.11	0.20	0.33	0.35	0.25

Representative input material parameters used for the various layers of the surface protection model.



Representative surface protection scheme modeled using COMSOL Multiphysics. The composite was modeled as two layers indicated by the red and light blue regions.



Von-Mises stress patterns due to thermal air to ground heating cycle. EMF mesh bleed-through is evident in the central portion of the figure and relatively large displacement variations are observed above the metal and voids. Note that the displacements have been magnified for illustrative purposes.

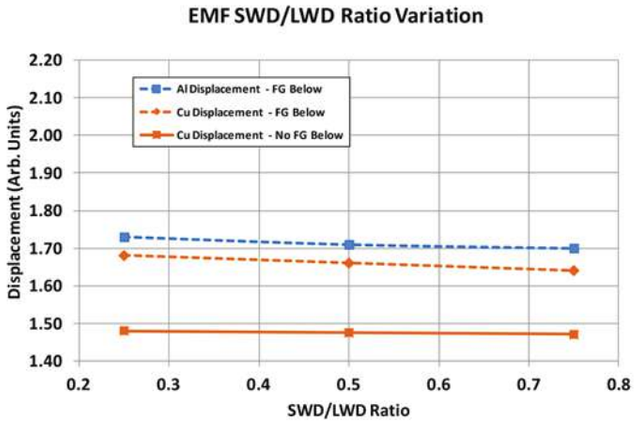
There are several contributors to the stress buildup, including the paint, primer, corrosion-isolation layer, surfacer, EMF, and the underlying composite substructure. BR&T focused primarily on the EMF contribution to the cracking mechanism, with computer-modeling analysis performed using commercially available **COMSOL** Multiphysics software that was supported by data from limited experimental testing.

The temperature cycle of the layers was simulated using a coefficient of thermal expansion (CTE) model developed with the software. The simulation allows determination of the thermal stress and displacements that result. Though the full complexity of crack genesis is not included, some insight can be gained regarding what the sensitive parameters of the EMF may be and the variations that can be employed to mitigate the resulting stress and displacements that lead to cracking.

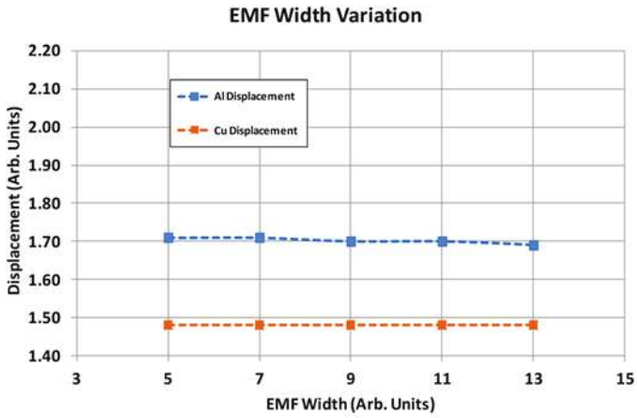
Of particular interest are the EMF width, height, aspect ratio, composition—aluminum (Al) or copper (Cu)—and surface layup structure. In the case of Al used for EMF, fiberglass is needed between the aluminum and the structure to prevent galvanic corrosion.

CTE model and experimental testing

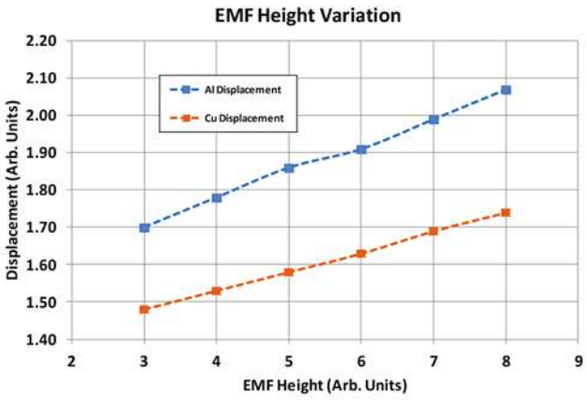
Simulations were conducted over an air-to-ground temperature range, typical of commercial aircraft applications. The model assumed constant material



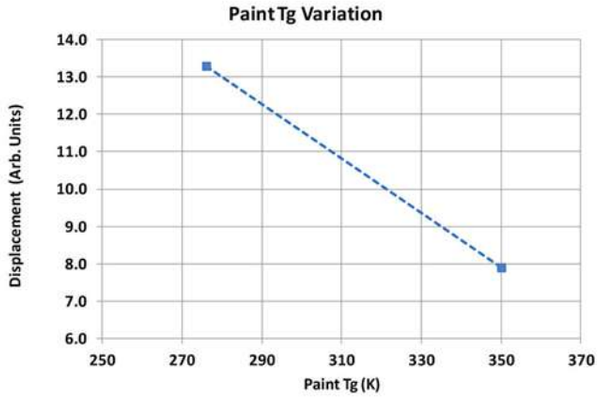
EMF displacement dependence on metal mesh SWD/LWD ratio for Al and Cu. (FG = fiberglass)



Variation of the EMF width by a factor of 2.6 for both Al and Cu. For this parameter set, the displacement remains essentially constant, but is significantly greater for Al than Cu.



Variation of the EMF height by a factor of 2.7 for both Al and Cu. For this parameter set, the displacement increases with metal height and also is significantly greater for Al than Cu.



Surface displacement of paint dependence on glass transition temperature, t_g. For illustrative purposes, note that only the temperature dependence of the paint CTE was modeled.

parameters (CTE, heat capacity, density, thermal conductivity, Young's Modulus, and Poisson's ratio) over the nominal temperatures with the exception of the paint layer CTE, where a Fermi-Dirac functional form was used.

The objective of the experimental testing was to assess a variety of candidate lightning-strike material systems that have near-term potential of meeting performance requirements for both lightning and long-term durability. The particular tests were limited to the adhesion, salt spray, wedge crack, and thermal cycling environmental durability.

For thermal cycling, test coupons were placed in a test chamber similar to the range used for the simulations. At prescribed cycles, a panel was removed for examination. Surface cracks and finish were evaluated and cross-sections and photo-micrographs were made as necessary.

Three EMF systems were evaluated: heavy expanded copper foil (ECF), light expanded aluminum foil (EAF), and heavy EAF. Overall, the three EMF surface protection systems passed the paint adhesion test. The heavy ECF, light and heavy EAF salt-spray exposure exhibited no paint blistering or corrosion. All three surface protection systems passed the wedge crack evaluation for absence of crack growth over time, demonstrating good adherence of the EMFs to the composite.

The intermediate to longer duration thermal moisture cycling results indicated no surface issues with the expanded copper foil system; however, there was some cracking shown in the micrographs at the primer for the light EAF system, some edge and surface cracks, and extensive cracks in the overlap regions. The heavy EAF system also had some cracking on the surface and significant cracking in the overlap regions.

Evaluating the results

Quantitative determinations of stress and displacement were not conducted in the experimental evaluations; however, qualitative agreement was observed with the simulations since the EAF consistently exhibited greater displacement over the various parameter sets than the ECF displacements. The researchers associate greater thermally induced displacements with increased probability that cracks will eventually become evident. The displacement differences may be small, but over thousands of cycles will eventually generate residual stress, defects, and result in cracking. From this standpoint, both the simulations and testing indicate that Cu would be a better choice for the EMF than Al.

The individual parametric variations also suggest some interesting effects. The parametric variation of SWD/LWD (Short Way of the Diamond/Long Way of the Diamond, as described by **Dexmet**, a commercial producer of EMF) indicates that larger ratio, more open EMF meshes lead to lower displacements. The dependence is weak, but high thermal cycling has a cumulative effect. From a weight perspective, higher SWD/LWD is also desirable. Provided the EMF function is not seriously degraded, there appears to be benefit with the more open mesh from multiple perspectives.

The effect of the additional layer of fiberglass under the EMF was considered. When the fiberglass was added under ECF, the displacement was significantly increased. The remaining difference between EAF and ECF is most likely due to the larger CTE of aluminum by about 35%.

Examination of the thermally induced displacements suggests that there is little cracking penalty from increasing the width of the EMF. Hence, if greater current-carrying capability is desired from the EMF protection function, increased width appears to be a viable approach. Of course, increased width leads to greater weight penalty, and these conflicting requirements need to be balanced.

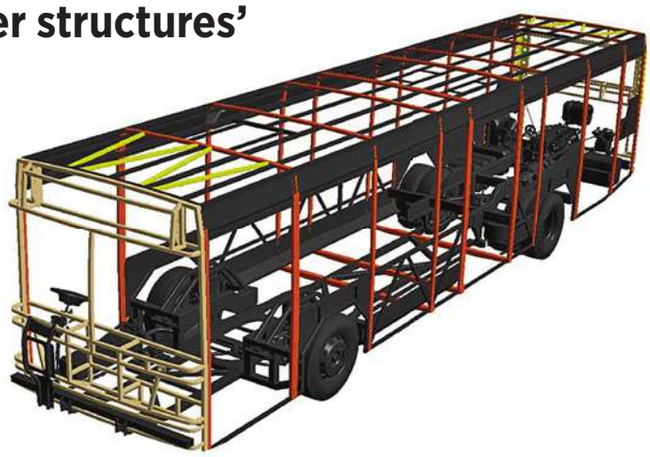
Alternatively, the increased current-carrying capacity of the EMF layer may also be realized with increasing height. However, height increase is not as desirable as it leads to greater displacements and hence cracking likelihood.

The researchers also observed that the paint glass transition temperature (t_g) had an influence on the displacement of the surface layer. Moving the t_g above the nominal temperature performance range reduced the displacements by a factor of about 1.6 for the CTE temperature profile used. However, to make any definitive conclusions the temperature dependence of the modulus also needs to be incorporated. These dependencies have not been included here, but are expected to be the subject of future simulations.

This article is based on SAE International technical paper 2013-01-2132 written by Jeffrey Morgan, Robert Greegor, Patrice Ackerman, and Quynhgiao Le of Boeing Research and Technology.

BUS MATERIALS

Ashok Leyland pursues stainless steel for bus 'super structures'



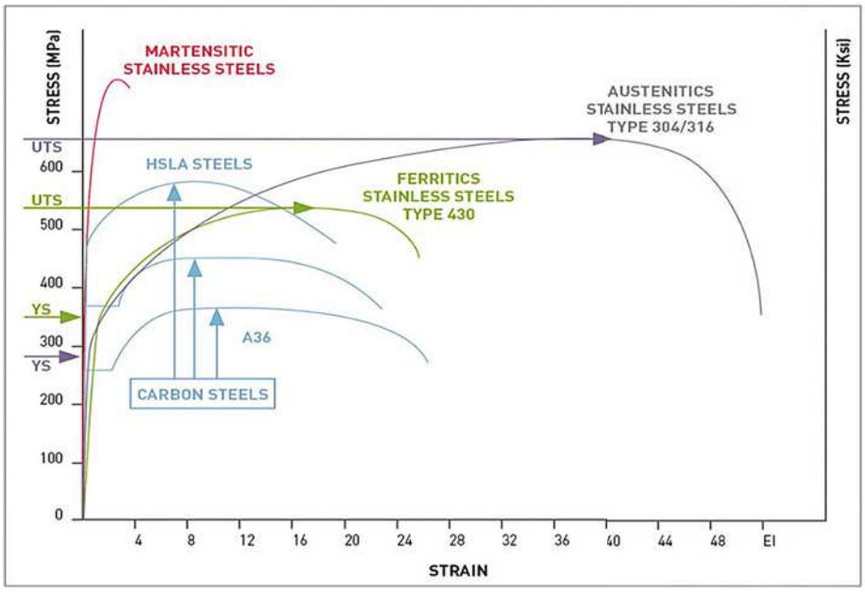
Concept bus structure with mixed-material concept, utilizing new ultra-light grades of stainless steel. (Grey = SS 1.4003; Orange = Duplex steel LDX 2304; Tan = Duplex steel LDX 2305; Yellow = SS Nitronic 60 grade)

The design approach for bus body architecture has gone through different phases—namely, chassis based, semi integral, integral, and monocoque. Equally varied is the choice of material for the bus "super structure," the predominant materials being mild steel with galvanization, stainless steel (SS), and aluminum.

Researchers at **Ashok Leyland** make a case for choosing stainless steel for the complete bus structure. With rapid development in infrastructure and the public mass transit system, particularly in the BRIC (Brazil, Russia, India, and China) countries, a robust structure for buses that is durable and crashworthy has become imperative.

Among the family of stainless steels, ferritic stainless steel exhibits excellent mechanical properties with corrosion resistance and better strength-to-weight ratio compared to the galvanized mild steel. Stainless steel, by virtue of its higher strength-to-weight ratio, brings down the unladen weight of the bus and hence improves its fuel efficiency.

Although the initial material cost is higher for stainless steel, it still scores better in other areas, namely lower weight, less frequent replacement, lesser downtime, and better recyclability. On the whole, the lower life cycle cost (LCC) offsets the initial material cost and yields rich dividends to the end customer.



Comparison of mechanical properties of stainless steel and carbon steel. (International Stainless Steel Forum)

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*Class is defined by the comparable hatchbacks in the range of 3.7m - 3.9m of overall length, petrol engine capacity ranging from 1100cc - 1250cc and diesel engine capacity ranging from 1100cc - 1500cc. Features & specifications as shown may not be part of standard fitment & are subject to change without prior notice. Hyundai urges you to follow traffic rules - these are meant to keep you safe on roads.

Why stainless steel?

The salient features of SS that make the material suitable for bus structures are superior mechanical and thermal properties, corrosion resistance, low LCC, optimized structure weight, and full recyclability.

The thermal properties play a significant role when the structure is exposed to very high temperatures during welding. The residual stresses in the structure thereby are reduced, which is a direct benefit in terms of the durability and longevity of the structure. Due to its superior thermal stability, SS retains its structural integrity much longer than that of carbon steel structure and even longer than that of aluminum.

Stainless steel, by virtue of 10-12% chromium content, has the intrinsic property to resist corrosion even in extreme corrosive environments. The chromium forms a passive layer of chromium oxide on the surface of the structure. Even in the event of damage to this layer, it has "self-repairing" properties that help form the passive layer. Galvanized steel, on the other hand, loses its zinc coating in three to four years, which leads to severe corrosion of the structure. While corrosion leads to poor aesthetics, it also adversely affects the reliability of the structure, compromising crashworthiness.

With increasing awareness of the characteristics of stainless steel and its long-term benefits, the developing BRIC countries are embracing SS in a big way. In India, the Indian railways, one of the largest rail networks in the world, have already started migrating to stainless steel. Also with the advent of metro rail transportation in India, these coaches perhaps will have SS content from local manufacturers.

Earlier SS applications in the BRIC regions required either importing the complete end assembly or getting the individual members and fabricating in-house. With such extensive demand and usage of SS, the necessary raw material availability is no longer a concern.

Another perceived challenge relates to painting SS because of poor adhesion properties on a smooth surface. This will not be a bottleneck in the case of a bus structure, which is always covered by outer panels and hence no painting for aesthetics is required. However, the underbody is given a protective coat of wax oil to protect it from erosion and corrosion.

Stainless steel is finding more extensive use in India for applications such as metro rail. (Indian Stainless Steel Development Association)

Manufacturing SS in complex shapes could be costly, but the type of profiles used in the bus body structure are simple tubes, channels, and formed sheet metal parts. So again, this is not a concern.

Looking ahead, new ultra-light grades of SS are being formulated that can be readily adopted for bus structures. These materials have to be judiciously used at critical locations to enhance the strength-to-weight ratio without drastically increasing the price.

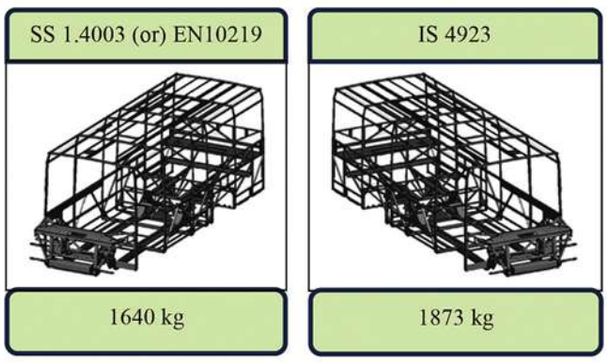
The 'super structure'

The bus super structure is often divided into the following basic assemblies, each of which has further subassemblies: roof structure, side structures, floor structure or under frame, and add-on structure such as front and rear fascia reinforcements, roof-mounted AC/CNG/hybrid supports, and reinforcements for rollover compliance.

The floor structure differs significantly according to the architecture of the bus. For instance, a traditional floor structure has chassis C frames and outrigger, whereas evolved structures have sturdy longitudinal hat sections that are integrated with equally strong transverse box sections.

The researchers from Ashok Leyland restricted their analysis to a monocoque city bus structure that is 8 m (26 ft) in length, because city buses carry the maximum number of passengers especially during peak hours and are subject to variable loading during its service cycle.

When it comes to the type of structural members used in a super structure, it is primarily square/rectangular tubes and sheet metal parts. Of course, there



Difference in cumulative structure weight between SS and conventional steel.

are other profiles such as L angles, hat sections, channel sections, Z profiles, and other custom-formed profiles out of sheet metal.

Irrespective of the dimension of tubes or the profile of the sheet metals, the costing is done based on weights. Hence, the weights of all the tubular sections of the super structure are grouped under one head, totaling 923 kg (2035 lb), and all the sheet metal profiles under the other, totaling 717 kg (1581 lb).

Life-cycle costing

LCC is a widely used technique to account for various costs incurred by the customer directly or indirectly starting from raw material, processing or conversion, manufacturing, assembly, logistics, maintenance, recyclability, and much more. It is a very useful tool especially during the process of material selection at the concept phase of design.

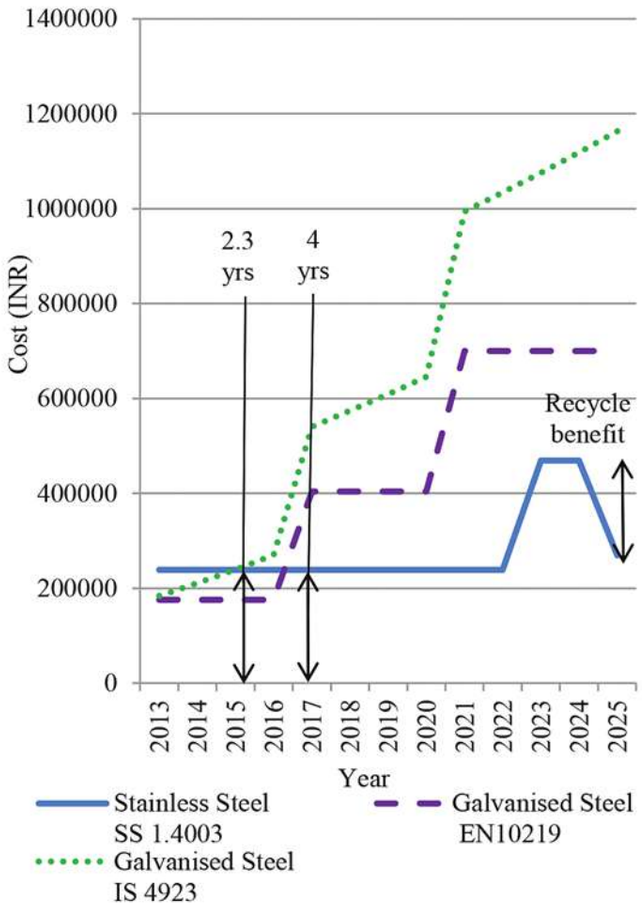
In the present context, this technique is used to compare the LCC of a SS bus structure and a conventional galvanized steel structure. The LCC is calculated for the desired life cycle of a bus, which is 12 years according to the "Urban Bus Specifications–II" report published by **Ministry of Urban Development, Government of India**. The typical life of a bus is expected to be in the range of 10–15 years.

