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Volume 4, Issue 1

March 2017

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Chennai, India

Theme
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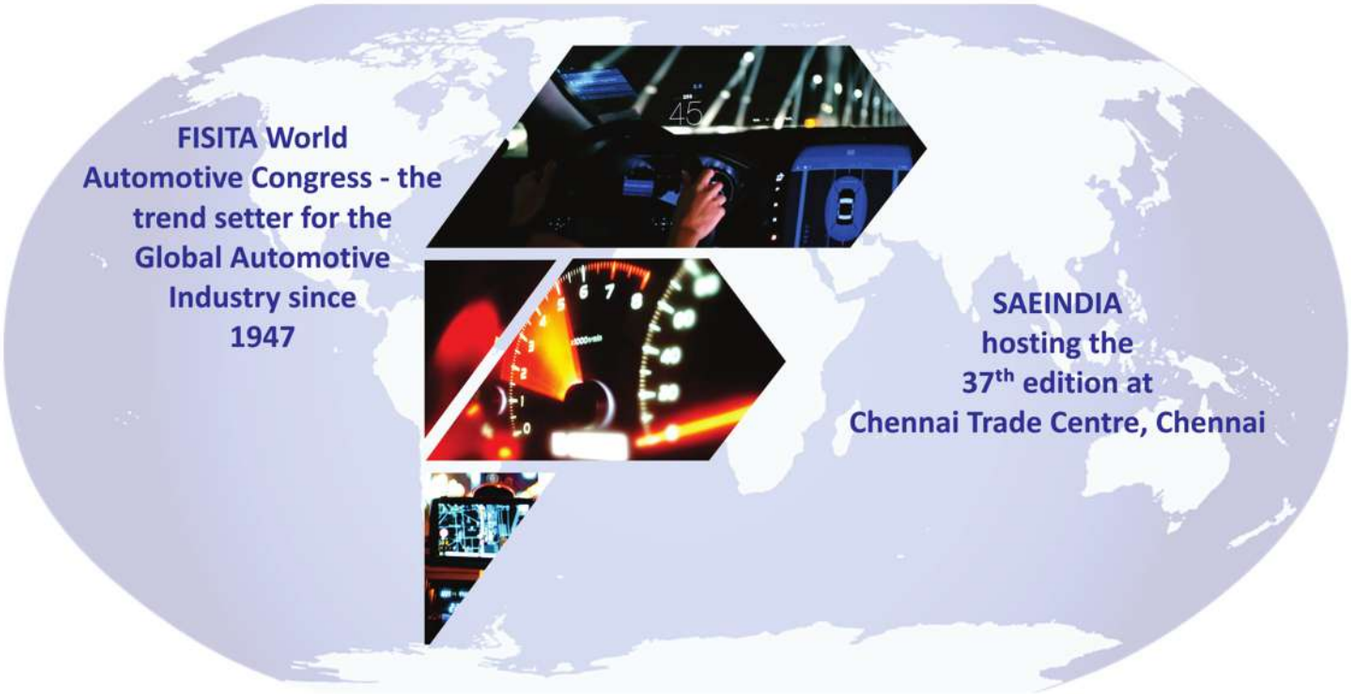

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EDITORIAL

Does "global" always mean "better?"

The final automotive sales and production numbers for 2016 demonstrate India's auto market is on the move—but India's obvious ascension in the global hierarchy, along with other recent auto-industry trends, has caused me to consider whether it's productive to aspire to being "global."

First, the figures. According to **JATO Dynamics**, India's 8.4% increase to 3.32 million cars and light-commercial vehicles sold in 2016 followed only China as the world's most-growing major vehicle market. I was further intrigued to see it reported that Mr. Ambuj Sharma of the Government of Tamil Nadu (see SAEIndia News, pg. 13) noted that India was the world's sixth-largest auto market in 2016 and project, "by the year 2020 we will be hitting third place in the world after the U.S. and China."

Buick's Regal was largely developed by the Opel unit that GM plans to sell to France's PSA Group.

Positive news, certainly. Just days after I absorbed this indicator of India's heightening global presence, however, **General Motors** and France's **PSA Group** announced that PSA will buy GM's **Adam Opel** European operations. It was a stunning and quickly-enacted deal that many auto analysts suggest is tantamount to making GM—currently the world's third-largest auto company based on sales—less of a global player. Unless, that is, GM voluntarily making itself smaller in the PSA deal could be the precursor to a GM move to merge with or fully acquire **Fiat Chrysler Automobiles**. Those who take note of the machinations of the multinational auto companies will remember that FCA's assertive CEO Sergio Marchionne has publicly coveted a tie-up with GM.

Basic economics teaches that size and economies of scale can be monumental advantages for manufacturing companies. But does getting bigger necessarily mean getting better? And is the point of globalization to get bigger—and to get better? Because some of the auto industry's latest news provides little evidence that globalization automatically is a positive thing.

Consider **Volkswagen**'s diesel scandal. The company's home market adores diesels and traditionally so has most of western Europe. But VW's desire to globalize that regional preference—economies of scale, don't forget—led company executives to disastrously cut corners to make diesel engines emissions-compliant in the United States.

Or how about the automaker coalition that's openly encouraging new U.S. President Donald Trump to ease the aggressive fuel-efficiency regulations installed by his predecessor, Barack Obama? Automakers have incessantly pined for the purported efficiencies of a single global emissions, fuel-efficiency and safety regulations—yet at the first opportunity they see for a rollback in the U.S. fuel-economy rules, they seem to have forgotten their high-minded global ideals.

And **Honda** recently raised eyebrows when it was reported the company's first battery-electric vehicle for the U.S. market, the Clarity, will have a maximum 80-mile (129-km) driving range, despite the clear development trend for U.S.-market EVs with at least a 200-mile (322-km) range. One competitor's engineer suggested to me that the Clarity's range target may have been dictated more by considerations for driving conditions in its home market of Japan than in other world regions.

So from the other side of the world, it's encouraging to see India's emergence as an automotive player, but I'll be intrigued to see how the nation's auto companies direct and nurture their expansion, because "globalizing" doesn't appear to be getting any easier.

Bill Visnic, Editorial Director

SAEINDIA News

NASSCOM Design and Engineering Summit, October in Bengaluru

Summit participants.

Group discussion moderated by Mr. Javaji Munirathnam, chairman of SAEBIS.

The Design and Engineering Summit organized by NASSCOM in October was co-supported by the SAEINDIA Automotive and Aerospace boards and the SAE Bangalore Section (SAEBIS).

The deep-dive session began with a talk on connected vehicles by Mr. Sree Gururaj from **Mahindra and Mahindra**. The focus of the presentation was "Connecting vehicles is both an art and a science." The presentation discussed the immense opportunity for connectivity advances in India. With the country's exploding smartphone proliferation leading to more than a billion connections, Mr. Gururaj's presentation focused on how India has been quick to take on to the digital revolution. With examples from both rural and urban India, he clearly demonstrated that the people of India are ready for the digital age and want to stay connected at all times.

The presentation's focus then shifted to the various reasons for why people also wish to stay connected with their vehicles and emphasized that it is clearly possible to leverage economies of scale in implementing a "Connected Solution."

Mr. Gururaj's presentation discussed implementation challenges in the Indian market, detailing technology complexities, business complexities and business-process complexities. Case studies included experiences derived from the "Digisense" connected solution developed by Mahindra. The pricing of connected solutions—particularly for the automotive market—also was examined, as was how the smartphone market had raised the customer expectations and how the consumer and automotive markets remain different in terms of reliability and other aspects.

Finally, the presentation examined ecosystem partners, their roles and the opportunities and challenges they bring, focusing on the dynamics of ecosystem orchestration and the need to harmoniously cooperate for successful implementation of a connected solution. The presentation concluded that despite the fact that engineering individual subsystems is a science, orchestration of the ecosystem for a successful implementation definitely is an "art."

Dr. Roshy John, Practice Head, **TCS**, explained the concept of autonomous vehicles, which he said can be largely considered "mobile robots" that use software algorithms relying digital filters that employ probability theory and advanced mathematics. He also gave insight on how new jobs will be created around the autonomous-vehicle domain and examples were presented on how some of these practices helped in developing India's first autonomous car, the driverless **Tata** Nano.

Dr. John predicted there will be fast-moving development in this domain because the price of electronic components and sensors is drastically falling. Almost every auto manufacturer is developing Advanced Driver Assistance Systems (ADAS) and limited self-driving as a feature within the next five years. The infrastructure to support these technologies is seeing exponential rates of development as well, he said.

The event also included a special panel session, "Digital Transformation in Aerospace industry – Experiences, Challenges and Opportunities." Panelists from **GE**, **Honeywell** and **SAFRAN** presented an excellent overview of the industry perspective; the event was well-attended by senior and practicing aerospace professionals from companies such as **Airbus**, **Boeing**, Honeywell, SAFRAN, **HCL**, **Infosys**, TCS and others. The panel session was moderated by Mr. Munirathnam J, Chairman of SAEINDIA BS.

October KRT and SAE Trek, Ernakulam

The SAEINDIA Southern Section conducted the KRT and SAE Trek at the **Muthoot Institute of Technology and Science** (MITS) at Ernakulam last October. Student members and members of the SAEINDIA Southern Section from various institutions participated in the event and made the program a success.

The SAEISS Trek was inaugurated with the welcome address from the host college. They gave a warm welcome to all the dignitaries and the participants for the Trek Program. Dr. E. Rajasekar, Secretary SAEISS, Mr. S. Shanmugam, Managing Director, **DDIPL**, Mr. R. Armstrong, MC member, SAEISS and Mr. D. Balaji, KRT Champion, lit the Kuthuvilaku.

Dr. E. Rajasekar, Secretary SAEISS and Mr. S. Shanmugam, Managing Director, DDIPL addressed the participants and gave a brief Introduction about SAE Trek and shared their experiences. Mr. D. Balaji, **KRT** Champion, Dr. S. Senthil Kumar, TOPTECH Champion, Mr. T. Ponraj, **KPIT** and Mr. Ramesh Krishnan, **Daimler**, conducted the engineering design process for the SAE Trek participants. All the participants enjoyed and learned the engineering concepts by building a Jet toy.

Participants built the Jet toy, tested its performance, measured its accuracy and the speed it can attain using different nozzles and varying loads. Participants were divided into six teams that learned about the objective and purpose of the challenge and the requirements and expectation from each team. Teams then planned, designed and built the Jet toy in the alloted time. The teams then tested their design for the competition's resource judges and the students made note of various parameters to compare the results.


KRT Trek and SAE Trek participants.

On the second day, the participants and volunteers trekked at Boothathankattu Hills, where they enjoyed the fresh air and the beauty of nature. Dr. E. Rajasekar, Secretary SAEISS, Mr. S. Shanmugam, Managing Director DDIPL, Mr. R. Armstrong, MC Member, and Mr. T. Kasiraja, MC Member, issued certificates to all the participants and SAEISS thanked MITS for hosting the popular Trek program at their college and presented the memento to the college.

Young Engineers Meet

The SAEINDIA Southern Section organized the Young Engineers Meet in October at **B.S. Abdur Rahman University**. Mr. C. Pradeep, Chairman MWC Division, welcomed the chief guests, Mr. Cuneyt L. Oge, **SAE International** President, Mr. Murli Iyer, Global Development Manager, SAE International and Mr. S. Sriraman, Chairman of SAEISS. He also welcomed all the other dignitaries and delegates to the Young Engineers Meet—the first program of its kind.

Mr. C. Pradeep briefed the audience about the program and stressed the need for such a program, highlighting its benefits to the participants. Mr. Oge inaugurated the auspicious event and gave his ideas and suggestions for the Young Engineers to be successful and dedicated.

Mr. S. Sriraman, Chairman SAEISS thanked the host institution, B.S. Abdur Rahman University, for its continuous support as well its initiative to host such events and presented the memento to Dr. V.M. Pariyasamy, Vice Chancellor, B.S. Abdur Rahman University.

Mr. R. Balasubramanian, Secretary, MWC Division, proposed the vote of thanks. He thanked the International President, Chairman SAEISS, Chairman SAEISS-MWC Division and the host institution for arranging the Young Engineers program.


Young Engineers Meet is inaugurated by the President of SAE International.

Mr. Narendra Kumar, **Paradigm Learning Solutions**, conducted the team-building activities. The participants interacted with the expert and lectures were given on self-confidence and developing skills. He also detailed some common mistakes and barriers to achieving great things.

Mr. S. Kumaresan and Mr. Sivakumar from **Mahindra and Mahindra** conducted the Auto Quiz, which engaged the audience and all participants. Dr. E. Rajasekar, Secretary of SAEISS, gave a lecture on automotive safety in which he explained advances in automotive sector with the emergence of autonomous driving, focusing on the advanced sensors used in the vehicle.

Toastmaster Mrs. Lalitha Giridhar handled the communication strategies session and Mr. M.P. Prasad, Champion, Team Building, gave a lecture explaining the vehicle design process and the various stages leading to the finished product. He also explained the strategies and plans involved in the manufacturing process.

Dr. E. Rajasekar, Secretary SAEISS and Mr. C. Pradeep, Chairman MWC Division, finished the program and presented mementos to Mr. S. Kumaresan, Mr. Sivakumar, Mrs. Lalitha Giridhar, and Mr. M. P. Prasad for their lectures and contributions to the Young Engineers Meet Program. He also distributed the certificates to all the Young Engineers participants and asked their continued support for such future programs.

SAEINDIA
News

AWIM Kickoff at B.S. Abdur Rahman University

Students with the dignitaries during the AWIM kickoff.

The SAEINDIA Southern Section kicked off AWIM 2017 at **B. S. Abdur Rahman University**, Vandalur, in October. Dr. R. Rajendran, MC member, SAEISS, welcomed the chief guests, Mr. Cuneyt L. Oge, **SAE International** President and Mr. Murli Iyer, SAE International global development manager, as well other delegates of SAEISS.

Dr. D. Muruganandam, MC member, SAEISS, briefly explained about AWIM and how students benefit by participating. Dr. V. M. Periasamy, Vice chancellor of B. S. Abdur Rahman University, presented the gifts to guests. Mr. S. Sriraman, Chairman, SAEISS, thanked B. S. Abdur Rahman University for hosting the AWIM Kickoff 2017 program and presented the memento to Dr. V. M. Periasamy.

Mr. Oge gave an inspiring speech about society and its working and also mentioned the benefits to students of SAE membership. In addition, he spoke about the future of automotive engineering and presented the memento to Mr. Pramod Kumar of **Global Straws**, the supplier for axles and bearings in the AWIM kit.

Mr. C. Shanmugam, Trainer AWIM, Dr. D. Muruganandam, MC member SAEISS and Mr. D. Raguraman, kickoff champion, conducted the engineering design process for the participants building the jet toys.

SAE International president launches tractor design competition

The SAEINDIA Southern Section launched a new round of the Tractor Design competition for its members during the recent visit of Mr. Cuneyt L. Oge, **SAE International** President. Mr. Oge, Mr. Murli Iyer, SAE International, Mr. S. Sriraman, Chairman, SAEISS, Dr. U. Chandrasekar, Vice Chancellor, VTU and Dr. E. Rajasekar, Secretary of SAEISS took the stage.

Mr. R. Alaguvel Armstrong, MC Member SAEISS gave a formal welcome to all the dignitaries, faculty members and participants at the launch of the Tractor Design competition. He explained the goals of the Tractor Design competition and also welcomed dignitaries to inaugurate the event by lighting the kuthuvilakku.

Dr. V. Chandrasekar, Vice Chancellor, provided details about VTU and his institution's activities with SAEINDIA. Dr. E. Rajasekar, Secretary of SAEISS, also thanked **Veltech University** in Avadi for the hosting the launch of the Tractor Design competition and asked Mr. Oge and Mr. S. Sriraman to issue the memento to the hosting institution. Dr. E. Rajasekar delivered the vote of thanks and thanked all the participants for making the event a grand success.

Dignitaries at the lighting the Kuthuvilakku during the launch of the Tractor Design competition.

Launch of Aero Design Challenge 2017

The SAEINDIA Southern Section and Aerospace Development Council launched the SAEINDIA Aero Design Challenge 2017 last October at MIT Campus, **Anna University**, Chennai. The Kuthuvilakku was lit by Mr. Cuneyt L. Oge, **SAE International** President, Mr. S. Sriraman, Chairman SAEISS and Dr. A. Rajadurai, Dean of the MIT campus, Anna University.

The welcome address was given by Dr. K. Senthil Kumar, Director CASR, MIT campus. Dr. S. Thamarai Selvi, Director CTDT, Anna University, gave an introduction about the Aero Design Challenge, followed by Dr. S. Senthil Kumar, Professor, **Vel Tech University**, who gave a detailed explanation of the event.

Dignitaries at the Launch of Aero Design Challenge 2017.

Dr. B.T.N. Sridhar, H.O.D, Aerospace Engineering, MIT campus, Anna University, introduced the Chief Guest to the participants. Mr. Oge and Mr. Murli Iyer, Global Development Manager, SAE International, spoke about the engineer's role in today's world.

The rulebook for the Aero Design Challenge 2017 was officially released by Mr. Oge, the chief guest, and the other delegates of the SAEISS signed the rulebook. The closing speech was given by Dr. A. Rajadurai and the vote of thanks was given by Dr. S. Senthil Kumar.

KRT Club inauguration at Veltech Univerity

SAEINDIA Southern Section inaugurated the New KRT Club at **Veltech University** in Avadi in October. Mr. Cuneyt L. Oge, President SAE International, Mr. Murli Iyer, SAE International, Mr. S. Sriraman, Chairman SAEISS, Dr. U. Chandrasekar, Vice Chancellor, VTU and Dr. E. Rajasekar, Secretary of SAEISS, took the stage. Mr. S. Senthilkumar, Professor at Veltech University, detailed the new initiatives and activities SAEINDIA planned and conducted at Veltech. He also formally announced the inauguration of the new KRT Club at Veltech University.

Certificate and memento issued to Veltech University during the KRT Club inauguration.

Dr. E. Rajasekar, Secretary SAEISS thanked Veltech University, Avadi for the new initiative and welcomed Mr. Oge and Mr. S. Sriraman to issue the KRT Club certificate to the hosting institution. Both presented the certificate to Dr. U. Chandrasekar, Vice Chancellor and a vote of thanks was delivered by the faculty of Veltech University.

Automotive Student Orientation Program launch

Dignitaries at the launch of the Automotive Student Orientation Program.

The SAEINDIA Southern Section launched a new phase of the Automotive Student Orientation Program (aSOP) for the student members of the SAEINDIA Southern Section in October 2016 at **B. S. Abdur Rahman University** in Chennai. Mr. Cuneyt L. Oge, President SAE International, Mr. Murli Iyer, SAE International, Mr. S. Sriraman, Chairman SAEISS and Dr. V.M. Pariyasamy, Vice Chancellor, B.S. Abdur Rahman University took the stage.

Mr. S. Shanmugam, Mentor, SAEISS, formally welcomed the dignitaries, faculty members and participants for the launch of aSOP. He explained about the need for aSOP for students and also explained the benefits of program. He also welcomed the dignitaries on the dais to light the kuthuvilakku and formally inaugurate the program.

Mr. R. Alaguvel Armstrong, MC Member SAEISS, thanked all the members and participants for making the event a grand success. He also thanked the hosting college and requested Mr. Oge and Mr. S. Sriraman to present the memento.

Technical lecture at Veltech University

The SAEINDIA Southern Section conducted a lecture meeting with a presentation entitled, "Stretch the Horizon: Auto Mobility and Aero Mobility 2050" by Mr. Cuneyt L. Oge, President, **SAE International** in October in Egmore. Mrs. Thangamalar welcomed Mr. and Mrs. Oge and Mr. Murli Iyer from SAE International on behalf of the participants and introduced the presentation.

Dr. Aravind S. Bharadwaj and Mr. S. Sriraman present the memento to SAE International President Cuneyt Oge.

Mr. Oge started his lecture with the basics of the emission regulations and the need for the emission controls for better life in the future. He also explained the current emission norm India follows, EURO IV, detailing the advances in emissions-control technology in context with concerns about the environment. He explained the need for adopting to EURO VI to reduce pollution and to increase fuel efficiency.

Mr. S. Krishnan, MC Member SAEISS, thanked Mr. Oge for his lecture. Dr. E. Rajasekar welcomed the Dr. Aravind S. Bharadwaj, Past President of SAEINDIA and Mr. S. Sriraman, Chairman of SAEISS, to present the memento to Mr. Oge. Dr. E. Rajasekar, Secretary of SAEISS, delivered the vote of thanks.

KRT Competition launch

The SAEINDIA Southern Section launched a new initiative of the Knowledge Round Table (KRT) Competition for the regular members in October at **B. S. Abdur Rahman University** in Chennai. Mr. Cuneyt L. Oge, President, **SAE International**, Mr. Murli Iyer, SAE International, Mr. S. Sriraman, Chairman, SAEISS and Dr. V.M. Pariyasamy, Vice Chancellor, B.S. Abdur Rahman University, were present.

Dignitaries at the launch of the KRT Competition at B.S. Abdur Rahmana University.

Mr. B. Srinivasan, MC Member SAEISS, welcomed all the dignitaries, faculty members and participants for the start of the KRT Competition. He explained the plan of SAEISS and the competition's role in continuing education for members. He requested Mr. Oge and Mr. S. Sriraman, Chairman to present the memento for hosting the event.

SAEINDIA News

Blue ribbon CXO conclave

The Blue Ribbon CXO Conclave was held at Hotel Le-Meridian in Chennai in October. A panel discussion, "Mobility for Smart Cities: Challenges and Opportunities" was the keynote event.

Dr. Arunkumar—Chair Automotive Board, SAEINDIA and GM–**M and M**, made the curtain-raiser presentation, explaining different challenges and opportunities for mobility solutions with "smart cities." He noted the increasing use of the Internet in connected vehicles, digital disruptions and "skilling" India, specifically highlighting the country's need for future skill development. He also detailed the S2I2 initiative of the SAEINDIA automotive board.

The panel was moderated by Mr. Rajendra Khile – DGM, Technical Regulations, **Renault Nissan** and featured as panelists: Mrs. Margo Oge, an environmental regulator who served as the U.S.'s Director of the **Environmental Protection Agency**'s Director of the Office of Transportation and Air Quality and Dr. N. Saravanan—Senior Vice President of Product Development at **Ashok Leyland** Ltd; Mr. Sirish Batchu—Head of Infotronics Technology and Advance Electronics, Mahindra and Mahindra.

The lively panel discussion examined various facets of mobility solutions for smart cities and the increasing shift towards an Internet of Things (IoT). Mrs. Oge said smart cities have one common theme: improving quality of life. She highlighted the issue of increasing emissions in cities and shared her experience with emissions-legislation development in the U.S. She also mentioned the need to reduce the use of private vehicles and increased sharing of vehicles to cut congestion and emissions.

Dr. Arunkumar Sampath with team SAE International during blue ribbon CXO conclave.

Dr. Sarvanan highlighted the need for holistic approaches with clear vision. He specifically mentioned that each smart city likely will require a different approach. He believes increased use of public transport would be on key to improved quality of life in cities, specifically pointing to the shift toward electric buses for public mobility and the need for supporting infrastructure to speed the process.

Mr. Sirish Bathcu said smart cities need to be supported by a "smart village" approach, suggesting smaller cities will help reduce the burden on mega-sized cities. He also spoke of the increasing role for software engineers in the automotive industry in view of increasing usage of IT and the connectivity of vehicles. He noted that connected vehicles will be generating huge amounts of data and there is need to properly understand the data to improve safety and air quality.

Mr. Oge suggested SAEINDIA explore possibility of partnering with smart cities to help frame mobility solutions. Mr. Murli Iyer, Executive Global Advisor of **SAE International**, pointed out the forums organized by SAE International with policymakers, government regulators and stakeholders in the mobility industry to provide solutions concerning all. He asked SAEINDIA to make similar initiatives to be part of the future solutions.

After the panel discussion, Mr. Rajendra Khile spoke about involvement of SAEINDIA with one or two smart cities and provided expert suggestions. He highlighted concerns over cybersecurity in such high levels of future connectivity. Smart cities, he said, will help improve quality of life and present greater opportunity for connected vehicles and increased usage of shared mobility.

SAE International with MC members of the Banglore section during a networking dinner in Bengaluru.

SAEBIS networking dinner

A networking dinner with SAE International President Mr. Cuneyt Oge was held during Mr. Oge's visit to Bengaluru in October. Mr. Murli Iyer and Mrs. Margo Oge also were present on the occasion. The event was well-attended and the brochure "Manovegam"—an aero competition for students being conducted by the section, was also released.

Two-wheeler conclave in New Delhi

Autocar Professional, in association with SAEINDIA, hosted the country's first-ever conclave for the two-wheeler industry in November in New Delhi. The event saw participation from more than 175 representatives of two-wheeler OEMs, component suppliers and other industry stakeholders. The theme of the conclave was "Preparing for a New Era," which was explored by eminent panelists of the Indian two-wheeler industry in three primary sessions:

- New era of regulations and technologies
- A new era of mobility
- A new era in the marketplace

The day's proceedings kicked off with a video message from **TVS Motor Company**'s chairman and managing director Mr. Venu Srinivasan, who said, "With the worsening pollution in Indian cities, we have to cut emissions significantly as well" we have to conform to higher standards of emissions and that can be achieved by either through improving combustion and efficiency or through light hybridization."

Bird's eye view of the conclave.

Session 1: New era of regulations and technologies

The session of the day began with an insightful presentation by Dr. Wilfried Aulbur, managing partner India, Head–Automotive, Roland Berger, which detailed the growth opportunities and the effect of changing domestic and global dynamics on the sale of two-wheelers.

The panel discussion was moderated by *Autocar Professional*'s associate editor Mr. Sumantra B. Barooah and industry representatives that included Mr. Vinay Harne, president, NPD, TVS Motor; Dr. Ravi Damodaran, president – strategy and technology, **Varroc Group**; Dr. Martin P. Flueger, director – sales (India), **AVL** and Mr. Sridhar V Pissay, vice-president, sales and marketing, industrial metrology division, **Carl Zeiss**. The session saw the panelists unanimously identify the upcoming BS VI emissions standards as both the biggest challenge and opportunity for the Indian two-wheeler industry.

Session 2: A new era of mobility—building the EV industry in India

The afternoon session, moderated by Roland Berger's Dr. Wilfried Aulbur, began with the engaging topic of electric vehicles and how they can make a difference. If the National Electric Mobility Mission Plan (NEMMP) 2020 is to achieve its ambitious targets, about a million high-performance electric two-wheelers are required on Indian roads.

"At the present rate of growth, we are heading for a 90 percent shortfall in NEMMP targets," said Mr. Sohinder Gill, CEO, **Hero Electric** and director of corporate affairs of the **Society of Electric Vehicle Manufacturers** (SMEV). The Faster Adoption and Manufacturing of hybrid and electric vehicles (FAME) scheme offers incentives to consumers for the purchase of electric and hybrid vehicles.

But the lithium-ion battery, along with critical components like the e-motor and controller continue to be imported from countries like China, Korea, Taiwan and even the U.S., raising

Session 1 panel.

Session 2 discussion.

Session 3 panel.

the price of the xEVs. Hence, local production of lithium ion batteries was seen as imperative to tap economies of scale.

M/s **Ather Energy** of Bangalore and M/s **Tork Motorcycles** are the two start-ups participating in this event.