The various components that contribute to the cost of the super structure include raw material cost, fabrication cost, maintenance/replacement cost, and recyclability benefits.

In the given scenario, three different materials are considered: ferritic stainless steel of 320-MPa (46.4-ksi) yield strength, galvanized steel also at 320 MPa, and a conventional structural steel of 240 MPa (34.8 ksi). The raw material and fabrication cost in itself is a sum total of various components.

It becomes evident from the cost breakup that the mild steel incurs additional cost for hot dip galvanizing. Also, this process involves sophisticated infrastructure with stringent safety requirements. Besides the cost, this process increases the manufacturing cycle time by 15%, as reported in *Australian Stainless* magazine.

Having worked out the raw material and fabrication cost per kilogram, SS tube and sheet at this point result in higher costs, followed by the equivalent-strength galvanized steel and then the conventional steel.



LCC trend over the expected life of a bus. The initial cost difference of stainless steel is bought back in 2.3 years compared to conventional structural steel and in 4 years compared to galvanized steel of equivalent strength.

Owing to the difference in yield strengths, the SS structure and the equivalent EN10219 galvanized structure are lighter than the conventional IS 4923 structure by 233 kg (514 lb). This directly translates into better fuel economy and hence reduced operating cost, as well as a reduced carbon footprint.

Tire life is another critical factor. With reduced unladen weight of the bus (the bus does not run at full capacity all the time), the tires are loaded less and their life increases significantly.

Regarding maintenance or replacement cost, the life of a galvanized steel structure is not more than four years, beyond which it starts to rust. The minimum expected life of a SS structure is more than 10 years. Over a 12-year span, the galvanized steel structure is expected to be replaced twice before the complete vehicle is scrapped. The SS structure is considered to be refurbished only once.

The comprehensive LCC comparison for a 12-year span reveals that the SS structure is about 2.5 times less expensive than the equivalent-strength galvanized structure, and about four times less expensive than the conventional galvanized steel structure.

This article is based on SAE International technical paper 2013-01-2418 by Sreedhar Reddy and Vignesh T. Shekar of Ashok Leyland, Ltd.

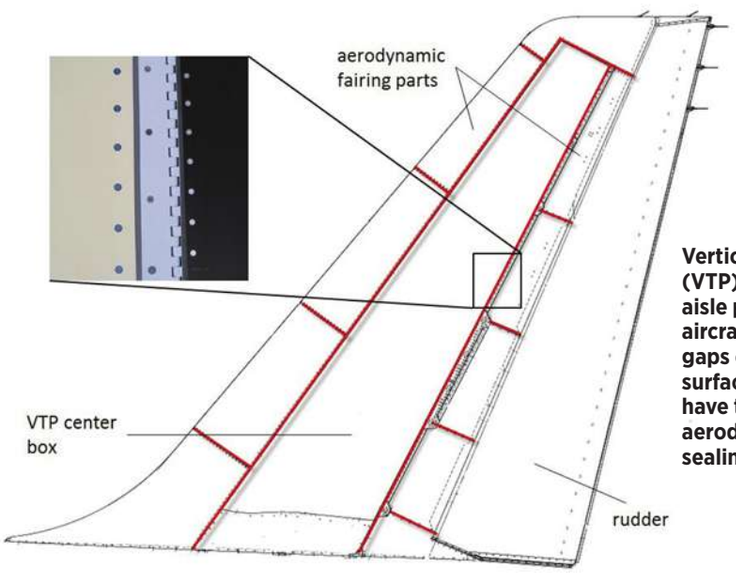
AEROSPACE MATERIALS

Heated air technology helps optimize CFRP assembly

In today's assembly of large and complex carbon-fiber-reinforced plastic (CFRP) components, such as passenger-aircraft vertical tail planes (VTPs), liquid resin-based materials are used for several applications. Commonly, these materials are used to close gaps between the CFRP single parts during assembly (shimming) or to smooth outer surfaces to fulfill aerodynamic requirements (aerodynamic sealing).

Depending on temperature and air humidity, these materials generally require curing times up to 12 h. From an efficiency and cost optimization perspective in running aircraft production, such long curing times are definitively waste in terms of lead time (critical path).

By heating and/or air-conditioning these resin-based materials, the common curing time can be drastically reduced—to 2 h. Due to the use of heated air—instead of, for example, heating lamps—the curing process can reliably be controlled, without any risk of overheating and destroying the sealant of shim material.



Vertical tail plane (VTP) of a single-aisle passenger aircraft showing gaps on the outer surface (in red) that have to be filled by aerodynamic sealing.

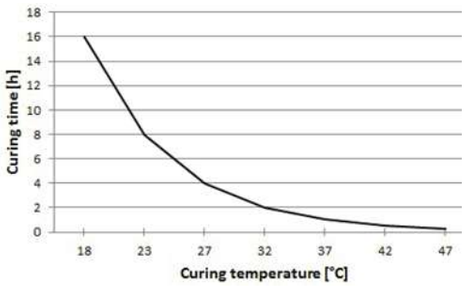
Researchers from **Airbus Operations** GmbH and **Marcotodo** GmbH describe two applications of heated air technology for the accelerated curing of resin-based shim and sealant materials. The first example is the aerodynamic sealing of a VTP; curing time of the aerodynamic sealant can be reduced by 8 to 10 h using the newly developed heated air technology. The second example is the shimming of gaps between a VTP center box and metallic parts attached to the box.

Tolerance compensation using resin-based materials

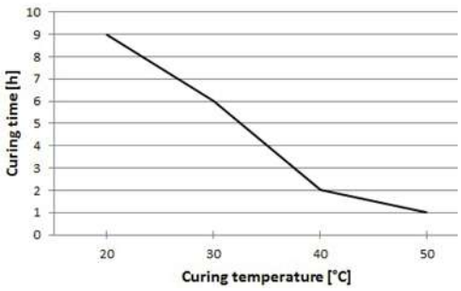
Large and complex parts made of CFRP commonly show larger tolerances regarding form and thickness accuracy compared to metal parts since higher accuracy would directly lead to exponentially higher costs of the single parts. Therefore, as a compromise, tolerance compensation has to be performed as part of the assembly process.

Shimming has to be performed between the single parts to close gaps that are caused by stack-up of thickness tolerances and to guarantee correct transfer of loads through the parts and the fastener elements. Closing gaps on the outer surface of assembled components, or aerodynamic sealing, has to be performed to smooth the surface.

The sealing material is a two-component polysulfide-based compound from **Chemetall**. With the current product variant, the curing time is about 8 h at 23°C to achieve a hardness of Shore A ≥ 30 of the cured material. By increasing the temperature, the curing time can be reduced; a decreased temperature leads to longer curing times. Especially during winter (with shop-floor temperatures less than 20°C), this could lead to curing times of up to 16 h.



Curing time of the used sealant material dependent on the curing temperature.



Curing time of the used shim material dependent on the curing temperature.

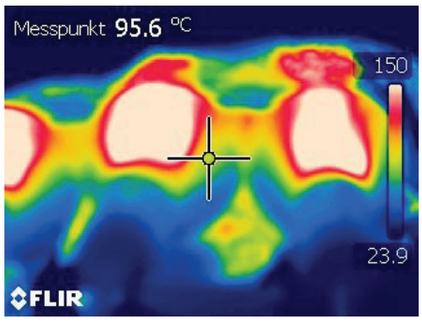
In addition, a minimum relative humidity is necessary for the initiation of the chemical curing reaction (vulcanization). Especially during winter, relative air humidity could be less than 10%, which leads to further extension of the curing time.

The used shim material is a two-component epoxy-based compound from **Henkel**. The curing time at 20±3°C is 9 h. By increasing the temperature, the curing time can be reduced to less than 2 h.

Improved aerodynamic sealing with heated air

Heating (IR) lamps have traditionally been used to heat the sealants; however, the heat distribution on the surface is very uneven, leading to uneven curing of the sealant. There also is a risk of overheating and damaging the sealant, or in the worst case, the CFRP material itself.

To overcome this risk, a new technology was introduced using heated air instead of lamps. By using heated air

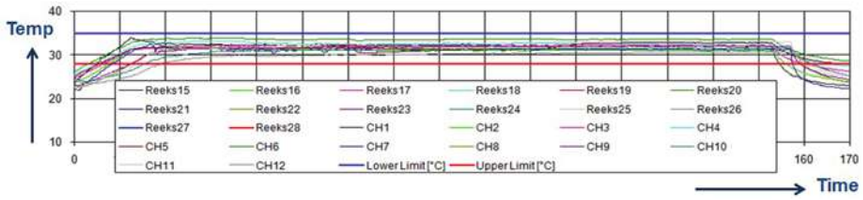


Heat distribution on the surface when using heating lamps (example).

The prototype heated air tube system, bottom view (top left), inside view (bottom right), ventilating fan (top right), and control unit (bottom left).

flowing slowly and continuously over the sealant material, a homogeneous heat distribution and curing process can be realized. The maximum temperature on the surface cannot be higher than the maximum air temperature independent of the position of the system. Therefore, the curing process can be reliably controlled, without any risk of overheating.

Together with other specialized companies, including **Oellerich** and **CFK-Valley Stade**, dedicated tooling was developed and introduced. It consists of a U-shaped air tube made of CFRP. Vacuum cups are used for mounting the tooling onto the surface without damaging it. Rubber lips at the edges guarantee a closed canal for the heated and moisturized airflow. The air tube is connected to a dedicated fan heater via flexible hoses. Several air tubes can easily be connected to each other depending on the length of the gap to be sealed. By means of a control unit, the air temperature and humidity can be adjusted, automatically controlled, and recorded. An additional electrical heating system and temperature sensors are installed inside the air tube.



Heat distribution inside heated air tube. The air temperature inside the system can be controlled very accurately, within a range of ±3°C.

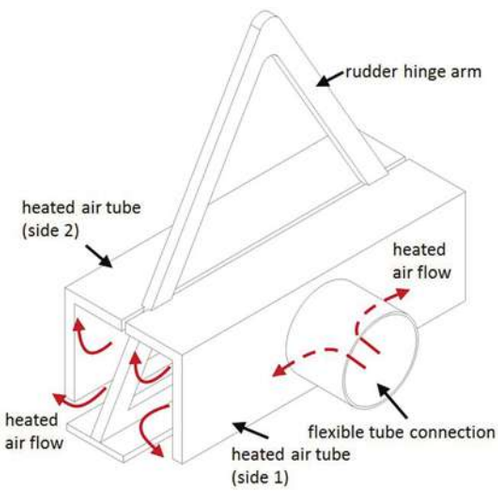
The air temperature inside the system can be controlled very accurately (by means of internal heating elements) within a range of ±3°C, which meets the curing requirements for the sealant material.

To maintain a relative humidity between 10% and 90%, a humidity control unit can be added to the system.

In first trials using the prototype, the operational readiness of the heated air tube system could be demonstrated. A curing time of 2 h was achieved including temperature ramp-up and installation time. The next step will be the introduction of serial heated air tubes.

Improved tolerance compensation with heated air

Heat can also be used to decrease the curing time of shim material. As risk mitigation, heating lamps are no longer used in the assembly of the VTPs. Another possibility to introduce heat is using flexible heating mats or metallic heating elements (e.g., beams) that are placed on the surface with the shim material underneath. In principle, this is only possible for less complex part geometries—e.g., flat or slightly curved surfaces. For complex surfaces, heated air again becomes an interesting option.



Schematic representation of the heated air system for accelerated curing of shim.

For joining the rudder with the VTP center box, aluminum hinge arms have to be assembled to the center box. Shim has to be used to fill the gaps between the rudder hinge arms and the rear spar of the center box to guarantee accurate positioning of the hinge arms and rudder hinge line. The heat introduction into the interface between hinge arms and the rear spar cannot be realized with a heating mat or other conventional heating elements due to the complex assembly situation. In particular, thermal expansion of the surrounding fittings has to be avoided. Therefore, a specifically adapted heated air tooling was developed that fits to the hinge arms.

In this case, the heated air system consists of two L-profiles that fit to the geometry of the dedicated hinge arm. Since the geometry of each hinge arm is different, individual systems have to be used per hinge arm. Rubber lips at the edges of the L-profiles ensure a closed inner room for the heated airflow. The profiles can easily be fixed at the part using conventional clamping devices. The heated air system is connected to a dedicated fan heater with flexible hoses and controlled by a control unit.

First trials at a test VTP were done using a prototype system. Again a curing time of 2 h was realized. Next steps will be the implementation of the heated air system in serial production.

Heated air technology enables the stabilization of the production process with regard to a clearly structured process and delivery planning since the curing time remains the same independent of the environmental conditions (temperature and air humidity) in the shop floor.

This article is based on SAE International technical paper 2013-01-2133 by Alexander Gessenharter and Bjorn Van Koppen of Airbus Operations GmbH, and Marc-Philipp Graf Bethusy-Huc of Marcotodo GmbH.

AUTOMOTIVE TESTING

EVs and HEVs bring new dimensions to durability testing

The advent of electric vehicles (EVs) and the steady increase in global acceptance of hybrid-electric vehicles (HEVs) are together introducing new dimensions to automotive design and engineering targets. Electric motive power must achieve ever tougher standards of required and expected end-user demands. Among the many salient issues it continues to raise are weight and size of battery packs, performance on inclines, and the crucial concern of achieving realistic and dependable driving range. Safety is also a mainstream subject.

And there is the added matter of convincing buyers of both EVs and HEVs of their through-life durability and reliability. Through all this runs the absolute necessity to provide realistic value for money, both initially and residually.

So, in parallel with the automotive industry's development of solutions to these challenges, the need to test and prove them is vital.

It is a tough task, as Alastair Wynn, Senior Engineer for Durability at the U.K. **Millbrook Proving Ground**, experiences daily as he deals with disciplines specific to EVs and HEVs alongside regular internal combustion engine-powered vehicles and the areas where their technologies cross-link: "The common goal of durability testing is to simulate the real world usage of a vehicle in an accelerated manner and to identify reliability, durability, and, particularly for EVs, interface issues so that they can be addressed."

Test requirements for EVs and HEVs are very different, but the way a test is designed is the same, he explains, saying that it is imperative that all eventualities that will be experienced in service are covered without conducting unnecessary tests that an OEM or supplier does not need.

Deciding just what is or is not needed is extremely important. So it is essential to establish the criteria of envisaged usage by the end-user of a particular vehicle and to then test accordingly: "For example, out of 100 customers of a C-segment (compact) vehicle, only two may see vertical loads that are considered excessive. As those loads may only be seen twice during three years of data, is it necessary to test to the needs of those two customers? If so, the vehicle could be at risk of being 'over engineered' for the 98 people of that 100 who will never see that event!"

Testing and proving EV and HEV technology brings added challenges to automotive engineers.

When durability testing, some subsystems are plainly more critical than others. These include brakes and steering, but specific testing should be conducted independently of the whole vehicle test, said Wynn, and safety systems including ABS, TCS, and stability control should be exercised periodically during the test to ensure functionality.

"Accelerating real-world usage can be challenging. If there are a number of events, these need to be sequenced without compromising test integrity. For example, it may be necessary to conduct a number of pothole impacts and complete a given distance of pavé. Conducting the pothole maneuver after the shock absorbers have risen in temperature on a paved surface could give unrealistic loads, due to reduced shock absorber performance."

Durability testing must always be aligned with the intended in-service use of the vehicle. This alignment covers areas such as the intended market for the vehicle, what type of vehicle it is, the body style, including car compared with van derivative, van, minibus, or chassis. A single vehicle platform could carry many body styles depending on its intended use. All of these factors will determine the validation regime required, and bespoke durability testing programs developed.

Millbrook Proving Ground Senior Durability Engineer, Alastair Wynn, stresses the importance of the interface between systems on an EV or HEV.

Wynn added: "Areas for consideration when testing HEVs and EVs that could be different to ICEs include driving style, average trip distance, speed profile, standard and additional features of the vehicle, the target customer, and risk assessment. Whilst many of these appear to be the same as ICE vehicles on first consideration, there are differences which need to be accommodated."

One is average trip distance, generally short in the case of pure EVs, the great majority of which at present are only practical for limited mileage, urban, stop-start travel. The second involves risk

assessment; special attention must be paid to the risk of fire and the potential danger presented to rescue services of EV batteries.

Due to the nature of EVs and HEVs, the most significant differences are in the usage of electrical system performance, battery performance, and engine performance.

The latter two will change depending on vehicle usage. Both battery state of charge (SOC) and the systems utilized in an HEV have a direct impact. Battery performance can also be affected by temperature changes and different charging strategies.

For an HEV, any use of ancillary systems, such as its air conditioning or lighting, affects engine running time, and driving style can have a thermal impact on the motors or power systems.

Constant high load running such as long ascents with throttle wide open can put both of the HEV's motive power systems under maximum loading, as can descents on regeneration systems, said Wynn: "Pure EVs will see similar issues to that of an HEV, except that the usage of ancillaries will have a dramatic effect on the SOC and ultimately the performance and range of the vehicle. High torque demand can put the batteries and motors under a lot of load, generally through lower speed, high load driving. This can impact the operating temperatures and overall range. Stop-start driving will have an impact on SOC and range, especially if ancillary equipment is being used at the same time."

Considerable damage can occur during stop-start non-run time, he explained: "With the engine not running there is no pressure in the lubrication system, which can lead to damage of some components, particularly bearings, where a condition known as brinelling occurs. Although the engine is not running, the components are still subjected to loads and vibrations as a result of low temperature operation when most wear occurs.

"The engine oil is not the only system normally hot and pressurized on an ICE vehicle; the cooling system operates under these conditions. An HEV may also have systems operating under similar conditions where the temperature profile is critical to avoid low temperature operation or overheating. This may not only apply to engines but also to their systems, notably electric motor cooling."

Constant high load running such as long ascents with wide throttle opening can put both motive power systems under maximum loading. This Vauxhall Ampera (Chevrolet Volt) is under test at Millbrook Proving Ground, UK.

An important aspect of durability testing is subsystem integration, with all functioning together as a single unit. Said Wynn: "Prior to this testing, sign off will have been achieved for the components and individual subsystems. Therefore, it is important that integration of all subsystems within the vehicle is subjected to the full load spectrum of all input types to ensure continued good connectivity and interface performance.

"The inspection process should include critical inspection of the batteries, battery carrier and wiring, in addition to the normal criteria."

To conduct a correlated test in an accelerated manner, the less damaging loads giving rise to fatigue damage and wear are significantly reduced. However, the interface between the systems on an EV or HEV may be more susceptible and should be scrutinized more closely, warns Wynn.

While today's whole vehicle corrosion protection is now generally exemplary, inspections need to include the extra electrical systems that are necessary for EVs and HEVs.

"Common concerns with electrical systems as a result of corrosion include its effect on connector blocks and terminals, resulting in a breakage of the connection, an increase in heat, or a voltage drop. Also of concern is capillary action, which can lead to a short circuiting of a system, a breakage in the wire, or a loss of communication and may occur some distance from the connection," said Wynn.

Generally, corrosion issues with electrical systems become evident during a loss of function or communication failure between control modules. However, when dealing with potentially high voltage systems it is important to identify any concerns as soon as possible, he warns.

Summing up Millbrook's approach to durability testing, Wynn emphasizes the overarching importance of methodology and a thoroughly strategic approach to the task.

"The actual specification of the vehicle/propulsion system must be reviewed and the test must include situations which exercise any additional systems, such as regenerative braking, torque vectoring, and torque-on-demand. All of these systems have an impact on how the vehicle feels to the driver. Sometimes it may be necessary to engineer the feedback to the driver. Durability testing is a good opportunity to get lots of drivers into the vehicle during its test; their subjective comments can be invaluable to the OEM, supplier, and end user."

Stuart Birch

AEROSPACE PROPULSION | SIMULATION

Predicting cavitation in fuel pumps

Liquid ring pumps are used in aircraft fuel systems in conjunction with main impeller pumps and serve the function of removing fuel vapor and air from the fuel. Thus, their reliable functioning plays a critical role in the safe operation of aircraft during flight. As cavitation has the potential to severely limit the operability of these liquid ring pumps and in severe cases may lead to their structural failure, accurate prediction of cavitation in the pumps is extremely important to design them for safe operation.

The cavitation phenomena occur in regions where large pressure drops result in the local pressure falling below the vapor pressure, resulting in formation of vapor bubbles. Typically for pumps, cavitation occurs in the suction side of the pump blades, which in turn results in a reduction of effective area of the blade, thereby diminishing the efficiency of the pumps.

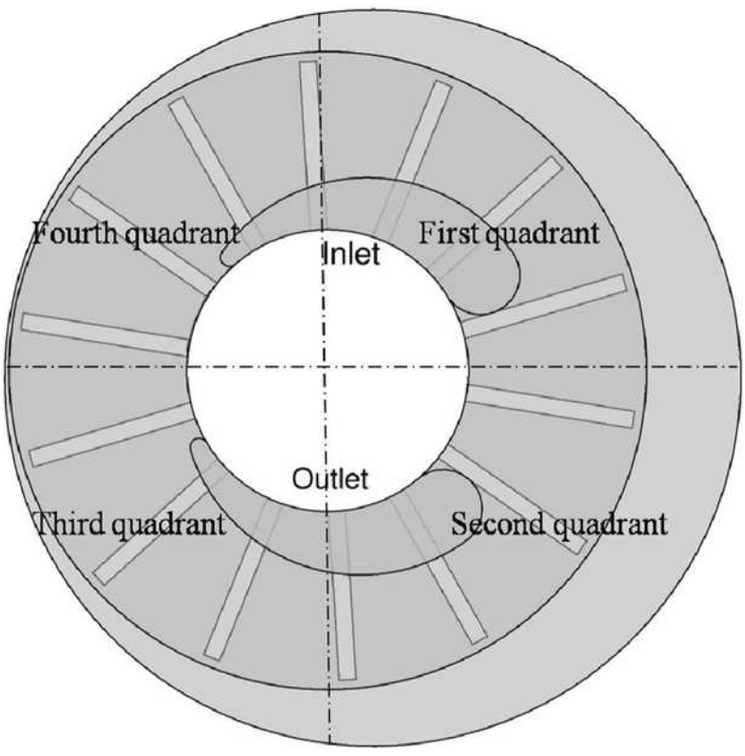
The formation of vapor bubbles and their subsequent bursting creates pressure impulses on the blade surfaces, which leads to vibration and fatigue-induced structural damage leading to pump failures.

The liquid ring pump's main function is to remove air and fuel vapor during the priming process of the main fuel pump. This becomes necessary for situations where a large quantity of fuel vapor is formed in the ullage area. In those situations, the main centrifugal pumps require the liquid ring pumps to generate a positive suction head and to separate the air and fuel vapor from the liquid fuel through compression.

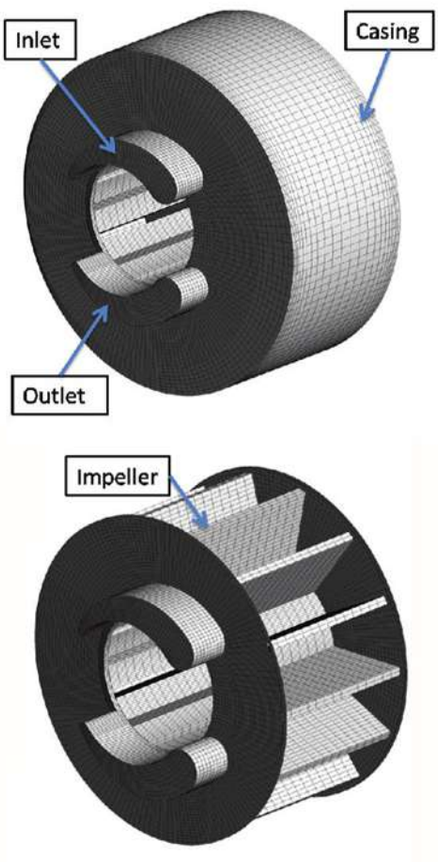
A typical liquid ring pump consists of a static casing that forms the outer surface of main pump and has an eccentrically mounted rotor assembly consisting of multiple rotating blade elements that are also referred to as impellers. The rotor assembly is mounted on the shaft of the main pump and is driven by the main fuel pump itself.

As the impeller rotates, the centrifugal force causes the liquid fuel present in the pump to form a ring around the pump periphery. This draws the air and fuel vapor mixture into the inlet port with the liquid fuel being discharged to the fuel tank and supplied to the engine units through the outlet port.

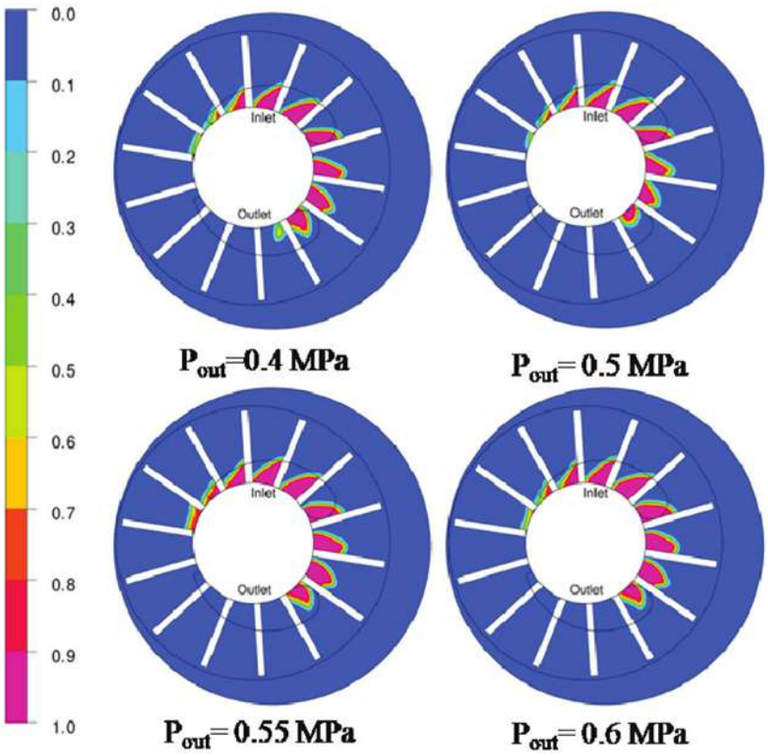
In a recent study, researchers used a steady-state multiple reference frame (MRF) methodology and a transient sliding mesh methodology to compare their ability to predict cavitation and pump performance in liquid ring pumps. As the assessment for the two computational approaches was relative to each other,



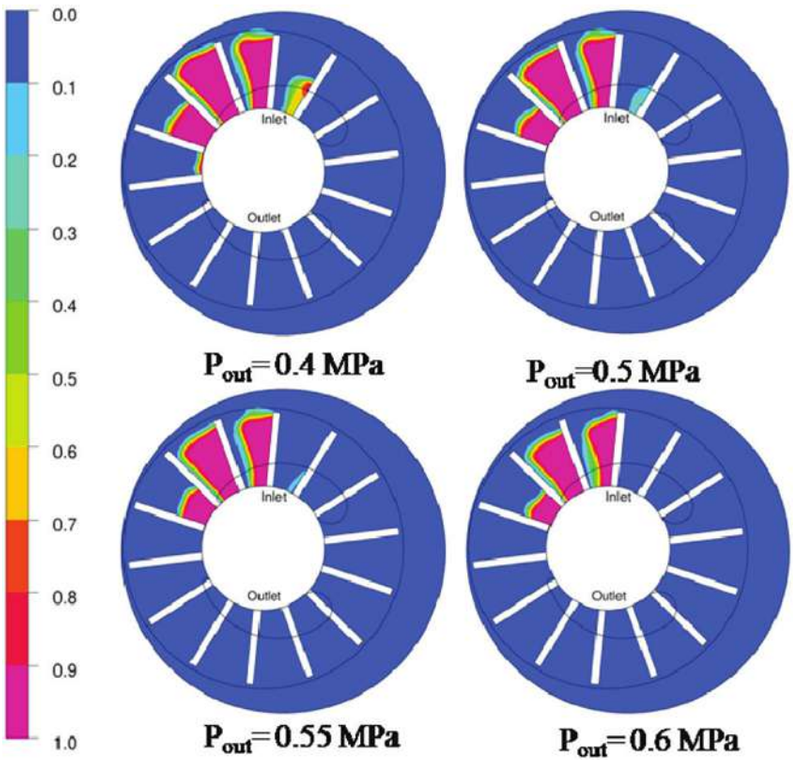
The liquid ring pump configuration that was studied consisted of a single-stage impeller with 14 blades arranged in an equi-spaced manner circumferentially.



The same mesh was used for both the MRF and the sliding mesh calculations to achieve mesh consistency between the two models for relative comparison and assessment.



Using the transient sliding mesh method, results demonstrated that cavitation occurs in the region between the inlet and the outlet port along the direction of rotation of the impeller, and that the cavitation area shrinks with in an increase in outlet pressure. The distribution of the vapor fraction shows the accumulation of liquid fuel around the periphery due to centrifugal forces and the accumulation of the vapor bubbles in and around the hub region as these regions experience the low pressure regions that lead to cavitation.



The vapor fraction distribution predicted by the MRF approach indicated an unrealistic unphysical location of cavitation. As can be clearly seen, the MRF model predicted that the cavitation occurs near the inlet port, which is not possible.

no special emphasis was placed to determine grid dependency individually for each of the approaches.

The liquid ring pump configuration that was studied consisted of a single-stage impeller with 14 blades arranged in an equispaced manner circumferentially. The impeller blades were of constant thickness and were mounted eccentrically relative to the pump casing. The cross section of the inlet and the outlet ports were airfoil-shaped to minimize pressure losses.

The CFD simulations carried out for both methodologies employed a fully structured hexahedral mesh, which was generated in commercially available software. The conformal mesh consisting of around 110,000 cells had an equivolume skewness and aspect ratio of the individual cells below 0.9 and 58, respectively. The same mesh was used for both the MRF and the sliding mesh calculations to achieve mesh consistency between the two models for relative comparison and assessment.

Results indicated that though the computation efforts were cheaper for the steady-state MRF model, the results obtained were physically not possible. The computationally expensive transient sliding mesh approach resulted in realistic predictions.

Due to unavailability of experimental data, a quantitative validation of the sliding mesh approach for cavitation prediction could not be performed, but the trends observed in the results showed promise in this approach as compared to the MRF approach. Further investigation along with experimental validation would be required to refine the prediction fidelity of the transient sliding mesh based cavitation model for liquid ring pump applications.

This article is based on SAE International technical paper 2013-01-2238 by Manoj Radle and Biswadip Shome, Tata Technologies Ltd.

Synergistic opportunities abound

The horizontal deployment of technologies and knowledge evident in mass-market personal mobility needs to be scaled up in magnitude and performance for commercial vehicles.

by Dr. Arun Jaura, Board of Directors, SAE International; Chairman, Automotive Board, SAEINDIA; and MD & Founder, Traktion Management Services Pvt. Ltd.

Dr. Arun Jaura.

The silver bullet from December's SIMCOMVEC 2013 event held in the mobility capital of South Asia, Chennai, for mobility practitioners is that synergies in commercial and passenger vehicle technologies can be effectively harnessed by practicing collaborative innovation and by empowering change through knowledge management.

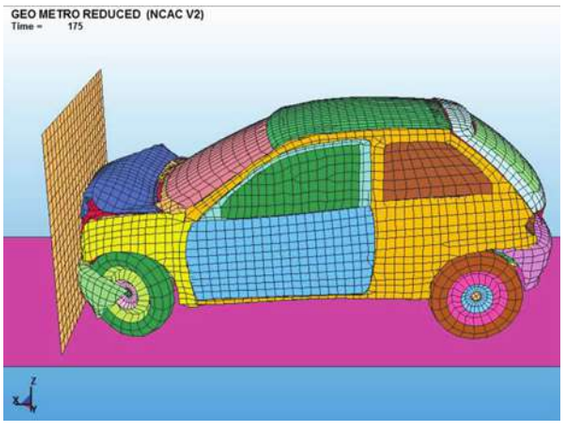
The horizontal deployment of technologies and knowledge evident in mass-market personal mobility needs to be scaled up in magnitude and performance for commercial vehicles. The technologies and solutions need to become cost-competitive through economies of scale. Necessary to achieve this is a supporting infrastructure for deployment and greater implementation knowledge. OEMs and system integrators have to spearhead the paradigm of open ideation platforms for a seamless exchange of knowledge-based experiential solutions and implementation opportunities.

Low-carbon footprint levers relating to fuel efficiency, safety, materials, and intelligent and smart solutions have been the domains of innovation and global cost-competitiveness in mobility. The additional dimensions in India that will supercharge the open innovation mind-set are growth of infrastructure, especially expressways; affordability through financing avenues; and consumer aspirations. This backdrop will continue to create a tremendous opportunity across the mobility canvas to innovate, incubate, and implement. India is smartly positioned to pick and choose relevant global solutions, and re-ideate them for local ecosphere deployment while avoiding huge R&D costs. This reduces time to market and bridges the gap of ever growing consumer aspirations. The knack for deployment of such solutions across passenger and commercial vehicles, in a market where the volumes are low, is a competitive advantage in India for all stakeholders.

Interestingly, safety has become as much of a selling point as fuel economy and performance. The United Nations General Assembly has proclaimed the period 2011–20 as the Decade of Action for Road Safety, "with a goal to stabilize and then reduce the forecast level of road traffic fatalities around the world by increasing activities conducted at the national, regional, and global levels." Out of the several offshoots of the UN resolution, one will bring in the perspective of communizing safety systems in mobility, especially commercial and passenger vehicles. Safety systems in a vehicle help the driver and occupants escape injury during an accident. Smart safety systems go a step further by proactively warning the driver to take actions that will avoid accidents. Many of the intelligent active safety systems in passenger vehicles can be deployed in commercial vehicles.

Varying regional regulations will dictate vehicle safety characterization and crash ratings. Cost, of course, is a major criterion in the deployment and penetration of technologies. The core premise that safety is non-negotiable drives vehicular systems integration to limit injury. In any case, there is no substitute for an alert and defensive driver at the steering wheel who can react to warnings and avoid injuries to self, occupants, and pedestrians.

Innumerable innovations, IPR, and developmental effort have gone into fuel efficiency and emissions technologies, and these also have seen the most cross-deployable solutions in



CFD simulation.

Hydrogen-fueled vehicle from Mahindra.

Crash simulation.

Tata hybrid bus.

addition to telematics and infotainment. xEVs ranging from electrics, hybrids, and fuel cells—besides the highly efficient diesel and gasoline powertrains—have been on a growth path. The innovative opportunity is to be able to cross-deploy fuel-efficient solutions across commercial and passenger vehicles that have the least life-cycle cost and lowest carbon footprint. The paradigm shift in a fuel-efficient environmentally friendly solution development is to be able to radically innovate for a common xEV mass-market deployment. The January 2013 announcement of the National Mission on Electric Mobility by the Prime Minister of India and subsequent formation of the **National Board of Electric Mobility** should be a catalyst.

Alternative materials for weight reduction such as high-strength steels (HSS); lighter materials such as Al, Mg, and plastics; evolution of lighter-design concepts; and forming technologies are some of the synergistic opportunities across vehicle types. In fact, commercial vehicles have seen use of plastics and other materials progressively increasing over time, although not always resulting in weight reductions and better fuel economy, but rather on many occasions to help improve energy management.

Driver and cabin comfort are excellent opportunities to innovate for cross deployment. In India, long-distance driving and traffic hiccups in inner cities have created an emphasis on innovation in ergonomics, seating, climate control, and infotainment. Infotainment solutions and energy-management techniques, communication networks, and their integration are superb opportunities besides vehicle-to-vehicle connectivity and telematics. Passenger vehicles are becoming communication platforms, and that is a great untapped opportunity—not least because of the potential for synergy with commercial vehicles.

Overlapping virtual engineering techniques and tools have been extensively deployed in the product-engineering process to reduce time to market and reduce development costs in commercial and passenger vehicle verticals. Use of FEA techniques, CFD software, mold flow software, ride and handling software, and crash and safety simulations is foundational in product development. Bringing the road to the lab by using data collected in real-life conditions, developing real-time tests, and simulating the consumer environment hastens common product development.

For sustainable synergy and horizontal deployment of technologies, stakeholders have to proactively participate in open-ideation platforms. The growth of public-private partnerships in India is beginning to enable innovation through common technology platforms with stakeholders. Collaborative innovation is necessary for integrating technology trends at an affordable cost to stay ahead of the curve. Holistic deployment through collaborative innovation will empower the ecosphere with knowledge and help harness relevant opportunities to minimize the vehicle's carbon footprint for the future inhabitants of Mother Earth. ■

Dr. V Sumantran

Q&A with Dr. V Sumantran

The Hinduja Group's Executive Vice Chairman talks about his company's award-winning vehicle and related commercial-vehicle topics.

How do you rate the success of the light commercial vehicle DOST, which is now well accepted in the market?

The DOST was just the first product from our (**Hinduja Group**) joint venture with **Nissan**. During the planning phase, we had converged on positioning the product above the high-volume (below 1T payload) SCV vehicles in the market. We were glad to note that the product and its positioning had turned out right. The DOST bagged the LCV of the Year Award and went on to very good acceptance in the market. As a result, we have seen the competition also alter its strategy, which perhaps validates the choice that we had made.

What do you think should be the long-term vision for Ashok Leyland and its group companies?

Ashok Leyland has over the years adopted a broader perspective to its goals. Moving from being a maker of trucks and buses, we have attempted to address the broader topic of mobility for people and freight. This has meant that we address a fuller range of commercial vehicles including light trucks, give greater focus to advanced mobility technologies, address growing urban needs with systems like bus rapid transit, and even offer better range of mobility solutions for the construction business covering everything from tippers to construction equipment.

Ashok Leyland's Partner.

Regarding the design of commercial vehicles, what are the new technologies you foresee for improvement in fuel efficiency?