Session 3: A new era in the marketplace

The speakers of this final session were Mr. Pankaj Dubey, managing director, **Polaris** India; Mr. Vimal Sumbly, managing director, **Triumph Motorcycles** India; Mr. Roy Kurian, vice president– marketing and sales, **Yamaha Motor** India Sales; Mr. Malo Le Masson, head–global product planning, Hero MotoCorp and Mr. Nikunj Sanghi, director – international affairs and global relations, **Federation of Automobile Dealers Association** (FADA). The session was moderated by *Autocar Professional*'s assistant editor Mr. Amit Panday.

All panelists unanimously agreed that increasing urbanization, female buyers across big and small cities, convenience of riding via automatic transmission systems (CVTs) and practical utility in scooters are major factors contributing to their growth. The panel discussion also highlighted a few sweet spots that have emerged within the scooter segment and various sub-segments.

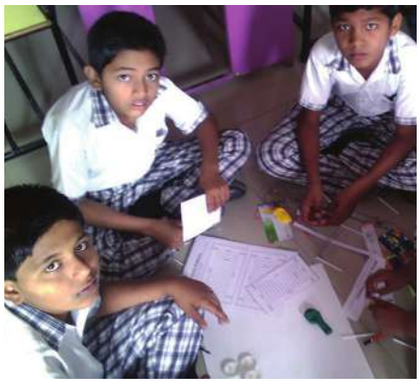
The conclave proved to be a day of exciting, industry-specific two-wheeler content. It is amply clear that industry executives are actively engaged in expanding new strategies across the manufacturing, technology and marketing verticals to address the two-wheeled industry of tomorrow.

AWIM regional Olympics, Solapur and Pune

The SAEINDIA Western Section, in association with **Mahindra and Mahindra**, conducted A World In Motion (AWIM) Solapur Olympics at N. K. Orchid School, Solapur, last December. This competition saw nine school students work as a team, applying scientific design concepts and exploring the principles of laws of motion, inertia, force, momentum, friction, air resistance and jet propulsion to create moving vehicles like skimmer and balloon-powered Jet-Toy cars. The competition was judged by a panel of eminent personalities from the automotive field. Mr. Manoj Girhe of **John Deere** Graced served as chief guest and gave away the prizes to the winning teams.

The winning team from AWIM Pune Olympics for "Jet Toy" and "Skimmer" will participate in the national competition and the team from Valentine Circle School was the winner in both the Jet-Toy Skimmer categories. The team from Ideal English School was the runner-up in Jet-Toy category.

The SAEINDIA Western Section, in association with **Automotive Research Association of India**, John Deere, **Eaton Technologies** and **Cummins India** also conducted the AWIM Pune Olympics at SNBP International School in Baner in December. This competition saw 21 school students work as a team to make skimmers and Jet-Toy cars.



Students prepare kits at the AWIM Solapur regional Olympics.

Team AWIM at the Pune regional Olympics.

The competition was judged by a panel of eminent personalities from the automotive field. Mr. Amit Agarwal, Director-Technical, **ANSYS India**, served the valedictory function and as a chief guest presented the prizes to the winning teams.

The winners of both regional AWIM Olympics were scheduled to participate in the 9th AWIM National Olympics, which was scheduled in New Delhi in the early part of 2017.

Automotive electronics conference, Chennai

SAEINDIA was the association partner with CII Southern Region in organizing the second edition of the Automotive Electronics conference in December in Chennai. SAEINDIA arranged speakers and panelists that included Mr. Claude DeGama Rose from **Continental India**; Mr. Bala Subramanian from **Renault Nissan India**; Mr. Shankar Venugopal from Mahindra and Mahindra; Dr. S. Devarajan from **TVS Motor Company** and Dr. Aravind Bharadwaj and Mr. Sirish Batchu, both from Mahindra and Mahindra.

Mr. Ambuj Sharma, Additional Chief Secretary / Industries Commissioner and Director of Industries and Commerce, Commissionerate of Industries and Commerce, Government of Tamil Nadu, in his inaugural address, said the automotive electronics market is vibrant and, "we are the sixth-largest auto market in 2016 and by year 2020 we will be hitting third place in the world after the U.S. and China." The Tamil Nadu Government is planning to set up an auto electronics Park in Oragadam as part of the Vision 2023 document prepared by the late Chief Minister J. Jayalalithaa.

In his welcome address, Mr. Sasikumar Gendham, Convener, CII Electronics Panel and Managing Director, Salcomp Manufacturing India Pvt. Ltd., said automotive electronics' role in the current economic and industrial spheres, considered the fastest-growing in Asian countries, is extremely important, particularly in India. Vehicles electronics have the highest density of electronic components when compared to other consumer electronics, he claimed, adding that the industry is witnessing vast transformation driven by stable economic growth and infrastructure development.

Visitors at the SAEINDIA booth.

Dignitaries during the inaugural session.

He said the car of the future will be equipped with a more advanced electronic systems to prevent accidents and entertain occupants—and at the same time prove to be eco-friendly. Automotive companies stretch their market by introducing newer features and evolving developments in the sector are capable of delivering more efficient power-management and conversion systems, the prime factors behind improved fuel economy and reduced emissions.

Referring to the Tamil Nadu scenario, particularly Chennai, he said the state is the major frontrunner in terms of automotive electronic production and the conference would hopefully present a draft to the State Government to come up with a comprehensive automotive electronics approach in the 2017-18 budget.

Mr. Amit Jain, Conference Chairman and Country Head, Electronics Group, India, **Visteon**, said Automotive Electronics has already matured and OEMs are still contemplating whether they should introduce more electronics into cars, because of the higher expensive involved. However, some areas have already seen acceptance: growth continues in infotainment systems, which used to come only in high-end cars. Now, entry-level vehicles are equipped with advanced infotainment systems, demonstrating that there is ready acceptance in the market, he said.

Safety-related devices will advance in the coming years, he added, driven mainly by regulations. Things like ABS and airbags are mandatory in foreign markets and in India will be fully implemented through strict regulations by the government.

Mr. Ashok Chandak, Senior Director - Global Sales and Marketing, South Asia Pacific Automotive and India Sales, **NXP Semiconductors**, said in his address that 90% of the automotive innovation is done through electronics, software and semiconductors and along with data analysis are the key drivers in automotive electronics.

Dr. Arvind S. Bharadwaj, Senior Vice President - Advanced Technology and Services, Automotive and Farm Equipment Sectors, Mahindra and Mahindra Ltd., in his special address said there were a few megatrends driving significant changes in the automotive industry, including connected vehicles, autonomous vehicles and shared mobility.

Mr. Claude d'Gama Rose, Country Head - India, **Continental Group** and Managing Director, **Continental Automotive Components** (India), in his special address, said electronics design is growing globally and digitization of components, dramatic advances in software and designs by **Google**, **Apple**, **Tesla** are growing on a wider scale.

SAEINDIA News

Indian Automotive Technology and Innovation Awards

SAEINDIA President and program senior management committee members.

Winners: IATIA 2016.

SAEINDIA was Association Partner with *Auto Tech Review* for the second time in reaching out to a large number of student members (approx. 45000+) to encourage members to participate in the Indian Automotive Technology and Innovation Award (IATIA), instituted by Auto Tech Review to honor excellence in the automotive technologies space and recognize the spirit of innovation among automotive manufacturers as well as engineering students in India.

With the third edition of the IATIA, held in December in New Delhi, the aim again was to recognize and award innovative new automotive technologies that have the potential to make a significant positive impact. The areas of work that the IATIA aims to recognize and award are local engineering and technology development, major improvements in engineering processes and significant technical upgrades. The focus is not just at the end products that get manufactured, but also at why it got made and how technical challenges were overcome.

Core categories in which awards were presented included engines, transmissions, safety, convenience, environment, and technology innovation. Entries were screened by our validation partner, Vehicle Certification Agency (VCA) and external jury members for this year included eminent, well-respected industry professionals like Mr. Shrikant R. Marathe, Ex-Director, **ARAI** and Past President SAEINDIA; Dr. RK Malhotra President, SAEINDIA and Director General, **Petroleum Federation of India**; Dr. Arun Jaura, European Advisory Council, **SAE International**; Mr. I V Rao, VP and Chair Engineering Education Board, SAEINDIA; Dr. Tapan Sahoo, SAEINDIA Automotive and Development Board; Mr. Sajid Mubashir, Scientist G, DHI-DST Technology Platform for Electric Mobility, Government of India and Mr. Indeep Madan, Managing Director, VCA India.

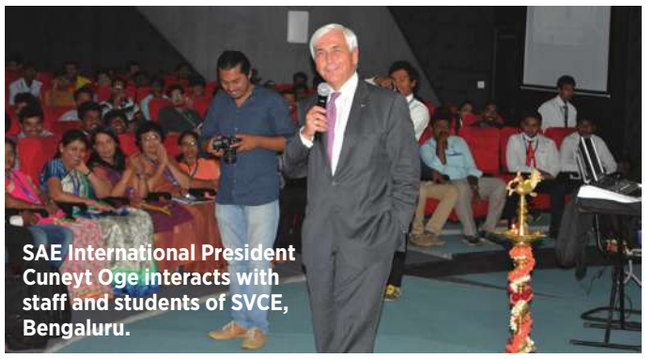
As part of the vehicle evaluation process for the IATIA, judges drove and rode in the cars and motorcycles that were nominated in various categories. This year, to help the editorial team with this evaluation process, Mr. Avik Chattopadhyay, an automotive industry veteran who has worked with major OEMs for more than two decades, and Mr. Rajiv Mitra, veteran automotive journalist who has worked with leading publications and TV channels for more than 20 years, also assisted. With this combined experience of driving, testing and evaluating all manner of vehicles, the goal was to provide testing scores that reflect each vehicle's technical prowess and real-world capabilities.

Attended by automotive industry leaders, the IATIA was once again a big success and garnered appreciation from OEMs and suppliers alike. "It's heartening to see the support we've received for the IATIA thus far, and the assurance of continued support in the future gives me a lot of confidence. What has come for special appreciation is our endeavor to recognize young engineering talent keen to pursue a career in the automotive industry. I believe IATIA is the right platform for the industry and academia to come together and push the innovation envelope in the student community," said Deepangshu Dev Sarmah, Editor-in-Chief, Auto Tech Review, summing up the proceedings of the IATIA 2016.

The IATIA 2016 was co-sponsored by **Ansys**, **Varroc** and **Ace Micromatic**, while supporting partners included SAEINDIA and IN-RDVS. Digital broadcast partnership was provided by 24 Frames Digital.

Student Interaction event at SVCE

As part of **SAE International** President Cuneyt Oge's visit to India, an interaction with the students at **Sri Venkateshwara College of Engineering** was organized. The students received the president and interacted with him enthusiastically.



SAE International President Cuneyt Oge interacts with staff and students of SVCE, Bengaluru.

UK Minister for Defence Procurement shows support of Indo-UK Advanced Hawk

During her visit to Aero India 2017 in February, Harriett Baldwin MP, UK Minister for Defence Procurement, met with **BAE Systems** and **Hindustan Aeronautics Limited** (HAL) and was given a demonstration of the partnership's latest collaboration—the Advanced Hawk fast jet trainer.

According to BAE Systems, after seeing the capabilities the Advanced Hawk features, the Minister said, "The UK and India have so much to offer one another in defense and I'm delighted to be at Aero India to build this close relationship.

The joint development of the Advanced Hawk by BAE Systems and Hindustan Aeronautics Limited is an outstanding example of what our defense industries can achieve together. Indian companies like HAL have been building UK-designed aircraft for over 40 years, so we are building on a strong foundation."

The Advanced Hawk's upgraded cockpit features large area display technology and a new wing with active slat and combat flap for fighter-like handling. (Image: BAE Systems)

"The Advanced Hawk is another demonstration of our commitment to Make-in-India and presents a unique opportunity to build on our track record of collaboration with HAL and Indian industry in developing technologies and capabilities," said Alan Garwood, Group Business Development Director, BAE Systems. "Advanced Hawk is a great example of Make in India, for India and Export from India."

Building on the success of the Hawk Mk132, which recently completed 100,000 flying hours with the **Indian Air Force** and the **Indian Navy**, the new features of the Advanced Hawk enable training activities currently performed on frontline fighter aircraft to be undertaken on the updated air platform.

The company claims the Advanced Hawk will reduce training demands on more expensive frontline aircraft, creating additional capacity for operational tasks, while delivering fast jet training in a more cost-effective, structured and safer environment. High commonality with the existing Hawk production and support infrastructure in India enables the Advanced Hawk to be manufactured and supported with maximum reuse of facilities, equipment and skills.

The Advanced Hawk has an upgraded cockpit that features large area display technology and a new wing with active slat and combat flap for fighter-like handling. It is also equipped

The Advanced Hawk fast jet trainer is the latest collaboration in BAE Systems' and Hindustan Aeronautics Limited's partnership. (Image: BAE Systems)

with advanced sensor simulation including radar, weapons and defensive aids, which, according to BAE Systems, provides flexible and cost-effective training for future combat pilots.

Ashok Leyland's 'Circuit' series is first electric bus made in India

Ashok Leyland's first Circuit electric bus is designed and engineered entirely in India, by Indians, for India, the company said in a recent product announcement. In line with Ashok Leyland's vision for the future of mass mobility, the country's first 'Made in India' 100% electric bus, launched last fall, is a zero-emission vehicle created by the company specifically for Indian road and load conditions. The new Circuit range of vehicles will be offered on multiple platforms.

"The Circuit series of buses is another testament to Ashok Leyland's commitment to leverage India's technological innovation to deliver relevant and best-in-class solutions for India and the world," said Vinod K. Dasari, Managing Director, Ashok Leyland. "In April 2015, at the FAME Delhi workshop, we had committed to vehicles with full-electric powertrains by January 2017. I am happy to dedicate the first vehicle in this new Circuit series, ahead of schedule. As a world leader in public transport, we can proudly say that we have created a product that will enhance the environment in the cities—this is in keeping with Ashok Leyland's philosophy of 'Aapki Jeet, Hamari Jeet.'"

"The Circuit series vehicles are all exclusively engineered on India-specific platforms that can tackle varied topography, gradients and usage conditions," said T. Venkataraman, Senior Vice President—Global Business. "Integrated with a fire detection and

Ashok Leyland's first 'Made in India' fully-electric bus is a zero-emission vehicle created specifically for Indian road and load conditions. (Image: Ashok Leyland)

suppression system (FDSS), this truly Indian innovation can travel 120 kilometers (in what the company called "standard test conditions") on a single charge. It is built on a simple, mass-market platform that will enable the operator to cater to customers in city centers with minimal operational and maintenance costs."

Additional details about the Circuit electric bus: an alert system to help the driver identify when the bus is running low on battery charge (the company claimed there will be sufficient charging points installed at bus depots to charge the new electric models); the Circuit is propelled by an AC motor with a dedicated controller and power-electronics components and lithium-ion batteries store the necessary electrical charge.

The SANY Rigid Truck (SRT) SRT55D dump trucks from SANY India are mainly used in large surface mining sites for transportation of OB (overburden), coal, iron ore, limestone, bauxite, etc., and in quarry segments. (Image: SANY India)

SANY India enters mining segment, launches range of off-highway dump trucks

SANY India, a manufacturer of construction, heavy machinery and renewable equipment, has entered into the mining segment. With this announcement the company also launched a range of off-highway SANY Rigid Truck (SRT) SRT55D dump trucks in India.

The new mining business unit will be headed by Dheeraj Panda, who is the Business Unit Head and Vice President of Excavators at SANY India.

Maruti Suzuki India Limited's Ertiga. (Image: Maruti Suzuki)

Commenting on the launch, Deepak Garg, CEO, **SANY Heavy Industries** Pvt. Ltd., said, "With our foray into the mining segment, we want to set new benchmarks for SANY India. SANY India will offer complete mining solutions and partner with big mining companies for end-to-end solutions. SANY has shown its commitment to the Indian market by announcing various investments across the country and is currently gearing up to realize this vision globally."

The SRT series trucks are mainly used in large surface mining sites for transportation of OB (overburden), coal, iron ore, limestone, bauxite, etc., and in quarry segments. According to the company, these trucks come with six core features that have a unique competitive advantage and is fundamental to SANY's mining equipment range. Equipped with high-strength frames, the company claims the trucks are 20% stronger than any other product in the same category. The SRT series has gross power of 480 kW (650 hp) at 1800 rpm and a payload capacity of 60 ton (55 t).

"We are excited to enter the mining sector in India," said Panda. "Since mining is a crucial segment that adds significantly to the gross domestic product of the country, we believe there is a huge potential for us in this market. With the launch of our new world-class product range, we are confident in our ability to contribute meaningfully to the growth of the industry."

With the launch of the new SRT series of off-highway dump trucks, SANY India will be offering mining solutions to the iron and coal, power, cement and construction industries. Currently, SANY will import these truck series as completely built units from China. The company will also introduce new solutions as per demand in the segment going forward.

Sales of Maruti Suzuki Smart Hybrid Vehicles surpass one lakh units

Maruti Suzuki India Limited announced that its Smart Hybrid vehicles, the Ciaz SHVS and the Ertiga SHVS, have crossed cumulative sales of 100,000 units in February.

In an effort to make technologies like Smart Hybrid create a significant positive impact, Maruti Suzuki made them available to a larger portion of its customers when it introduced India's first Smart Hybrid Vehicle, Ciaz SHVS, on Sept 1, 2015. It subsequently introduced the technology in Ertiga Diesel in Oct 2015.

Smart Hybrid Vehicle by Suzuki (SHVS) is a technology that uses an integrated starter generator (ISG) and an advanced high capacity battery to supplement the engine's power. SHVS technology makes it more efficient than the conventional set-up and saves energy while decelerating/braking.

The company's Ciaz and Ertiga Smart Hybrids participate in the Government of India's FAME India scheme, which aims to promote Faster Adoption and Manufacturing of Hybrid and Electric vehicles in India.

"As we move towards hybrid and electric cars, we see this as a first important step in this space," said R. S. Kalsi, Executive Director, Marketing & Sales, Maruti Suzuki, in a release about the announcement. "Both Ciaz SHVS and Ertiga SHVS are high on fuel efficiency, come with reduced running costs and lower levels of CO_2 emission, thus making these popular among customers. The response we have received for SHVS-equipped Ciaz and Ertiga encourages us to continue to invest in new technologies that support the environment while benefitting the customer."

According to a release from the company, Ciaz SHVS, with a certified fuel efficiency of 28.09 km/l, tops the mileage chart in India. Ertiga SHVS, with 24.52 km/l, has set new benchmarks in fuel efficiency in its category. The company claims both vehicles are market leaders in their respective segments. SHVS-equipped vehicles account for more than 60% of volume of the two models.

AUTOMOTIVE PROPULSION

Honda's new 10-speed is a slick shifter

Less than 15 in long, Honda's new 10-speed transaxle for FWD applications is a packaging triumph. (Lindsay Brooke photo)

The 10-speed's torque converter is an entirely new design aimed at optimally collaborating with the engine's cylinder deactivation and stop-start systems. (Lindsay Brooke photo)

Honda's 2018 Odyssey offers room for eight passengers and its all-new transaxle packs 10 forward gears. Developed in-house over a three-year period, the new automatic is the industry's first production 10-speed for front-drive vehicles. It is being produced at the company's Tallapoosa, GA, transmission plant.

Mobility Engineering spoke with Tom Sladek, principal engineer at Honda R&D in Raymond, OH, about the new gearbox during the Odyssey's media unveiling at the 2017 Detroit auto show. He said the transaxle's input torque rating is 370 N·m (275 lb·ft) "with some degree of headroom designed in." While Honda has yet to announce the **SAE**-rated torque of the Odyssey's 3.5-L V6, it is expected to be greater than the 2017 engine's 250 lb·ft (338 N·m). SAE peak power for the 2018 engine is 280 hp—a 32-hp increase over the current engine's output.

Interestingly, Honda is launching the new minivan with two available automatic transaxles—a **ZF**-sourced 9-speed and the new corporate 10-speed. The latter, equipped with standard stop-start capability, initially goes into the premium-trim Odyssey models; it is slated to proliferate steadily throughout the Honda and **Acura** ranges, replacing Honda's 6-speed automatic currently coupled with the 3.5-L V6. The new Odyssey is front-drive only.

The 10-speed transaxle's overall ratio spread of 10.1 compares with 9.81 for the ZF 9-speed used for the Honda Pilot/Acura MDX and TLX and marks a 66% upgrade compared with the 6.03 spread for Honda's 6-speed. The 10-speed is over-driven in gears 7 through 10. Sladek promised "beautifully smooth" kickdowns for rapid acceleration because the transmission is designed for non-sequential skip-shifting—it is capable of instantaneously downshifting from 10th to 6th gear or from 7th to 3rd.

Optimized internal ratios in combination with "a continuing focus on reducing internal friction" help boost the Odyssey's fuel economy by at least 6% over the 6-speed, he said. The wide ratio spread allows engine rpm to be reduced to 1500 rpm at 62 mph (100 km/h), compared with 1920 rpm on 6-speed vehicles. The spread of ratios (Sladek did not have gear-by-gear specifics at the show) enables a 14% improvement in highway passing acceleration, while a lower first-gear ratio boosts off-the-line grunt. Redesigned electro-hydraulic controls and a revised solenoid design provide a 30% faster gear-change response time, he claimed.

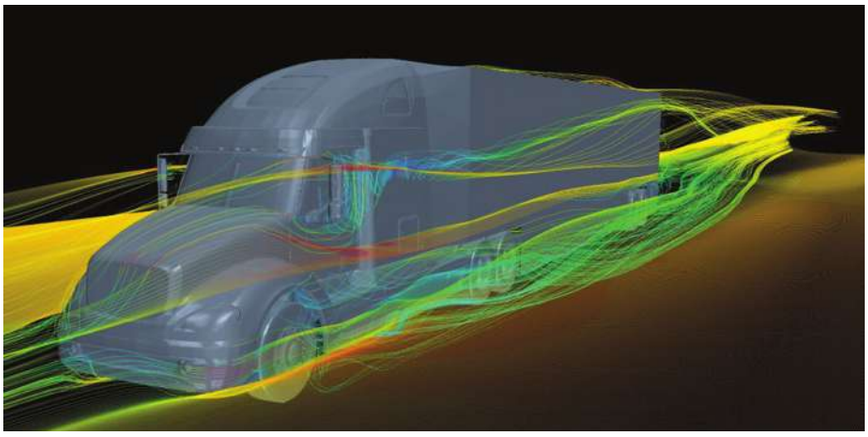
"Optimizing the overall package was one of our primary design goals," Sladek noted. "Overall length is just under 15 in (375 mm)—about 1.7-in (45-mm) shorter than our existing 6-speed." There are four planetary gearsets aligned with the crankshaft axis, along with the three clutches and three brakes. Sladek pointed to key design elements that contribute to the ultra-compact package: a new two-way clutch that replaces the forward/reverse mechanism's one-way clutch and multi-disc brake; a smaller diameter and slimline torque converter; and a clever ring gear incorporating a row of teeth on its inner diameter that transfers torque to the differential.

The high-attenuation/low-inertia torque converter incorporates a three-stage vibration damper that was engineered and calibrated for the V6's cylinder deactivation and stop-start systems, Sladek noted. An accumulator activates the 1st-gear clutch either rapidly or slowly, depending on operational inputs, to optimize the engine stop/restart sequence.

Lindsay Brooke

OFF-HIGHWAY AERODYNAMICS

Glowing aerodynamic add-ons could boost big-rig fuel economy by 7-10%

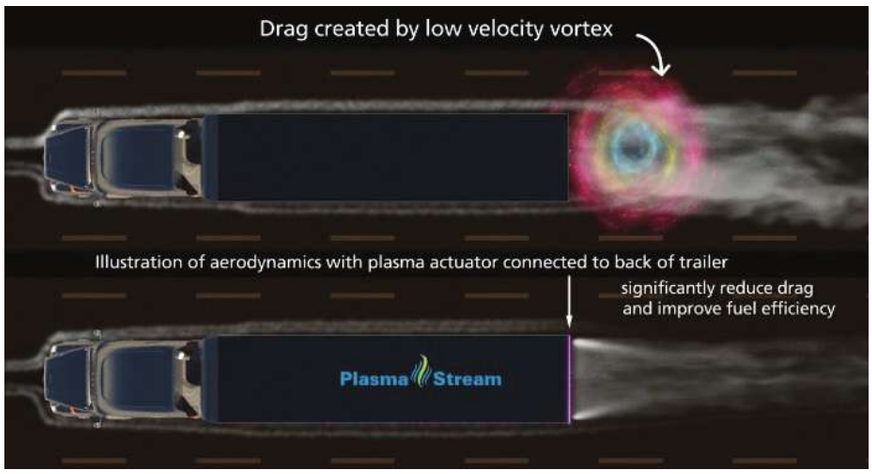


About 65% of the fuel that a truck burns is wasted in overcoming highway drag.

"Headlight white" and "stoplight red," the characteristic colors of the highway at night, could soon get a companion: "plasma purple"—that is, if a new fuel-saving, aerodynamic technology catches on big with big-rig trucks. The electric plasmas emitted by the devices, which glow purple-violet in the dark, can smooth the turbulent wakes that sweep off the rear edges of truck trailers travelling at highway speeds. Simulations and wind tunnel tests indicate that these novel active-flow control systems could reduce the aerodynamic drag generated by semi-trailers by almost one-fifth, thus lowering fuel consumption by up to 10%.

Plasmas, the lesser-known "fourth state of matter," are clouds of charged atomic ions created in the air by high-voltage electric fields. The glowing electric-flame phenomena are commonly seen in household air purifiers and more rarely in natural phenomena such as St. Elmo's Fire, the ghostly purple haze sometimes seen hanging off airplane wings. For application to trucks, strong electric fields emitted by surface electrodes push the plasmas around, producing breezes that can redirect critical airflows at the trailing edges of "bluff-bodied" vehicles such as Class 8 cargo trucks, helping to smooth out the turbulent, high-drag wakes.

Somewhere around 65% of the fuel that a truck burns is wasted in overcoming highway drag, researchers say. And with about 133 million American trucks consuming 60 billion gallons of fuel annually, if only a fraction were to adopt this promising new slipstreaming technology, the effect would soon start to become significant.



Plasma actuators could smooth the turbulent airflow coming off of semi-trailers, cutting drag.

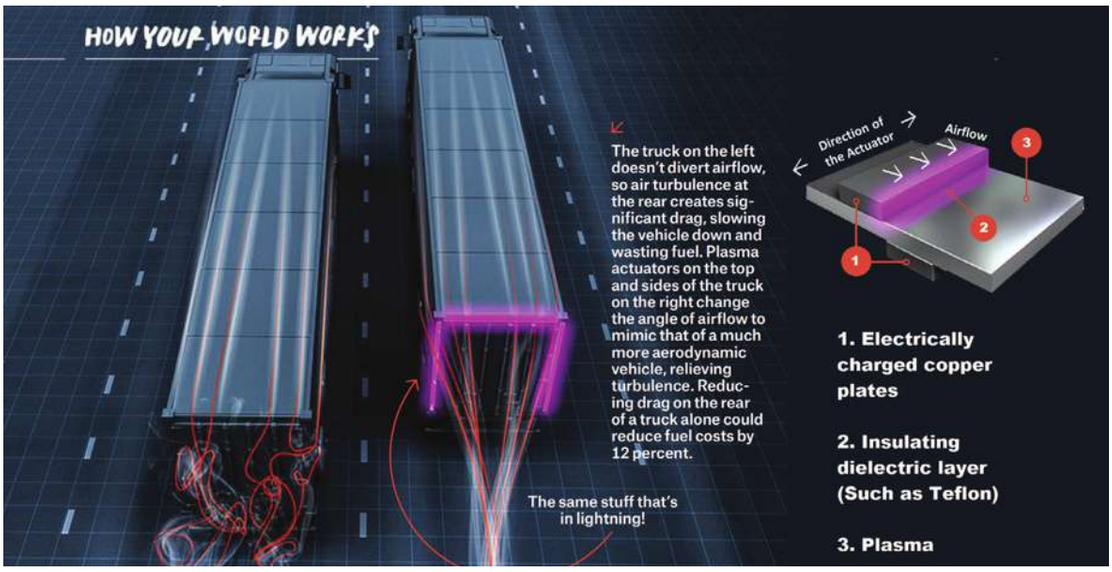
Plasma actuators

That's the ultimate target for **Plasma Stream Technologies**, the small start-up firm based in Bettendorf, Iowa, that is developing the "dielectric-barrier plasma actuator" devices for trucks. Up to now its concept has been tested solely in supercomputer simulations and subscale wind tunnels, but real-world confirmation should come from road tests planned for this March, according to Pranay Bajjuri, a cofounder and investor. Favorable results would mean that the company could proceed toward full commercialization in the hope that retrofit products could hit the market in early 2018, he noted.