Over the past two decades, the design of commercial vehicles has seen emphasis in two important areas:

- Powertrain technologies with emphasis on improving fuel efficiency and meeting new emission regulations and
- Improved cabins, offering lighter weight and yet better comfort.

In many ways, I see these trends continuing with an even greater role to be played by electronics. For example, automated manual transmissions will optimize shift points to improve efficiency. Electrification of systems such as water pump, power steering (for lighter vehicles) will reduce parasitic losses. Better thermal management of engines will improve thermodynamic efficiency. Going forward, I also see an important role for weight reduction and hybridization, particularly for urban applications such as city buses and garbage trucks.

Do you think the impact of human activities on climate change is as adverse as projected? What are your views on moving to the next stage of emission norms, following Europe?

Since the onset of civilization, human beings have had an impact on the environment around them and reciprocally have adapted to their environment and surroundings. What is important is that modern society has to learn—with the considerably greater power we hold in our hands today—that we impact the environment, and can do so in ways that may be an impossible remedy for decades. Hence, it is important that we assess every major technology and activity through the lens of sustainability. At the end of the day, looking at it in personal terms, we have the responsibility of stewardship of our environment for our children.

While India has wisely aligned its road map to the directions being set in Europe, it is important that we assess the manifold implications—including economics, sustainability, and applicability—for our context. Further, we need to factor the realization that solutions in the transportation sector must be advocated alongside advances in other industrial sectors (such as power, mining, etc.) so that the country is able to make meaningful advances with the best macroeconomic benefits.

What new lightweight materials do you foresee to increase performance parameters such as durability, reliability, and fuel efficiency in commercial vehicles?

About two decades ago we saw a renewed spurt of competition between steel and aluminum as automotive materials. This led to a very healthy competition and promoted advances such as tailor-welded blanks, hydroforming, spaceframes, and secondary closures. The steel industry has definitely responded to the challenge with higher-strength alloys, and with better strength-forming and welding characteristics.

DOST is winner of the LCV of the Year Award.

The Dost Ambulance.

Equally, aluminum has made headway not only in powertrain systems, but also in chassis and increasingly for skin panels and closures. Most recently, we have seen the commendable efforts leading to practical uses of carbon-fiber structures. Unfortunately, many of these gains in lightweighting have not been fully visible because of parallel increases in safety, structural rigidity, NVH, and overall performance. I believe, looking to the future, one will gravitate to materials that offer better prospects for recycling and reuse.

Apart from safety regulations and considerations in designing and manufacturing vehicles, what approach would you suggest for India in terms of improving safety on Indian roads?

The bulk of safety engineering and regulations in the West have been oriented toward vehicle occupants. Unfortunately, in India, we have seen the bulk of our concern emanating from overall traffic patterns, roadway design, and prevalence of multiple modes. The best return on investment that we can harvest in India will come from a combination of road and traffic systems design, driver training, and stricter enforcement of road safety rules. Even if the Indian auto industry were to dramatically increase vehicular content with additional safety systems, we will not make much of an impact since a majority of the fatalities on Indian roads are related to persons outside the vehicle.

What are the major features that are being worked out in enhancing comfort and providing better ergonomics in vehicles?

This is actually a more complicated topic. For sure, with better understanding of ergonomics and driver psychology, we have found ways to improve the driver and occupant environment via better interiors, seats, and driver controls. The explosion in vehicle electronic content has also meant that we have to pay greater attention to the man-machine interface. With topics such as driver distraction and driver drowsiness alerts, we are getting vehicle systems to better interact with the human being.

JIT has proven to be very effective across the globe. In the Indian Context, is JIT workable and effective?

JIT (just-in-time) has been demonstrated by Japanese manufacturing to be an excellent tool, enabling lean manufacturing and working capital efficiency. Yet it is disheartening to realize that in some sections of logistics, particularly relating to building construction, it is quicker to shift components from China to Chennai than it is to transport similar freight from Mumbai to Chennai. Unless we achieve far greater logistics efficiency for such transit, we can never make JIT work efficiently. JIT is also conducive to a national landscape, where we had a few number of auto clusters such as Gurgaon, Pune, and China. With proliferation of auto clusters through new incentives in many new states, we have perforce scattered our national supply chains and caused local assembly units in close proximity to each auto cluster. Hence, for the advantage of achieving JIT, we have lost the advantage of scale.

In this age of multiple models and variants, how do you think automotive manufacturers can make best use of flexible manufacturing?

We live in an age when consumers demand personalization. As a result, manufacturers will be compelled to offer a larger variety of product, very

Q&A with Dr. V Sumantran

Ashok Leyland's newly launched Stile.

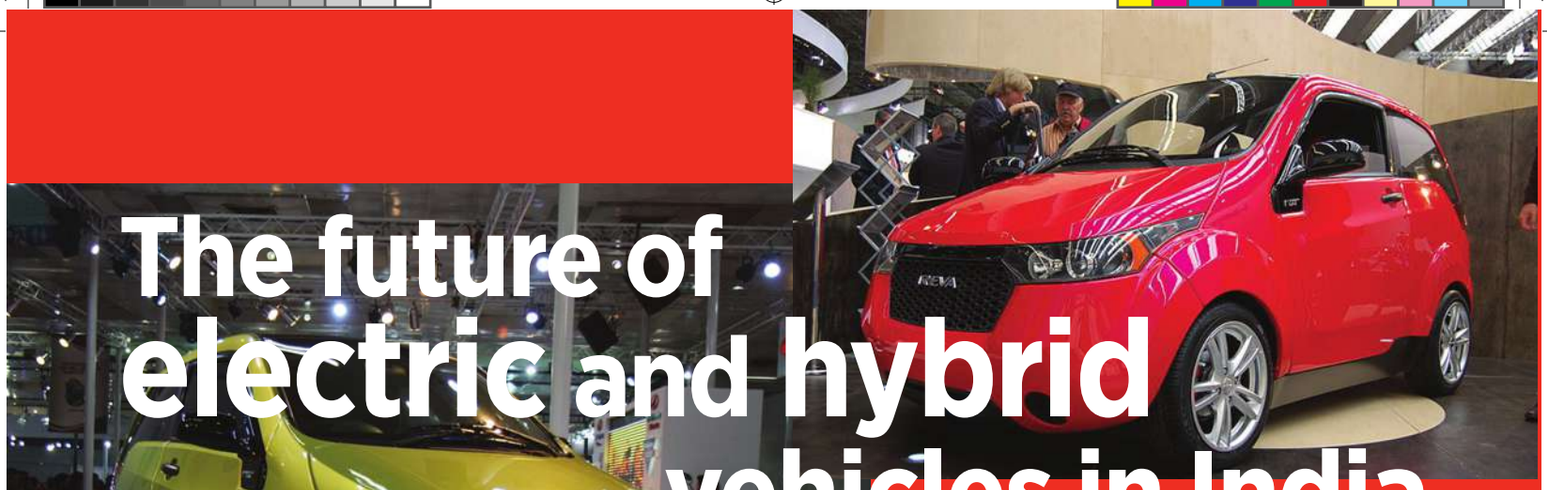
The Jan Bus.

often customized to individual customers. There are many textbook approaches to address this: modular platforms, modular configurations, and more carefully thought-through options. On the shop floor, we know how flexibility may be achieved; typically this is expensive since it requires reconfigurable and adaptable manufacturing systems. Looking further into the future, who knows, advances in technologies such as digital "printing" of hardware parts may get us within the reach of the Holy Grail of individual products for individual customers.

In your opinion, what are the areas India must focus on manufacturing competency improvement vis-à-vis China, Brazil, Russia, and South Africa?
While we have celebrated India's emergence as a global auto hub, in my opinion we have a long way to go. Compared to China, India faces a scale disadvantage and hurdles related to speed of setup of industries, infrastructure shortcomings, and a tax regime that still needs improvement. Even a country such as Brazil has more readily embraced advance production methodologies. Importantly, skill development oriented to manufacturing is a key shortcoming. India faces the uphill task of preparing its manufacturing sector to grow in scale, to absorb up to an additional 100 million people who will migrate from agriculture over the next decade. While India has potential to be a major global manufacturer, unless we tackle skill development on a war footing, we will fail to realize India's full potential.

What enablers do you think that the government, industry, and others should look at in creating and sustaining demand for commercial vehicles?
The primary enabler will be to ensure steady, broad-based economic development and growth since, at the end of the day, this is a primary driver for both people and freight mobility. The second topic, which is repeated ad nauseam, is our pathetic state of road infrastructure, both urban and rural. Further, in the pursuit of road safety and environmental considerations, we need to ensure that the vehicle inspection regime is strengthened so that vehicles that fall short of minimum safety and emissions norms are withdrawn.

Is there a frequent shift in buying patterns of commercial vehicle customers? If so, what are the reasons and how do think the industry should handle this?
I am not concerned about the buying patterns of the commercial vehicle customers. As an industry, we have to go where society and our customers want us to go. If demands change as a result of economic conditions for customers, as an industry we need to be agile and flexible to follow customer trends. ■



The future of electric and hybrid vehicles in India

Technical and political challenges alike have held back the electric and hybrid market, but there are signs of hope.

The REVA electric car from Mahindra REVA Electric Vehicles Pvt. Ltd. was launched in India in March 2013 at a price between Rs 6.5 lakh (US$11,900) to Rs 8.5 lakh (US$15,670) depending on the city and before any subsidy.

Early in the 20th century, Henry Ford and his engineers made the car available to the common man by cutting down the cost, in the process revolutionizing the private transportation system. After a century, the automobile industry seems ready for another burst of evolution. This time the reason is to preserve Mother Nature, and electric and hybrid-electric vehicles are the stars of this evolution.

Globally, degradation of air quality is one of the most researched topics today. The automobile industry is one of the main contributors to current environmental conditions. Waves of activities going on suggest that now may be the right time to bring change in the automotive industry.

India, being the second-fastest-growing automobile market with increasing pollution, faces lots of challenges and opportunities for electric and hybrid vehicles. Currently, India is one of the few countries in which electric vehicles are manufactured and used, but unfortunately the popularity of electric vehicles among Indians is very low. This is because of initial high capital cost, unreliable electricity conditions, unawareness among consumers of pros and cons, and encouragement of compressed natural gas and liquefied petroleum gas vehicles by the local automobile industry.

As of today, India has only 0.8% of the total global electric vehicle fleet. The Indian government promised to encourage reliable, affordable, and efficient xEVs through collaboration with industry, with a target of 2 million four-wheelers and 4 million two-wheelers by 2020. India's national electric mobility mission plan 2020 is a part of its national fuel security aim. The Indian government soon realized that with growth also comes the responsibility of meeting the associated challenges of fast depletion of traditional energy sources, rising energy costs, higher oil import bills, and degradation to the environment.

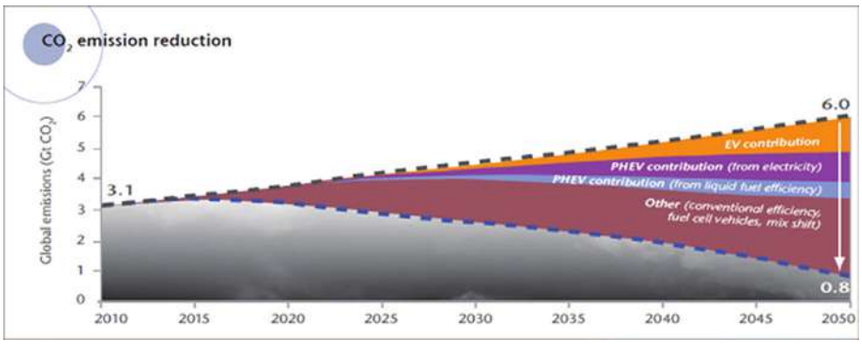
Electric and hybrid vehicle challenges fall into four categories, the first being infrastructure. The second is technical: battery costs, charging time, safety, reliability, range anxiety, and battery disposal and maintenance. The third is resources and comparison of electric and hybrid vs. conventional technologies. Fourth, and most important, is adaptability and change required to move from oil to electricity.

Today in India, electric and hybrid vehicles are in the very early development stages. This stage is supported by the Indian government in terms of policies, such as the national electric mobility plan 2020. The government can support electrifying mobility in the following five ways:

- Provide demand incentives
- Provide supply-side incentive to spur manufacturing
- Support the power and charging infrastructure
- Offer research and development incentives
- Impose stringent fuel-efficiency norms

The Indian government two years ago set the goal of 2 million units by 2020, but it hasn't yet developed policies and infrastructure needed to realize this dream. As of today, the Indian government is providing only some support in terms of cash subsi-

The future for electric and hybrid vehicles in India



Electric vehicles of different types have a role to play in achieving a future similar to this road map from the International Energy Agency.

dies on the purchase of the country's only electric car, the **REVA** E2O. In an automotive manufacturer's conference, the government's secretary of the Ministry of Heavy Industries said the government is hard-pressed for cash: "The level of the incentive which we are thinking is about to the tune of $2 billion over the next seven years, which is a big sum." He added, "If the electric vehicle market takes off [according to] plan, $7 billion worth of fuel will be saved, which will be a great relief from huge bills for oil."

These investments were to support the development, manufacture, and deployment of batteries, components, vehicles, and chargers necessary to put millions of electric vehicles on the road. Unfortunately, government plans have been delayed for several years and several times. However, it does intend to offer as a subsidy the differential cost between an electric vehicle and its gasoline version.

A government official said his hope is that Indian automobile manufacturers will bring in electric vehicles in the next two to three years. He noted that "five to six leading domestic manufactures are already in the fray, and we hope that foreign OEMs will also bring in their smaller cars at least."

The government strives hard to make EVs affordable, but the current condition of political indecision has resulted in delayed plans. Recently the Indian government revised its plans and targets to roll out subsidies and policies for electric cars by April 2014.

An early stage of development and changing technical basics of mobility poses a lot of challenges. When it comes to plug-in vehicles, questions such as charging infrastructure and charging time become roadblocks. Arguably there already is a vehicle charging station and ample time for charging at one's home and office. As the number of electric vehicles increase, charging-station companies will come into the picture, too, with fast-charge technology. A potential alternative to waiting for a battery to be charged is the battery-swap station where a depleted vehicle battery pack can be replaced with a fully charged one in just a few minutes.

Range anxiety is a major concern with electric vehicles. Based on an independent survey, 85% of total drivers globally drive less than 65 km (40 mi) daily and can do charging in the evening or overnight when the vehicle is parked for more than 12 h straight. Shai Agassi of battery-swap company **Better Place** said in a TED talk about India driving behavior, "In India, where people fill 2–3 gallons of fuel for one time, a battery range of 120 mi is an extension of range, not a reduction."

Still, a detail and deep study is required to understand drivers' range needs. For this study, vehicle range can be plotted against driver satisfaction. Or maybe the time has come to focus on customization of the car; the car owner can pay for whatever range he requires. On the other side of coin, some people argue that range is really not a worry except for extended drives such as weekend outings beyond the city. It may be that with their shorter range, electric cars are best used as a second car for city driving.

In terms of safety, statistics show that it is not a problem for electric vehicles. Until now, only few electric cars had fire issues, and it is important to note that the fires in the battery were contained to a small section near the front by the internal firewalls built into the pack structure. At no point did the fire enter the passenger compartment. The owners were nonetheless able to exit the highway as instructed by the onboard alert system, bring the car to a stop, and depart the vehicle without injury. Owners of one of the burned cars stated that the car had performed very well under such an extreme test. The batteries went through a controlled burn. An Internet depiction of one case exaggerates the fire, and the driver said he

The REVA Concept.

The oldest REVA model is shown here in an undated photo in front of the Indian parliament building.

National Electrical Mobility Mission Plan 2020

1. Mandate higher fuel efficiency norms
2. Mandate Electric vehicles in Government and public transport fleet.
3. Incentive sales through cash subsidy
4. Phase out low import duties to encourage localization.
5. Roll out pilots to support electrical vehicles.
6. Make modest investment to build public charging infrastructure.

India's mission plan.

looks forward to getting back into another one. Patience is needed in this area, as battery technology will advance.

One of the most difficult-to-tackle questions is the adaptability of electric vehicles in mass market. In the words of Alejandro Agag of **Formula One** and Formula E fame, "People don't view electric cars as cool or exciting, and they don't believe they can work for their needs." This is one of the main barriers preventing the growth of the industry.

But through entertainment, sporting competition, and investment in R&D, Formula E can help change this. This barrier is explained by Simon Sinek and his law of diffusion. In a TED talk, he says that a product's success in the mass market consists of 2.5% innovators, 13.5% early adopters, 68% majority or mass market, and 16% laggards. The law of diffusion of innovation tells us is that if you want mass-market success or mass-market acceptance of an idea, you cannot have it until you achieve this tipping point between 15 and 18% market penetration, and then the system tips.

Formula E, starting in September 2014, can be the catalyst for change. According to a survey report, Formula E will accelerate the market penetration on the tipping point theory. Formula E has an overall strategy to encourage technological innovation, social awareness, and infrastructure development. According to a Formula E holding commission 2013 report, Formula E will help break down the current barriers, contributing to additional sales of up to 77 million electric vehicles worldwide by 2040.

In the words of the Indian government itself: "The national mission for electric mobility is an investment for our future generation." Electric mobility can transform the automotive and transportation sector by reducing dependence on fossil fuels. The national mission for electric mobility has national energy security within it.

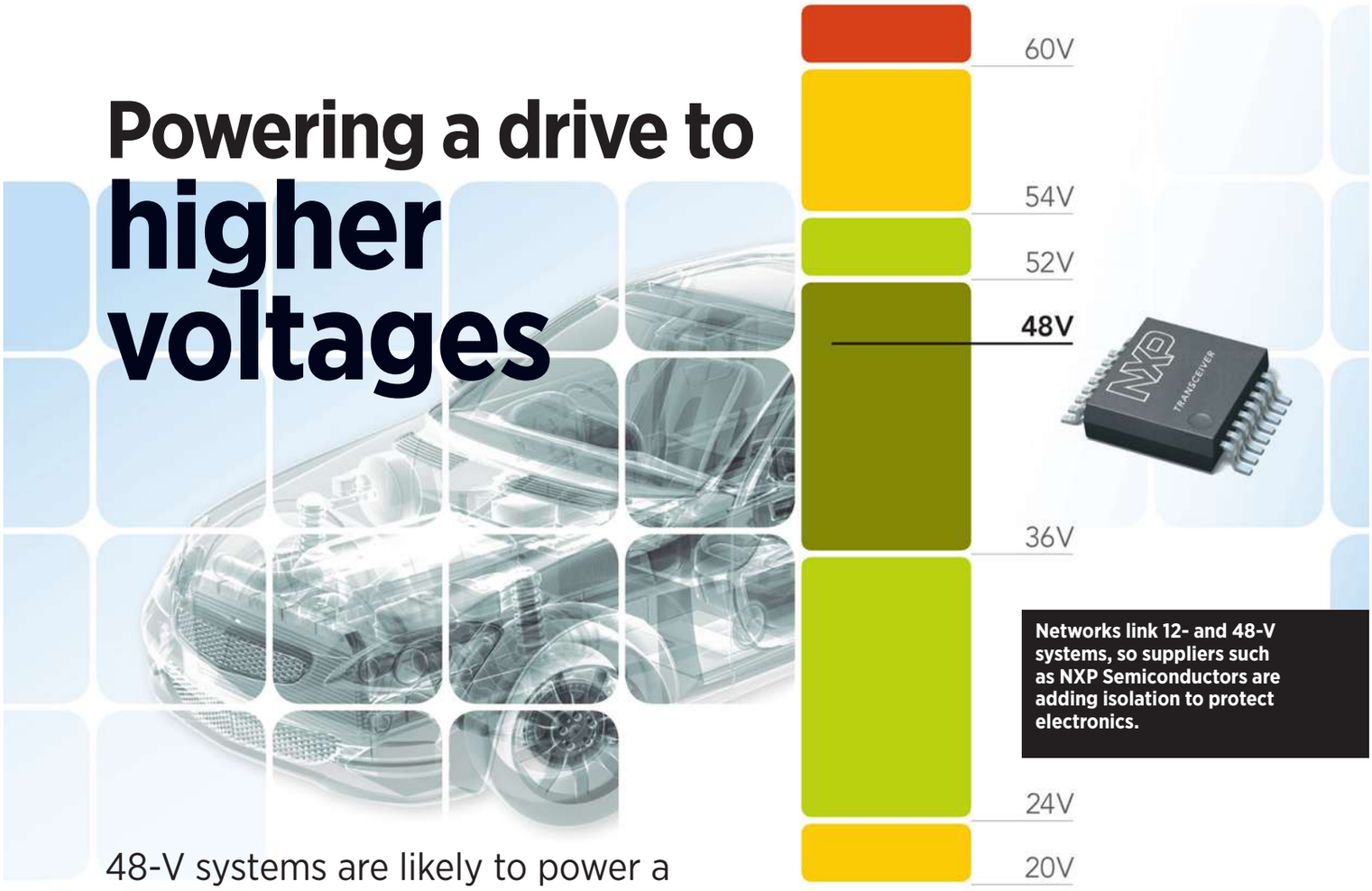
Surely there are and will be other solutions available in the market, and there are many configurations of hybrid and electric vehicles. The market is big enough to support all the solutions, and people making more informed choices.

But none of this is going to happen quickly, so in the near future the world's car fleet is likely to comprise a broad mix of powertrains. "Survival of the fittest" will prevail. ■

Vibhor Jajoo

Vibhor Jajoo is a graduate of mechanical engineering from Indian Institute of Technology, Varanasi. He is interested in sustainable development of the transportation sector in India. He can be visited at www.jajoovibhor.co.nr.

Powering a drive to higher voltages



Networks link 12- and 48-V systems, so suppliers such as NXP Semiconductors are adding isolation to protect electronics.

48-V systems are likely to power a new generation of functions including stop-start technology.

by Terry Costlow

A push to convert conventional automobiles to high-voltage power systems was a flop in the 1990s. But a number of factors have prompted many technical strategists to once again promote the benefits of higher voltages.

This time, 48 V will be an auxiliary power architecture, not the sole power architecture. Most electronic components will continue to leverage the huge 12-V infrastructure. Stop-start is a major driver, though many other functions are creating demand for higher voltages.

"Today, 48-V systems are offering the OEM [an opportunity] to implement functions that are difficult to realize with 12-V batteries," said Joseph Notaro, Vice President, Global Automotive Sales and Applications, **Fairchild Semiconductor** GmbH. "It allows for passive coasting—shutting down some cylinders at cruising speeds—and allowing several convenience loads (such as air-conditioning) to function during stop-start operation."

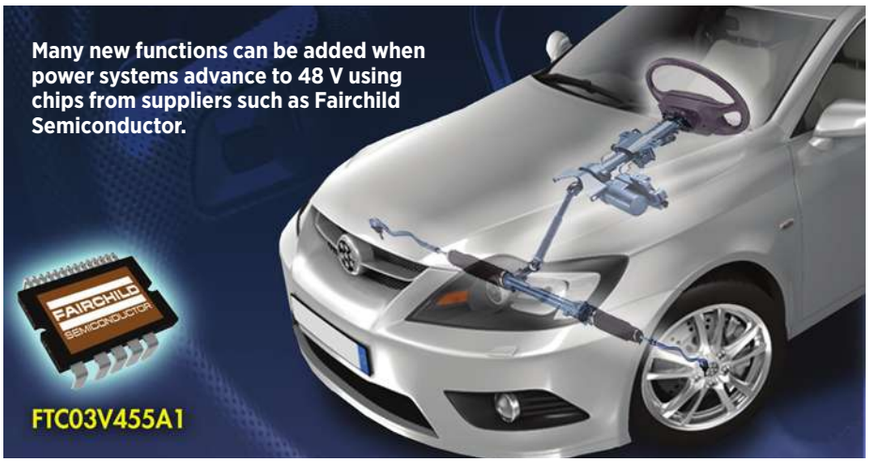
Many observers link the emergence of 48-V power systems to stop-start technology, sometimes considered a mainstay of microhybrid technology. Stop-start capabilities are expected to see significant acceptance in North America in coming years, following a trend that's well under way in Europe. Compared to hybrids, stop-start technology is relatively inexpensive, and it provides fuel savings that are significant and fairly easy to justify.

"A microhybrid can provide a better economic return than a hybrid because it avoids high voltages and all the cost that entails," said Craig Rigby, Vice President of Product Management and Strategy at **Johnson Controls** Power Solutions. "Microhybrid technology 48 V will impact the cost, but it's hundreds of dollars more instead of thousands more for a hybrid."

Just as they led the way with stop-start technology, Europeans are expected to spearhead the adoption of 48-V technology.

"In Europe, microhybrids still use 12 V, but the five largest OEMs are looking at 48 V," said Jifeng Qin, Product Manager for Automotive MOSFETs (metal oxide semiconductors field effect transducers) at **International Rectifier**. "Several Tier 1s have started building 48-V systems. They will start ramping up in 2017, hitting the market in mass production in calendar year 2018."

The transition to 48 V lets design teams add more fuel-saving techniques. Higher voltage ensures that there's enough power for all



Many new functions can be added when power systems advance to 48 V using chips from suppliers such as Fairchild Semiconductor.

functions even when the engine is constantly being restarted in rush-hour traffic.

"The introduction of 48-V bus for mild-hybrid diffusion is enabling more options for new electric functions such as power steering, interior heating, and electric cooling systems," said Gaetano Pignataro, Technical Marketing Manager at **STMicroelectronics** Power Transistor Division. "The 48-V bus is now strategic and not only linked to simple load increases as it was some years ago."

Though the adoption of stop-start technology is expected to help increase the role of 48-V systems, not all U.S. companies are jumping on the bandwagon. Some plan to use 12-V systems, noting that European automakers have fared well with the combination of 12 V and stop-start.

"Depending on which OEMs you're talking to, some are pretty skeptical and some have a renewed interest, saying there's no other option," said Ron Timmermans, Product Marketing Manager IVN, CAN Segment, **NXP Semiconductors**.

Isolationist policies

When automakers add 48-V systems, they have to ensure that voltage surges from these systems don't damage electronics that run on 12-V buses. For 12-V systems, the breakdown voltage for surges is 40 V. It rises to 75 V for 48-V batteries, forcing chip makers to redesign some power devices.

"MOSFETs and other power devices for 40-V breakdown voltages are very mature; now devices have to go well beyond that level," IR's Qin said. "We're already working on a 100-V platform. That's not an easy task, especially when you're talking about meeting automotive requirements."

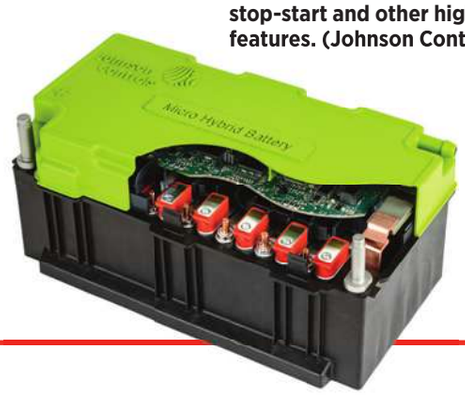
Typically, networking cables will be the link that opens the channel for these surge voltages. That puts some of the onus for isolation on suppliers of networking chips. Many of them have already geared up for the move to high-voltage architectures.

Batteries go to the mat for higher voltages

Automotive battery technologies used in mainstream internal-combustion-engine vehicles haven't changed significantly in several decades, but that's likely to change if 48-V technology emerges as expected. Absorbed glass mat (AGM) technologies can provide higher voltages while retaining most of the pricing benefits of conventional lead-acid batteries.

AGM batteries also mesh better with the demands of stop-start systems that are expected to take off in the U.S. after seeing solid acceptance in Europe. Stop-start has already fueled major changes in lead-acid batteries. AGM technologies accept charges far more readily than conventional lead-acid types do, so lifetimes aren't as negatively impacted by the discharge/recharge cycle.

Equally important, AGM batteries cost far less than lithium-ion technologies used in many hybrids and electric vehicles. Many feel AGM can be a mainstay in 48-V systems, although Li-ion may play a greater role as stop-start technologies evolve.

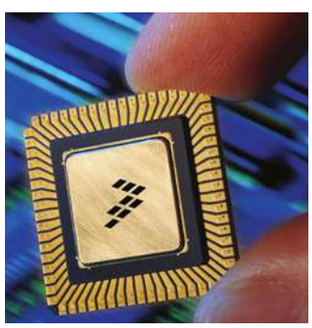


Better batteries are critical for stop-start and other high-power features. (Johnson Controls)

"Better batteries are a key enabler," said Craig Rigby, Vice President of Product Management and Strategy at **Johnson Controls** Power Solutions. "AGM lead-acid batteries are well-suited for stop-start; most European companies use AGM now. Lithium-ion is more beneficial for OEMs that want to take advantage of brake regeneration. Li-ion can accept power more readily than lead-acid can."

The **United States Advanced Battery Consortium** is giving 48-V technology a big push. In 2013, the group (operated by **Chrysler**, **Ford**, and **General Motors**) issued a request for proposal information for the development of advanced 48-V batteries for mild-hybrid vehicles.

Developers are also striving to make battery controllers that can operate with any voltages, from basic 12-V systems to higher-voltage systems for electrified powertrains. Reducing development time is a major goal for any new technology. If ECU designers create control platforms that can be altered by changing only software, time to market and cost will both be reduced.



Battery-management systems from Freescale will address a range of voltages.

"You want the battery-management device to be agnostic when you go beyond 12 V. Whether you're going to 400 V for a hybrid or EV or using 48 V, the battery-management systems should be the same," said Jaime Pla, Analog Power Products Operations Manager at **Freescale**. "That way, engineers don't have to learn about new silicon.

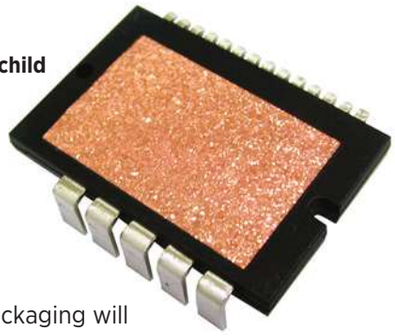
Terry Costlow

Powering a drive to higher voltages

Stop-start systems help automakers trim emissions. (STMicroelectronics)

MOSFETs from International Rectifier help automakers migrate to 48 V.

Power devices from International Rectifier are being redesigned to meet automakers' high-power requirements.



Power devices from Fairchild Semiconductor can be combined in modules to reduce size and simplify manufacturing.

"You've got some ECUs working on the high-voltage side and some ECUs working on the low-voltage side, but they've still got to communicate," NXP's Timmermans said. "If there's a breakdown or ground loss, ECUs connected by the same CAN bus can see significant changes in voltage on the CAN bus. We've integrated isolation on CAN transceivers to prevent this type of high-voltage breakthrough."

High-voltage surges are not the only worry for designers. When engines shut down, voltages can drop below acceptable levels. Drivers won't accept any disruptions when engines are shutting down and restarting. Radios and displays can't turn off.

"Start-stop is a critical step towards improving fuel efficiency, but the challenge is that when this mode is engaged, the battery voltage can dip as low as 3 V to 4 V, and all downstream electronics must be modified to operate through this mode," said Jim MacDonald, Marketing Director for **Texas Instruments**' Infrastructure Power Business Unit. "Automotive manufacturers are developing start-stop stabilizer systems that are designed to protect downstream equipment from disruption of the battery voltage."

Many devices

The transition to high voltages is forcing suppliers to rethink many different technologies. Even if 48 V becomes a standard technology, 12-V components aren't going to go away. That means voltages must be converted from 48 to 12 V.

"You've got to have good dc-to-dc converters so you can get the 12-V levels you need for the radio, LEDs, and other things that will remain at 12 V," Qin of IR said.

Packaging will also change. Multichip packages, already common in the world of power devices, will continue to evolve to meet changing demands. Combining power devices and power conversion controllers is on International Rectifier's road map.

"Integration is a key trend," said Qin. "We want to combine the MOSFET and the driver that basically syncs with the converter so you can get the voltage you need. We have discrete solutions, but we're working on ways to integrate two MOSFETs and a driver into one package."

Other companies are also focusing on power modules that house several power devices, drivers, and passive components. Going forward, a single molded package will hold many components, giving system designers many benefits.

"Modules bring several advantages in standard and mechatronic applications: more efficient electrical coupling with the mechanical load, less power losses, higher efficiency, increased system reliability, and simplified system manufacturing and assembly," Fairchild's Notaro said. ■

Designing for downforce

The 2014 Camaro Z/28's rear spoiler was modified with a "wickerbill"—a small, vertical tab at the edge of the spoiler—that allows the car to handle turns at higher speeds and have greater overall high-speed stability.

Airflow is paramount for performance vehicles, which require aerodynamic enhancements to promote high-speed stability and greater cornering capability.

by Ryan Gehm

Aerodynamics currently is a hot topic for the transportation sector, from passenger vehicles all the way to Class 8 trucks. Along with advanced powertrain technologies and lightweight materials, aerodynamics is an area receiving considerable engineering attention due to its potential for improving vehicle fuel efficiency—a major goal as stricter regulations loom for cars and light-duty trucks as well as medium- and heavy-duty vehicles.

But for cars that easily surpass the 100-mph (161-km/h) mark and feel as at home on the racetrack as on the road, airflow takes on added significance. Their speed potential must be complemented with the appropriate aerodynamic solutions to keep such cars safely and firmly planted to the driving surface at high speeds.

Following are details of two recently announced performance vehicles—the **Ferrari** 458 Speciale and the **Chevrolet** Camaro Z/28—that place particular emphasis on design for downforce.

Active aerodynamics for special Ferrari

Ferrari revealed at the 2013 Frankfurt Motor Show a new special-series sports car, the 458 Speciale, to join stable mates 458 Italia and 458 Spider. Derived from the 458 Italia, the new berlinetta (i.e., sporty coupe) embodies an even-greater focus on performance and boasts an abundance of advanced technologies not just in the powertrain and chassis, but also in the finer details of its body.

"The engine, in which we have put a lot of **Formula One** technology, is not the only news in this car," Ferrari Chairman Luca di Montezemolo said at the Frankfurt reveal. "We have a very innovative, patented active aerodynamics. This is Ferrari technology and is completely new on the market."

Mobile aerodynamic solutions at the front and rear of the car ensure that different aerodynamic configurations can be adopted in cornering, where maximum downforce is required, and on straightaways, where drag must be minimized. The 458 Speciale has a downforce (Cl) value of 0.53, along with a 0.35 Cd.

At the front of the car are two vertical flaps in the center and a horizontal flap below them. The company explains that at relatively low speeds, the vertical flaps are closed, channeling air into the radiators for engine

The Z/28 features rocker moldings and unique wheelhouse extensions that help push air past the tires. Deflectors at the bottom-front corners of the front wheel flares take the place of a conventional air dam.

Designing for downforce

Ferrari 458 Speciale's performance specs are impressive: a weight/power ratio of 2.13 kg/PS, acceleration from 0-100 km/h (0-62 mph) in 3 s, and maximum lateral acceleration of 1.33 *g*. Aerodynamic refinements were necessary to complement such performance.

By repositioning the tailpipes, Ferrari engineers could design a new diffuser that optimizes the extraction capacity of the underbody, increasing downforce (Cl) value by 6.5 points.

Turning vanes at either side of the front bumper are designed to slow the airflow and increase downforce, shifting the aerodynamic balance 4% over the front.

cooling; but at speeds in excess of 170 km/h (106 mph), the flaps open to reduce the volume of air flowing into the radiators, thereby cutting drag. Above 220 km/h (137 mph), the horizontal flap lowers to balance downforce between the front and rear axles, leading to a 20% shift in overall downforce toward the rear, Ferrari claims.

Turning vanes at either side of the front bumper are designed to slow the airflow and increase downforce, shifting the aerodynamic balance 4% over the front, according to Ferrari. Aerodynamic fins ahead of the rear wheels increase downforce in a similar fashion as the front turning vanes.

Ferrari engineers developed a rear spoiler with a larger surface area and more pronounced shape, which improves underbody efficiency and also increases downforce by 7 points. And by repositioning the tailpipes, engineers could design a new diffuser that optimizes the extraction capacity of the underbody, increasing Cl by 6.5 points.

Flaps at the rear of the 458 Speciale have two configurations: raised for higher downforce and lowered to minimize drag. Sensors and a specific algorithm allow the flaps to be lowered by as much as a 17° angle, thereby stalling the diffuser and reducing Cd by 3 points, the automaker claims.

The Ferrari Style Center collaborated with **Pininfarina** on the car's racing-inspired styling. Most of the body panels have been redesigned without modifying the passenger cell or the signature design features of the 458 Italia. Glass thickness has been reduced to cut weight, and the rear windscreen is now a Lexan (from **SABIC Innovative Plastics**) polycarbonate panel. The composite bumpers were redesigned, and the front hood features two deep air outlets to channel away the air exiting the radiator.

Aero-focused Camaro Z/28

The new Camaro Z/28 is the fastest factory-produced Camaro ever on a track, posting a lap time at Nürburgring that was 4 s faster than the Camaro ZL1's and beating published times for the **Porsche** 911 Carrera S and the **Lamborghini** Murcielago LP640, according to **General Motors**.

To accomplish such a feat, GM engineers had to focus on more than just what was under the hood; they had to modify numerous exterior elements compared to the Camaro SS to improve downforce. These modifications help press the Z/28 to the ground with 440 lb (1.96 kN) more force at 150 mph (241 km/h) than the SS model, which generates slight lift at that speed.

(To read more about the whole vehicle, go to http://articles.sae.org/12583.)

"Most production cars are designed with some lift at speed in order to slip through the air for greater fuel economy, but the all-new Camaro Z/28's track-oriented purpose dictated an entirely different take on airflow management," said Tom Froling, Lead Development Engineer–Aerodynamics. "Its carefully tailored aerodynamics package generates downforce for greater handling stability at speed, and the grilles are optimized to meet stringent cooling flow and brake-cooling requirements."

A functional carbon-fiber hood extractor not only increases engine cooling but also provides a path for air channeled through the grille to exit out the hood and over the car. Without the vent, the air would be pushed out the bottom of the engine compartment, possibly generating lift.

The Z/28 shares0 several racing-inspired aero features from various Camaro and Corvette racecars, Froling noted. A front splitter that provides downforce at the front of the car is designed to withstand 250 lb (1.11 kN) of force at its tip. The splitter is matched with an aero closeout panel under the front of the engine compartment, along with molded-in aero features forward of the front wheels.