(Go to https://www.youtube.com/watch?v=8HAa-bI6170 for a company video on the technology and its development.)

Bajjuri, whose day job is as an electrical engineer at a heavy-equipment maker, explained that a few years ago he and his partners had searched for promising technology to commercialize and discovered the potential benefits of plasma actuators in improving aerodynamics in applications such as airplane wings, wind turbine blades, and even compressor blades in turbine engines. They also learned that **General Motors** and other organizations had investigated using plasma-based active airflow control

The design requires only a 4-in extension around three sides of a trailer, which makes it considerably smaller than boat-tails, which add about 4.5 ft to the trailer length.



How Plasma Stream's eTail device would look when installed on the rear edges of a semi-trailer.

devices for highway vehicles and had achieved favorable results in the lab.

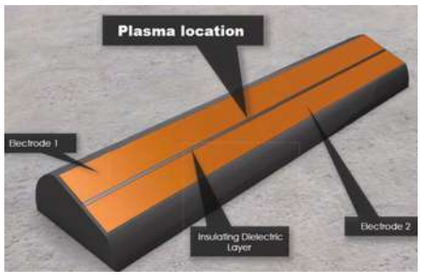
"Plasma actuators have been around for about 15 years, but there's still no commercial product yet," Bajjuri said. "We're trying to be the first to bring them to the commercial market in volume."

The Plasma Stream team realized that these plasma actuators could replace the many passive flow-control add-ons that trucking firms have employed over the years to reduce vehicle drag, including air deflectors, vortex generators, and aft boat tails.

Simple electrode strips

The simple retrofit device, called eTail, has no moving parts. It's basically two long, high-voltage electrode strips made of copper separated by an insulator such as Teflon (polytetrafluoroethylene), he explained. The 4-inch-wide (102-mm) units are fitted to the top and side trailing edges of semi-trailers. When the juice switches on at speeds of 45 mph (72 km/h) and up, the surface electrodes energize the air above, producing charged ions that the field then sends in one direction as wind. The wind alters "the turbulent, high-energy airflow at the edges and directs it to a low-energy region" right behind the vehicle, minimizing drag losses, Bajjuri explained.

Even though the strap-on eTail system runs on high-voltage current, operations are quite safe because it requires low amperages. "The average power of the electrode strips is only about 1 watt per meter," he stated. He added that the



A plasma actuator is a simple device—two copper electrodes separated by an insulator.

technology works in all weather conditions—rain, snow and dust—and with an added grid overlay, it might even be possible to heat up the electrodes for deicing in winter.

The company's prototypes are based on licensed plasma actuator technology developed by a group of aerodynamics engineers and researchers at the **University of Notre Dame**, said Thomas Corke, who leads the team. "For a ground vehicle, the general approach is to shape the wake, to smooth out the airflow coming off the rear," he said. "The optimum is to turn the airstream about 12 degrees from the horizontal."

The flow-control devices are powered by a compact, lightweight power supply also of UND design that can be operated with an **Apple** iPad. Low power is achieved, Corke said, because "the DC power is pulsed, so the device is powered only for brief intervals," giving it a duty cycle of 0.001%.

In contract research conducted in late 2015 at Notre Dame, Corke's team ran CFD simulations to investigate the use of plasma actuators to cut drag on Class 8 truck semi-trailers. The virtual truck's shape resembled a 1/12th-scale model that had been previously evaluated in wind tunnel tests at the university. The computer simulations sought to determine an optimum arrangement of an aft ramp geometry (the slope and width of the device) and plasma actuators that would in combination, yield a drag reduction comparable to the passive boat-tail retrofit devices currently used on semi-trailers. And unlike conventional boat-tail units, the eTail does not impede easy access via roll-up doors and swing doors.

Plasma Stream's final design, which features an 11-degree angle, attains this goal, achieving a predicted 22.7% drag reduction at highway speeds that would yield an 11% fuel savings. The design requires only a 4-in extension around three sides of a trailer which makes it considerably smaller than boat-tails, which add about 4.5 ft (1.4 m) to the trailer length. The retrofit product is expected to cost around $2,000, Bajjuri said, and could save somewhere around $8,000 per year in diesel fuel.

The new technology can be installed at various locations around a semi-truck to streamline the aerodynamics including near the gap between tractor and trailer, on the rearview mirrors, and in the front grille area of tractors. The company thinks that the technology could also work on buses, locomotives and racecars.

Steven Ashley

AEROSPACE ELECTRONICS | AVIONICS

Unmanned Canada works to elevate drones

The 2016 Unmanned Canada (UC) conference, hosted in Alberta, provided a venue for companies to outline their programs for new UAV technologies, capabilities, products, and services. One of the key discussions included the effect of visual line-of-sight operational limits on wide ranging commercial UAV applications while the regulatory framework evolves in North America and Europe. However, progress is being made in bringing forth new collision avoidance, or sense and avoid (SAA), systems to enable safe beyond visual line-of-sight (BVLOS) flight.

Canada has focused on developing a national strategy and infrastructure for UAV operations—a prime example being LOOKNorth, a national non-profit center dedicated to accelerating the development of remote sensing technologies to support sustainable Canadian natural resource development.

LOOKNorth provides economic benefit, identification of specific high technology business opportunities for remote communities, increased export opportunities, attraction of investment capital, and increased productivity through more efficient monitoring of key infrastructure and resources. LOOKNorth has secured investment for operational demonstrations, validated and legalized UAS-related technologies, awarded demonstration projects, and disseminated results and validation programs for stakeholders.

All these things are regarded as a highly attractive framework for innovation.

The Meggitt Innovator Technologies Mosquito UHV-T unmanned helicopter was on display and is making market headway as a target or multi-role rotary wing UAV platform.

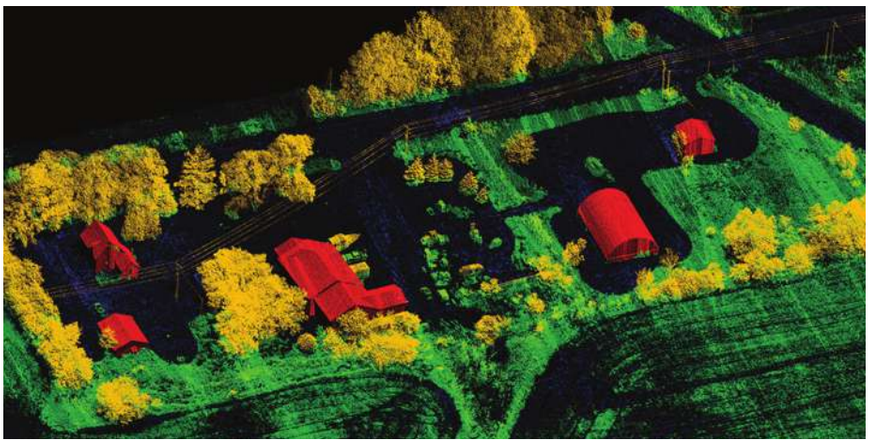
According to LOOKNorth, three key enablers are required for establishing an effective infrastructure: evidence-based decision-making, a common risk management collaborative environment, and shared knowledge.

Wildfire management

From January 2016 to October 2016, Alberta suffered 1329 wildfires that required emergency support aircraft from 103 companies. Over 30,000 hours were flown to support emergency operations, which included UAV operations from a variety of service providers. With increasing use of drones, investments have been made training operators, standard operating procedures have been established, and enforcement legislation has been reviewed and updated.

Robert Atwood, CEO of Hummingbird Drones, explained how the use of drones had introduced a new transformative role in the detection of "hot spots" where visually unseen high temperatures beneath the surface or amongst smoldering tree remains might lead to another eruption of flames.

Manned helicopters using handheld IR cameras and GPS monitors for "cold trailing" could miss hot spots and other natural heated objects, such as deer, bears, or rocks, could give a false indication. Drones provided a highly efficient and accurate solution (compared to higher-flying aircraft, satellite sensors, and ground sensors) and could cover extensive areas in a repeatable grid pattern over a time frame of up to seven hours. Software discrimination solutions allow operators to discount false heat source indicators and to concentrate on those that look of most interest.



Digital terrain modeling software enabled by drone coverage extends into analysis of ground surfaces for survey or agricultural purposes

Land management

RME Geomatics, a Calgary-based division of Rocky Mountain Equipment Canada Ltd, was founded in 2012 to provide aerial data capture and mapping for survey, engineering, and construction industries. Their business has expanded to include energy, agriculture, forestry, mining, and government agencies responsible for land management. Its UAVs are used extensively for digital terrain modeling and analysis using LiDAR (light-detection and ranging) data capture via specialist sensors,

which can map ground surfaces, even under tree and vegetation cover in daylight or darkness—the latter an important benefit when long Northern winters severely restrict daylight hours.

Three dimensional models can be produced of terrain or industrial sites and multi-spectral photography can map soils, crops, and forests to monitor their health and help develop optimized drainage and fertilization schemes. The company offers an end-to-end service, and is one of the few Canadian companies that holds an Unspecified Location Specific Flight Operations Certificate for all regions from Transport Canada (TC). At the exhibition RME Geomatics displayed its compact Renegade multi-purpose rotary wing UAV mounted on the flat deck of a small all-terrain vehicle.

An operating crew prepares a RME Geomatics Renegade rotary-wing UAV.

Risk-reduction measures

Mark Hovdestad from Locked On Solutions, drew upon his experience as a bush pilot and as a worker for the federal government air service to establish a robust RPAS program that combines his client activities with a continuing role with the Royal Canadian Mounted Police (RCMP) in charge of the Edmonton Air Section. Recognizing that the growth in UAV flight is causing increased pressure on air space and a growth in reported "near misses," he has built a partnership between his company and GIS software-development specialists to introduce a user-friendly software based solution being launched as RPAS (remotely piloted aircraft system) ARMS (Airspace Risk Management System).

This equips the remotely located UAV pilot with a tool that allows safe and simple, legally compliant management of the vehicle's own airspace. It also allows the airspace control providers the ability to adjust privileges and limitations as required.

Wildfire monitoring is a UAV mission that has become an important role throughout Canada's Rocky Mountain regions.

As airspace integration processes change, whether locally or on a national scale, users will be made aware of the changes where applicable, depending on their flight location. This will give an assurance to the pilot that the flight is legal and safe where limitations are understood and all other integration instructions are followed. This airspace risk management solution is subscription-based with updates sent to subscribers and is aimed at providing a flexible new tool for pilots, regulators, air-traffic controllers. and program managers.

Search and rescue

The increasing use of drones for law enforcement use was mentioned in several conference sessions. David Domoney, who has been closely involved in the RCMP RPAS program described how RCMP UAV operations began and developed from one vehicle for incident photography to 150 for collision reconstruction, examination of crime scenes, assisting emergency response teams, and search and rescue. Domoney mentioned that the RCMP used a UAV in a search and rescue situation where snow conditions made other methods of searching problematic.

There are now 200 trained and equipped RCMP RPAS operators comprising regular officers and civilian members of the force. A pilot training course for RPAS operations had been developed by the force and applied nationally with vehicles optimized for the role and region as required.

Collision avoidance

One enthusiast for disruptive technology solutions linking up drones, autonomous operations, and real-world applications is Alexander Harmsen, CEO of Iris Automation. Alex has a background as a software developer, having worked at NASA's Jet Propulsion Lab on computer vision systems and was also closely involved at Matternet, Silicon Valley's medical drone package delivery startup.

At UC he presented his vision of how Iris Automation was bringing BVLOS operations closer to reality. Currently, TC and the FAA set limitations on operating only within sight of UAV hinders the utility of using UAVs for dull, but essential tasks such as power supply, pipeline inspections, and monitoring fire-risk areas. Iris Automation has developed a collision avoidance system that it hopes will move the whole drone sector toward BVLOS operations.

The company's first product is a combination of off-the-shelf chips and components, plus proprietary software that can instruct a drone's autopilot system when there is any obstacle nearby and how to make adjustments instantly to avoid it. He said that test flights have started with selected partners and his intention is to build systems that are agnostic and can be added to drones and autopilots made by any manufacturer for

commercial markets. These include DJI, Firefly Precision Hawk, MicroPilot, and Airware.

The company raised $500K in pre-seed funding from Bee Partners and Y Combinator. Partner Geoff Ralston said, "To do real work with drones you have to prove to TC and the FAA that they can co-exist with passenger airplanes and that the probability of a collision is something like that of a jet airliner, or even less." The Iris Automation solution processes visual data in real time so it can see structures or objects that suddenly appear, like birds, helicopters, or airplanes, and not just static hazards that can be mapped using GPS.

Moving Target Indication (typically out to 1000 m) could classify a target and then the algorithm design would apply a trajectory model based on the prediction, integrating the data with the auto-pilot to produce a collision avoidance capability. Iris Automation is working toward solving these problems by integrating data from numerous input sources and incorporating it in software that can be part of compact flight system packages carried in small air vehicles.

Airspace awareness

Kongsberg Geospatial specializes in precision real-time software for mapping, geospatial visualization, and situational awareness. It has developed a new platform for commercial UAVs that incorporates technology from its work on air-traffic management display systems, and military UAVs. It features 2D maps and 3D terrain data and overlays additional information highlighting dangerous surface obstacles, air traffic zones and airfield locations, and real-time sensor inputs from multiple sources including radar, electro-optical inputs, and weather data, all integrated in a user-friendly visual display that can show predicted potential airspace conflicts, alerting the pilot with a yellow highlighted symbol in plenty of time to change course.

For the last two years the system has been used by Kongsberg Geospatial and UAV manufacturers and potential operators in field trials in collision-avoidance scenarios. The UAS application has also been selected for the FAA ASSURE program for ongoing research into collision avoidance and BVLOS technologies.

Richard Gardner

AUTOMOTIVE SIMULATION

Combating motion sickness in autonomous-driving simulators

Ansible Motion's Phil Morse (right) with an engineer in the company's driver-in-the-loop (DIL) simulator. Its technology can help overcome motion sickness in both conventional and autonomous vehicles, according to the company.

Motion sickness has become a very real issue for engineers developing and testing autonomous vehicle technologies. Automotive simulators can reach such high levels of realism that they may cause their 'drivers' to experience motion sickness similar to that in a real car. Overcoming the issue is vital for ensuring that autonomous vehicle passengers don't suffer the same 'stop the car, I've got to get out' nausea.

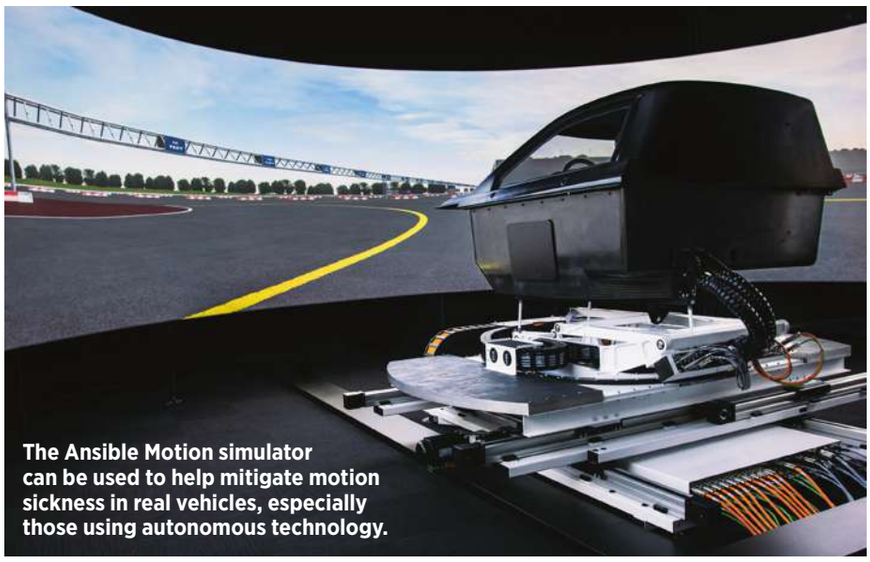
Phil Morse, Technical Liaison Manager of **Ansible Motion**, a U.K.-based simulator specialist, cites a recent **University of Michigan** study which concluded that in some situations, up to 31% of adults are likely to experience significant discomfort in an autonomous car.

"Other studies predict even higher percentages," Morse noted. "One, by the **University of Coventry** [U.K.], refers to motion sickness in automated cars as being 'the elephant in the room.'"

The problem starts with occupants take their eyes off the road. Causes of car-sickness include reading and texting, laptop computer use, watching videos and gaming—each a plausible scenario for occupants (including the "driver") during an autonomous car journey.

Do you suffer SAS?

Design factors such as the vehicle's road disturbance transmission frequency; noise, vibration and harshness (NVH) characteristics and, depending on the vehicle, the levels of outward visibility are all likely to influence the onset and



The Ansible Motion simulator can be used to help mitigate motion sickness in real vehicles, especially those using autonomous technology.

severity of car sickness. Now, add the potential that the occupants are focused neither on the ride nor their vehicle's surroundings. Those sitting in the front seats may, in the future, even be turned rearwards during highway stretches.

"Essentially, it occurs as a result of a perceived mismatch between the eyes and the vestibular system—when motion is seen and not felt, or vice versa," explained Morse, whose company specializes in Driver-in-the-Loop (DIL) simulator systems for vehicle engineering, including motorsport.

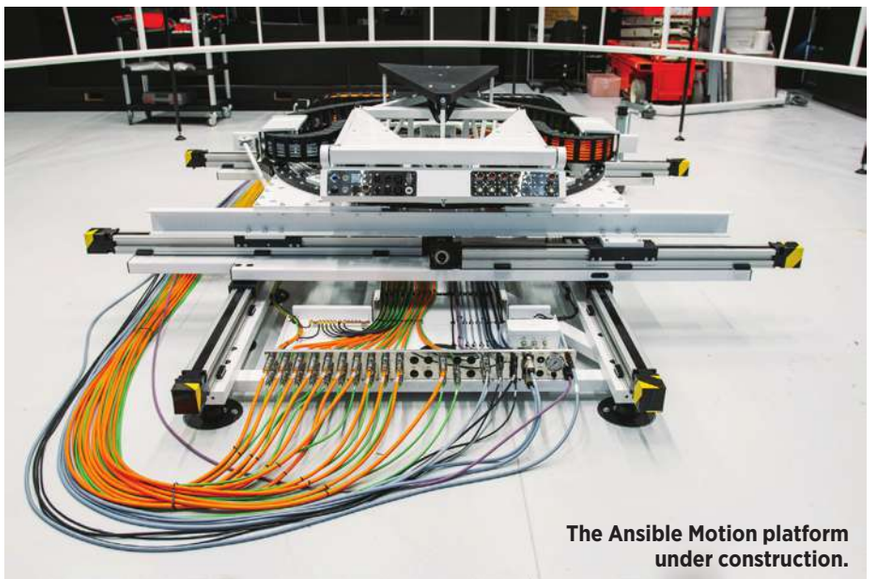
He said that because so much time is spent inside simulators conducting virtual test drives, recent trends in engineering-class simulator technologies have been aimed squarely at mitigating driver discomfort via more responsive machinery, graphics and driver feedback systems. "Today, OEMs are turning to the use of these simulator sickness-mitigation technologies as a means of investigating car sickness," he said.

Great attention is paid by vehicle designers and engineers to achieve optimum ride and handling combinations. But too much or too little suspension compliance—soft, under-damped ride quality particularly in large cars and poorly controlled body roll—also conspire to cause motion sickness. Inadequate HVAC performance and non-optimal seat structure design may further compound the problem.

Drivers in vehicle simulators may suffer Simulator Adaptation Syndrome (SAS) just as their aerospace-industry counterparts do in aircraft multi-axis simulators. "Even very small amounts of latency and/or mismatch between the various environmental feedbacks, e.g. motion, video feeds, etc., can lead to problems," Morse explained. The University of Coventry found that 50% of participants dropped out of simulation tests caused by SAS."

Because of this, Ansible Motion is working to counter real-world motion sickness, using its knowledge of and experience with the symptoms. For example, company engineers can induce motion sickness deliberately by tweaking the simulator's settings, creating a useful path to explore human sensitivities while people are engaged in different tasks inside a car. It's hardly a popular test regimen, but analyzing and understanding these sensitivities are useful for informing the design of production vehicle.

Engineers in Ansible Motion's simulation suite.



The Ansible Motion platform under construction.

Taking a different approach

Morse explains that as semi-autonomous (**SAE** Level 3) and fully autonomous vehicle (Levels 4 and 5) capabilities begin to blur the lines that separate the in-car experiences of drivers and passengers, occurrences of car sickness could become more prevalent. The University of Coventry researchers stated that in non-autonomous vehicles about 66% of all people have experienced motion car sickness, and that the use of in-vehicle entertainment systems can increase its incidence.

DIL simulators offer a unique environment for investigating these effects because they provide a repeatable, controlled environment in which the surroundings, weather, the car itself (physical behavior and ergonomic elements) and the sensory feedback delivered to the driver/occupant, can be altered with a few keystrokes.

By swapping real and virtual components around, designers can efficiently study the combinations that work best to mitigate motion sickness. But manipulating driver/occupant experiences with the required degree of precision is far from straightforward.

"Even cutting down on the graphical latency to an acceptable degree requires highly sophisticated hardware and software," Morse said. The most complex challenge is the motion control. Simply attempting to replicate or scale down the real-world forces doesn't necessarily work

in a laboratory environment, he noted.

To tackle this, Ansible Motion uses what it describes as a radically different approach. It is centered on a carefully developed model of the human vestibular system mated to "industry-unique" motion control systems, designed to stimulate the brain's perception of movement and spatial orientation, which is inherently non-linear.

The technology incorporates a six-degrees-of-freedom (6DOF; the number of axes that a rigid body can freely move in three-dimensional space) stratiform motion machine. This device simplifies the actuation requirements by placing the cabin on top of layers of precision-controlled actuators.

The first stages provide ground-plane cueing, while upper layers generate the pitch, roll and ride motions. This results in a considerably lower center of gravity than hexapod simulators (used by the aerospace industry) would provide.

"Forces are much easier to manage and primary axes are governed by single actuators, which gives it linear control authority with far less inertia – a perfect fit for connectivity to sensitive vehicle physics models," explained Morse. The system was first developed for motorsport applications (Ansible has three F1 customers) where subtle steering and stability cues are crucial in providing the right feedback to highly experienced drivers.

Tim Roebuck, Head of Vehicle Dynamics at **Corum Technology**, a chassis dynamics and subjective specialist testing company, has sampled the Ansible Motion system. He noted that the simulator's physics and cueing feedback can be altered on the fly, "so assessing changes in my comfort level as I carried out driving and non-driving tasks could happen at a much faster pace than any testing in a real car. Adjustments in the simulator are almost infinite it seems," Roebuck said.

He was able to experience anything from 'normal' vehicle driving responses to 'extreme' variations, "so it was easy to describe any improvements in how I felt, and how those related to the vehicle tuning states." Use of such technology and testing methods will become more valuable as the auto industry increases its development of autonomous-driving systems.

Stuart Birch

OFF-HIGHWAY POWERTRAIN

Enhanced Cat 3500 engine boosts power 20%, trims fuel usage by 10%

Cat's 3500E engine adds power and trims fuel consumption while retaining existing form factors.

The 3500E, the latest iteration of **Caterpillar**'s venerable 3500 engine family, provides up to 20% greater power density, 10% greater fuel efficiency, enhanced durability and longer life before overhauls. The upgraded engine maintains existing form factors, so rebuilds and replacements can be utilized with minimal infrastructure changes.

The 3500E outputs 188 kW (252 hp) per cylinder, more than double the 75 kW (101 hp)/cylinder output of the first 3500, which went into production in 1981. Overall, the engine offers up to 4040 hp (3015 kW). Engine displacement ranges from 34 L for the eight-cylinder model to 78 L for the 16-cylinder version.

While improved performance was the primary goal for developers, maintaining backwards compatibility was also a key parameter. The 3500 has been in production for 35 years, with more than 190,000 engines in the field. Those engines are operating primarily in mining, rail, electric power, oil & gas and marine applications, as well as in Cat machines.

Joe Markun, Cat's General Manager of Large Engine Manufacturing, highlighted the engine's legacy by noting that one of the first 3500Es is being shipped to a company that bought a very early 3500 engine.

Redesigned but backwards-compatible

The revamped engine series achieves its power increases from the enhanced cast-iron engine block and cylinder heads. A redesign for the block and crankshaft increases durability.

"We redesigned the crankshaft, though it remains backward compatible with existing engines," said Ronald Smith, Engineering Manager for the 3500 platform. "We added material to the cylinder head and block in some places. We also altered the processes, but we didn't change the steel. We also increased the pressure in the cylinder."

Cat has remanufactured more than 13,000 model 3500 engines at the Lafayette, IN, facility where the engine is manufactured. Rebuilds in Indiana and a second engine manufacturing

plant in China augment rebuilds done by dealers and others. The factory has several ongoing programs designed to ensure quality while meeting demanding specifications. Though the 3500E is huge, it's manufactured with extreme precision.

"The crankshaft tolerances go down to five microns," Smith said. "Every fourth crankshaft is validated to maintain those tolerances. The whole factory is temperature controlled so all our measurements are precise."

The engine has two fuel system options: mechanical electronic unit injector or common rail. Various fuels can be used. Gas, diesel, biofuels and any mixture of these options can be burned efficiently, letting users in different markets pick the best solutions for their operating environment, gaining fuel efficiency improvements of up to 10%.

Aftertreatment options are also available. The 3500E uses either a selective catalytic reduction (SCR) or an exhaust gas recirculation (EGR) aftertreatment system to meet U.S. **EPA** Tier 4 Final and EU Stage IIIB emissions standards.

"Some engines will use SCR, using urea," Smith said. "In applications like fracking, they don't want another fluid, getting it to a remote site is difficult. EGR is an alternative to urea. The cost of ownership is also different."

Those are just a few of the available options for the engine line, which is designed for customization so variants can be produced in small volumes for specific markets. In many applications, orders are for only one or two engines. Even versions built for data centers, a higher volume application where five to 10 similar units will be produced at one time, will have differences such as right- or left-hand servicing.

"We make as many as 900 variations," Smith said. "We build everything to order, 44% of our engines are unique."

Improved performance was the primary goal for developers, but maintaining backwards compatibility was also a key parameter. These 3500Es are ready to ship from Caterpillar's plant in Lafayette, IN. (Terry Costlow photos)

Telematics for predictive diagnostics

The 3500E is also getting upgraded electronics. Cat's A5 engine control module provides enhanced I/O capabilities along with a faster processor and more memory. One of its key roles is to drive the injectors.

The additional processing capabilities also help provide more diagnostics and predictive diagnostics, or prognostics. Monitoring engines so maintenance can be performed before breakdowns occur is becoming simpler. Technicians can more easily monitor usage from remote sites so they can determine the optimal time for servicing.

"We're putting telematic modules on the engine," Smith said. "Users can interrogate any sensor, getting readings and doing things like comparisons of the sensor compared to 30 days ago. Product Link uses cellular or satellite connections to operate anywhere."

Cat isn't limiting its focus on reducing energy consumption to the hours that the engine is operating in the field. When engines are being validated at the factory, they're used to generate up to 6.5 kW of electrical energy. That's roughly half the consumption of the 1.3 million square foot Lafayette facility, Markun noted.

Terry Costlow

AUTOMOTIVE AUTONOMOUS DEVELOPMENT

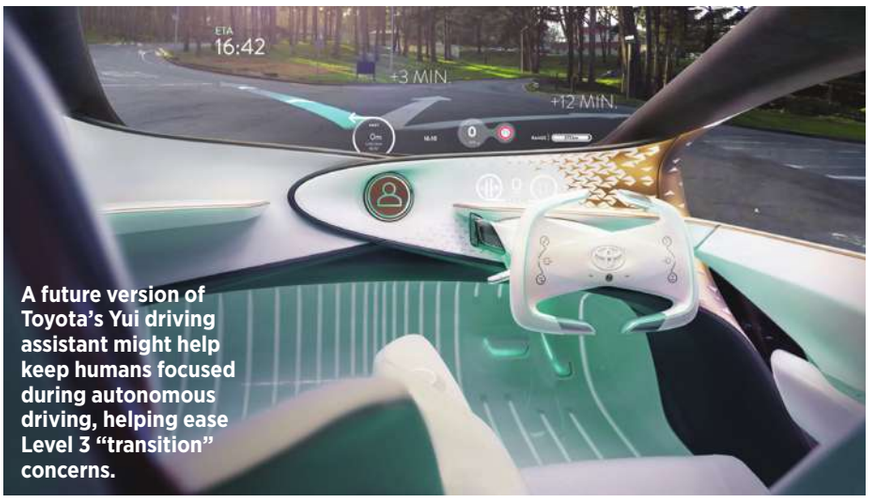
SAE Level 3 'hand off' challenging AI researchers

When Gill Pratt, the CEO of **Toyota Research Institute**, the carmaker's artificial intelligence (AI) lab in Menlo Park, CA, mounted the CES 2017 stage in January, he delivered a reality check about automated driving.

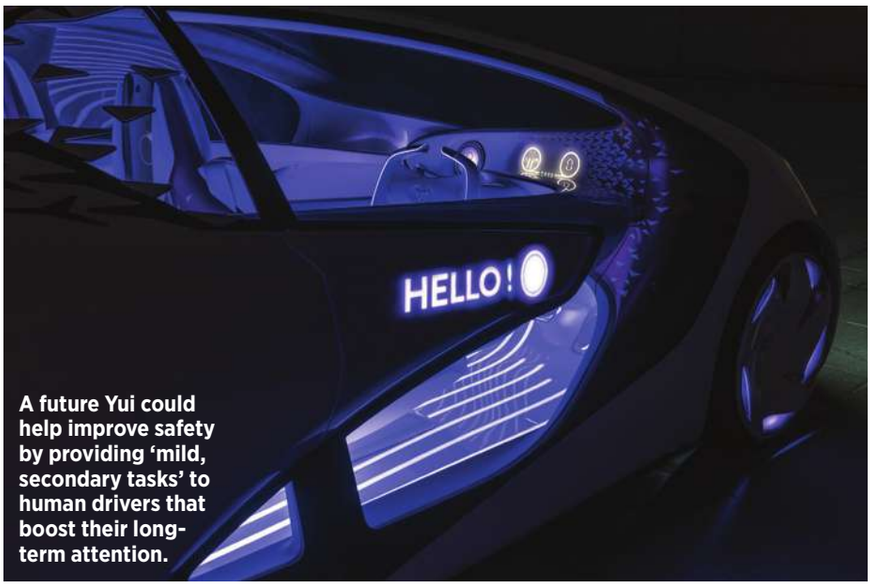
"We're not even close to Level 5 autonomy, which the **SAE** defined as full robotic control everywhere, at any time, in any conditions," Pratt told the audience. "We have many years of machine-learning research to do to achieve Level 5."

Later, in an interview with *Mobility Engineering*, Pratt credited recent steady progress to most driving being relatively easy—"we do most of it without half thinking," he said. But true self-driving vehicles will need "trillion-mile reliability" and the elusive ability to handle "corner cases" in their automated search for the best solutions. These are the difficult and rare problems or situations that can occur outside of normal operating parameters. He likened the required robo-driving skills of the future to those of trained professional airline pilots. Current driving capabilities are more like the skills of general-aviation pilots.

On the other hand, SAE Level 4 autonomy, where the car operates fully automatically only at limited speeds in certain operational areas, weather conditions or time of day, "is coming much faster," the former **MIT** professor and **DARPA** director told the CES audience. "In fact, it's very likely we'll get to Level 4 within the decade."



A future version of Toyota's Yui driving assistant might help keep humans focused during autonomous driving, helping ease Level 3 "transition" concerns.



A future Yui could help improve safety by providing 'mild, secondary tasks' to human drivers that boost their long-term attention.

Warning is 'hard to guarantee'

Pratt then highlighted a key challenge to Level 3 and 2 operations that his all-star team of AI scientists in now studying. "If the autonomous car needs to hand-off control to a human driver in Level 3 driving, it must ensure that it gives sufficient warning, a "request to intervene" to the driver, who may not be paying attention at the time," he explained.

Perhaps even more challenging, he believes, is the requirement for the Level 2 human driver to always supervise the operation of the autonomy, "taking over control when the autonomy fails to see danger ahead." To give a disengaged driver 15 s of warning at 65 mph (105 kmh), the system must spot trouble ahead at a distance equivalent to five football fields. Such a feat requires prediction before the hazard has yet appeared.

That's extremely hard to guarantee," Pratt asserted, "and unlikely to be achieved soon. In fact, it is possible that Level 3 may be as difficult to accomplish as Level 4."

Further, tests demonstrate that "the longer drivers disregard control of the vehicle, the longer it takes to regain control," he noted. Psychologists who studied this "breakdown of vigilance" in WWII radar operators, call this issue the "vigilance decrement."

Pratt asked the CES audience if, over a two-hour road trip, they would be likely to remain vigilant for a possible handoff of the Level 2 vehicle's autonomy. "Does this mean that Level 2 is a bad idea? Some companies have already decided to skip Levels 2 and 3," he noted.

To help investigate this and other such technical challenges, the TRI leader said that Toyota Motor Corp. is doubling the size of the 100-member team that he assembled a year ago to conduct the $1-billion collaborative program, which includes researchers from **Stanford University**, MIT and the **University of Michigan**.

Steven Ashley

OFF-HIGHWAY POWERTRAIN

Fan-shroud optimization for enhanced thermal performance

Tighter emissions requirements and underhood packing due to higher power demands from engines necessitate more optimized cooling packages. Fan and fan-shroud design is crucial for underhood airflow management. Fan shrouds funnel cooling air, which is sucked by the fan and passed through heat exchangers. Shroud design affects both the airflow and the noise generated by the fan.

The vehicle underhood compartment consists of the engine and cooling package. In heavy-duty trucks, the cooling package includes the heat exchanger, fan shroud and fan. To optimize the fan-shroud shape to maximize cooling air mass flow rates through the heat exchangers, researchers from **Argonne National Laboratory**, **Cummins** and **CD-Adapco** used the Adjoint approach to optimization. Adjoint optimization is an efficient sensitivity analysis method for aerodynamic shape and pressure drop evaluation.

The optimization process was accomplished using the Adjoint solver and mesh morpher in STAR-CCM+. First, a well-converged primal solution was obtained on a polyhedral mesh. The solution was solved steady-state, using a coupled solver approach and k-epsilon turbulence. A moving reference frame approach was used to simulate the effects of the moving geometry. The primal solution was driven to convergence by successively increasing the coupled solver Courant number.

Using the converged primal solution, a cost function of mass flow rate through the radiator with respect to fan-shroud position was solved on predefined control points near the fan-shroud surface to obtain a solution to the Adjoint equation. The solution to the Adjoint was used to calculate sensitivities of the primal flow to changes in control point position, resulting in a field of Adjoint sensitivity vectors on those points. The vectors were scaled to limit the maximum displacement of the morpher and produce a smoother transition to the optimal shape. The scaled sensitivity vector values were then used as displacements for the morpher. The morphing of the control points resulted in deformation of the mesh, and ultimately of the underlying fan-shroud geometry.

The process of solving for the primal solution, Adjoint solution, Adjoint sensitivities, and mesh deformation was repeated 20 times to generate a cumulative displacement of the control points and the shroud geometry to increase the mass flow rate through the radiator. Figure 1 shows the original shroud surface, which consists of sharp edges when compared to the morphed/optimized surfaces. The highlighted areas show the modified/optimized edges that provide lower pressure loss and higher mass flow rates through the heat exchangers.

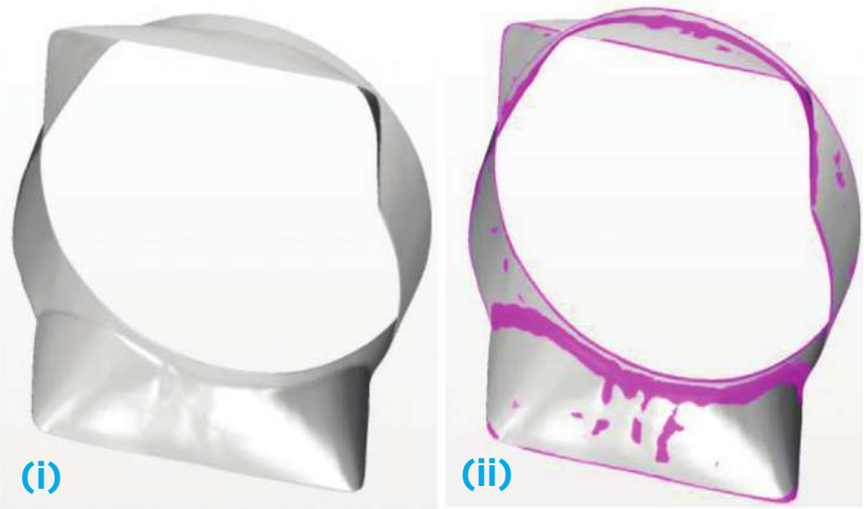


Figure 1. The main difference between the original (i) and optimized (ii) fan shroud is variation in the shape of the surface edges.

Figure 2 reveals that the velocity flows away smoothly from the fan. In underhood compartments, stagnant flow zones are common between fan and engine block.

The optimization process resulted in a 1.4% increase in cold airflow with optimization of the fan-shroud surface. The improvement was primarily due to smoothing of the fan-shroud surface edges compared to the sharp edges in the original model. The airflow around the optimized edges was much smoother, as the edges act to reduce pressure losses and ultimately led to a higher mass flow rate through the heat exchanger. Further evaluation is ongoing to maximize the cooling air mass flow.

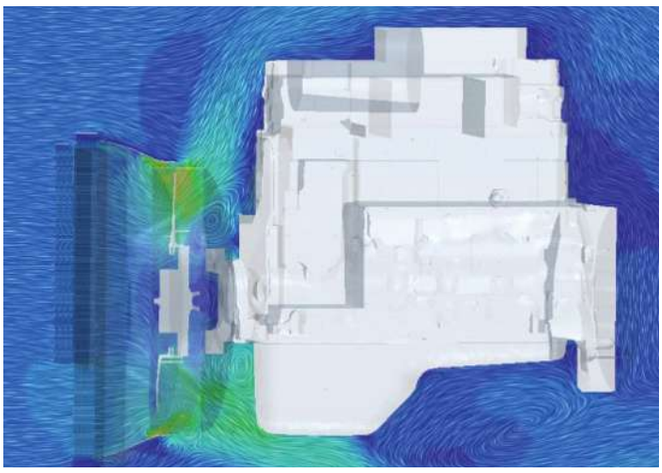


Figure 2. Velocity contours. The velocity flows away smoothly from the fan.

This article is based on SAE technical paper 2016-01-8070 by Prasad Vegendla and Tanju Sofu of Argonne National Laboratory; Rohit Saha, Mahesh Madurai Kumar, and Long-Kung Hwang of Cummins and Steven Dowding of CD-Adapco.

AUTOMOTIVE PROPULSION

Exclusive first drive: Torotrak's V-Charge technology

The Torotrak V-Charge weighs about 6 kg.

Being the first journalist to test drive the only example of a new piece of technology still in development always concentrates the mind. Doing so in wet and windy weather battering rural roads close to England's North Sea coast brings an added dimension to the experience.

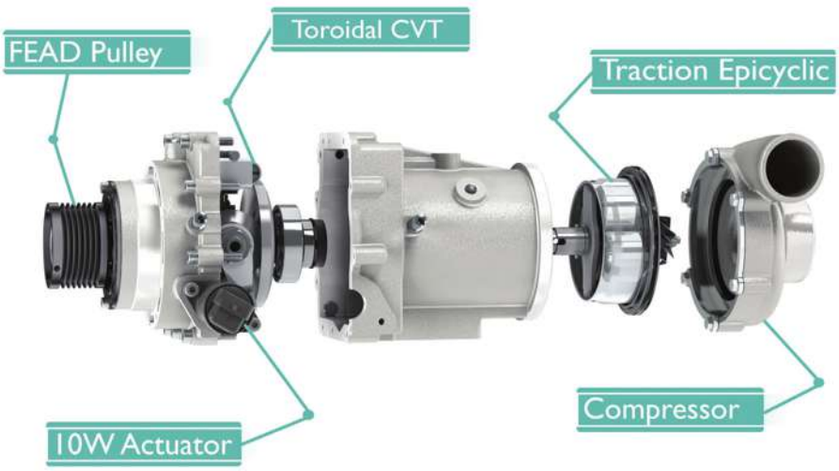
But that was how **Torotrak** demonstrated to *Mobility Engineering* the potential of its new, CVT-controlled V-Charge pressure charger—a mechanical, gearless, fully variable pressure charger driven by a conventional pulley. It allows compressor speed to vary independent of engine speed. It's designed to provide low-end torque and tackle the effects of turbo-lag on downsized gasoline engines. (See http://articles.sae.org/12401/; also SAE Technical Paper http://papers.sae.org/2015-01-1971/).

Fitted to a 1.0-L **Ford** Focus as a technology demonstrator (Torotrak is partnering with Ford on the project), it is currently being shown to industry engineers and senior executives across Europe.

As well as general downsizing, V-Charge is proving of particular interest to those companies working on Miller-cycle engine applications to meet Euro 7 emissions legislation, said Richard Dunne, Torotrak's Group Business Development Manager. Independent testing has been conducted by the U.K.'s **University of Bath**.

Getting something for nothing has always been a problem for engineers. So V-Charge does not reduce fuel consumption of the regular 1.0-L— that isn't "Plan A," Dunne explained. But compared to the equally regular Ford Sigma 1.5-L (a 4-cylinder powerplant) it is claimed to cut fuel consumption by up to 12%, with a comparable cut of CO_2 emissions.

The V-Charge setup does this without recourse to 48-volt mild-hybrid technology and uses a standard, off-the-shelf (OTS) compressor. Unlike an e-boost system, V-Charge provides continuous boosting, asserted Dunne: "It is not complex; the variable-ratio traction drive is a scaled-down version of our established and proven toroidal CVT technology," he noted. System weight is 6 kg (13.2 lb).



Exploded view of the V-Charge showing the rotors of its toroidal CVT. The compressor is an off-the-shelf component.

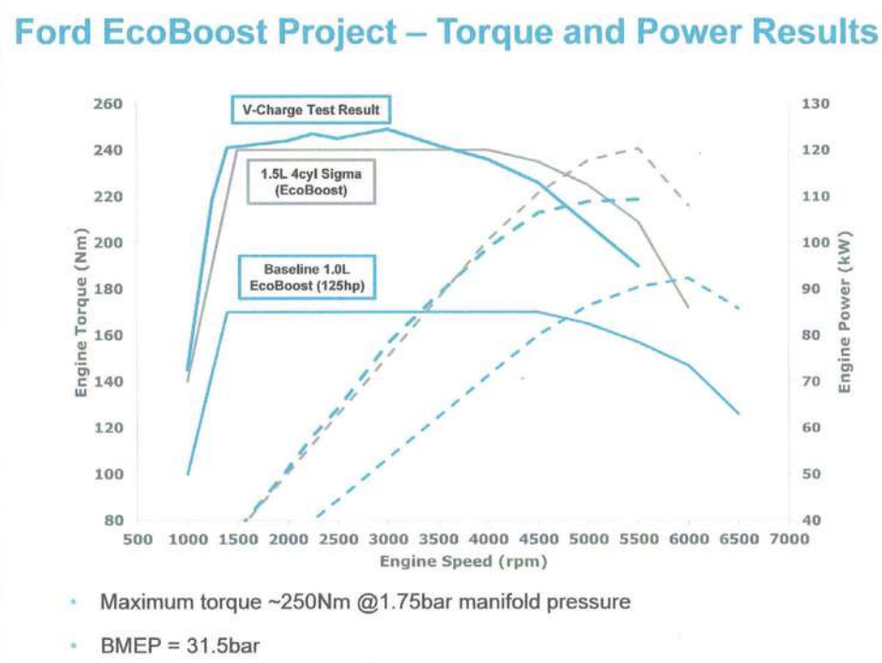
The test drive

In a manual-gearbox Focus demonstrator, Dunne used laptop control to switch the system in or out to give direct engine-behavior comparisons. The development car uses a turbocharger slightly larger than that of the standard Ecoboost unit to give 110 kW (147 hp), an 18-kW/24-hp increase.

The efficacy of the V-Charge was apparent on the first steep hill encountered; the initial step-off from an intersection and in a 90° corner tackled with engine speed dropping towards 1000 rpm in 3rd gear. Low engine speed and (relatively) high torque were smooth partners—typically (and critically) without the need for downshifting.

Baseline rated torque for a regular Ford 92-kW (123-hp) triple is 100 Nm (74 lb·ft) from 1000 rpm and 170 N·m (125 lb·ft) from 1400 rpm. With V-Charge the figures rise to 145 N·m (106 lb·ft) and 240 N·m (177 lb·ft) respectively, very similar to those for the 1.5-L 4-cylinder. It seems perfectly amenable for C-segment or smaller cars with a curb weight of 1289 kg (2841 lb).

With a CVT ratio spread of 10, an 1100-rpm engine speed can be converted to anywhere between 10,000 and 100,000 rpm at the impeller without any traditional gearing, explained Dunne. The system is designed to provide greatest efficiency from idle to 2500 rpm, tapering off to avoid over-boosting. It provides a ratio change in a maximum of 400 ms.



The V-Charge 1.0-L triple's performance against the 4-cylinder 1.5-L engine demonstrates its potential. (courtesy of Torotrak)

All this happens quite quietly; Dunne said the system is 97% quieter than a comparable Roots-type supercharger. It is easily packaged at the rear of the engine and no noise attenuation is required, he claims.

An electric actuator is used to change ratios (there are no control hydraulics), so parasitic losses are minimized. There is no metal-to-metal contact in the CVT, which uses traction fluid of proven performance. The ratio spread provides 0.28 to 2.82:1 gearing. When the charger is not needed, the ratio moves to its minimum and there is no need for a disconnect clutch.

The system is designed to provide a power capacity of up to 17 kW (23 hp) and can run at that level continuously.

Claimed fuel consumption and emissions for the 1.0-L with V-Charge are 2-5% higher than the standard engine due to the added load (about 100 W) caused by the system. However, the figures are estimated to be 12% lower than the 1.5-L 4-cylinder's at similar or improved performance.

Cost similar to a VGT

Torotrak is not a manufacturer; it would sell or license V-Charge technology to a Tier 1 supplier. Doug Cross, Torotrak's Chief Technical Officer, says the V-Charge would represent cost comparable to a variable-geometry turbocharger.

"The complete on-cost needs to be considered to determine a cost/benefit ratio," Cross told *ME*. "When you sell technology to an OEM, your transfer price is effectively doubled by the time it reaches the customer." But offsets include cost saved by using a triple instead of a 4-cylinder engine without loss of performance.

It is possible, therefore, that by adding V-Charge only a modest cost penalty might be involved — and even a cost saving, Cross believes.

Miller-cycle compatible

One concern regarding use of any CVT was once the behavior of its traction fluid in extremely low temperatures, explains Cross: "We have done a huge amount of development and we now have a traction fluid that is liquid-pumpable down to -30°C."

With many OEMs involved in Miller-cycle engine development (or variations of it), Cross is confident that V-Charge would be compatible with the technology.

Although Torotrak has concentrated on gasoline engine applications for V-Charge, it would also be applicable to turbodiesels, overcoming the negative aspects of transient load steps when the accelerator is floored.

Stuart Birch

AUTOMOTIVE MOTORSPORTS | PERFORMANCE

Simulation squeezes more range out of Formula-E racers

"Range anxiety" is not just affecting electric vehicle drivers on the road—it is also a significant hurdle for Formula E teams on the track. Highly accurate energy consumption prediction using knowledge not just of race circuit layout but also of track surface detail is vital.

The all-electric Formula E race series, supported by a growing list of OEMs including **Audi**, **BMW**, **Jaguar**, **Mercedes** and **Renault**, requires every team to find ways of extracting, and making best use of, all the potential energy from the battery pack by the time the car crosses the finishing line. This is to enable a driver to use maximum power in appropriate situations, otherwise the car could have gone faster at some point in the race.

"Optimizing the energy consumption by adjusting the calibration before the race relies on having an accurate circuit model," explained Chris Hoyle, Technical Director at **rFpro**, a U.K.-based simulation software company. "But with many circuits based in parks or city centers, the exact geometry of every corner may not be known until the barriers are erected."

There are further complications. Apart from variations in circuit layout, accurate prediction of energy usage is made more difficult by the irregularity of many track surfaces, Hoyle noted. Bumps, road repairs, pot holes or drain covers could result in loss of control or reduced grip, often forcing drivers to take a completely different line to the shortest or theoretically quickest racing ideal.

Conventional circuit mapping, such as using **Google** Earth data, fails to give a true representation of the vehicle path around the full lap, he said. Knowledge of a circuit's full details is a must; in the precise and challenging world of E racing, a car's electric energy consumption can make the difference between a podium place and a DNF.

To cope with this, rFpro has developed TerrainServer, a simulation package designed to accurately reproduce literally every bump, curb, ripple and degree of camber of a track, feeding

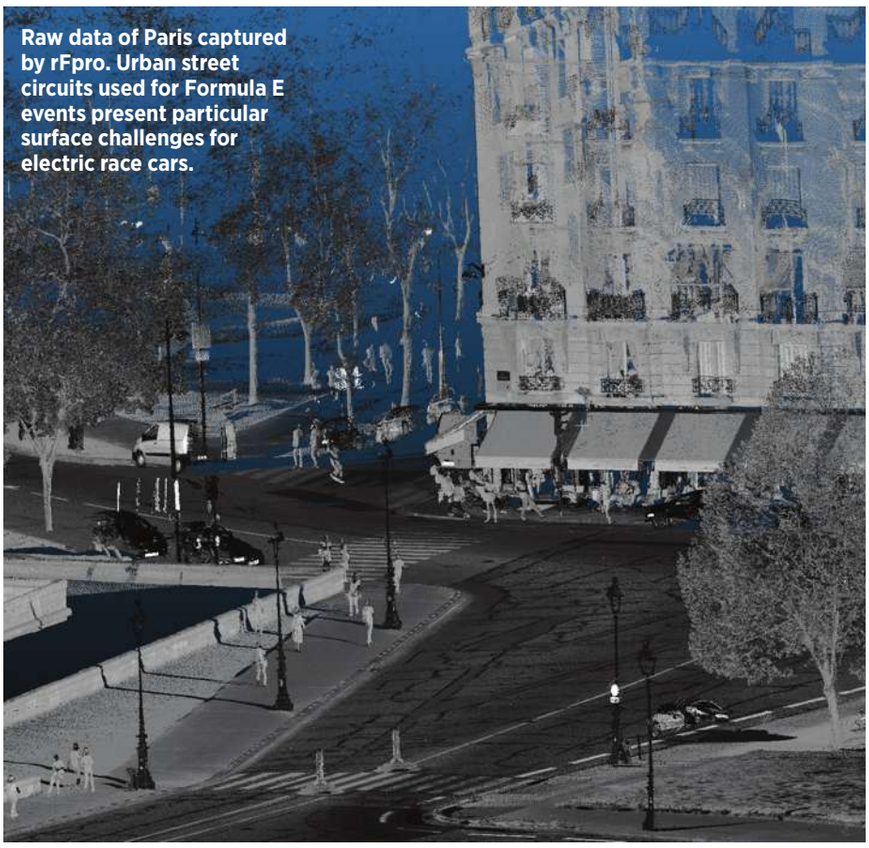
high-bandwidth, high-fidelity, cleaned-LiDAR-point cloud data for each tire contact patch into the vehicle model in real time at up to 5kHz.

As Formula E racing gains popularity, the category is gradually assuming F1 levels of sophistication. Hoyle's company is now supporting the series, complementing their established driver-in-the-loop (DIL) simulator software solutions for Formula One, NASCAR and World Endurance Championship teams.

The company now has most of the established Formula E circuits scanned and modeled to the same levels of precision as the world's F1 tracks. Its improved modeling accuracy helps the cars make full use of all available energy, to run faster for longer. With regulations placing limitations on Formula E chassis design, rFpro has found that teams are increasingly concentrating simulation time on improving the accuracy of their energy consumption predictions—and developing their complex control systems.

Overcoming the first challenge—circuit layout—is achieved by scanning after the barriers have been erected and updating the data in the circuit model which is used by the simulator. The second issue, accounting for road surface features, has only been made possible by two fundamental developments in DIL performance: faster response and improved surface data capture.

Jaguar's I-Type Formula E race car.



Raw data of Paris captured by rFpro. Urban street circuits used for Formula E events present particular surface challenges for electric race cars.

"To ensure that a driver behaves exactly the same in the simulator as on the track, the experience must be totally convincing. This means all the cues—visual, aural, haptic—must arrive on schedule in real time," Hoyle explained. He noted that some older-generation simulators had up to .25 s latency (delay) which meant they were limited in their capabilities and too slow for chassis dynamics work.

The rFpro software provides video signals ten times faster and audio signals 20 times faster, which overcomes this limitation, he claimed.

Having provided a convincing simulation environment in which the vehicle responds in real time, the further key ingredient is always the accurate road surface model. It provides the correct inputs to the vehicle's tires—the task of TerrainServer.

"The pressure on teams to extract the maximum possible energy from their car's battery pack by the time it crosses the finishing line is likely to intensify if proposed 2018-2019 rule changes go ahead," Hoyle added. These will see the end of drivers switching to a second car during the race.

Having only one car, with one battery pack as an energy source, will place even more emphasis on extracting the maximum without exhausting their energy supply prematurely. "Highly accurate simulation can help to achieve that," he said.

Stuart Birch

AUTOMOTIVE POWERTRAINS | PROPULSION

The upside of downsizing: senior executives have a say

Mercedes-Benz's Dr. Thomas Weber always talks of rightsizing rather than downsizing—and emphasizes the importance of engine electrification.