To meet downforce requirements for Z/28, the rear spoiler used for Camaro SS was modified with a "wickerbill"—a small, vertical tab at the edge of the spoiler. The "minor" change adds about 28 counts of drag, improving rear lift performance by 70 counts, according to GM.

A functional carbon-fiber hood extractor—similar to the one featured on the Camaro ZL1—not only increases engine cooling but also provides a path for air channeled through the grille to exit out the hood and over the car. GM notes that without the vent, the air would be pushed out the bottom of the engine compartment, possibly generating lift.

The Z/28 underbody incorporates a belly pan that helps reduce front lift and also contributes to drivetrain cooling. Modified NACA duct profiles draw air into the underbody tunnel area to provide extra cooling for components affected by the engine's exhaust thermal energy. Unique wheelhouse liners with closeouts also assist with airflow.

The fog lamps, air dam, and upper grille found on the front fascia of the Camaro SS are replaced with covers, an air duct support bracket, an airflow-optimized upper grille for enhanced cooling, and a modified fascia lower inlet that helps funnel air from the splitter/lower grille through ducts to the brake rotors and calipers.

Engineers employed CFD, reduced-scale rolling wind-tunnel testing, full-scale clay models, and full-size prototypes tested in several wind tunnels, including GM's facility in Warren, MI, for the aerodynamic development of the new Z/28. ■

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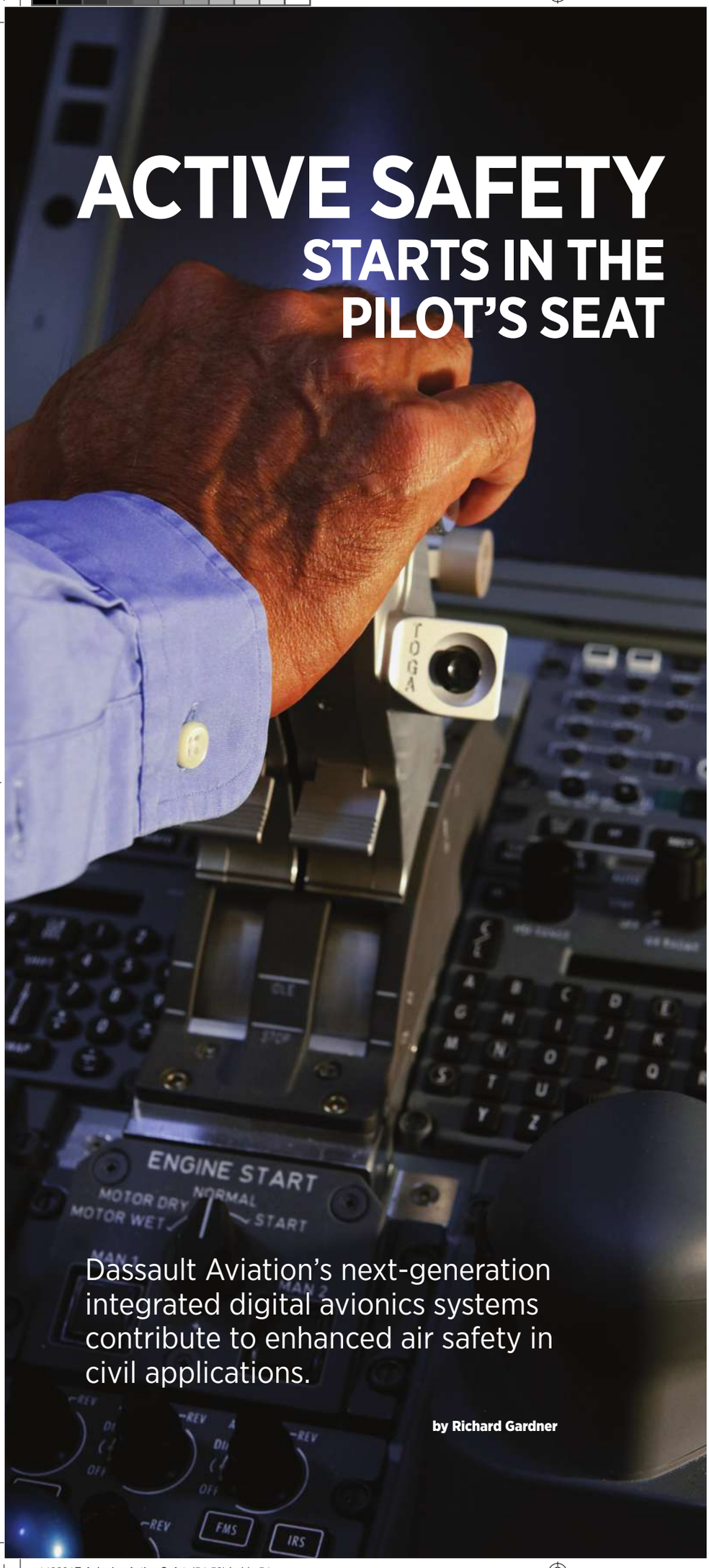

Dassault Aviation's next-generation integrated digital avionics systems contribute to enhanced air safety in civil applications.

by Richard Gardner

As the basic configuration of any new business jet is likely to differ little in comparison to rival airplanes, the key to making a significant leap forward in technology while offering a competitive advantage is, for the immediate future, always going to be found beneath the skin, rather than in its shape.

Increased safety is paramount in any new aircraft program, and modern digital avionics has considerably eased the pilot workload over the years, though the sheer quantity of data that is available in flight now brings additional challenges in the cockpit.

Throughout the flight regime, enhanced pilot situational awareness (SA) is generally thought to be one of the most important requirements to avoid information overload and to make for safer flight, and this is where **Dassault Aviation** has concentrated a major proportion of its efforts on its new aircraft. In doing so, it has also shown the likely future direction that the wider commercial airplane market will take.

Bizjet evolution

When the tri-jet Falcon 7X first arrived, it introduced digital flight controls, side-sticks, and a host of other features that combined to make that aircraft the most technologically advanced business jet then available. No longer could it be said that the business jet sector was lagging behind the major mainstream commercial giants and that executive jets were less capable.

Dassault has steadily enhanced its Falcon family, leading up to the most recent 5X announced late last year at NBAA. Designed to offer pilots a comprehensive integrated package of avionics solutions that allow safe passage through the most difficult situations and environments, the new flight deck environment increases SA well beyond what was available even a short while ago.

The Falcon 5X is a beautifully proportioned shape, but in the cockpit it offers features designed to make the

Falcon 5X's EASy flight deck features 32% more window area, dual-HUD capability with Synthetic Vision System and Enhanced Vision System, and an electronic flight bag that is integrated into the front panel.

The Falcon 7X's EASy II instrument.

flying experience as safe and easy as the system name suggests—EASy II. This latest development of the Falcon's avionics suite, a cooperative initiative between Dassault and **Honeywell**, is claimed to be the most advanced flight deck system in civil aviation today, adding more features and functionality to meet the increasingly demanding safety requirements out beyond the next decade. It takes the avionics capability package even beyond what is currently offered in the **Airbus** A350 and **Boeing** 787.

Dassault is the primary systems architect and has concentrated its efforts on implementing its design philosophy on the hardware platform provided by Honeywell's Primus Epic system. The main Dassault focus has been on the man-machine interface to create a highly intuitive and interactive solution, which it believes is the key to maximizing SA and thus flight safety. Honeywell's Primus Epic product has established an enviable reputation for reliability and digital display quality and, working closely with Dassault, the company has adapted the basic system hardware to meet very demanding new objectives.

Avoiding overload

The "glass cockpit" concept transitioned very rapidly in commercial aviation, replacing familiar analog cockpit layouts to embrace the adaptability of multi-functioning displays and the flexibility to incorporate vastly more information, enabled by the digital revolution.

Today, even the smallest general aviation aircraft can come equipped with advanced digital displays and avionics systems. However, within the civil sector, following several high-profile air incidents, there is a growing view that information overload and perhaps an over-reliance on automation in the digital environment can sometimes present pilots with a very challenging situation, especially when things go wrong.

The debate continues as to where exactly the balance should be between systems that have a high degree of autonomous functionality and the need for pilots to retain a wider 3-D perspective, especially if the computer software is overwhelmed by conflicting data being input from damaged or non-functioning sensors. The problems can be compounded even more when the pilots are flying at night or in storms with few if any visual cues, such as a horizon seen through the cockpit windows.

But things are changing to reflect this concern, and one step toward a solution in the cockpit and incorporated in this latest iteration of the EASy flight deck on the 5X is to separate out the immediate priorities in presenting data for managing safe flight, and follow-up actions required later during the flight.

Of course, at all times key information must be available regarding the totality of the flight, both aboard the

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

aircraft and outside where the aircraft interfaces with such factors as airport activities, air traffic management, navigation, weather, and local terrain. But a more intuitive approach on the flight deck can deal with these factors in a logical sequence and help the pilots to react quicker by giving them exactly what information they need, when they need it.

Dassault refers to this as tactical and strategic decision making by the pilots. Developments in avionic systems now allow all the information required by the pilots, from pre-flight checks to final shut down, to be shown automatically, in the right sequence, but presented in a way that makes it easier and safer for the pilots who remain in full control of the aircraft at all times.

The latest EASy II system aims at doing just this, and such is its potential. Four 14.1-in multifunction display units (MDUs) in a "T" configuration can show all the information from the aircraft sensors affecting systems, communications, navigation, and flight management and are key to the pilots' control over those functions.

The two outboard screens are directly in front of the pilots and are dedicated to short-term "tactical" information essential to piloting the aircraft. The traditional presentations are permanently accompanied by data on engine parameters, aircraft configuration, and a crew alerting system.

Two inboard MDUs are stacked vertically in the center of the cockpit to be visible to both pilots and are configurable so they can show selectable "strategic" information. Typically, the upper MDU would be used to control and display navigational functions, with the lower MDU handling the flight management system, systems pages, and checklists.

A new feature is the interactive nature of the automated checklists. As soon as an action has been performed it is automatically checked off through auto-sensing and changes color from blue to green and then opens up the next item on the checklist. It also provides secure options to override or defer any item if need be.

EASy checklists are linked to synoptic system displays. For example, if a fuel-related item is selected on the checklist, a fuel system diagram will pop up adjacent to the checklist window. It shows the real-time position and operation of pumps and transfer valves with a graphic description of fuel quantities in each tank.

Navigation aids

The EASy II avionics package incorporates technologies on the leading edge of navigation capabilities. These include WAAS/LPV GPS guidance to provide horizontal and vertical guidance down to 200 ft, near Cat 1 minima, so non-integrated logistic support (ILS) equipped or operating runways can be used with greater safety margins. This is a particularly important benefit on the 5X, which can fly international sectors but is not limited to the use of long commercial airport runways. Many serious air accidents involving flight into terrain occur in poor weather or at night while attempting to use airports close to mountains or locations with tall structures or potentially dangerous features nearby.

XM Weather, using NexRad satellite imagery, gives weather information and warnings of winds aloft, storm tops, lightning, and clear-air turbulence. Pilots can use these data to plan in flight for diversions to avoid challenging weather. The navigation package also gives automatic descent mode in the event of cabin depressurization at high altitudes. This will take the aircraft down to 15,000 ft where there is sufficient oxygen for crew recovery.

Other features included within the EASy II system include paperless charts and an improved flight-management system. A new Honeywell RDR 4000 radar will give additional range for alerting pilots to hazardous weather conditions up to 320 mi away.

For flight planning, the graphically based intuitive displays can be selected by either pilot calling up a menu by clicking on an icon depicting the phase of flight (for example, initialization, climb, cruise, and descent). The system requires very little data entry (and therefore distraction) as most of the information will be prestored in the databases. These include worldwide data covering airports, airways, navaids, and radio frequencies as well as a complete aircraft performance database.

EASy II can automatically calculate

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

The Falcon Simulation Bench comprises a cockpit mock-up coupled to a real-time simulator and a panoramic external visualization system depicting the artificial flight environment. It allows pilots to test all phases of flight, from takeoff to landing, and to fine-tune and validate control laws before the maiden flight of the aircraft.

everything required for the flight, such as takeoff performance and appropriate speeds for the runway length, through to climb schedules and landing distances. As the flight proceeds, EASy II provides updated information as required.

On descent the system can look ahead to show the best approach transition and other runway data and can incorporate air traffic control arrival instructions. All this can be done in seconds with the flight needing only the pilot to click on to the "current settings" on the menu, or making new selections.

Other windows can be opened up to show additional display data and key performance information, such as landing weight, runway length, and optimum approach speed. The upper MDU is usually used to show terrain data if flying in mountainous regions, and pilots can zoom in or out and select the map orientation.

Another development that has been taken to a new, higher level of functionality in the cockpit of the 5X is the use of user-friendly hand controllers.

The cursor control device (CCD) is the pilots' primary means of controlling the flight deck on this aircraft, with Windows-like pull-down and pop-up menus using the trackball controller. Each pilot has an individual controller located at the side of the central pedestal, giving a comfortable and natural position for the hand. It is claimed to be as easy to use as a PC mouse and also has fingertip controls for displaying switching and menu selection and multifunction knobs with a push-to-talk function.

A great deal of design development has gone into the ergonomics of this system, and using the CCD is said to be fast and intuitive, and hardly affected by changing environmental conditions such as darkness or turbulence. Dassault says that the system allows pilots to control every function faster without diverting their eyes from the panel, as is the case with pedestal-mounted keyboards. This translates into more head-up time, which is safer.

The company says that this new design as a whole contributes greatly to increased SA. By limiting the time spent entering data into a flight-management system and the common workspace, the crew can work better as a team. Dassault says that the key benefits of the EASy II are: intuitive man-machine interface, improved crew coordination, reduced pilot workload, and a better informed crew.

Focus on 5X

Dassault has built into the Falcon 5X flight controls and displays experience not only from the Falcon family of business jets but also from the

ACTIVE SAFETY
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During the design of the Falcon 5X cockpit, engineers were able to take advantage of the company's Virtual Reality Center in Saint-Cloud.

advanced Rafale multi-role combat fighter. This is particularly important for it incorporates many thousands of hours of operational military flying aboard air combat planes, and this brings direct first-hand technological feedback that is unavailable to most other manufacturers of business aircraft.

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

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

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

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

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

As well as the SVS, the aircraft also has an enhanced vision system (EVS) with nose-mounted sensors that are fully integrated to give even further SA during takeoff, approach, and landing, and also during ground maneuvering at busy airports. This provides an image on the new-generation wide-angle **Elbit**-supplied HUD and on flight deck displays and gives an improved image of terrain near the airport and of the airport environment in conditions such as fog, haze, and at night.

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

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

IMPROVE INTERIOR PACKAGE DESIGN, INCREASE VEHICLE SAFETY, AND ENSURE INTERNATIONAL COMPLIANCE WITH THE SAE H-POINT MACHINE

A three-dimensional manikin that provides the physical representation of driver H-points, the ***H-Point Machine (HPM)*** is used to define and measure vehicle seating accommodations. Offering a deflected seat rather than a free seat contour as a reference for defining seat space, it is a vital tool in the design of interior packages.

Available through SAE International, the *HPM* is used in conjunction with SAE Standard J826 and is currently referenced in various federal and international regulations including NHTSA's FMVSS in the US and ISO standards. Utilized in testing for compliance to such regulations involving impact/crash, head restraint, or vision, it is the required safety certification tool for vehicle production in many countries around the world. Additionally, those who need to locate seating reference points and torso angles as reported by manufacturers employ the *SAE H-Point Machine*.

SAE provides comprehensive support for the *HPM* including, calibration, spare parts, and maintenance. And for advance design and research applications, the ***HPM-II*** is available, which includes reformed shells for a consistent and reliable fit in bucket seats, an articulating back for lumbar support measurement, and the ability to measure the H-point without using legs resulting in simpler installation.

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SYSTEMS THAT TALK TOGETHER, ARE EFFICIENT TOGETHER

Design teams take a holistic view, linking engines, transmissions, hydraulics, and aftertreatment systems to boost efficiency and performance.

by Terry Costlow

When engines and transmissions are tightly linked with good communications, there's more potential for downsizing engines to trim costs. (Perkins)

The need to trim fuel consumption and emissions is forcing design teams to take a broader look at equipment operations, linking various systems so they work together closely. Engines, transmission, hydraulics, and even aftertreatment systems share data so that demands and power output are coordinated for optimal performance.

Advanced electronics are being used to analyze ambient temperature and many other parameters making it possible to make the most of every drop of fuel. The benefits extend beyond fuel consumption, even extending component lifetimes by reducing friction.

"When the engine and transmission know more about the operating conditions of the other systems, the operation of the entire powertrain can be set to the most efficient point using data-based criteria rather than a generic set of rules," said Chris Mays, Senior Technical Specialist at **BorgWarner**'s Advance Engineering Group. "For example, the system can warm up faster for friction reduction as well as for aftertreatment conversion efficiency."

More powerful controllers also let OEMs customize installations. Typically, machine developers target specific characteristics related to transient response, smooth and stable equipment operation, or efficient use of equipment. ECUs ensure that engines stay near their sweet spot for longer periods so engines don't have to be oversized to meet peak requirements.

"The benefits are significant, as it is possible to automatically control the engine and transmission to operate in the most efficient points without compromising machine performance," said Mike Cullen, **Perkins**' Product Marketing Specialist. "It is also possible to monitor and anticipate machine load, which allows us to work with our customers when considering engine downsizing."

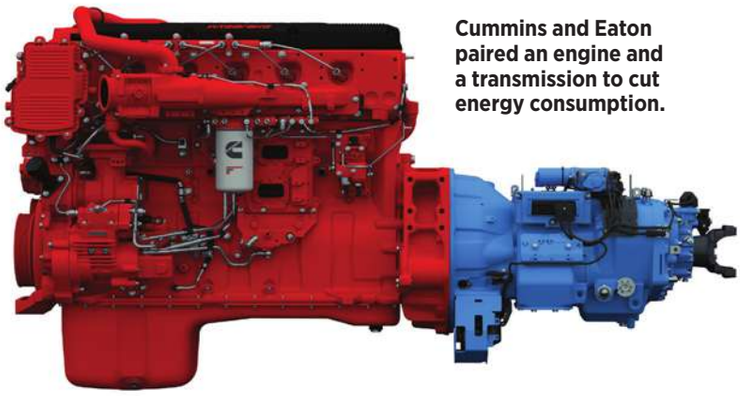
Smart shifting

This right-sizing extends to transmissions. With integrated controls, the transmission can reduce the worst-case condition to its mechanical limits. That lets the transmission maximize the engine's output.

"Active torque limiting allows lower cost transmissions without sacrificing reliability or durability," an engineering spokesman from **Cummins** said. "A transmission can sometimes be limited by having to avoid torque capacity in lower gears or by component stress during gear shifts. By using advanced electronics, the transmission has the ability to limit engine torque or power output when needed, but allow full or higher torque when possible."

The benefits extend to operations in the field. Engines can adapt to the varied conditions seen by equipment, providing optimal performance in a range of environments.

"Advanced electronics allow engine power curves to be optimized along with transmission capability to achieve the best efficiencies from each, particularly with changing environmental conditions, such as altitude, machine



Cummins and Eaton paired an engine and a transmission to cut energy consumption.

load, and ambient temperature," said James Krueger, Senior Sales Engineer at **MTU**. "Transmission life and engine life can both be extended in certain situations, for instance, where electronics allow engine torque-limiting or the transmission can 'teach' an operator to operate the engine/machine more efficiently."