To downsize or not to downsize? That's the engine-development question facing all OEMs. In an initial move to be seen to be more environmentally responsible, for many, downsizing seemed to be a thoroughly sensible answer. Engineers were delighted to demonstrate their ideas for extracting maximum energy from minimum cubic capacity— and marketing executives were equally delighted with the advent of a new angle for product promotion.

But as with most elements of automotive engineering, engine downsizing has proven to be not quite that simple. "Rightsizing" is the alternate term to emerge to describe rather more pragmatic solutions to reducing a vehicle's carbon footprint. Not as emotive or positive-sounding as downsizing, "rightsizing" nevertheless has found approval among several OEMs and Tier 1 suppliers.

Arguably, "rightsizing" simply means doing it as it's always been done. For an OEM, the whole point of engine design is to match it to the entire vehicle and sell the result in large numbers at an equally large profit, while meeting fuel-consumption and emissions legislation, not to mention buyers' expectations.

Mercedes-Benz recently revealed new 3.0-L 6-cylinder engines and even a new V8 (see story here), albeit with capacity reduced by a relatively modest 0.7-L compared to the previous generation. It regards these engines as rightsized for present and anticipated future legislation, environmental responsibility and efficiency requirements, while giving customers what they expect a Mercedes to provide.

Prof. Dr. Thomas Weber, retiring head of **Daimler** Group Research and Mercedes-Benz Cars development, always talks of "rightsizing" rather than downsizing: "Instead of trimming the number of cylinders from the outset, thereby foregoing refinement and output, there are much more intelligent solutions. Our M176 V8 engine uses cylinder shut off; at part-load up to 3600 rpm it is an especially efficient 4-cylinder. Then, imperceptibly for the vehicle's occupants, cylinders 2, 3, 5 and 8 cut in."

Mercedes also is heavily committed to powertrain electrification via 48V technology to enhance efficiency.

At **Delphi**, Vice President Engineering (Powertrain), Martin Verschoor, believes progress in downsizing won't slow—but it will change: "So far we have seen very successful downsized engines that are enabled by pressure charging and variable valve control. The benefits on a gasoline engine of keeping the load high and the throttles open are so significant that I can't see this trend abating, but I can see diverging technical strategies, with different solutions for different types of vehicle."

While there is a variety of clever solutions proposed by the pressure-charging specialists, he believes that electrification of the powertrain will provide an attractive answer for all but the lowest-cost vehicles: "Testing shows that Delphi's new 48V electrical system

Martin Verschoor, Delphi's VP of Engineering for Powertrain, sees 48V technology as an enabler for continuing downsizing.

for mild hybrids delivers 50% to 70% of the CO_2 and fuel economy benefit of a full hybrid for just 30% of the cost. But the advantages run deeper than that: with a 48V electrical machine, you have enough instant traction energy to fill the low-rpm torque gaps of a highly downsized engine. We see 48V as an enabler for continuing downsizing for the majority of passenger cars, removing the need for some of the additional complexity that could slow progress in this field."

'Clever controls'

New control strategies that take advantage of very powerful yet affordable computing are a vital part of 48V systems, he explains. What he terms "clever control" is being used to release further downsizing opportunities through areas like variable valve control and cylinder deactivation techniques that can also be used to enhance Miller-cycle operation, too.

An additional consideration is NOx, which can be more of an issue with aggressively downsized engines. Says Verschoor: "This could lead to some engine designers deciding to increase capacity. "However, for the majority, the benefits of downsizing are so well-established, I can't see the overall trend changing significantly."

But there are limits to downsizing, stresses **Federal Mogul** Powertrain Chief Technology Officer, Gian Maria Olivetti, who recently stated: "We have reached the end of extreme downsizing. It is difficult to imagine a certain level of power with fewer than three cylinders. Also, (Europe's) Real Driving Cycle (RDE) is not helpful for further downsizing because extreme downsized engines—both gasoline and diesel—run at really high loads, so their emissions and fuel economy are compromised."

Although Federal Mogul Powertrain is developing technologies to reduce friction on all engine sizes, including coatings for pistons, rings and bearings, additional challenges are posed by downsizing, says Olivetti. "More aggressive combustion, higher temperatures and pressures and increasingly corrosive exhaust products place higher demands on many of our components. Stop-start and hybrid operations demand new solutions for running surfaces that are subjected to intermittent operation. To provide the required durability, we are continually increasing the fatigue strength, wear resistance, temperature resistance and corrosion resistance of our products."

"The trend now is rightsizing," said Dr. Oliver Taylor, BP Castrol's Nexcel Chief Engineer.

Advances outside the engine

Oil companies also have views on downsizing/rightsizing. **Castrol**, a subsidiary of global oil company **BP**, recently launched its advanced NEXCEL oil-change system. Nexcel's Chief Engineer, Oliver Taylor, said the company is confident of a strong future for ICEs. "The increased loading present in the WLTC (Worldwide harmonized Light Vehicles Test Cycle) and RDE cycles in Europe means that manufacturers will review what the 'right' size approach is for modern engines; some will be downsized, some may be bigger. The trend now is rightsizing.

"Engine development is driven by the need to reduce emissions. Increasing the effective engine load level through downsizing reduces the relative magnitude of friction present and, for a spark-ignition engine, reduces the pumping work at part-load. We expect to see increasing levels of sophistication as mild-hybrid control systems mitigate the transient loads on the ICE, enabling tighter control of NOx and PM (particulate matter)."

To help maintain the durability of increasingly heavily loaded components, downsized engines depend on sophisticated oils with complex additives. Taylor stated: "A significant barrier to downsizing is the need to design the engine to accommodate low-performance generic oils later in its life. An electronically connected, smart lubricant management system such as NEXCEL removes that barrier."

With a sealed oil-management system, engine designers can extend the possibilities available to them in areas like higher average bearing loads and peak temperatures, while retaining durability: "Add the ability to actively manage oil quality through the oil drain interval and you have a powerful new tool that enables new generations of highly-efficient, rightsized engines."

As recently reported in Automotive Engineering, the UK company **Torotrak** has developed a CVT-controlled variable supercharger system called V-Charge to make engines downsized to only a liter return performance similar to a 1.5-L, with fuel consumption of that engine significantly reduced.

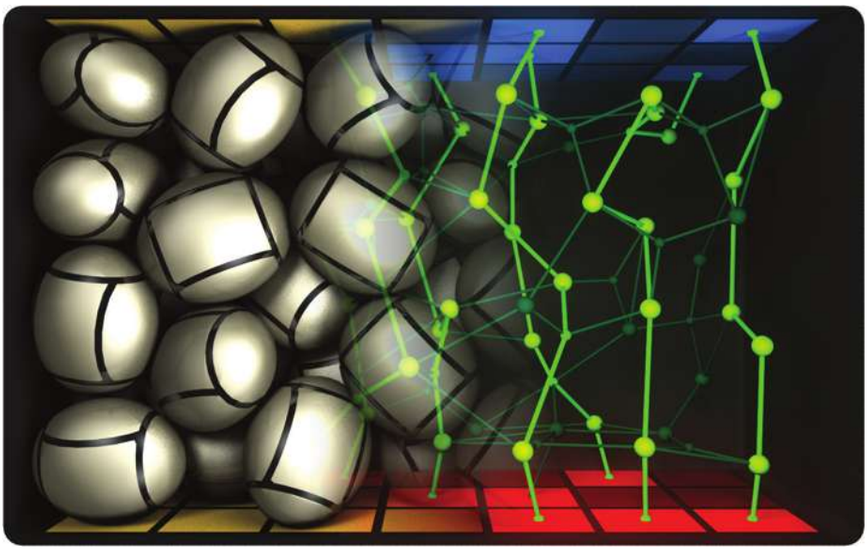
"For some time, we have raised concerns about the sole use of turbochargers for the increasing levels of boost being employed on downsized engines, both gasoline and diesel," said Torotrak Group's Chief Technology Officer, Doug Cross. "Turbocharging creates higher combustion temperatures and pressures that increase the formation of NOx and introduces additional thermal mass into the exhaust stream, which makes it harder to maintain catalyst temperature when running at part-throttle. It is also least effective at matching intake charge delivery against demand when operating at low engine speeds and torque levels that reflect the driving style of owners seeking maximum economy."

Cross is confident that variable supercharging—instead of turbocharging—in the lower engine speed range (but retaining a larger turbo for higher engine speeds) offers significant advantages, improving control of intake charge delivery while maintaining adequate exhaust temperatures "Combined with aftertreatment using selective catalytic reduction (SCR), this approach enables effective downsizing while meeting lower NOx and particulate targets."

Stuart Birch

AUTOMOTIVE ELECTRONICS

Pour your next EV battery?

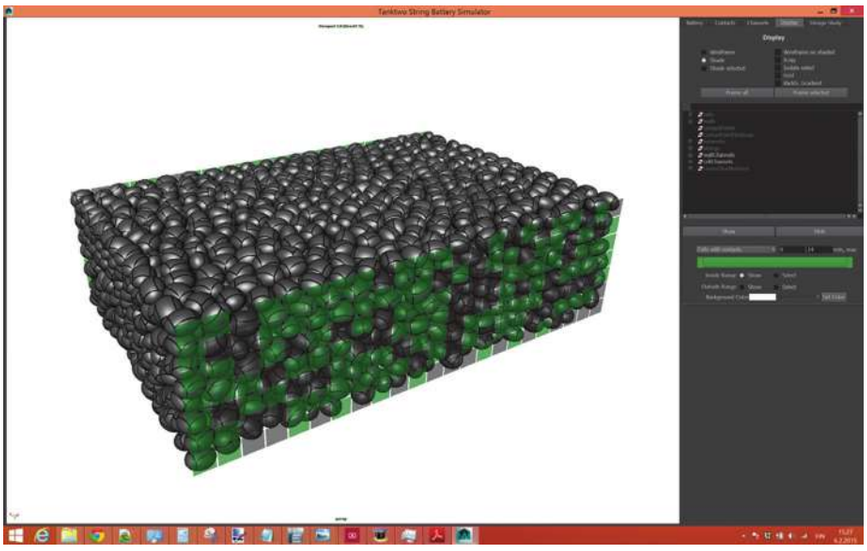


String Cells automatically "string" connections together without human intervention to create a functioning pack they call a String Battery. Stringing algorithms continually monitor the network and create new ones as needed.

While electric propulsion appears destined to supplant the internal combustion engine at some point in the future, the laws of economics and market forces will likely keep ICEs around for decades. Batteries for EVs remain expensive. Packs are heavy and recharging takes longer than pumping liquid fuel into a tank. Despite their many advantages, EV disadvantages are hard to ignore.

Enter **Tanktwo** and a truly novel approach to the basics of EV batteries.

The basis of EV batteries today starts with a small component collectively known as a cell. Typical cells are shaped as cylinders or rectangular slabs. What makes them attractive to electrified-vehicle battery makers is they already are widely used in consumer electronics. Cells are combined into modules, modules into a highly engineered, static battery pack.



Simulated illustration of a String Battery. Inflatable bladders made from silicone apply mechanical pressure to keep the cells in place while in a moving vehicle. The company claims that for cells with 6 contacts there are enough connections to get 98% utilization or greater. Contact degradation and possible corrosion over time can be handled a number of ways, according to the company.

Tanktwo's vision is a battery pack composed of egg-shaped String Cells. The Finland-based company's founders exploited their background in telecommunications to create 'smart' cells that contain small, programmed computers. Poured (literally) into an inexpensive passive container with contacts on the inside, they create a String Battery.

Conventional batteries too big

One of the biggest benefits of the String Battery lies in a problem with current battery concepts—capacity rigidly designed from the outset, according to Bert Holtappels CEO of Tanktwo, which has an office in New York.

"These systems are inefficient because they need to be over dimensioned with significant margin, so that the likelihood of field failure is within an acceptable margin," he said. Some EV makers are delivering cars with 100 kW·h battery packs when their owners might drive only 12,000 mi (12,300 km) per year, meaning that "most of the depreciation of the battery is coming from aging, not wear"—a costly loss of an asset, Holtappels explained.

Sizing the Tanktwo String Battery container for the maximum scenario requires filling only as many cells as needed for a typical usage, plus a healthy margin. The container would recharge the cells through the today's conventional **SAE** J1772 plug. "This prevents underutilization of the pack," he explained. "During the period he owns the vehicle, the same customer could visit the dealer and get an upgrade to the battery pack quite easily."

The simplest version of the swapping device resembles a glorified Shop Vac. Holtappels recognizes that the more ambitious goal of convenient and fast battery swapping requires an infrastructure change that could inhibit adoption—think hydrogen fuel cell vehicles. "That might come naturally over time," he speculated.

The String Cell from Tanktwo replaces a "dumb" battery cell with one with multiple pressure contacts on its skin and a computer to make it "smart." The cells shown here have 6 external contacts.

Efficient by design

There are some other potential efficiencies of the String Cell approach. Current battery packs need to level the charge between cells in each module. So, if one cell has deteriorated by, say 20%, the rest of the cells in the module must bleed off energy to balance the cells within the module. So, each module is limited by the deterioration of any individual cell.

This also causes traditional packs to need large safety margins. Often, this means a battery designed to maintain an 8 kW·h capacity over the life of the car might start out with 14 or 16 kW·h.

Because String Cells are 'smart', the pack is not limited by the least-charged cell. As Holtappels describes it, if an individual cell deteriorates by 20%, the cell is simply bypassed for 20% of the time when the pack is contributing power. Each cell contributes to the pack to the best of its ability without any need to bleed off charge.

He estimates this as providing 10% more energy efficiency when compared to traditional pack designs with the same rated energy.

"Our packs can last much longer on a practical level as well," Holtappels claimed. "Most companies [think they should retire their] pack from the vehicle even when it is still 70% usable. For String Cells, anything over 10% of initial capacity is okay for each cell."

Dead or semi-dead cells that would be ruinous in a traditional pack can be bypassed in a String Battery and easily replaced at a service or swap event, the company claims. So the packs are sized for the mean, not the worst case. The containers they go into also are fairly simple. Important components, such as bus communications and wire harnesses are already commoditized. Because of the unique character of the String Cells, there is flexibility in the shape of the container.

"This technique is agnostic about the battery cell chemistry: any improvement in the chemistry of cells would also improve the String Battery," he said.

According to Holtappels, a couple of industry partners are already working with Tanktwo on initial deployments, including Firefly with an electric service vehicle. In these cases, the rapid battery replacement—3 minutes according to the company—was an important factor.

"This is definitely an out-of-the-box idea, but it seems quite challenging," observed Dr. Menahem Anderman of **Total Battery Consulting.** Interviewed by the author for this article, Dr. Anderman would like to see future trials prove out the quality of the 'dynamic' electrical contacts between the cells and examine complexity, cost and reliability in real life.

"I believe it will be quite a stretch to make a real viable system out of the concept," he said. There is no doubt the Tanktwo principals are just as aware of the challenges. Stay tuned.

Bruce Morey

OFF-HIGHWAY SIMULATION

Follow the chemistry to better CFD combustion simulations

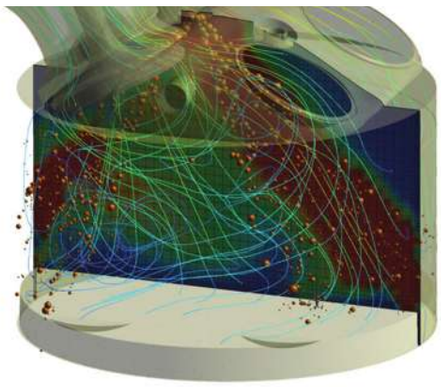
For internal-combustion (IC) engine design, companies need to stay ahead of not only the competition but also of new emissions mandates.

Computational fluid dynamics (CFD) can help engine designers create higher performance, lower emissions IC engines without costly physical prototyping. CFD lets engine designers visualize and test fuel and ignition behaviors within a virtual combustion chamber, providing a faster way to design cleaner, more efficient engines by simulating ignition and fuel dynamics.

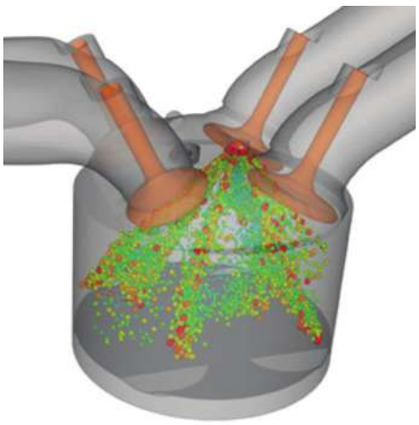
But combustion CFD can only be of value if the results predict real-life behaviors. To predict actual performance and pollutant emissions, simulations need to accurately account for the chemical kinetics of the combustion process. Simulations that rely on drastically simplified fuel chemistries and ever-finer meshing technologies fall far short of this goal. And when they fall short, designers must fall back on expensive, time-consuming physical testing for answers.

Combustion CFD challenges

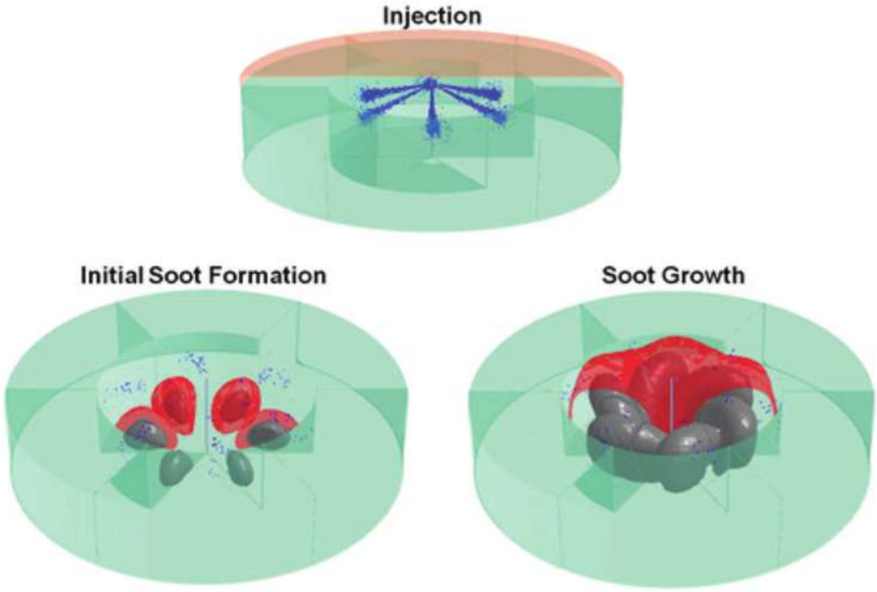
Combustion CFD is complex and computation-intensive, especially for applications such as soot formation and engine knock. Times can easily stretch into days for traditional CFD multi-



ANSYS Forte accurately simulates IC engine combustion by precisely accounting for real chemical kinetics.



Spray droplet visualization at the beginning of injector for a SI sector-mesh simulation.



Soot formation process simulated with ANSYS Forte.

stage simulations with thousands of variables. Incremental changes to engine geometries and fuel models can stretch the total time to weeks or months before an optimized design is realized.

To speed design time, many CFD solutions simplify combustion chemistry, trusting that severe mesh refinements can make up in detail what they lack in precise chemistry. These simplified fuel models rely on weakly validated, third-party mechanisms from disparate and incompatible sources. Using models from multiple sources makes it very difficult to blend or customize fuels in simulations because species and reactions may be duplicated—perhaps in a contradictory way—in different sources.

Better models are needed now because motor fuels have become more complex. Fuels vary by seasonal formulation (U.S. summer gasoline contains less butane than winter formulations), by region and by application (U.S. diesel has different properties than European diesel). Alternative fuels such as ethanol and biodiesel now supplement petroleum-derived fuels.

To understand the effects of these diverse fuel types, chemically correct fuel models are required. Unfortunately, fuel model algorithms in conventional CFD packages are complex and compute time can multiply exponentially when they are combined to represent multicomponent fuels.

Simulating soot formation and engine knock

New particulate matter (PM) regulations present particular challenges for engine designers. Soot phenomena are notoriously difficult to simulate and too complex to run in conventional CFD software, due to the physics and chemical reactions leading up to soot formation. As a result, optimization of soot in conventional combustion-engine design typically requires years of building and testing prototypes.

Knocking occurs when the highly compressed fuel and air mixture in the combustion chamber auto-ignites, either before or after the spark that is meant to trigger ignition. Accurately modeling the location and structure of the flame front as it expands into the combustion chamber is extremely important for predicting knock. But simulating auto-ignition is very difficult with conventional CFD approaches that rely on mesh refinement and simplified chemistry.

Since the scale of the flame front thickness is significantly smaller than computational mesh—even with severe grid refinement—CFD simulations that rely on mesh to resolve the flame location will require an inordinately large number of tiny cells to resolve the flame topology sufficiently. Simulations with large numbers of small cells can easily get bogged down by the tiny time steps needed to maintain simulation stability, and require an impractical amount of computation time.

What's an engine designer to do?

Follow the chemistry

Chemistry is crucial. It's at the heart of combustion, and for internal-combustion CFD to accurately predict real-world engine behavior, it must precisely account for real chemical kinetics.

ANSYS Forte, for example, changes the well-established scaling equation: instead of scaling with the cube of the number of species, the simulation time scales linearly. This allows an engine designer to include as many reactions as he or she requires for accurate simulations, without incurring a compute time penalty. Even larger, more accurate fuel models achieve compute times comparable to those with severely reduced, less accurate models. As a result, designers can quickly and accurately predict emissions that translate reliably to actual engine designs—with far less trial-and-error hardware prototyping.

Fuel components derived from the industry-validated Model Fuel Library enable ANSYS Forte to simulate combustion for a large variety of new or existing fuel blends and foresee what emissions will occur for a wide range of operating conditions.

By using accurate fuel models based on precise chemistry, engine designers greatly increase the predictive quality of combustion simulations, to more quickly and effectively meet strict regulatory guidelines and create advanced clean engine and fuel technologies.

Bill Kulp, the lead product marketing manager for Fluids at ANSYS, wrote this article for *Mobility Engineering*.

AEROSPACE POWERTRAINS | PROPULSION

S.S. White Technologies lending flexibility to new GE9X, 777X

S.S. White Technologies is supplying flexible rotary shafts for the **Honeywell Aerospace** Air Turbine Starter (ATS) on the next-gen **GE Aviation** GE9X high-bypass turbofan engines.

The Honeywell ATS comprises the starter and starter air valve. The flexible shafts are specifically designed to transmit rotary torque for the manual override of the starter air valve in case of an operational failure. The ATS is powered by complex turbo machinery to provide starting power to a gas turbine engine. Together, the components convert pneumatic energy to mechanical torque, which accelerates the engine to its required ignition speed.

The starter air valve controls air flow from the engine bleed, auxiliary power unit, or ground supply to the ATS and has significant built-in operational and protection features that reduce start-induced stresses to the engine. It also includes a high-temperature containment feature to reduce the risk of secondary collateral damage to personnel and machinery.

One of the features of the flexible rotary shaft is that it allows ground crews, if necessary, to manually actuate the starter air valve to enable aircraft dispatch. The ability to do so can prevent flight delays and cancellations further down the aircraft's operational schedule.

S.S. White engineers utilize an in-house computer modeling software program to "more fully model the behavioral characteristics of the wire bundles within the shaft core" and provide "maximum bending flexibility and torsion strength while allowing minimal torsion deflection." The company provides flexible rotary shafts for the aerospace, medical, industrial, and automotive industries.

The S.S. White Technologies flexible rotary shaft will be employed in the Honeywell Aerospace Air Turbine Starter (ATS) on the new next-gen General Electric GE9X high-bypass turbofan engines.

The GE9X engine, which incorporates the Honeywell ATS and S.S. White flexible rotary shaft, is a derivative of the GE90 which was developed for the Boeing 777. Studies began on a more efficient variant, the GE9X, in February 2012 to power Boeing's new 777X. The final GE9X design features a 3D-woven composite forward fan case and a 16-blade, carbon fiber 134-in diameter composite fan—wider than a Boeing 737 fuselage. The design also incorporates CMC (ceramic matric composite) materials in the combustor and high-pressure turbine, which GE claims will be a third of the weight, with greater thermal management capabilities, than a similar metal counterpart. The engine's force is currently rated at 105,000 lb.

GE recently conducted second-phase testing of the GE9X CMC components in a GEnx demonstrator engine. The components successfully completed testing in a dust and debris environment. GE9X Certification is still on target for certification by 2018, with introduction on the 777X planned for 2020.

Beyond S.S. White and Honeywell, several other partners will help contribute to deliver a combined total of 25% of GE9X components. **IHI Corp.** is responsible for the design and manufacturing of low-pressure turbine components, as well as the fan mid-shaft. IHI has participated on the CF34, GE90, GEnx, and Passport engine programs and has been producing GE military engines under license for more than 60 years.

France-based **Safran Aircraft Engines** will be designing and manufacturing the composite forward fan case and the turbine rear frame. Safran currently produces the CFM56 and LEAP engines with GE through **CFM International** and contributes to the CF6, GE90, and GP7200 programs. **Safran Aero Boosters**, will contribute to the GE9X with the design and manufacturing of the low-pressure compressor and will manufacture the fan disk. **MTU Aero Engines AG** is responsible for the GE9X turbine center frame.

William Kucinski

The GE9X engine will power Boeing's new 777X, with introduction planned for 2020.

AUTOMOTIVE AUTONOMOUS DEVELOPMENT

Continental demonstrates new sensing tech for SAE Level 4 capability

A braking and cruise-control system that can move a vehicle up and down steep off-road hills. Vehicles that can detect at-risk road users not in the driver's field of vision. These production-ready and production-intent technologies are in **Continental**'s product pipeline.

Pedestrians, joggers and bicyclists are vulnerable to a vehicle impact when hidden from a driver's sight. While a camera-equipped vehicle can alert its driver to someone partially concealed by a parked car or other obstruction, even earlier detection is possible.

Continental is testing the use of ultra-wide-band sensors to identify at-risk road users. These proximity-based sensors, like those used in key fobs, are located on the side mirrors and on the passenger-side C-pillar of a demonstrator car tested by *Mobility Engineering* recently at the supplier's Brimley, MI, Development Center. A sensor-equipped safety dummy stands in for a wandering pedestrian.

By triangulating the sensor signals, the sedan's communication network detects the safety dummy "target" three to four seconds earlier than a vehicle using cameras.

"This demonstration is a thought-starter. We have to start thinking about how to avoid accidents with vulnerable road users in order to have a solution in the future," said Jeremy McClain, Continental's North American Director of Systems and Technology, Chassis & Safety Division.

A Jeep Grand Cherokee fitted with Continental technology self-climbs a 30-degree rock-laden grade. (Kami Buchholz photo)

The 'Cruising Chauffeur'

Like V2V and V2I communications, knowing the precise location of a road user can help prevent an accident. Said software engineer Ganesh Adireddy, "It's all about sharing information from the pedestrian road user, who in actual use likely would have a smart phone, a smart watch, or a special transponder." Short-range communication can identify a person's position more accurately and do so more quickly than GPS.

Precise location information is critically relevant in autonomous driving scenarios, which is why Continental's "Cruising Chauffeur" feature is designed to add another layer of sensing capability to compliment long- and short-range radars and cameras. According to Eric Mertz, senior staff technical specialist for the V2X team, Continental's M2XPro algorithm fuses GPS and vehicle sensor data.

"There are situations, like an urban canyon, where a GPS signal reflects off buildings," Mertz noted. "And when that happens, it gives a false indication of where you're at in the city." By incorporating M2XPro with the Cruising Chauffeur's existing communication technology, positioning accuracy below 1.5 m (5 ft) is expected, he said.

Automated lane change and lane-change recommendation capabilities were added recently to the Cruising Chauffeur demo vehicles, according to Steffen Hartmann, test and validation engineer involved with the automated driving project. When a Cruising Chauffeur vehicle is in automated driving mode, a driver's turn signal movement tells the car to make a lane change if it's safe to do so. A lane change recommendation occurs via the HMI interface if a vehicle in front of the Cruising Chauffeur slows down.

Engineering teams in the U.S., Mexico, Germany, Japan, and Shanghai are working on the Cruising Chauffeur. "We're making more and more steps toward our final **SAE** Level 4 automated driving vehicle," said Hartmann. Continental officials expect technology for highly automated driving to be ready by 2020 and fully automated driving technology to be ready by 2025.

Tip-toeing off road

Continental is production-ready with its MK C1 electronic brake system with Off-Road Cruise Control (OCC). The MK C1 portion of the system recently debuted on the European-market **Alfa Romeo** Giulia.

The innovative MK C1 unit integrates brake actuation, brake booster, and control systems. It weighs 13 lb (6 kg), about 4.4-6.6 lb (2-3 kg) less than a traditional system. According to Tim Buchert, a vehicle test engineer with the electronic braking systems group, the electro-hydraulic MK C1 uses a linear actuator instead of the two- or six-piston pump that's in conventional braking systems.

During a demonstration, a **Jeep** Grand Cherokee equipped with the MK C1 only required the driver to steer the SUV after the OCC was set at 1.2 mph (1.9 km/h). The vehicle climbed a rocky 30° grade. It also moved itself down, and up, a similarly steep grade while in reverse. "The system is silent when building up brake pressure, so there isn't any NVH or pulsating as the vehicle climbs or descends the hill," Buchert explained. "In a hybrid driving application, you can hit the brake pedal to send a deceleration request to the electric motors. The vehicle will slow down using the electric motors and over time slowly fade-in conventional braking."

Kami Buchholz

A GREENER FUTURE FOR TWO-WHEELERS

The Indian government's proposed leapfrog move to BS VI emissions standards—from the current BS IV level—for the two-wheeler industry presents an opportunity for a greener environment. A new systems-engineering approach is desirable to create an agile and evergreen commuting option for the Indian middle class.

We expect to see various available powertrain technological combinations to meet BS VI norms. Electrification and hybridization possibilities are not included in this work.

India's two-wheeler market

In India, two-wheelers account for up to 80% of total vehicle sales. The domestic two-wheeler industry reported 16.4 million sales in FY 2015-2016 and a 4.4% year-on-year (YoY) growth in Q3 2016. According to *Autocar Professional*, the industry projects a medium-term volume compound annual growth rate (CAGR) of 8-9% to reach 22-23 million (domestic plus exports) by FY 2019. The statistics point to an ever-growing two-wheeler market in India—so strict and stringent emissions regulations definitely are a welcome move considering the pollution India has endured in recent times.

Emissions regulations

With emissions regulations becoming more stringent, improved fundamental engine design and innovative technologies are required to optimize the powertrain. The move to BS VI for 2020 would bring Indian regulations on par with western-European regulations, allowing manufacturers the opportunity to export a common platform. With the limits for hydrocarbons (HC), carbon monoxide (CO) and oxides of nitrogen (NOX) heavily reduced for BS VI, a robust core competency in powertrain engineering will be required for manufacturers to meet BS VI regulations.

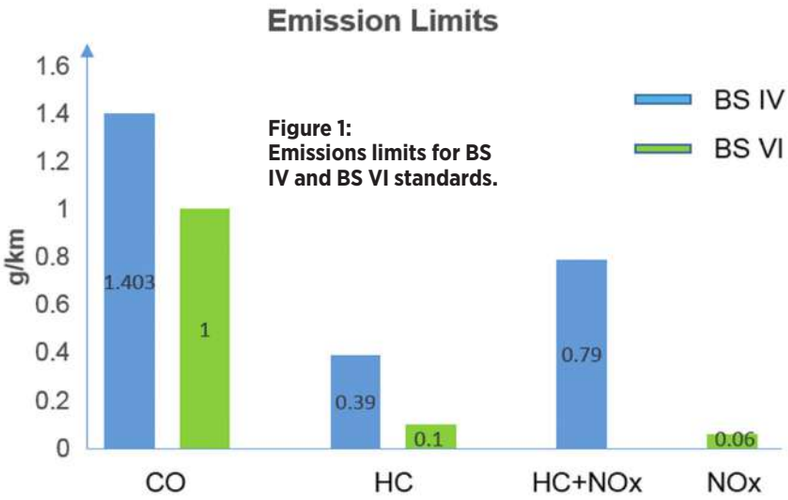


Figure 1: Emissions limits for BS IV and BS VI standards.

In addition to the tailpipe emission limits, evaporative emission tests (which might require a carbon cannister for BS VI compliance) and fuel-economy regulations also are components of the BS VI regulations, although not covered under this work.

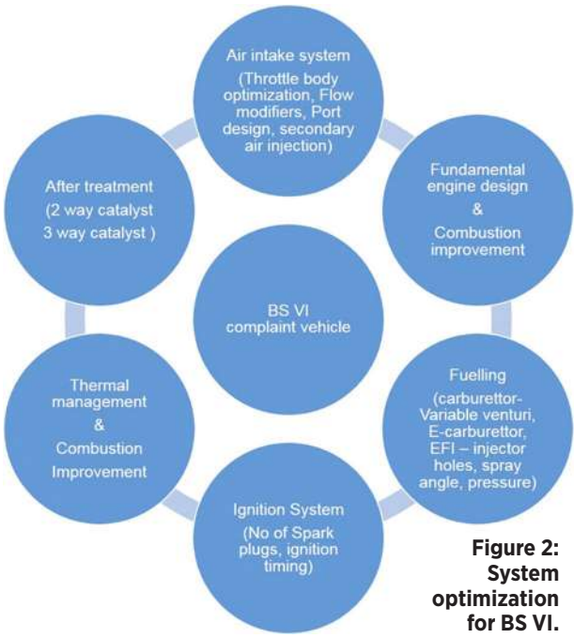


Figure 2: System optimization for BS VI.

Challenges for BS VI

The shift from the Indian driving cycle in BS III to the World Motorcycle Test Cycle (WMTC) for BS IV generated challenges for manufacturers—but that experience now can be leveraged to prepare for BS VI emission regulations, which also will likely require manufacturers to run WMTC cycle tests. This move brings an opportunity for manufacturers to export BS VI-compliant vehicles wherever similar regulations are applicable. So the industry must learn the intricacies and benefits of the WMTC for emissions qualification.

The jump from BS IV to BS VI requires hefty investments, as well as highly competent and skilled engineering teams to overcome the technical challenges. This skill gap, when bridged, produces a cost efficiency as technology transfer costs are reduced. Teams need to be trained in various core-competencies like powertrain simulation, combustion development, system engineering, calibration and embedded-systems development and onboard diagnostics (OBD). Simulation of in-cylinder emissions throughout the engine operating range can be helpful in determining the requirements for exhaust aftertreatment systems.

A mean shift in fuel quality from 50 parts per million sulphur to 10 ppm is expected to be required to meet BS VI regulations; the reduced gasoline and diesel sulphur content also will cut particulate emissions for gasoline direct injection (GDI) and compression-ignition engines. Sulphur also being a retarder of catalytic converter efficiency (since it reacts with platinum group metals), its reduced content in fuel will ensure the effective working of catalytic converters and in turn lead to improved oxidation conversion rates for CO and HC to carbon dioxide (CO_2) and water and a better reduction rate for NOx to nitrogen (N2) and oxygen.

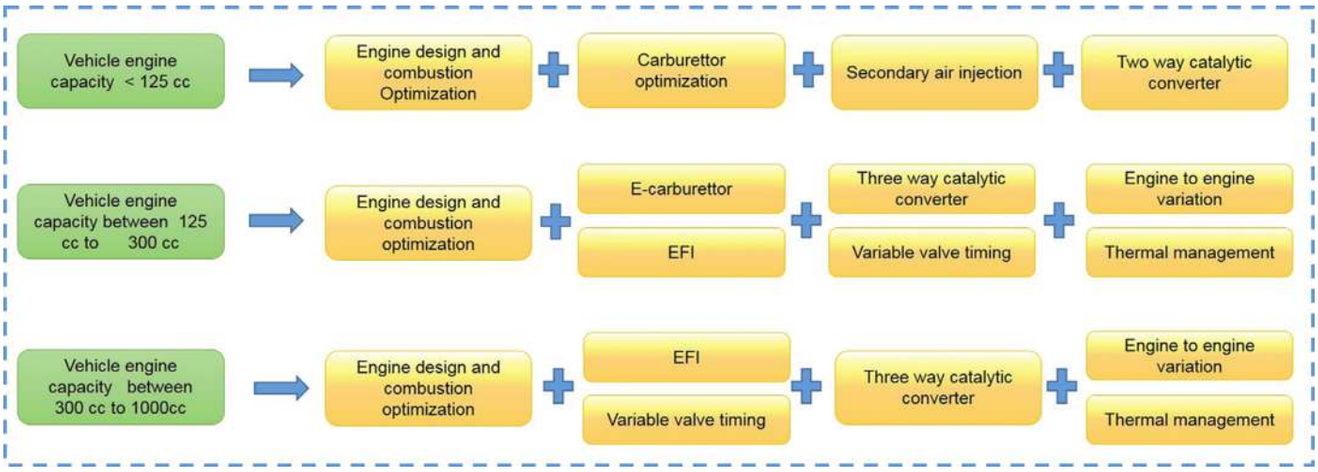


Figure 3:
Compounding of technologies for BS VI with reasonable cost.

The BS VI regulation calls for huge investments from Tier 1 suppliers to develop the relevant technologies. The higher engineering costs and increase in component technology costs should be compensated largely by using available technologies and compounding of technologies. Some of the cost compensations are listed in this article.

Current thought process

Major technologies that could be employed to meet the new two-wheeler regulatory norms are combustion optimization, thermal management and carburation-optimisation/fueling and spark control, as well as after treatment technologies such as secondary air injection and 2-way/3-way catalysts.

The present scenario suggests the motorcycle industry will continue to grow in electronic fuel injection (EFI)-segment vehicles. Compounding of those available technologies could be effectively used to meet BS VI norms with reasonable cost.

Cost compensation

The transition of vehicles to meet BS VI regulations will increase costs. For the two-wheeler industry, a rise in price as high as 10% is expected for BS VI-compliant models. With BS VI transition set to be implemented, there should also be corresponding focus on reducing the overall cost of the vehicle.

The increased cost of BS VI-compliant powertrains could potentially be offset by improved powertrain systems engineering, functional integration of components, component or design modularity and friction-reduction technologies. The lead time of 3-4 years also allows for in-house development and localization of components required to meet the new emissions regulations. This in-house manufacturing would, in the long term, reduce the cost of the vehicle and powertrain and also improve the organization's technical competency. An opportunity to grow exports also can be realized.

Reduction of engine-to-engine variation, meanwhile, can help improve the prospects for a robust and lean aftertreatment system.

TABLE 1: AVAILABLE TECHNOLOGIES TO MEET BS VI

S. NO	TECHNOLOGY	BS III	BS IV	BS VI
1	Carburetor optimization	✔		
2	Carburetor with flow modifiers and multi jet		✔	✔
3	Electronic carburetor (e-carburetor)		✔	✔
4	Engine fundamental design and combustion improvement	✔	✔	✔
5	Friction and weight reduction and functional integration			✔
6	Catalytic converter (2-way/3-way)	✔ (2-way)	✔	✔
7	Variable valve timing		✔	✔
8	Electronic fuel injection (EFI)		✔	✔

Summary

With the competency of Indian automotive giants that are pioneers in the motorcycle industry, coordination, hard work and investment in advanced technologies will surely yield BS VI-complaint vehicles by the April 2020 deadline.

To retain sales volumes and customer value, it is essential to keep the cost under control and offer the prospect of good fuel economy, which also could yield an increase in year-on-year motorcycle sales. Intelligent combining of available technologies can lead to cost-effective, BS VI-compliant two-wheelers. ■


Authors: Meenakshi Sundaram I, AVP, Powertrain System, Hinduja Tech Limited, Chennai; and Arun Krishnan S, Powertrain system Engineer, Hinduja Tech Limited, Chennai.

Additive manufacturing

How 3D printing will transform the A&D support chain

3D printing, or additive manufacturing (AM), is quickly becoming a 'must have' for aerospace and defense (A&D) manufacturers rather than just a luxury R&D project with the A&D sector now contributing 12 percent of 3D printing's $3.1 billion global revenue. A&D companies began experimenting with 3D printing as early as 1988, and industry leaders are now starting to recognize the unique capabilities of 3D printing, and searching for ways to exploit them. The **U.S. Navy** is currently working on 3D manufacturing at sea, which would revolutionize the military support chain, while in civil aviation, companies such as **Boeing** and **Airbus** have been using the process to manufacture components for over two years.

In the future, 3D printers will allow commercial aviation manufacturers to print parts for aircraft under construction, in addition to defense manufacturers and service providers producing replacement parts on demand for damaged equipment to support defense operations. Despite the increased uptake of 3D printing in A&D we have only glimpsed the tip of a large and growing iceberg.

Spare part required? Print one!

The complex and specialty nature of A&D equipment makes for a vast support chain. The thousands of constituent parts required to assemble an aircraft or vehicle are typically sourced from companies scattered across the globe. With strict industry safety regulations, this poses a support chain problem for A&D firms, particularly when it comes to maintenance, repair & overhaul (MRO). With utilization of spare parts a key to keeping assets operational for the maximum amount of time, 3D printing offers a solution.

Spare parts are prime candidates for 3D printing.

Spare parts are prime candidates for 3D printing. Demand is hard to calculate at the best of times as most spares must be kept in stock or within reach of procurement at short notice. Production units and spares could be produced on demand, avoiding expensive set-ups and large quantities of stock, thereby streamlining the entire support chain.

When MRO software indicates a component is faulty or at the end of its life span, the availability of a replacement can affect operations. Instead of ordering in specialty parts from any given corner of the globe, 3D printing could allow A&D enterprises to access the design electronically and manufacture the required part quickly, cost-efficiently and crucially, on-site. With the threat of operational downtime negatively influencing revenue, 3D printing offers savings on both fronts.

The Impact on ROI

One of the key inhibitors to large scale adoption of any new technology such as 3D printing, particularly in the civil aviation sector, is perceived return on investment (ROI). 3D printing can build parts with designs and structures that help reduce the weight of a part without compromising its mechanical performance. For example, **Rolls-Royce** and **General Electric** have shown that they can produce lighter engines more quickly by incorporating 3D printing into their manufacturing process - both have announced they will produce engine parts through additive manufacturing processes over the coming years. **GE Aviation** recently became the first OEM to use a 3D printed part to house its T25 sensor - providing pressure and temperature measurements for the control system – and fitted it to more than 400 of its engines currently in service.

The ROI is not difficult to see.

When **BAE Systems** became the first company to create and use a 3D printed part on board a Tornado fighter jet – a protective cover for the cockpit radio – it made it in one day for less than $150, and with a projected 4-year reduction in manufacturing costs of $1.8 million.

In theory, 3D printing is hugely cost effective since there is little waste. The process involves adding material rather than chipping it away. On average, the AM process generates

only 5 to 10 percent waste material – which can be recycled and reused – instead of the 90 to 95 percent from current machining. That's a critical attribute when using expensive A&D materials. Again the ROI is plain to see.

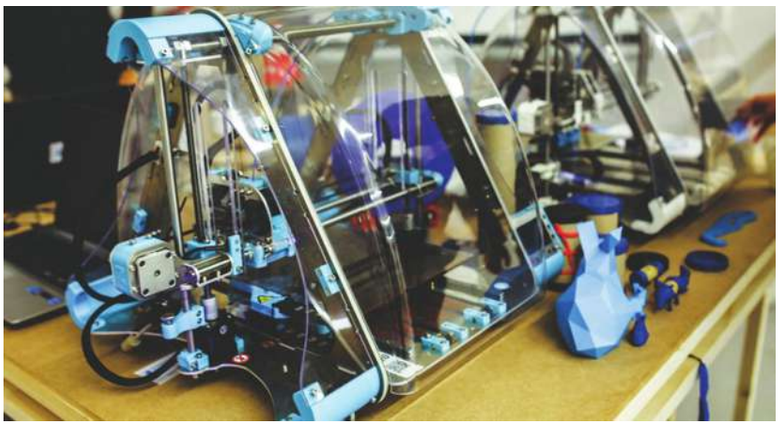
As the technology becomes more advanced and affordable, more enterprises in the A&D sector will see the business benefits. A recent study by **PricewaterhouseCooper** estimated that the MRO market stands to save $3.4 billion annually in material and logistical costs alone. The ROI is clear – AM has the potential to save millions of dollars in manufacturing costs across the A&D sector.

Make it or fake it?

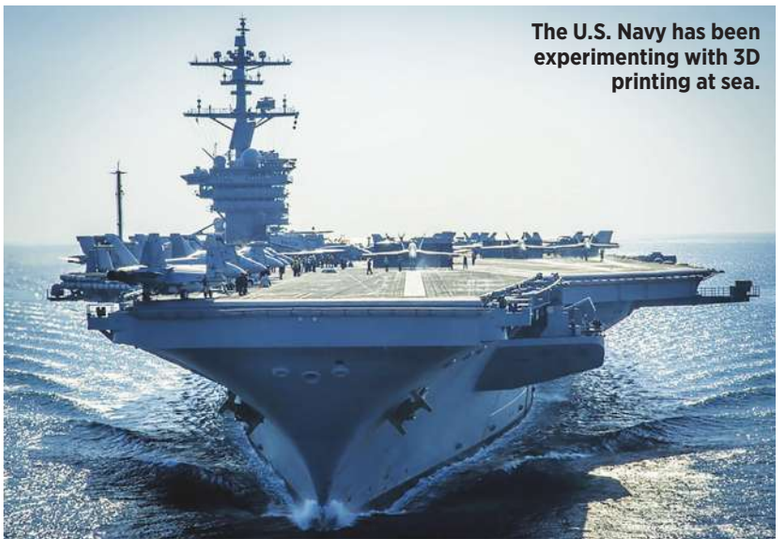
Comprehensive training around the use of 3D printing machines will become a necessity, alongside quality control methods when assessing components manufactured by the process. 3D printing's ability to create complex designs and fabricate lightweight but strong structures makes it a natural fit for the A&D industry. However, product quality is the Achilles' heel of every production technology, and as with all new technologies there are issues that need to be addressed.

The threat of counterfeit parts from easily accessible 3D printers, coupled with the endless amount of designs available on the Internet, could fuel a black market of counterfeit parts. OpSec, a developer of anti-counterfeiting technologies, says online libraries are starting to appear, where object files for 3D printing can be shared on a peer-to-peer basis. This has the potential to severely impact the support chain costs, enabling anyone with the technology to sell counterfeit parts at a discount and leave unsuspecting businesses at risk from poorly performing and dangerous parts. A report from the **Organization for Economic Cooperation and Development** (www.oecd.org/sti/38707619.pdf) put the value of counterfeit goods that crossed international borders at over $250 billion as far back as 2007, while the International Chamber of Commerce expects the value of counterfeit goods globally to exceed $1.7 trillion this year.

While 3D printing is rightly being welcomed in the A&D industry, it will also require key changes in ERP systems to control every element of the manufacturing, maintenance and support chain processes to manage the possibility of counterfeit parts entering the support chain. This is crucial in an industry as heavily regulated as aerospace and defense, and where safety is paramount.



3D printing can build parts with designs and structures that reduce weight without compromising mechanical performance.



The U.S. Navy has been experimenting with 3D printing at sea.

3D printing puts ERP center stage

As more A&D organizations embrace 3D printing, IT infrastructure will have to adapt and integrate - and quickly. Traditional ERP solutions can take months or even years to install, let alone adapt to an entirely new production process, such as 3D printing, that has a dramatic and immediate effect on the support chain, safety and the whole MRO operation.

Modular, application-based ERP solutions remove the time and pain required to modify processes and make it possible to deploy new technology quickly. These agile ERP systems are far more able to accommodate new technologies such as 3D printing in a way that will allow operators to streamline the support chain, reduce time-related costs and reduce maintenance turnaround times.

Undoubtedly, 3D printing has provided the A&D industry with an enormous opportunity to make and replace parts with accuracy. The time saved when replacing parts out in the field, as well as the potential manufacturing and support chain cost savings, cannot be ignored. But in order to integrate new manufacturing processes such as 3D printing, A&D organizations need to be able to easily customize and adapt their IT infrastructure, making agile ERP software even more vital to managing MRO. ■

This article was written by Kevin Deal, Aerospace and Defense VP, IFS North America (Brookfield, WI). For more information, visit http://info.hotims.com/61068-503.

AUTONOMOUS

Agriculture, construction, mining—even marine—are advancing autonomous technology to improve the productivity and safety of vehicles on the job.

by Ryan Gehm

In the future, CNH's concept tractors will use "Big Data" such as real-time weather satellite information to automatically make best use of ideal conditions. The New Holland T8 NHDrive autonomous concept with the 2085 air disc drill is pictured.

When engineers and executives discuss macro technology trends, regardless of the specific off-highway sector, increased automation of vehicles is inevitably among them. Though experts recognize that achieving full automation in production equipment will take some time, operator-assistance technologies such as automatic braking are becoming more widely available today.

And companies aren't shy about revealing autonomous prototypes that promise what's on the horizon. For example, **Komatsu** unveiled its Innovative Autonomous Haulage Vehicle featuring a cab-less structure at MINExpo in September. Unlike its 930E and 830E autonomous models, Komatsu claims it developed this vehicle exclusively for unmanned operation to maximize the advantages.

By distributing equal load to the four wheels when the vehicle is loaded and unloaded, and adopting four-wheel drive, retarder and steering, Komatsu is aiming for high-performance shuttling of the new haulage vehicle in both forward and reverse travel directions, eliminating the need for K-turns at loading and unloading sites.

Komatsu plans a market introduction for the new autonomous vehicle "in the near future."

CNH Industrial and **Volvo Construction Equipment** are two other companies with big plans for automation. Their latest autonomous vehicle demonstrators and development programs are detailed here.

CNH advances driverless tech for tractors

Precision farming and machine automation already play a significant role in agriculture. CNH Industrial's Innovation Group is focusing on key times of the year when farm work still requires long days in the field, particularly when harvesting a crop or planting the next one. Working with Utah-based technology provider **Autonomous Solutions Inc.** (ASI), the Innovation Group developed concept autonomous technology to meet this challenge and demonstrated it via tractor concepts based on the existing **Case IH** Magnum and **New Holland** T8 high-horsepower conventional tractors.

"There have a been a number of groups and product platforms that have been involved with automation of some of the tractor onboard systems, and those are all enablers that allowed us to put together a very successful autonomous concept vehicle program," John Posselius, CNH Industrial Head of Agricultural Innovation Technology, told *Mobility Engineering*. "Things as simple as having ISOBUS Class 3 capabilities on our tractor allows us to communicate by wire to all of the important functions on the tractor such as the hydraulics, the hydraulic remote, the three-point hitch, PTO, steering, transmission and engine control."

The concept tractors are configured as two distinct versions: the cab-less Case IH Magnum and the New Holland T8 NHDrive concept that maintains its cab for operating flexibility. Both use a conventional engine, transmission, chassis and implement couplings.

A fully interactive interface has been developed to control the tractors. Three operating screens include a path-plotting screen that shows the tractor's progress, one that shows live camera feeds with up to four views (two front, two rear), and a screen that enables monitoring and modification of key machine and implement parameters such as engine

plows ahead

The Case IH Magnum autonomous concept tractor, shown with the Early Riser 2150 planter, looks futuristic with its cab-less design, carbon-fiber front fenders and signature LED status running lights.

speed and implement settings.

Once path plotting has finished, the user can choose a job from a pre-programmed menu by selecting the vehicle, choosing the field and then setting the tractor out on its task. The sequence takes about 30 seconds.

The two tractors have a complete sensing and perception package in common, which includes radar, Lidar and video cameras to ensure obstacles in the tractor's path or that of the implement are detected and avoided. If an object is detected in the tractor's path, visual and audio warnings appear on the control interface—either tablet interface or desktop—which offers a choice of how the tractor should respond: by waiting for human intervention, driving around the obstacle using either a manually or automatically plotted path, or driving onwards if the object is not a danger.

"The fencing and perception is a real challenge," said Posselius. "We've built in some nice systems in our concept vehicles and they do what we need right now. But one of the real challenges to truly move forward is our sensing and perception has to get much smarter."

When operating parameters become critical, as in the case of low fuel or seed levels, the same notifying system is employed. Any critical machine alarms or loss of critical machine control functions cause the autonomous vehicle to stop automatically, or a stop button on the control interface can be activated manually.

Machine tasks can be modified in real time, such as if a storm is approaching. In the future, these concept tractors will be able to use "Big Data" such as real-time weather satellite information to automatically make best use of ideal conditions, independent of human input, regardless of the time of day, the company claims. For example, the tractor would stop automatically should it become apparent weather would cause a problem, then recommence work when conditions have sufficiently improved; or they could be sent to another field altogether where conditions are better.

The tablet interface also can be mounted in another machine whose operator can supervise its activities. As an example, from the seat of a combine or tractor, the operator can monitor the progress and eventually modify the performance of an autonomous tractor/planter combination working in the same or neighboring field. This allows autonomous tractors to "seamlessly integrate" into an existing farm machinery fleet, with minimal operational changes.

According to CNH, the autonomous technologies have been designed so that, in the future, they could be further developed to enable their application across the full range of equipment in a farmer's fleet. This could encompass the full range of tractors, harvesting equipment and support vehicles, such as sprayers.

Being a diverse company with operations in three segments—Commercial Vehicle, Agricultural and Construction Machinery—transfer of technology from one application to another is not only possible but an actuality. CNH's construction business is in the early stages of applying autonomous technology to some of its smaller equipment.

"What we develop in one sphere we can very easily adapt and apply in the others," a spokeswoman told *ME*. "You've got truck platooning [by **Iveco**] and all the technology behind that, which we can sort of cherry-pick what we can from the experience there and then apply it to

Komatsu's Innovative Autonomous Haulage Vehicle, shown at MINExpo 2016 in Las Vegas, demonstrates a trend toward cab-less structures as vehicles become fully automated.

the Ag sphere and Construction business. We're not operating in silos."

With the autonomous tractors, the company is already working with some customers in the U.S. to set up an initial pilot program over a small group of farms with diverse operating conditions and environments. The program, which is expected to start next year, will help to determine how these products work in the real world and where some of the snags might be when operating in different conditions.

"So far, work has been strictly under the engineering organizations, specifically the Innovation Group, but we are broadening that," said Posselius. "As we work with our customers, what we're trying to see is how they would use something like this if it was a production piece of equipment. What specific needs do they have that we may not have foreseen yet? A lot of that work will not be done by our other organizations that deal closer with our customers."

Volvo CE demos prototype autonomous machines

Automation is one of three main technology areas—along with connectivity and alternative drivelines and fuels—that Volvo Construction Equipment is devoting significant R&D resources to further develop. At its recent Xploration Forum in Eskilstuna, Sweden, the company demonstrated for select media including *ME* several advanced prototypes highlighting these technologies. Among them were a prototype autonomous wheel loader and articulated hauler working together: The wheel loader filled the articulated hauler, before dumping its

Self-driving by land—and by sea

Sea Machines Robotics is developing autonomous technologies that it believes will revolutionize the marine sector, enabling smarter, safer and more efficient operations via self-aware and self-driving boats and ships.