The results can be significant for equipment makers striving to meet demanding expectations for fuel conservation. For example, matching a Cummins ISX15 engine with an **Eaton** Fuller Advantage Series 10-speed automated transmission improves efficiency and trims fuel consumption for on-highway vehicles.

"Sharing data allows the engine to determine the torque curve and power level to match real-time demand, providing additional torque when necessary and better fuel economy as a total unit," the Cummins spokesman said. "As a tangible example of benefits, the SmartAdvantage Powertrain offers customers a 3-6% improvement in fuel economy."

Sharing data, sharing power

Maximizing efficiency extends beyond the basic powertrain. Engines must also interact well with hydraulic systems. In many existing equipment designs, hydraulic systems sometimes apply loads faster than the engine can accept them. When electrohydraulic controllers and engine controllers communicate, performance and fuel consumption can be improved by managing how loads are applied to the engine.

"Typically, the load is applied and the engine reacts to changes in speed by lugging," the Cummins spokesman said. "The auxiliary device must be designed so it cannot lug the engine too low in speed or the engine speed must be increased to provide sufficient lugging capability to react. In a more integrated system, the engine can operate at low speed to save fuel when no load is applied, but then receive advanced communication prior to application of a load."

Engineers try to keep the engine running at its optimal rate when the engine isn't idling. When loads are added, it's not always optimal to have the engine or the hydraulic system work at a level that's very efficient for either system alone. The end goal for many design teams is to get the most overall efficiency.

"Instead of asking for an engine speed set-point to make the hydraulics most efficient, at the possible expense of engine efficiency, the machine could choose a point that means neither engine nor hydraulics are at optimal efficiency, but the net efficiency or productivity is maximized," Mays said.

Chips, sensors, and networks combine to enhance efficiency

When design teams link engines, powertrains, and hydraulics together to improve efficiency, they're employing a range of tools. Faster processors, real and virtual sensors, and multiple networks make it possible to improve performance and trim fuel consumption and emissions.

Equipment developers are leveraging the rapid advances of the semiconductor industry to meet growing demands for more information. Tighter regulations are also forcing design teams to keep adopting more powerful electronics in ECUs.

"Processor and data-handling capabilities are increasing to meet regulated diagnostic requirements and the needs of aftertreatment control," said Michael Pipho, technical lead at **John Deere Power Systems**. "While their capabilities are increasing, electronic control modules are generally becoming smaller in size for improved density."

Microcontrollers continue to make dramatic advances in speed and capability. Floating point math capabilities that were once costly are now offered on relatively inexpensive controllers. At the same time, the emergence of the Automotive Open System Architecture (AUTOSAR) standard may make it simpler to use a range of technologies.

"As the cost of floating point arithmetic processors drops, ECUs for subsystems can be upgraded from fixed point to floating point capabilities," said Joe Steiber, Principal Engineer for Engine, Emissions, and Vehicle Research at **Southwest Research Institute**. "This improves controllability without cost increases. Architectures like AUTOSAR are enabling decoupling of software layers and hardware layers of ECUs and increasing reusability and standardization between subsystem controllers."

A range of sensors is being used to provide real-world data so these controllers can make intelligent decisions. As the need for information becomes more acute, many design teams are using existing sensor data to collect data that previously required an additional sensor.

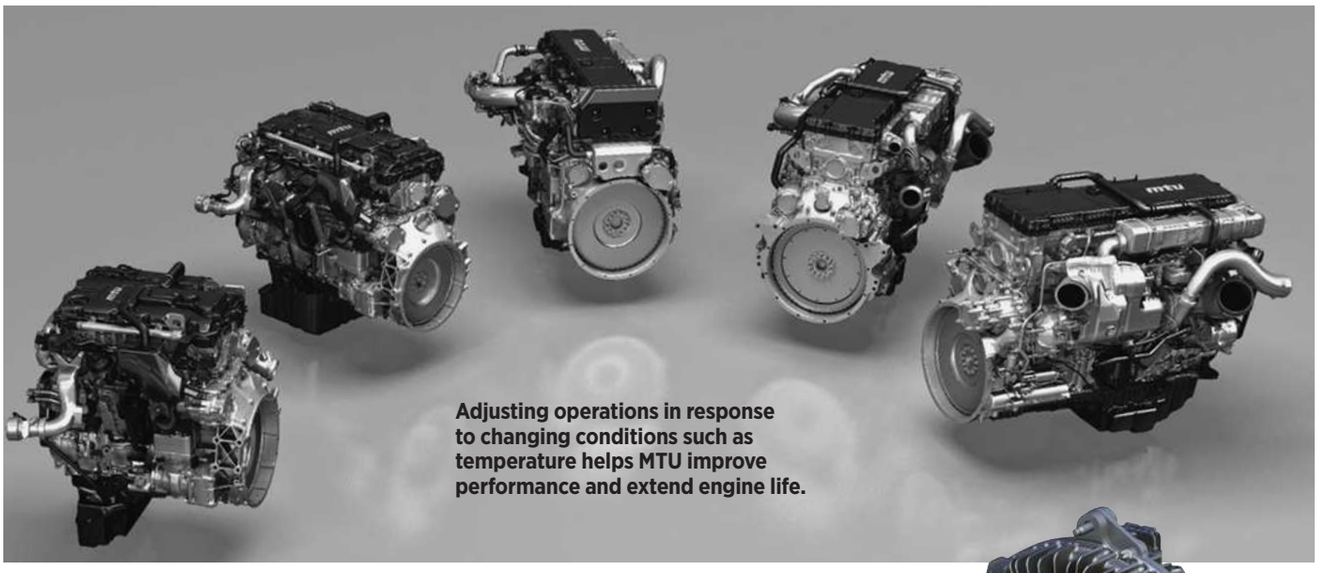
"Virtual sensors and model-based controls are made possible by this increased computing power and cannot only improve the quality of the control, these complex controllers and networks can also improve the long-term emissions compliance over the life of the vehicle," said Chris Mays, Senior Technical Specialist at **BorgWarner**'s Advance Engineering Group.

A number of networks link sensors and controllers from a range of systems, creating a holistic design that can improve overall efficiency. Standards bodies are helping engineers by updating existing communication standards such as **SAE** J1939, which now runs at 500K bit/second.

Terry Costlow

Linking hydraulic systems and engines lets controllers adjust engine speeds to keep Deere hydraulic operations running efficiently.

SYSTEMS THAT TALK TOGETHER, ARE EFFICIENT TOGETHER



Adjusting operations in response to changing conditions such as temperature helps MTU improve performance and extend engine life.

Deere links transmissions and engines to deliver power to tracks efficiently.

Intelligent controls from BorgWarner use real-time information instead of generic rules to adjust performance and improve efficiency.

Clean communications

For many design teams, tighter emissions regulations have expanded the definition of a powertrain. Aftertreatment systems are now a critical factor that impacts engine operations. Design teams must include treatment technologies as they optimize powertrain parameters.

"The aftertreatment system, engine, and transmission need to be optimized as a complete system instead of individual elements," Mays said. "For example, getting the SCR aftertreatment to its operating temperature quickly means that the engine can move to more efficient operation sooner. The engine needs to interact with fuel injection, throttles, and variable valve train components as well as the transmission to enable a rapid warm-up. This is a system decision to sacrifice lower engine efficiency for a short time to achieve a net overall system benefit for the full operation cycle."

When all these systems share information continuously, there is a lot of data traveling over networks. Getting the right data to each node at the right time is a challenging task. If the combined systems and networking links aren't considered as elements of a larger system, problems can arise.

"Another challenge associated with communication between the engine and transmission is obtaining accurate load information at very light loads," said Michael Pipho, technical lead at **John Deere Power Systems**. "Aftertreatment technologies also increase the amount of data on the network structure due to additional control requirements and the need to communicate aftertreatment information to operator interfaces. The increased sharing of data among systems can result in high network loading and cause some data latency issues."

Most developers are using a number of networks linked together using gateways. That provides the necessary bandwidth without adding a lot of complexity.

"As the engine subsystems develop, particularly those related to aftertreatment, it is necessary to use multiple networks separating machine and application data from subsystem monitoring," Cullen said. "One example is NOx sensors, which run on a different network to that of the machine. As the number of variables increase, the limitations of a network become apparent. To maintain a responsive system and avoid latency issues it is sometimes necessary to rethink the network architecture of a machine." ■

EU group develops electric 'Microsupercar' concept

An electric car is only as green as the electricity that powers it. And given that most power generators burn environmentally suspect fossil or nuclear fuels, it is noteworthy when someone develops an EV that can self-charge from the sun.

That's true even if the European Union's P-MOB micro EV concept can manage only 20 km (12 mi) on a full day's solar-power charge, and then only in sunnier regions such as southern Europe. But that should be enough range for many city travelers in Italy and elsewhere, said Pietro Perlo, a former **Centro Ricerche Fiat** (CRF) director and now principal at **Interactive Fully Electric Vehicles**, which is dedicated to urban e-vehicle development and local production.

The three-seat, solar runabout, which has a mass less than 600 kg (1323 lb) without a battery, has a top speed of 100 km/h (62 mph) and a fully charged range of more than 100 km (62 mi).

P-MOB is the product of a three-year, $6-million joint industry-university research program, partly EU funded and partly industry financed, that aimed to develop "Integrated Enabling Technologies for Efficient Electrical Personal Mobility." CRF-coordinated the research consortium, which included Germany's **Siemens**, Spain's **Mazel Group**, and the U.K.'s **University of Sheffield** and **Magnomatics**.

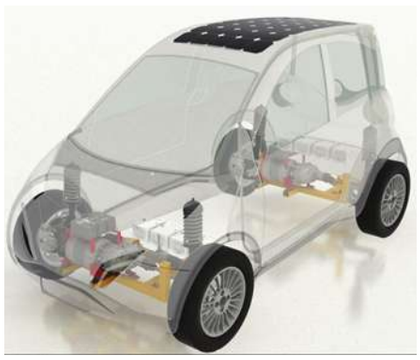
In sunny climes the P-MOB's 2 m² (22 ft²) of solar cells can generate enough juice for 20 km (12 mi) of range.

Micro EVs, such as the P-MOB, will soon be the fastest-growing e-vehicle segment in Europe.

P-MOB was accompanied by a parallel, $5.3-million (partially EU-supported) program that addressed the design and development of the basic building blocks of EVs and attempted to solve some specific technical shortcomings. WIDE-MOB, also coordinated by CRF, involved not only the P-MOB partners, but **Warsaw University of Technology**, France's **IFP Energies**, Swiss **DuPont**, and the French-Italian **STMicroelectronics**.

Safe as a tank

"Our goal was 'small and clean, but safe as a tank,'" said Perlo, who helped guide the project. "The P-MOB has met the highest safety ranking, a low footprint, and extremely low energy consumption, making the vehicle ideal for most people's needs in cities as well as on suburban roads." During track-testing this summer at Fiat in Turin, "the vehicle's performance met our expectations for the design," he said. "It showed very high stability on small radius curves and had an average energy consumption of around 80 W·h/km."



The EU's P-MOB microcar has a two-motor powertrain with independent batteries.

The design meets new European regulations on micro EVs, he noted, adding, "The idea of having a vehicle that with minor additions could meet both the homologation of micro electric vehicles and the classical M1 world is new." (M1 is a vehicle category, a car with eight passenger seats or fewer.)

Electric microsupercar

Although reducing system complexity while focusing on the essentials was key to lightweight design, "we're Italian, so of course we wanted to build an electric microsupercar,'" Perlo said. The little car thus has a good deal of style as well as four-wheel drive, precise handling, swift acceleration, and low-drag aerodynamics. The design may even presage some

The P-MOB's single, wide, dual-door side opening provides easy entry and exit.

trends in this expanding and changing car segment.

The problem with current fuel-burning microcars, Perlo said, is that they are "unsafe, inefficient, and very polluting." In Europe, quadricycles or 'q-cars' are defined as weighing 700 kg (1540 lb) maximum, though the category also extends to Japan and China. In the city car market, he observed, top speed is less important to drivers; a focus on the essential functions is what is required.

And it's only a matter of time until this market goes increasingly electric. Today micro EVs such as **Renault**'s Twizy, make up only a tiny fraction of the European car fleet, but exponential sales growth is expected in the next few years. Micro EVs are expected to be the fastest growing e-vehicle market segment. "By 2020, all **Smart** cars and most Japanese 'kei' cars will be electric-powered," he said. The Colibri EV micro-car, which was unveiled in the spring of 2013, has already netted 700 pre-orders for German firm **Innovative Mobility Automobile**, for example.

EV building blocks

The WIDE-MOB effort focused on design elements to boost the efficiency of the solely solar-powered city car and on developing more efficient solar cells, improved electric motor and magnetic torque control, better batteries, and adaptive technologies to enable e-vehicles to inject power back into the grid and home (V2G, V2H) when they have no need for it. Aerodynamics advancement was another goal; according to EU contract documentation, the team was to implement "embedded synthetic micro-jets that radically reduce the drag at any speeds."

The little supercompact has garnered some press attention, but interest has been mostly from Europe.

All the technologies were developed during the course of the project by the partners, Perlo said. The concepts have been patented. "Only the battery cells were produced outside Europe, though the design came from within the project."

The vehicle sits on a low-cost tubular frame stiffened with formed sheet-metal parts that was developed by the WIDE-MOB team for acceptable crash resistance. The bench seats serve as structural supports, a part of a full safety cage that has a single aperture on the side.

"We have two doors on one side only, which helps ensure a high degree of safety, better ergonomics, and reduced complexity with extremely low aerodynamic drag, around 30% lower than similar size vehicles," Perlo explained. The facing double doors enable "easy entry for 90% of people."

Fail-safe propulsion

Perlo said that this project has had several funding stops and starts until it was completed last spring, but even in its initial stages in 2008, the P-MOB vehicle was always to have "two electric motors on two axles, a high stability, and fail-safe configuration...that has since been adopted by **Tesla** and others."

The integrated ICT-based control systems allow two motors and two differentials to operate simultaneously, providing independent axle actuation and therefore 4WD capability and the ability to alter torque ratio as driving conditions change. "The split-power provides for control, makes it easier to recover energy, and a fully independent fail-safe propulsion system," he said. The system enhances control on tight turns,

When parked, the P-MOB's solar cell sunshields can slide out to soak up sun and more range.

supplies more grip on wet and icy roads, and delivers quicker acceleration without drawing more power.

The plug-in supercompact EV features just under 2 m^2 (22 ft^2) of crystalline silicon solar cell panels on the roof and on solar windshield and window sunshades that slide out on the inside to soak up sun while parked. The car's photovoltaic arrays operate using smart diodes and self-adapting electronics to minimize energy loss during reduced-light conditions or malfunction.

Part of the P-MOB concept is that distributed battery packs separately power the motors. The photovoltaics feed into the front axle motor/battery whereas some of the rear battery modules—at 8 kg (18 lb) each—can be easily can be swapped out by hand in seconds.

"Who needs a fast-charging battery if you can just change out the batteries?" asked Perlo, an experienced practitioner who shares Leonardo da Vinci's view that "simplicity is the ultimate sophistication."

Steven Ashley

Steyr debuts CVT multiple-purpose tractors

Steyr took advantage of the biennial Agritechnica to debut its new Profi CVT (continuously variable transmission) series tractors. With the new Profi CVT series, Steyr has extended its tractor program with a CVT in the 110 to 130 hp (82 to 97 kW) power range. The Steyr-developed CVT is based on double-clutch technology and features two mechanical forward ranges and one reverse range.

Steyr engineers at its St. Valentin, Austria, location designed an intelligent power split concept that allows for speeds up to 50 km/h (31 mph) at a reduced engine speed of only 1750 rpm. The transmission also allows creeper speeds down to 20 m/h (66 ft/h).

All new Profi models are equipped with **FPT Industrial** engines with a turbocharger and intercooler as well as Steyr ecotech, featuring SCR exhaust aftertreatment to meet Stage III B emissions standards, and an intelligent control system for the engine-transmission-management. The 4.5-L, four-cylinder engines are equipped with an electronic common rail injection system. Due to a powerboost, an additional power output of 22 hp (16 kW) is available for transport and PTO applications.

Steyr's CVT series includes the models 4110 Profi CVT, 4120 Profi CVT, and 4130 Profi CVT with 110 to 130 hp (82 to 97 kW) rated power. The S-Tronic engine-transmission-management system is part of the standard configuration.

In terms of the Profi CVT's cab, an improved Multicontroller provides for simplified operation and optimum workplace ergonomics. The Multicontroller is fitted with backlighted operating keys allowing for easier and safer operation in the dark. Up to seven key functions of the tractor can be operated with just one lever, and only one button is needed for changes of direction.

With Steyr S-Tech, the engine and CVT, electronic hitch control, PTO, four-wheel drive, and differential lock, as well as additional controls and S-Guide auto steering, are all interlinked.

An improved Multicontroller provides for simplified operation and optimum workplace ergonomics. It is fitted with backlighted operating keys allowing for easier and safer operation in the dark.

Profi CVTs feature a new system for idling speed control. Thirty seconds after the operator has left the cab, the idling speed will automatically be reduced from 850 to 650 rpm unless either electronic remote valves or the hydraulic system are in operation. Fuel consumption is further reduced by means of a newly developed software function, lowering operating costs accordingly.

The window area alone offers 5.78 m^2 (62.2 ft^2) in the four-post design-cab. The integrated roof window allows for a 105° angle of vision on the front work space. Steyr also claims it is one of the quietest cabs in the tractor market, with a 69 dB(A) noise level and an optional cab suspension.

Front end construction and the central drive set of the new tractor design enable a steering angle of 55°, allowing for improved driving characteristics and a turning radius of just 4.04 m (13.25 ft).

An electric parking brake is standard on the Profi CVT and can be engaged or disengaged comfortably from the steering column. The parking brake is activated automatically when the engine is switched off, and disengaged when the tractor is started again. A pneumatic trailer brake, operated via the power-shuttle, is also part of the standard equipment.

The tractor's hydraulic system consists of an axial piston pump that delivers a high flow capacity of up to 125 L/min (4.4 ft^3/min), including pressure and flow regulation if needed.

The rear hitch is capable of lifting up to 7850 kg (17,306 lb), and the front hitch lifts up to 3100 kg (6834 lb). A maximum of seven electrohydraulic remote valves allow for the control of a wide range of functions.

Front hitch lifting configurations can be preset by means of a management program. When the respective working

To satisfy the more rigorous work site requirements, which result, for example, in more torsional moments, Steyr has developed the next generation of the municipal frame, which is used in the Steyr Profi CVT for municipal applications.

depth is reached during operation, the automatic load control of the front hitch activates the electronic float position, making the operation of front-mounted mowers more comfortable.

For tractors that are used in municipal operations, the front mounting space is one of the most important areas for the use of implements. Over the past few years, however, implement weights and implement reach have increased steadily. To satisfy the more rigorous requirements that result, for example with respect to torsional moments, Steyr has developed the next-generation municipal frame, which it has also introduced in the Profi CVT.

With the Steyr municipal combi-frame, fast mounting is possible in the front mounting space. Central to the system is a standardized quick-change plate, which can be fitted as an option with a front hydraulic combination. This makes it possible to use front-mounted implements safely and to minimize setup times when changing implements.