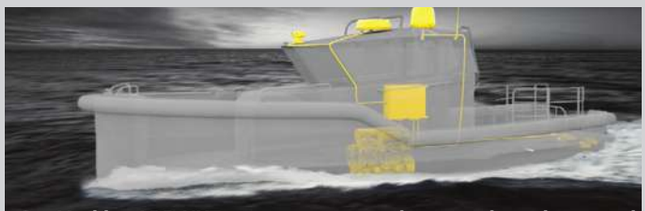
"The transition of one of the world's oldest forms of transportation to autonomous operation is inevitable and necessary," said Michael Johnson, founder of the Boston-based startup. "Sea Machines provides systems that give real and immediate value to vessel operators by increasing safety and efficiency. And our technology will facilitate entirely new oceanic applications, enabling better use of the seas to accommodate a growing world."

Founded in 2013, Sea Machines develops advanced control systems for boats and ships and specialized unmanned surface vessels. The technology can be deployed as an autonomous "overwatch" system on manned vessels. A Remote Command System, called RC-NXT, provides PLC-based wireless control of a vessel and is suitable for day-vessel operations such as work boats, tugs, and launches operating within 1000 m (3280 ft) of the pilot. With the RC-NXT upgrade kit, full manual controls of the vessel are retained and rapid transition between remote and traditional operations is possible.

An Autonomous Navigation System, called DP-NXT, uses vessel-based sensors—inertial navigation system/GPS, 4G radar, AIS (automatic identification system), EO/IR camera, sonar—and proprietary algorithms to enable watercraft to self-motor from point-to-point while avoiding active and passive obstacles or collaborate in tandem with another vessel.

DP-NXT is currently offered for vessels up to 24 m (80 ft) in length but can be configured for larger craft operations. The system can be integrated to various propulsion and steering configurations including electric, gas/diesel, diesel-electric, inboard, outboard, sterndrive, and water jet and can be augmented by maneuvering thrusters.

Sea Machines is currently testing its technology on commercial vessels in Boston Harbor where remote piloting of an unmanned vessel, unmanned oil spill response, and autonomous waypoint navigation have already been



Sea Machines' DP-NXT autonomous control system, shown integrated with an OEM hull, allows vessels to be operated in Line of Sight, Over the Horizon, Collaborative and Direct Belt-Pack Control modes.

demonstrated. Upcoming demonstrations include collaborative multi-vessel operations and automated obstacle avoidance.

The company believes the marine domain is even better suited for autonomous systems than aerospace, automotive and off-highway sectors. Why? Fewer barriers to entry, a high risk operating environment, and an accommodating regulatory space make marine ripe for a transition to highly automated operation.

With more than 20 million vessels plying the world's waters including 15 million recreational boats and 100,000 cargo ships, Sea Machines foresees autonomy disrupting this largely manual sector and developing into a $60 billion space.

This vision includes eliminating everyday boating accidents and shipwrecks via self-aware, self-driving navigation; increasing commercial marine productivity by automating vessel tasks; furthering safety of personnel by using unmanned vessels to perform work in hazardous environments like oil spills, marine firefighting, or other high risk operations; and enabling new remote oceanic industries such as deep sea fish farming and clean energy production.

Ryan Gehm

load and repeating the cycle.

"The technologies that are exploding in autonomous cars, we are able to leverage in our industries—infrastructure solutions, construction equipment, highway trucks, buses," said Martin Weissburg, member of the Volvo Group executive board and president of Volvo CE. "And you can easily argue that autonomous vehicles are easier to launch first in an infrastructure setting like a quarry or a mine or even roadworks, because they're contained."

Volvo CE conducted a one-hour comparison between the autonomous wheel loader and one run by a skilled operator, and found that the autonomous prototype could reach productivity levels at the equivalent of 70% when loading and unloading. Jenny Elfsberg, director of emerging technologies, notes that this finding is not just theoretical—the machine has done "real work" for a Volvo CE customer at an asphalt plant in Sweden.

"The demonstration machines were programmed to work together and carry out a specific set of actions on a pre-defined route," Elfsberg explained. "The machines can perform the same task over and over again, along a fixed route, for a relatively long period of time. But it's still early days for this technology; we are working on developing solutions that have the required safety and performance levels that the market will accept."

Significant work still needs carried out before such machines can carry out more complex tasks and ultimately reach production, she said: "There are no plans for industrialization at this stage. Currently these prototype machines don't communicate with each other and machine-to-machine communication technology—where machines 'talk' to one another and to a central control point—is crucial when it comes to avoiding collisions and facilitating an efficient flow of equipment."

The demonstrator machines are standard Volvo products—a L120 wheel loader and an A25F articulated hauler—which have been upgraded with autonomous technology. Add-on equipment includes high-performance computers compared to the standard ECUs, roof-mounted GNSS on the hauler, which provides about 1-cm (0.4-in) accuracy in positioning, and a Lidar system and radar on the loader. Algorithms can recalculate a vehicle's route in real time for obstacle avoidance.

Once a solution is finalized, the technology could be applied to other products in Volvo CE's range, Elfsberg said.

"In the future, you could potentially have one operator for three or four machines, increasing productivity and further decreasing costs," she said. "Looking ahead, I imagine that autonomous machines will be smaller and more robust. There will be no need for a cab or suspension, much like the HX1 concept which Volvo CE unveiled as part of its electric site research project."

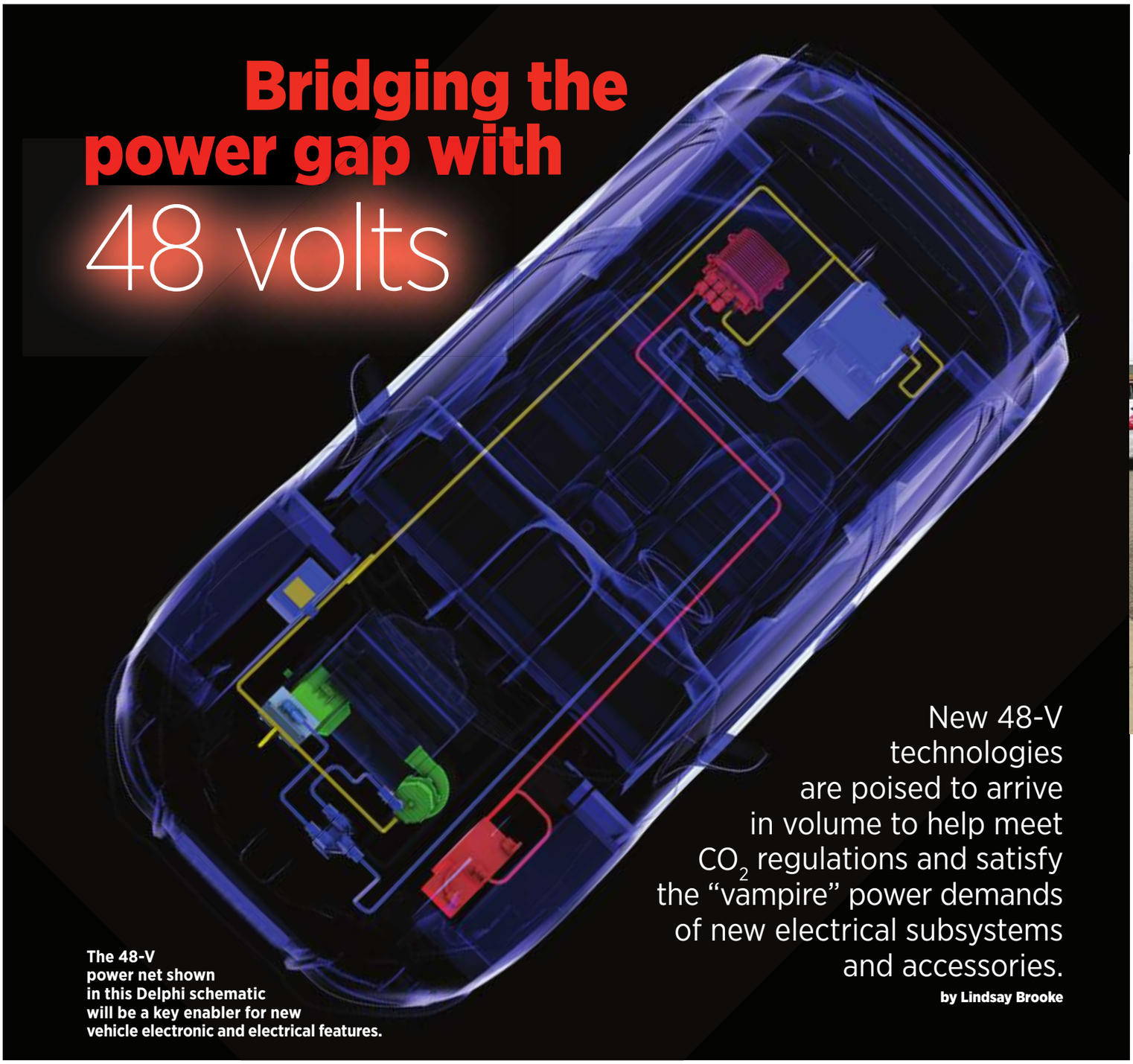
The demonstrator machines are standard Volvo products—a L120 wheel loader and an A25F articulated hauler—which have been upgraded with autonomous technology. Add-on equipment includes high-performance computers, roof-mounted GNSS, a Lidar system and radar.

The autonomous battery-electric HX1 load carrier prototype was demonstrated by Volvo CE as one component of its electric worksite project, which can possibly result in 95% less carbon emissions and a 25% reduction in total cost of ownership.

Volvo CE has been working on autonomous-machine research for more than a decade, resulting in the development of what the company terms "mid-term innovations." Semi-automated or automated functions will support more immediate developments years before realizing full autonomy. For example, Volvo Co-Pilot, launched earlier in 2016, offers a range of intelligent machine services to help operators, including Load Assist, Dig Assist, Compact Assist and Pave Assist.

"We are starting to see systems that are less dependent on operator skills, ones that support operators with guidance or control primary functions," said Elfsberg. "In the future, we will see increased machine autonomy and the operator will act more in a supervisory capacity...Of course, some tasks are so complicated that you really need to feel what you're doing; in those cases, we will still need operators controlling the machines from inside the cab." ■

Bridging the power gap with 48 volts



New 48-V technologies are poised to arrive in volume to help meet CO_2 regulations and satisfy the "vampire" power demands of new electrical subsystems and accessories.

by Lindsay Brooke

The 48-V power net shown in this Delphi schematic will be a key enabler for new vehicle electronic and electrical features.

The hybrid **Lincoln** MKZ I'm driving feels like it's floating on air as we hustle down Michigan's I-75, the combustion engine having been shut off by a clever bit of electrification. On this long, flat stretch of highway the ICE is just along for the ride, not "turning and burning" as the aircraft guys like to say. There's an EV-like quality to this operating mode and it has clearly boosted this car's feeling of overall refinement during my brief test drive.

"We're in 'sailing mode'—pretty nice for steady-state operation, huh?" asks Dr. Matti Vint, director-engineering R&D at **Valeo North America**, as he looks up from behind a laptop in the passenger seat. Vint has been demonstrating this 48-volt-equipped Lincoln to interested OEMs all week. "Very cool indeed," I reply, or something to that effect.

But the sailing function (in which the hybrid system can provide some propulsion assist under light load conditions when the ICE is shut off) is only one customer-delighting aspect of the Valeo 48/12-V hybrid system. Engine downsizing is another. So is the system's ability to serve as a buffer within the car's conventional driveline making torque-converter engagement literally imperceptible, even under my heavy right foot.

And the 48-V delivers a meaty wallop of supplemental torque, allowing me to easily squeal the front tires during a WOT launch in Valeo's parking lot. A little bit of Mustang GT in your MKZ, sir?

After our demo drive, Dr. Vint pops the Lincoln's hood and decklid to show me the guts of the 48-V system. Up front there's a compact liquid-cooled belt-starter generator (BSG) tucked into a dark corner way down in the P0 (front-end accessory drive) topology. Dr. Vint points to Valeo's own e-supercharger, a highly effective device for optimizing Miller-cycle engines and improving hybrid-vehicle driveability. It's an integral part of Valeo's 48-V system strategy. In the car's trunk reside a

Dr. Matti Vint and Valeo North America's 48-V demonstrator vehicle that combines greater fuel efficiency with tire-chirping performance. (Lindsay Brooke photo)

48-V controller, high-efficiency (~96%) bi-directional DC/DC converter and a compact, air-cooled 8 a·h Li-ion battery from **A123 Systems**.

Such set-ups I've seen a lot of recently, during various 48-V demonstration drives with **Continental**, **Delphi**, **AVL**, **BorgWarner** and **Schaeffler**. Though not production vehicles, all have displayed impressive on-road performance, lack of NVH intrusiveness and capability to deliver up to 12% improvement in vehicle fuel efficiency, engineers from the companies say. **Bosch**, **Ricardo**, **FEV** and others also have 48-V systems on the road and in the works.

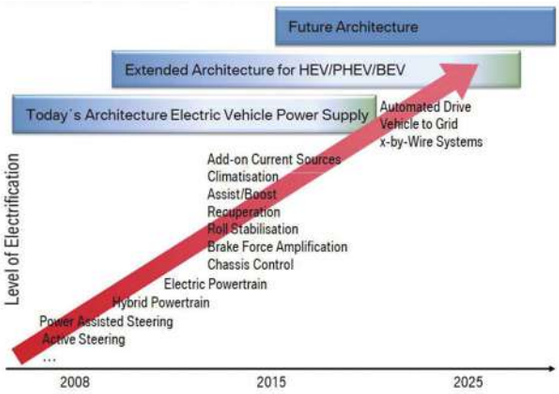
And the 48-V system's inherently lower currents enable cables with smaller cross-sections to be used, reducing vehicle mass by up to 10 kg (22 lb) which also helps reduce CO_2 emissions.

Satisfying the "vampires"

The global Tier 1s are battling for 48-V system supply contracts that are expected to reach 13.4 million vehicles per year globally by 2025—about 10% of total industry volume, according to analyst Christian Mueller, with industry forecaster **IHS Markit**. Another recent study by **Navigant Research**, Low Voltage Vehicle Electrification, is less optimistic; it forecasts global sales of 48-V vehicles to reach 9 million in 2025. C-segment vehicles are expected to be the largest market.

"Typical low-voltage mild hybrids alone will not get your fleet below 95 g CO_2 per kilometer," Mueller asserts. "You have to go plug-in full hybrid or have a significant proportion of BSG in your lineup." The 48-V system can be used for extended stop-start functionality, 'sailing' on the highway and for low-speed self-parking applications.

But its real benefit is in boosting on-vehicle electrical power from 2.5 kW to 10 kW, thus enabling a growing list of power-gobbling features



BMW's view of the trajectory of vehicle electrification within increasing on-board power requirements.

not related to the vehicle's actual propulsion: electric power steering (≤2 kW), e-compressor (3 kW - 7 kW), electric AC compressor (≤3.5 kW), 'smart' cooling pumps (≤400 W), windshield heaters (≤700 W) and electro-hydraulic brakes (≤900 W).

"The new generation of high-load accessories, particularly e-boosters, e-chargers and active chassis-control systems are huge 'vampires' in their power needs," observed Mary Ann Wright, vice president of engineering at battery maker **Johnson Controls** and a former **Ford** hybrid engineer.

Such subsystems can run on the 48-V power net and indirectly contribute to the reduction of fuel consumption, Wright said, while the parallel 12-V system continues to handle vehicle hotel loads.

Racing to be first to deploy 48-V hybrids in 2017, Continental has announced its system (also featuring an e-turbo) is on the new **Renault** Scenic MPV, Valeo has the **Audi** SQ7 and Mercedes recently unveiled new engine families designed to incorporate 48-V hybridization from yet-unannounced suppliers. (See SAE.org for related articles.) **VW**-owned **Bentley** is powering the active roll control system of its Bentayga SUV with a Schaeffler-developed 48-V system.

At its Paris investor meeting last fall, Valeo executives noted that the company has more than 25 contracts for 48V systems in China, Europe, India and Korea. Continental's hybrid-electric business unit chief Rudolf Stark said his company has 48-V production programs in the pipeline for both gasoline and diesel vehicles in North America, Europe and China; he expects 20% of new vehicles worldwide will be equipped with a 48-V system by 2025.

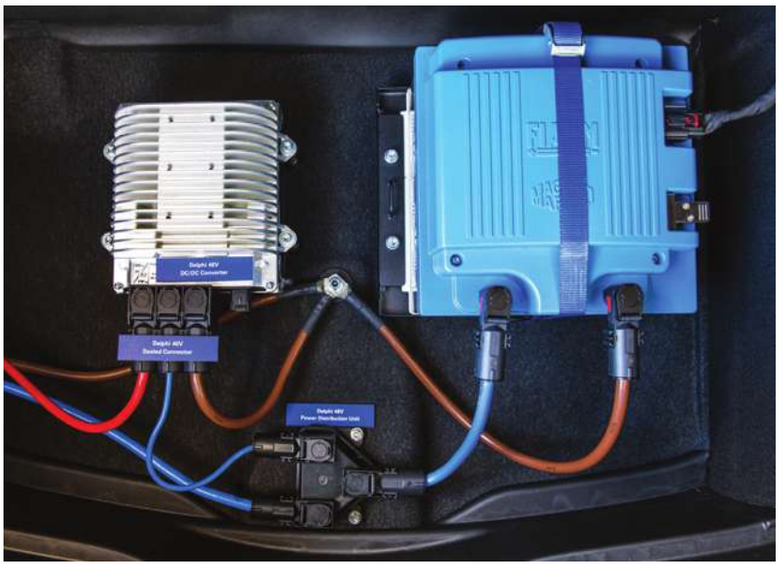
A plethora of creative technologies are being developed for future 48-V power.

Bridging the power gap with 48 volts

Audi's eROT dynamic chassis control system is one of many power-hungry subsystems in development that require 48-V power.

Audi's eROT (electromechanical rotary) suspension dampers are powered by a 48-V battery mounted to the car's axle, replacing traditional hydraulic shocks. The units enable electric energy to be recovered from the compression and rebound strokes—effectively "harvesting" energy from every dip and pothole.

Audi engineers believe eROT, while a "vampire" in terms of energy consumption, can reduce fuel consumption by ~ 0.7 L per 100 km. And while traditional dampers generate waste heat, the eROT units can generate energy to be used for other vehicle functions. The system, expected to enter production for 2018, offers a wide range of compression and rebound tuning to suit ride comfort, handling or both.



Inside the trunk of Delphi's Honda Civic diesel 48-V demo vehicle are DC-DC module (left), power distribution unit and fan-cooled Li-ion battery. (Lindsay Brooke photo)

$500 system cost

While they do not offer real electric-only drive capablity, 48-V BSG-type hybrid systems have "a good balance and better capacity for capturing braking regen energy, up to about 60% of that available—and it's a good stop-start enabler," noted Dr. Mazen Hammoud, Ford's Powertrain Director for Asia Pacific, at the 2015 SAE Hybrid & Electric Vehicle Symposium.

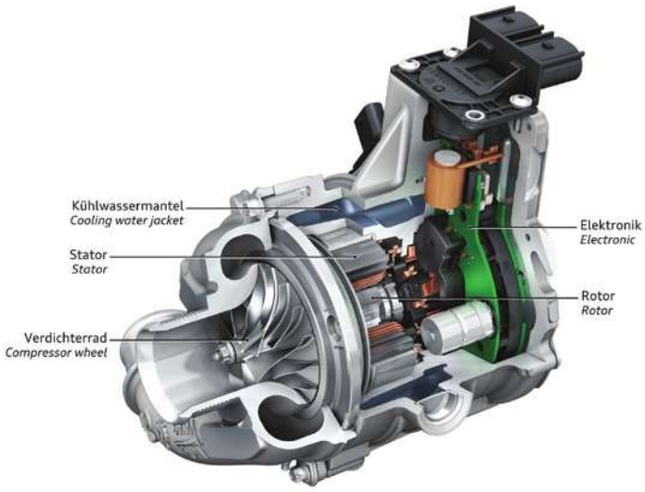
Perhaps best of all, the technology has undeniable "bang for the buck"—about 30% of the cost of a high-voltage full hybrid system while delivering about 70% of the benefit, said engineer Sam Abuelsamid, senior research analyst with Navigant Research. "They're one of the most cost-effective solutions to continue reducing fuel consumption and emissions," he noted.

Dr. Byung Ki Ahn, **Hyundai**'s Director of Alt-Fuel Vehicle Engineering, agrees. "Cost efficiency is the big attraction—about $500 per system," he told *Mobility Engineering*.

The fuel economy gains "are not as great as with a full hybrid," Dr. Ahn explained, but 48-V systems "are still worth it for meeting all the government regulations. We're making a lot of hybrids," he said, "but even with them we probably can't meet all the standards and regulations such as the EV mandate and the EU's 95 g CO_2/km rule. We need all means possible and in that sense 48-V could be an option. We are looking at it."

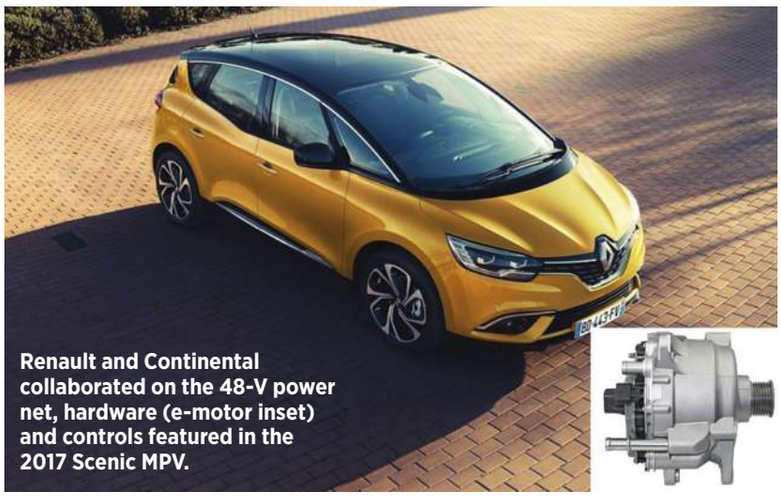
New regulatory hurdles that concern Dr. Ahn and his colleagues include the more aggressive WLTP (Worldwide harmonized Light vehicles Test Procedures), which call for additional reductions in CO_2 emissions from the current NEDC (New European Drive Cycle) test. The WLTP aims to reduce by half the CO_2 reduction that is currently gained from 12-V stop-start systems. Supplier and OEM engineers are encouraged that the 48-V BSG systems will help them meet the new more real-world-focused test cycles.

Non-plug-in hybrid vehicles will feel 48-V's impact the most, the



Sophisticated engineering within the Valeo-supplied electric supercharger used in Audi's 2017 SQ7, the company's first production 48-V vehicle.

Battery suppliers are engineering modular energy storage solutions dedicated to 48-V systems. This JCI example features lithium nickel-manganese-cobalt (Li-NMC) cell chemistry.



Renault and Continental collaborated on the 48-V power net, hardware (e-motor inset) and controls featured in the 2017 Scenic MPV.

experts reckon. JCI's Wright believes 48-V "will seriously challenge any hybrids going forward, because of its cost and performance."

Higher cost 48-V systems with greater capability are poised for introduction. The P1 through P4 vehicle topologies—e-motor positioned at the front of the crankshaft (P1), between engine and transmission (P2), behind the transmission (P3) and on the rear axle (P4)—are in development at various suppliers. Continental's P2 system co-developed with Schaeffler allows all-electric driving at up to 31 mph (50 km/h) with a claimed fuel savings of up to 25% greater fuel efficiency than a non-hybridized model, according to Juergen Wiesenberger, director of the hybrid vehicles business unit.

"Big business"

Suppliers develop complete systems with the hope that OEMs will purchase them rather than target-source a motor here and a DC converter there. Packages have thus emerged: for example, Valeo's 48-V offerings include the basic Hybrid4All based on the 48-V BSG; the e4Boost which adds the e-supercharger and the e4Sport introduced at the 2016 Paris show—it adds a 48-V electric rear axle drive. To reduce system cost, an air-cooled BSG is in the pipeline for 2017.

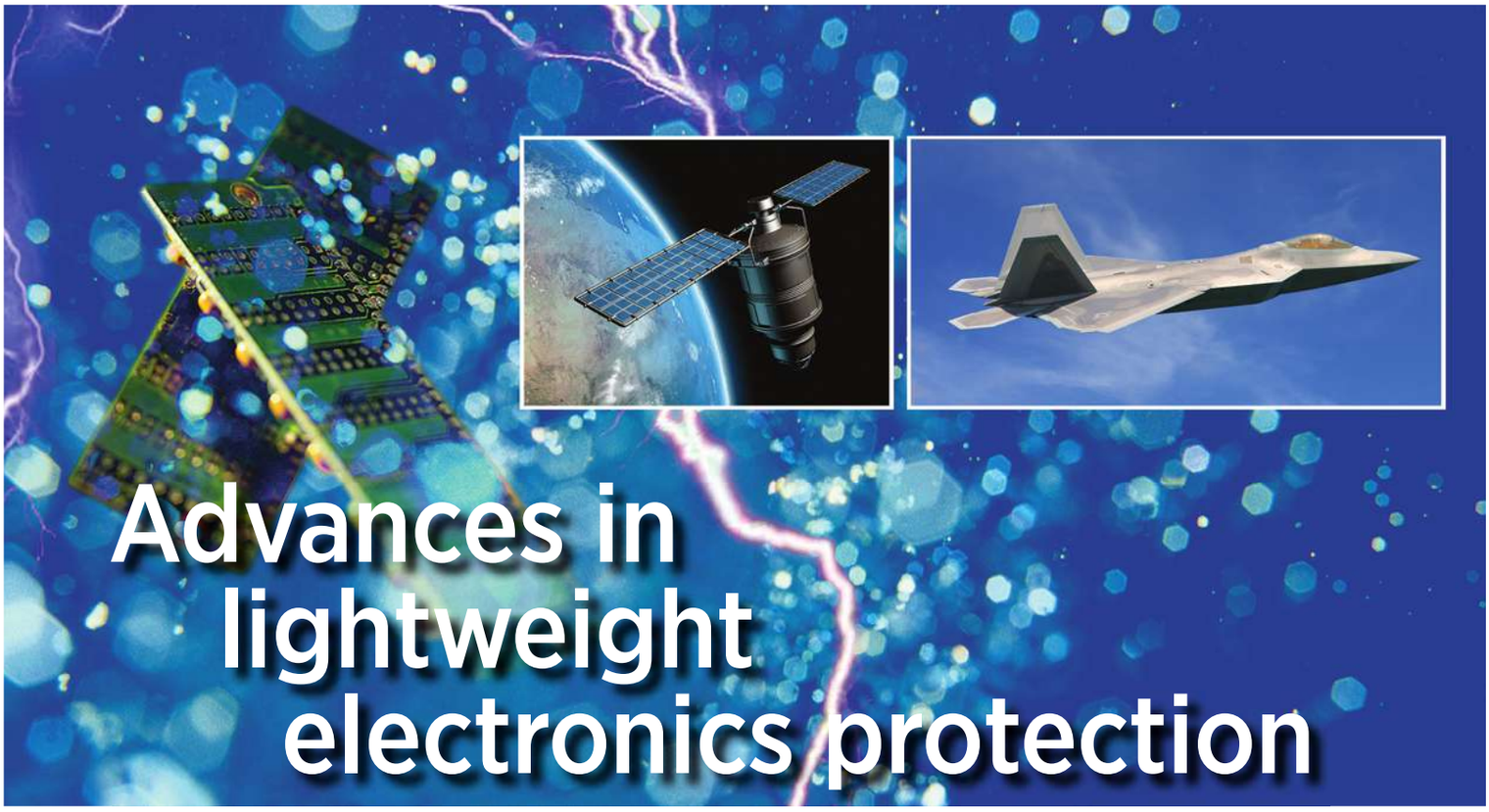
Engineering leaders interviewed for this article generally agree that 48-V systems will serve as a "bridge technology" between current mild HEVs and full EVs. "It's a transitional propulsion technology between today and the plug-in world," observed IHS analyst Mueller. "But what is the timeframe until that happens—particularly in the U.S. where fuel prices are expected to remain low for quite some time? OEMs will do whatever is necessary to achieve the regulations at that time."