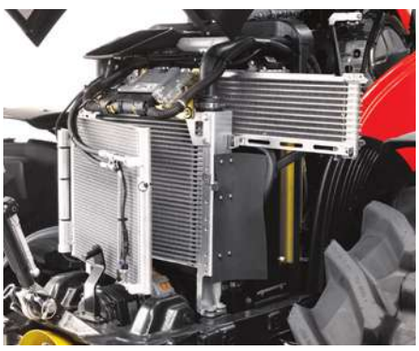
For the first time with Steyr municipal frames, "side-rails" are used for a more sturdy design and torsion-resistant construction. A new central support bracket, integrated in the combi-frame structure contributes to a buckle-resistant and torsion-free structure allowing heavy mounted implements with high torsional moments to be operated safely.

There is also an optimized rear-axle support. It guarantees optimum force transfer and avoids overloading the front-axle support, says Steyr. The use of snowplows/blowers and slope mowers involves high loads. To address that issue, the quick-changing plate has been enforced and additional struts added to the rear axle support structure.

With the municipal frame torsional moments of up to 52 kN/m (5.8 ton/m)—according to model—can be absorbed without difficulty.

In the front area, new adjusting strips are also used, making it simple to make a longitudinal adjustment to the municipal plate. As an option, there is also a new heavy-duty frame that is used wherever high lateral forces are to be expected, for example, where slope mowers have long side arms.

Jean L. Broge



All new Profi models are equipped with FPT Industrial engines with a turbocharger and intercooler as well as Steyr ecotech, featuring SCR exhaust aftertreatment to meet Stage III B emissions standards, and an intelligent control system for the engine-transmission-management.

Deere's updated skid steers and compact track loader

John **Deere**'s newest additions to its E-Series line of skid steer loaders and compact track loaders (CTLs) include two skid steer models (318E, 320E) and two CTL models (319E, 323E). These are in addition to other larger-frame models introduced earlier in 2013.

The machines include upgraded boom performance; auxiliary lines that are integrated through the boom for improved visibility and added protection; and cab improvements aimed at improving operator and machine productivity, uptime, and lower daily operating costs.

According to Gregg Zupancic, Product Marketing Manager, John Deere Construction & Forestry, the mid-frame models provide contractors more choices when choosing a skid steer loader or CTL, adding that the E-Series is "customer inspired."

Deere says it is offering all major control patterns on the new models to meet customers' specific needs, including traditional hand and foot controls, hand-only controls, or low-effort, electrohydraulic joystick controls in both the ISO and "H" patterns. The E-Series features an option that allows the operator to switch between all three industry control patterns so operators can choose the control pattern they're most comfortable using.

The mid-frame models also include improvements that enhance performance and make the machines more

Deere's newest additions to its E-Series line of skid steer loaders and compact track loaders include two skid steer models (318E, 320E) and two compact track loader models (319E, 323E).

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In addition to standard improvements, the mid-frame E-Series models offer several options that enhance productivity, says Deere.

versatile. An optimized boom design offers greater reach at truck-bed height and increases lift height to the hinge pin.

Other new features include connect-under-pressure auxiliary hydraulic couplers and courtesy lighting that stays on up to 90 s after the engine is shut down, illuminating the way for easier exits out of dark barns or after-hour job sites.

In addition to the standard improvements, the mid-frame E-Series models offer several options that enhance productivity, including a new keyless-start sealed-switch feature with an anti-theft system and a ride control option that features shock-absorbing boom cylinders that cushion bumps, helping retain full bucket loads to the intended destination and help navigation over rough terrain. Another option gives customers the ability to convert the foot throttle pedal into a decelerator pedal for increased productivity in dozing and loading applications.

The mid-frame models boast several customer-favorite features from their D-Series predecessors, including a pressurized cab with best-in-class visibility, auto-idle to help conserve fuel, and best-in-class service access. In addition, industry-leading options such as the reversing fan can be set to automatically reverse to clear core-clogging buildup.

The 318E, 320E, 319E, and 323E are powered by **Yanmar** Final Tier 4 diesel engines. The engines in all E-Series models feature cooled EGR with an exhaust filter consisting of a diesel oxidation catalyst and diesel particulate filter.

Jean L. Broge

Volvo CE's new short swing radius excavator

With a weight of 2.5 ton (2.3 t), the ECR25D compact excavator from **Volvo Construction Equipment** achieves greater breakout and tearout forces—8453 lb (38 kN) combined—than the 2.8-ton (2.5-t) ECR28 excavator it replaces. It is also easy to transport from site to site. Total transport weight—including three buckets, a hydraulic breaker, and small trailer—is 3.5 ton (3.2 t).

Its narrow design enables it to work in confined areas and urban environments for such operations as electrical wire installation or water piping repair with limited impact on traffic or residential areas. For operations that require a bit more might, it can be equipped with an additional counterweight. In such applications, the tail radius minimally exceeds track width, preventing collision or damage.

The ECR25D is powered by a Tier 4 Interim, 20.9-hp (15.6-kW) three-cylinder engine. The 1.12-L engine features a bore and stroke of 3.07 x 3.08 in (78.0 x 78.2 mm) and a maximum torque of 53.2 N·m (72.1 lb·ft) at 1600 rpm. Contributing to fuel efficiency and lowering operating costs is an optional auto-idling system, which reduces engine speed when controls are inactive

This 2.5-ton (2.3-t) machine is particularly mobile and efficient, making it suitable for any application requiring small excavators.

The access area into the cab is large enough that operators can get in and out easily without bumping controls, and a flat, uncluttered floor offers ample foot space.

for over 5 s or when the left-hand console is raised.

Its hydraulic system includes a flow sharing main control valve that offers fast cycle times, while a load- variable displacement piston pump delivers flow on demand, lowering operating costs. Featuring a patented, multifunctional hydraulic oil filter, filtration occurs when the tank is filled or topped up and before the oil returns back via the drain lines.

The access area into the cab is large enough that operators can get in and out easily without bumping controls, and a flat, uncluttered floor offers ample foot space. An adjustable seat, ergonomic armrests, and efficiently positioned controls facilitate intuitive operation. The machine can be positioned quickly and easily, as slew and offset movements are controlled simultaneously via a proportional roller and joystick.

Large, hydraulic travel pedals provide the operator accurate, hands-free track control, while an automatic, two-speed travel function allows the machine to downshift when more effort is required. Low-speed mode can be enabled at the flip of a switch for more sensitive operations. Visibility is improved to the blade, digging equipment, and tracks—improving precision and job site safety. Whether equipped with a Volvo cab or canopy, three-point entry and rollover protection are standard.

All checkpoints on the ECR25D compact excavator are readily accessible at ground level and grouped under a wide-opening, lockable hood. Greasing need only be carried out every 50 h. A patented multifunction hydraulic oil filter/filler improves protection of the hydraulic system and provides early detection of oil pollutants.

The ECR25D is available with several packages, along with options such as long arm for enhanced working range or additional rear counterweight to better handle heavy attachments. Work tools can be installed via an optional attachment carrier (hydraulic or mechanical) available installed from the factory. Auxiliary hydraulic flows can be adjusted from inside the cab via the joystick for optimal attachment function.

Optional Volvo CareTrack remote telematics system provides owners information to optimize performance and maximize uptime, including geo-fence, geo-tracking, an engine on/off status monitor, and hourly-based work reports.

Jean L. Broge

SR-72 flies into 21st century at Mach 6

Lockheed Martin recently confirmed that its Skunk Works engineers are developing a hypersonic aircraft that will go twice the speed of the SR-71 Blackbird, called the SR-72. The SR-71 is renowned for having flown from New York to London in less than 2 h, a world speed record that exceeded Mach 3 and has remained unbroken for more than 38 years.

Unlike the SR-71, the SR-72 will not be developed with slide rules, protractors, and paper. The SR-72 will be managed by millions of lines of software code and powered by computers.

"Hypersonic aircraft, coupled with hypersonic missiles, could penetrate denied airspace and strike at nearly any location across a continent in less than an hour," said Brad Leland, Lockheed Martin Program Manager, Hypersonics.

For the past several years, Skunk Works has been working with **Aerojet Rocketdyne** to develop a method to integrate an off-the-shelf turbine with a supersonic combustion ramjet air-breathing jet engine to power the aircraft from standstill to Mach 6. The result is the SR-72, which will integrate an engine and airframe that is optimized at the system level for high performance and affordability.

Envisioned as an unmanned aircraft, the SR-72 with an intelligence, surveillance, and reconnaissance mission, would fly at speeds up to Mach 6 (six times the speed of sound). At this speed, the aircraft would be so fast, an adversary would have no time to react or hide.

"Hypersonic aircraft, coupled with hypersonic missiles, could penetrate denied airspace and strike at nearly any location across a continent in less than an hour," said Brad Leland, Lockheed Martin Program Manager, Hypersonics. "Speed is the next aviation advancement to counter emerging threats in the next several decades. The technology would be a game-changer in theater, similar to how stealth is changing the battle space today."

SR-72 is not the first hypersonic Skunk Works aircraft project. With **DARPA**, engineers developed the rocket-launched Falcon Hypersonic Technology Vehicle 2 (HTV-2). The HTV-2 R&D project was designed to collect data on three technical challenges of hypersonic flight: aerodynamics; aerothermal effects; and guidance, navigation, and control.

The SR-72's design incorporates lessons learned from the HTV-2, which flew to a top speed of Mach 20, or 13,000 mph, with a surface temperature of 3500°F. At those speeds, flight time between New York City and Los Angeles would be less than 12 min.

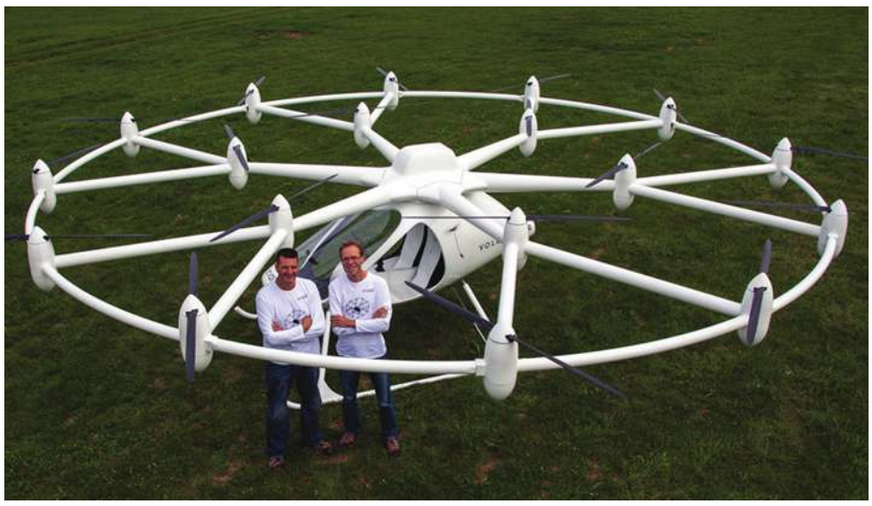
Lockheed Martin projects that the SR-72 could be operational by 2030.

Jean L. Broge

Hybrid copter is first of its kind

A small team of inventors in Germany is moving closer to first flight of its VC200 volocopter—a helicopter-like aircraft conceived from the start to be powered by batteries and electric motors.

In contrast to conventional helicopters, **e-volo**'s tail-less VC200 (the 200 means two-seater) uses a web of paired electric motors and propellers for vertical takeoff and landing plus forward motion. Independently controlled for rotational speed, the 18 motors/propellers are used to steer the aircraft. No mechanical pitch control of the propellers is necessary.



The inventors of the volocopter plan to put their VC200 into the air by year's end.

A "pusher" motor and propeller pairing, aft of the cockpit, was envisioned from the beginning. But the "range-extender" version—likely using an internal-combustion engine feeding a generator—is two or three years down the road, Alexander Zosel, e-volo CEO, told **SAE International** Magazines via email.

In the prototype version of VC200, electricity for the equally rated (about 3.9 kW) motors is stored in a centralized battery pack—details of which the company is not releasing. The serial version of VC200 will have 18 decentralized packs as well as some "centralized batteries," said Zosel.

He and his e-volo co-executives and co-inventors—Thomas Senkel, Lead Drive Development; and Stephan Wolf, CFO, Lead Software Development—have designed VC200 to eventually achieve:

- Cruising speed of at least 54 knot (100 km/h)
- Flight altitude of up to 6500 ft
- Maximum takeoff weight of 450 kg
- More than 1 h flight time.

It will be seen over the next few years whether those bogies are actually achieved. Currently, battery capacity is sufficient for only about 20 min of flight time. The company is confident battery technology will advance significantly by the time the first VC200 is placed in a customer's hands, which, Zosel said, will happen in 2016.

The first VC200 prototype was completed in time for the world premiere in Berlin on Aug. 13, 2013, as part of Europe's GreenTec Awards program. **Airbus** won the "Goliath" award for work in fuel cells, and e-volo won the "David" award for the VC200.

"We are on schedule with the development," e-volo's Wolf said at the time; a manned flight was still being planned for 2013. "Many thanks go to our key partner, **DG Flugzeugbau**. In the recent weeks, their employees have tirelessly produced the last parts of the VC200."

In his email exchange with SAE Magazines; however, Zosel stated that the first flight—to be held in November—would be unmanned.

The volocopter's maiden flight was held Nov. 17 in the dm-arena in Karlsruhe. Video of the flight can be viewed at http://youtu.be/tNulEa8LTHI.

The project has gotten €2 million in support from the federal government.

The range-extender version of the volocopter will have a propeller behind the cockpit. Shown is the all-electric version.

"This green aircraft is a perfect blend of German engineering and innovative ingenuity," Federal Environment Minister Peter Altmaier said at the GreenTec event.

The VC200 is a group effort, with e-volo of Karlsruhe having invented the basic concept. Its role is project coordination, technical project management, architecture of the steering software, test flights, prototype certification, marketing, and sales.

Research partners and their roles are:

- Institute of Applied Research, **University of Applied Sciences Karlsruhe**: automatic and interactive steering system
- **NAVKA – Navigation Algorithms and Platforms Karlsruhe**: multiple redundant multisensor system optimized for configuration to calculate navigation status
- Institute of Aerodynamics and Gas Dynamics, Department Helicopters, **University of Stuttgart**: aerodynamic blade design, aerodynamics of multirotor alignment, assessment of aircraft performance and controllability, configuration optimization, and emergency scenarios in case of rotor failure
- **IMST** Corp., Kamp-Lintfort: 24-GHz radar system for collision avoidance and landing support.

Industry partners and their roles are:

- DG Flugzeugbau: passenger cabin and mechanical assembly of lightweight fuselage construction
- **ICS** AG, Stuttgart: risk management and development of intelligent solutions for critical IT environments
- **W. Gessmann** Corp., Leingarten: threefold-redundant control joystick
- **Smoto** Corp., Augsburg: e-drives
- **Helix Carbon** Corp., Würselen: rotors for lift and propulsion
- **ATB Blank Corp. / Blank Sky-Control**, Roggenburg: cockpit electronics and steering hardware
- **Smart Battery Solutions** Corp., Kleinostheim: energy storage with battery housing and battery management system
- **Wankel SuperTec** Corp., Cottbus: serial hybrid drive
- **Junkers Profly** Corp., Kulmbach: rescue system (vehicle parachute).
- **Maus** Corp., Karlsruhe: model and mold, rotational molding
- **Apfel** Corp., Dossenheim: aircraft trailer for the VC200 including shelving and an intelligent assembly aid for the rotor arms
- **SinusLeistungsSteller**, Waldbüttelbrunn: motor control for electric drives
- **mach:idee, Engineering Company**, Karlsruhe: 3-D visualization, animation, simulation, and real-time presentation
- **ISIS Technologies** Corp., Karlsruhe: production of CNC parts and small series for the prototype.

Patrick Ponticel

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Thomas R. Stover, shown at the SAE 2013 Commercial Vehicle Engineering Congress, succeeds Bharat Vedak, Vice President, TCI and Deliver Customer Value, Deere & Co., as SAE Vice President of Commercial Vehicle. Vedak served from 2011–13.

Eaton CTO assumes SAE VP post

Thomas R. Stover, Chief Technology Officer for **Eaton** Corp.'s vehicle operations, recently began his term as **SAE International**'s 2014-2016 Vice President–Commercial Vehicle. The 22-year member of SAE International, who joined Eaton in 2002 after 25 years with **Cummins** Engine Co., will be charged with providing leadership and continuity for the society's commercial vehicle initiative and for ensuring that industry needs are integrated into the standards, events, and educational programs. In his current role at Eaton, Stover is responsible for technology, innovation, and engineering excellence for the Vehicle Group worldwide. SAE Magazines Assistant Editor Matthew Monaghan recently spoke with Stover about his new role with SAE and the current state of the industry.

As a longtime member of SAE, what have you gained from your experience, and what do you tell young people is the value of SAE?

Personally, it's a sense of connectivity with the industry. It's allowed me to keep up with developments, provided forums for interchange of ideas and information, and it's provided me with a network of professional associates. I'm continually surprised by how valuable that's been to me, both in terms of my development as an engineer and in my professional life as an engineering leader. What I tell young engineers is that in order for them to really find their full potential, they need a way to influence events beyond the boundaries of their own organization. Professional organizations like SAE are an ideal way to do that, whether it's through standards development, committee work, organizing sessions, or being part of local section organizations. Engineers that understand that and take that to heart are the ones that really do begin to influence not only externally but internally as well.

SAE's Commercial Vehicle sector encompasses both the on- and off-highway segments. Do the trends in those industries often align?

There are a lot of common elements. When I look at the history of the commercial vehicle industry as it relates to engineering over the past 30-40 years, it's been driven by the march on criteria pollutants, NOx and particulate matter. Lately, the same has been true of the off-highway industry with the advent of Tier 1, 2, 3, and 4 off-road emissions in the U.S. Many of the same technologies have been applied. One of the things that's new now is the advent of fuel-economy regulations in the U.S. in the commercial vehicle industry. What's going to define the challenge for the next 20-30 years is how do we improve fuel efficiency and reduce greenhouse gas production in the commercial vehicle space. Ultimately, I think that's going to translate into the off-road space as well, even though that's not really being broadly discussed at this point.

What can SAE do to help find solutions to the fuel efficiency and greenhouse gas challenges?

We certainly want SAE to be an asset to the industry, but I think SAE has to find the right way to participate as those regulations, procedures, and processes unfold. Some of the things that are certainly possible are things like standards for aerodynamic testing for heavy-duty trucks, for example. That's a key piece of the fuel-economy regulation. It's a very complex and demanding test environment, and it's an area that really calls for the development of standards. There are a number of other activities that relate to new testing approaches and new ways of complying with the regulation that I think SAE could definitely play a key role.

Innovation plays a key role in your position as Chief Technology Officer. What are the keys to fostering that innovation among your staff at Eaton?

We really define our space in the market by our ability to innovate and provide differentiated solutions for our customers. In the Vehicle Group, we take a very strategic approach to innovation. We have a dedicated team of advanced development engineers that are charged with creating a certain growth potential each year. We have dedicated innovation events where we bring together large cross-functional groups of people, and that process has been consistently producing growth potential on the order of 10% every year. The fact that we put focus on it, support it, and talk about it at the leadership level gives it a lot of visibility in the organization and it energizes the entire engineering organization to know that the business leadership is behind the work and supporting it and actively helping it move toward realization.

Matthew Monaghan

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