"It's a gap-bridging technology from today to the high-voltage systems," commented Dr. Ray Kuczera, Vice President of Global Product Technology, **GKN Driveline**. He said his engineers "potentially see 48-V doing some boosting on the rear axle, adding a 48-V motor and battery to give some 'sailing' capabilities, some extra power and certainly some energy recuperation. It's an interesting technology. We could be a Tier-2 player in it because it's a good fit for our axles."

His colleague Jochen Weiland, GKN's head of business development, argues that the 48-V solution is being driven mostly by suppliers who have a big stake in extending the life of ICE-based propulsion. "That's why the BorgWarners, Schaefflers and Contis are pushing 48-V—they have a lot of content on the combustion engine side," Weiland said.

BorgWarner CTO Chris Thomas has another view. "I don't see 48-V necessarily as a 'bridge' from today's hybrids to high voltage EVs. "Some automakers will go across the board with 48-V for their engines and combustion systems then have a small portion as hybrids as balance to meet their CO_2 and CAFE standards."

For BorgWarner, the fast-rising 48-V tide "is huge business for us—I've got requests from three different OEMs to have a 48-V workshop by the end of this year," Thomas said last November. ■



Advances in lightweight electronics protection

Conformal coatings increase reliability of aerospace and military assemblies

Lightweighting continues to be a key topic for the aerospace, avionics and defense industries as new metals and composites are being integrated into end products and assemblies with the goal of decreasing overall system weight. As technologies continue to evolve, with components often decreasing in size and increasing in complexity, the materials used to manufacture and protect the latest components and systems are also improving. Whether used in commercial or military aircraft, rockets, satellites, terrestrial or water vessels, or the latest in unmanned air, land and sea vehicles; systems within these industries must meet similar requirements – assemblies, components and electronics must be both lightweight and designed to withstand harsh operating conditions.

Aerospace, avionics and defense systems depend on the latest in electronics and communication technology, and reliability is crucial. In these industries, where lives hang in the balance, failure modes must be eliminated. Signal interference or failures due to corrosion, for example, are intolerable due to the nature of these systems and all that relies upon them. Components must be thoroughly shielded from their harsh operating environments and remain protected for the life of the system. Engineers must include this level of protection in their designs – without adding significant bulk, weight or anything that may interfere with system communication.

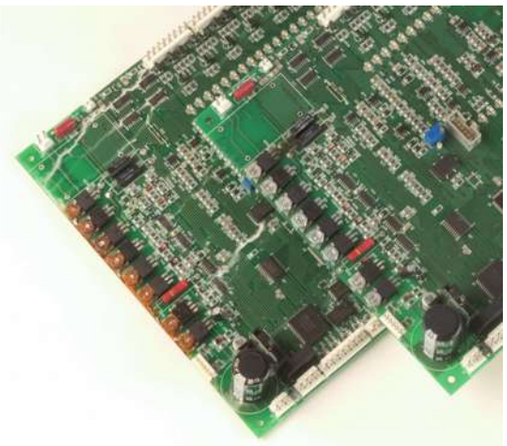
Component protection

The goal of lightweighting is not just an issue of construction materials or shrinking the size and weight of actual devices and internal components – protection of devices and electronic assemblies must also be taken into account. Liquid conformal coatings, commonly applied by spraying, dipping or various dispensing technologies, have historically offered a certain level of protection to components in these industries, but as avionics continue to move to smaller, more complex components, these coatings add unnecessary weight and dimension to critical, lightweight electronic, optical and communication devices. Additionally, their application methods can result in uneven thickness, pooling and meniscus effects, leaving microscopic voids that greatly increase the propensity for component failure. Parylene coatings provide superior protection without adding significant mass to electronic assemblies.

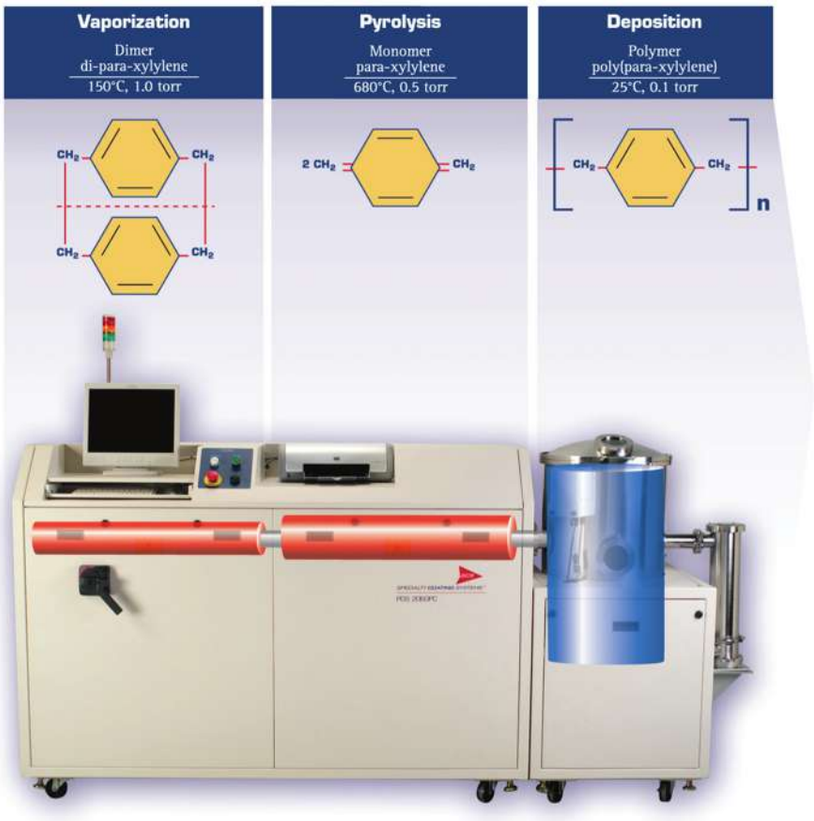
Parylene conformal coatings

Parylene conformal coatings have provided rugged and reliable protection for a wide range of aerospace, avionics and defense applications for over 45 years. Listed on the QPL for MIL-I-46058, the coatings are also recognized as meeting the requirements of IPC-CC-830 and are RoHS compliant. Parylene films are optically clear, do not interfere with electrical, optical or RF signals, and have been shown to mitigate the growth of metallic whiskers in lead-free solder applications. Parylene coatings provide:

- Ultra-thin, conformal coating of all exposed surfaces;
- Excellent dielectric properties;
- Excellent moisture and chemical barrier properties;
- Thermal stability up to 350°C long-term;
- Superior ultraviolet stability.



Parylene HT coated (top) and non-coated (bottom) boards after testing in a salt-fog environment.



Ultra-thin Parylene conformal coatings are applied as a vapor at room temperature.

Its application process is what differentiates the Parylenes from all other conformal coatings and is the reason they provide a truly protective barrier to electronics and devices, regardless of their size or complexity. Rather than being dispensed, sprayed, brushed or dipped, Parylene coatings are applied via vapor deposition. In this process, the parts to be coated are placed in a deposition chamber and a powdered raw material, known as dimer, is placed into the vaporizer at the opposite end of the deposition system. The dimer is heated, causing it to sublimate to a vapor, then heated again to break it into a monomeric gas. This gas is then transferred into an ambient temperature chamber where it spontaneously polymerizes onto the parts, forming the ultra-thin Parylene film. The Parylene process occurs in a closed system under a controlled vacuum, with the deposition chamber remaining at ambient temperature throughout the process. No solvents, catalysts or plasticizers are used in the coating process.

Parylene coatings are extremely lightweight, offering excellent pinhole-free barrier properties without adding dimension or significant mass to delicate components. Parylene is typically applied in thickness ranging from 500 angstroms to 75 microns. A 25 micron coating, for example, will have a dielectric capability in excess of 5,000 volts. No other coating material can be applied as thinly as Parylene and still provide the same level of protection.

Because there is no liquid phase in the deposition process, there are no subsequent meniscus, pooling or bridging effects as seen in the application of liquid coatings; thus dielectric properties are never compromised. The molecular "growth" of Parylene coatings also ensures not only an even, conformal coating at the thickness specified by the manufacturer, but because Parylene is formed from a gas, it also penetrates into every crevice, regardless of how seemingly inaccessible. This ensures complete encapsulation of the substrate without blocking small openings or vias.

As mentioned above, Parylene coatings offer a host of benefits to critical aerospace, avionics and defense applications. Following is a deeper look into a few of these beneficial properties:

- **Smallest molecular structure:** The ultra-thin and extremely small molecular structure of Parylene allows the coating to ingress deeper through open areas on the top or bottom of packages, regardless of the size or complexity of integrated devices. This complete encapsulation of the device components enables a high level of protection without adding significant weight or dimension to critical components.
- **Lowest dielectric constant and dissipation:** Parylenes have an extremely low dielectric constant and dissipation factor, enabling the coatings to provide small, tight packages with dielectric insulation via a thin coating. It has been demonstrated that the voltage breakdown per unit thickness increases with decreasing Parylene film thickness.
- **High-temperature stability:** Parylene is thermally stable in operating temperatures up to 350°C long-term and can withstand short-term exposures to 450°C. Parylene's ability to survive these temperatures, while continuing to provide excellent moisture and dielectric barrier properties, is of great benefit to designs that must survive high heat environments.
- **UV Stability:** Unlike other conformal coating formulations, Parylene HT will not yellow or crack when exposed to ultraviolet light, offering

PARYLENE PROPERTIES

		Parylene HT	Parylene C	Parylene N	Acrylic (AR)	Epoxy (ER)	Polyurethane (UR)	Silicone (SR)
Dielectric Strength V/mil		5,400	5,600	7,000	3,500	2,200	3,500	2,000
Dielectric Constant	60 Hz	2.21	3.15	2.65	–	3.3 – 4.6	4.1	3.1 – 4.2
	1 KHz	2.20	3.10	2.65	–	–	–	–
	1 MHz	2.17	2.95	2.65	2.7 – 3.2	3.1 – 4.2	3.8 – 4.4	3.1 – 4.0
Dissipation Factor	60 Hz	<0.0002	0.020	0.0002	0.04 – 0.06	0.008 – 0.011	0.038 – 0.039	0.011 – 0.02
	1 KHz	0.0020	0.019	0.0002	–	–	–	–
	1 MHz	0.0010	0.013	0.0006	0.02 – 0.03	0.004 – 0.006	0.068 – 0.074	0.003 – 0.006
Water Vapor Transmission Rate (g•mm)/(m^2•day)		0.22	0.08	0.59	13.9	0.94	0.93 – 3.4	1.7 – 47.5
Water Absorption (% after 24 hours)		<0.01	<0.1	<0.1	0.3	0.05 – 0.10	0.6 – 0.8	0.1
Service Temperature	Continuous	350°C	80°C	60°C	82°C	177°C	121°C	260°C
	Short-Term	450°C	100°C	80°C	–	–	–	–
UV Stability		≥2,000 hrs	≤100 hrs	≤100 hrs	–	–	–	–
Tensile Strength (psi)		7,500	10,000	7,000	7,000 – 11,000	4,000 – 13,000	175 – 10,000	350 – 1,000
Penetration Ability		50 x dia.	5 x dia.	40 x dia.	Spray or Brush	Spray or Brush	Spray or Brush	Spray or Brush

Parylene properties.

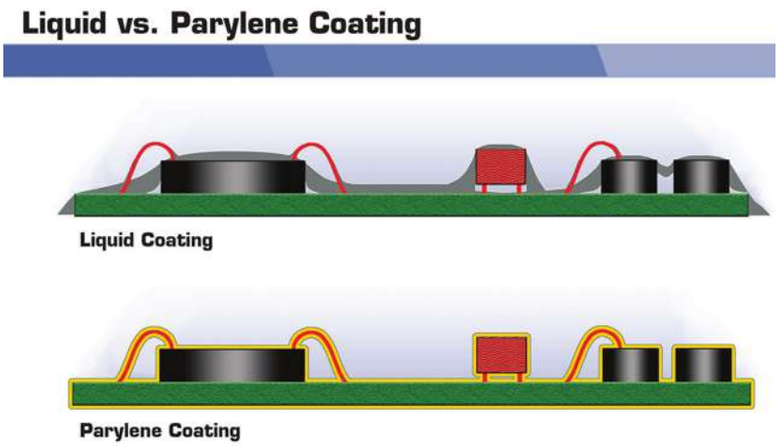


Illustration of liquid vs. Parylene coatings.

measureable UV stability after more than 2,000 hours of an accelerated weathering, UV exposure test (ASTM G154). Its chemical structure provides protection from degradation and discoloration as a result of such exposure.

- **No Outgassing:** Since Parylene is applied in a vacuum, there are no hidden voids or incomplete coverage that may present pathways for failure when exposed to altitude.

Aerospace, avionics and defense applications

Parylene coatings protect a wide array of systems and components throughout the aerospace, avionics and defense industries, including printed circuit boards (PCBs), complex circuit assemblies, wafers, sensors, LEDs and elastomeric components. These components, and more, are often subjected to hostile operating environments, including extreme temperature fluctuations, pressure changes, vibration and exposure to harsh chemicals and/or biological agents. Parylene not only provides protection for components operating in these environments, but does so while ensuring stable communication between systems and devices, e.g., aircraft, missiles, UAVs and UUVs, etc. Many applications within these industries benefit from the lightweight and reliable protection Parylene coatings offer, including:

- flight data and recording systems;
- communication systems between all vehicle types;
- aircraft, UAV and UUV monitoring;
- electrical power generation and distribution;
- control monitoring systems;
- fuel systems integrity;
- LEDs for interior, exterior and display lighting;
- space vehicles, satellites and cameras.

Parylene coatings also play a role in protecting COTS (commercial off-the-shelf) components, which are not specifically designed for the demanding environments that many aerospace and defense applications must survive. As these components continue to be integrated into critical industry applications, Parylene provides protection to ensure their reliability.

The growth of the aerospace and defense industries, along with continued commercial investment in the space/satellite sector, will increase the demand for technologies that service these markets. Parylenes enable engineers to advance their designs due to the coatings' lightweight, ultra-thin nature, while offering a host of beneficial properties that ensure the reliability of total systems and their components. ■

This article was written by Tim Seifert, Military & Avionics Market Manager, Specialty Coating Systems (Indianapolis, IN). For more information, visit http:// info.hotims.com/61068-502.

New Ford Fiesta claims B-car tech leadership

It may look similar to the current model, but **Ford** describes its next-generation Fiesta as the "world's most technologically advanced small car."

Revealed in Cologne at the company's latest "Go Further" event that signals what's in the design, technology and engineering pipeline, the new Fiesta will project Ford's determination to produce models with "more premium appearance," complemented by other aspects of quality ascendance.

For the Fiesta, these span everything from quieter cabins (road noise reduced by a claimed 7%), more luxury touches and enhanced safety, to achievement of improved build quality that even includes analysis of noise frequencies produced during parts stamping to identify any component that is below required quality standards.

The Fiesta variants now include an Active crossover, marking the introduction of the Active category scheduled to join the Ford model range. Just how "active" the Fiesta Active will be is not yet clear; Ford describes it as having SUV-inspired styling with roofbars and raised ride height. It will be added to the range after the launch at a later, unspecified date.

Clearly a Ford Fiesta, but the new generation is more sculpted and gets an even larger front grille. A design aim was to achieve a "more premium appearance." Shown is the ST-Line version.

An opening panoramic roof is one of the luxury touches available for the new Fiesta.

Taking the B-car upscale

Engine choice includes a 103-kW (138-hp) 1.0-L Ecoboost triple and an 88-kW (118 hp) 1.5-L diesel 4-cyl. (Ford also announced cylinder deactivation for its diminutive triple.) A new 6-speed manual transmission with reduced internal friction is also introduced. Although not yet officially confirmed, the best Fiesta CO_2 emission figure is 82 g/km (equivalent to 66.5 mpg). An ST-Line Fiesta has sport suspension and sporty styling touches.

A high-performance ST is expected. The Fiesta will be manufactured in both 3- and 5-door hatchback configurations.

Jim Farley, Ford's Executive Vice President and President Europe, Middle East and Africa, says the evolutionary and highly mature new car brings technologies and features that customers for small cars "could only have dreamed of just a few years ago."

Cabin noise reduction

Ford targeted cabin noise reduction as a must for the Fiesta; a 15% torsionally stiffer body structure helps. It uses 36% more boron steel incorporated in key areas such as the upper section of the B-pillars where a T-section more effectively transfers side-impact energy into the roof. The car also gets stiffer front subframe attachment points, welded twistbeam attachment points, reduced NVH via powertrain isolation and an acoustic windshield. All this supports claims of a best-in-class interior road noise level of 29.3 sone at 100 km/h.

"We have paid a lot of attention to elements and features that customers notice, without realizing it, from panel gaps to pedal feel," explained Darren Palmer, small car vehicle line director, Ford of Europe.

Safety engineering

Fiesta is the first Ford in Europe to undergo computer simulation crash tests of a complete vehicle using advanced new FEA to generate more effective optimization of safety features.

Interestingly, the introduction of a locking seatbelt tongue to help prevent belt slippage during an accident is described as obviating the need for a driver kneebag.

Complementing the luxury touches are 15 driver examples of specific assistance technologies including cameras (two), radars (three) and ultrasonic sensors (a dozen). They work together to provide 360° ambient monitoring and a 130-m forward scan range.

Cross Traffic Alert is claimed by Ford as a first in the small Ford's sector. Adaptive cruise control is available.

Excellent and nimble handling has always been a major part of the all generations of Fiesta. The new car is claimed to have 10% more cornering grip than the outgoing model, partly due to electronic torque vectoring. Front track is wider by 30 mm (1.1 in), rear by 10 mm. The wheelbase is increased by just 4 mm, overall body length by 71 mm, and width grows by 12 mm. Eighteen-inch wheels are an option.

Braking distances from 100 km/h (62 mph) are shorter by 8%, the engineers claim. Steering friction is reduced by 20% and steering response benefits from the use of double-bonded suspension bushings. Twice as stiff as those on the "old" Fiesta, the new bushings "bulge in a specific shape" to better deal with road imperfections and to complement the larger rear-suspension twistbeam to reduce the effect of small bumps and also contribute to reduced cabin road noise.

Stuart Birch

Mazda's all-new CX-5 takes a chance: diesel engine for North America

Mazda says the 2017 CX-5 is all-new, but its major dimensions almost exactly replicate the current model, seemingly indicating the company believes its established footprint is near-perfect for the compact-crossover market (Bill Visnic photo).

Mazda made no secret it would unveil an all-new CX-5 compact crossover—now one of its best-selling models in the U.S.—at the 2016 Los Angeles auto show. The surprise Mazda saved for the day after the 2017 CX-5's introduction was that the new version of the company's popular crossover will offer a diesel-engine option for the North American market.

It will be Mazda's first-ever U.S. diesel when it goes on sale in the second half of 2017.

Big torque, less clatter

The company did not provide specifications for the Skyactiv-D 2.2.-L four cylinder slated for the U.S.-specification CX-5, but Akira Marumoto, Mazda executive vice president, promised it will "have the torque of an engine almost twice its size," while delivering "fuel efficiency at the hybrid level."

Mazda sources told *Mobility Engineering* the diesel engine is a new architecture designed from the outset to be coupled with selective catalytic reduction (SCR) exhaust aftertreatment. The current Skyactive diesel engine family—used extensively in Japan and once earmarked for U.S.-market vehicles such as the Mazda6 sedan—does not employ SCR technology. The lack of SCR likely is what caused Mazda to suspend its initial plans for deployment of the diesel in the U.S.; in wake of the Volkswagen diesel-emissions scandal that also centered largely on VW's desire to use diesels without costly SCR technology, hindsight might indicate Mazda was wise not to deploy its non-SCR diesel in the U.S.

At the Los Angeles auto show unveiling of the 2017 CX-5 and announcement of the new diesel-engine availability, Marumoto admitted that developing a diesel to reliably comply with U.S. emissions standards "took longer than expected," but added, "I can promise this engine will not disappoint."

He also said that Mazda has engineered unique technologies for the new, all-aluminum Skyactiv-D engine to dampen diesel clatter, dubbing them "Natural Sound Smoother" and "Natural Sound Frequency Control," without elaborating further. Sources did say, however, that exceptional efficiency and low emissions are expected because of the new engine's extremely low compression ratio, which is projected to be near or even equal to the company's gasoline 4-cylinder.

The current Skyactiv diesel 4-cylinder has a compression ratio of 14:1—Mazda claims it to be the diesel-world's lowest—while the Skyactiv gasoline four-cylinder used in the 2016 CX-5 crossover has a 13:1 compression ratio. Mazda did not provide any guidance on power or torque for the new 2.2-L Skyactiv-D, but the output of the current Skyactiv diesel might offer useful reference, that engine developing a listed 173 hp (129 kW) and 310 lb·ft (420 N·m).

The company further promised the 2.2-L Skyactiv-D will uphold Mazda's reputation for engaging driving characteristics thanks to its high torque output and a focus on revving willingly to high rpm.

New CX-5

The new 2017 CX-5 seems an ideal candidate for Mazda's first-ever diesel: its styling is husky and assertive, with a grille that closely mimics the recently launched CX-9 large crossover. The new crossover's interior also appears upgraded and more substantial and the company promised improved interior quietness and refinement.

In size, however, the 2017 CX-5 closely mimics the current model. The 106.3-in (2700-mm) wheelbase is the same, and the 2017 model's 179.1-in (4549-mm) overall length and 72.5-in (1842-mm) width are within a couple tenths of the current CX-5. Mazda did not yet list curb weights for the 2017 CX-5 lineup, but the current model in top-trim all-wheel-drive form weighs 3589 lb (1628 kg).

Mazda said the new CX-5 has an increase in torsional rigidity of 15.5% and there is increased use of ultra-high-tensile steel, including 1180 MPa steel for the A-pillars and 980 MPa steel for the side sills and B-pillars.

The front suspension continues with a MacPherson strut layout and there is a multilink design for the rear suspension. Mazda is incorporating its recently introduced G-Vectoring Control (http://articles.sae.org/15002) to sharpen corner turn-in characteristics.

The 2017 CX-5 will launch in early 2017; for now, Mazda indicates the only gasoline engine used will be the 2.5-L Skyactiv-G; the current CX-5 also offers the smaller 2.0-L version of the Skyactiv-G. The company's early specifications also list only a 6-speed automatic transmission as being coupled with the 2.5-L engine. For the diesel-engine launch time frame, company officials would not commit to anything narrower than the second half of 2017.

Bill Visnic

Cat 14M3 'most technologically advanced' motor grader for construction

The new Caterpillar 14M3 features a host of operator-assist technologies including the patented Stable Blade, a "first-of-its-kind" anti-bounce system for a motor grader.

Caterpillar plans to showcase 40 machines at ConExpo-Con/Agg 2017 in March, one being its new 14M3 motor grader that features a larger engine, increased power to ground, and a host of integrated technology solutions such as the newly patented Stable Blade anti-bounce system, to increase operator efficiency and boost productivity levels.

Wade Porter, motor grader product application specialist, described Caterpillar's M Series 3 motor graders including the new 14M3 as being the "most technologically advanced in the industry, based on facts and data." Many of the exclusive, patented technologies in the 14M3 are shared across the entire M Series 3 platform, he said.

The fourth largest motor grader in the Caterpillar fleet, the 14M3 is the "bread-and-butter construction motor grader"—but it is also a viable machine for the mining sector, according to Porter. "When you put the 20.5 tires on it, a push block, a ripper and the 16-ft blade, you've got a very, very capable motor grader."

A standard blade float feature allows the entire blade to follow the ground contour, or the toe of the blade can follow a hard surface, while the remaining cylinder is controlled manually. A 14-ft (4.3-m) moldboard is standard; the 16-ft (4.9-m) version is optional. A range of cutting edges and bits are available, as are a three-shank ripper, scarifier, and snow plow and snow-wing options.

Built in North Little Rock, Arkansas, the 14M3 is the only one in its size class now, Porter noted. "We see an industry opportunity, that's why we continue to manufacture the product," he said. "Within North America, it's the right-sized machine for a lot of the heavy construction jobs."

Larger engine, heavier machine, improved power to ground

A Cat C13 ACERT Tier 4 Final engine replaces the C11 used in the predecessor model, providing up to 8% more power and torque. Net power range is 238-285 hp (178-213 kW) and maximum torque is 1137 lb·ft (1542 N·m). The standard Variable Horsepower system is designed to effectively match power requirements in all gears. A Consistent Power to Ground feature automatically changes engine power levels to compensate for cooling fan speed variations, resulting in consistent power delivery in all ambient temperatures and working conditions.

"The constant power-to-ground strategy is new to the 14-sized product, we introduced it with our larger 16 and 18 M3 products," said Porter. "With an on-demand hydraulic fan, it's only going to turn as fast as it needs to based on the ambient conditions and the thermal temps underneath the hood. As we speed up or slow down that fan based on those conditions, we'll either increase or save power."

The 14M3 is 5% to 6.5% heavier than its predecessor, at 57,250 lb (25,970 kg) operating weight. "It's a bigger machine by design," said Porter. "As we put more iron in the engine enclosure area, it increases the rear-end weight of the machine; motor graders need to have proper balance, rear to front. So we added more weight to the front (about 1% more than predecessor)."

Compared to the 14M, the new machine has about 6% more power to ground. In terms of drawbar power, the 14M3 has about 9% more drawbar pull. The machine can do about 20% more work than its predecessor, according to Porter, and it's about 10% more efficient.

"We've got more torque, greater lugging ability in the engine (torque rise of 41%)," he said. "When you go up 2 L in displacement, that engine can work at a more comfortable operating zone, which helps it be more fuel efficient and productive."

Wade Porter called the 14M3 the "bread-and-butter construction motor grader," but said it's also a viable machine for the mining sector. (Photo by Ryan Gehm)

It features a standard ECO mode that boosts fuel economy by limiting high idle speed to 1750 rpm in working gears, while still maintaining lugging power.

"If a customer chooses to turn on that feature, they're going to save upwards of 5% in terms of fuel burn," he said.

An engine over-speed protection system prevents downshifting at excessive ground speeds, and under-speed protection prevents engine stall by automatically downshifting the transmission at lower ground speeds, to allow engine recovery to peak torque levels. The standard automatic differential lock disengages and re-engages automatically when threshold parameters are met.

An optional compression brake helps save the brake life of the machine. "With this motor grader's weight and power now, it can definitely get into the mining space. In the mines, you start working on more aggressive grades; the compression brake as an optional attachment definitely comes in handy," he said.

The 8F/6R power-shift transmission has a wide operating range for application flexibility and maximum productivity. The Caterpillar Advanced Productivity Electronic Control System (APECS) enhances gear-to-gear shifting, through improved software intelligence that maintains consistent torque and smooths out shift points.

APECS was first introduced on its wheel loaders before migrating to motor graders.

"The hardware of the transmission is virtually the same; it's the software side that we're starting to get more intelligent in," Porter said. "It's a true event-based shifting transmission...We're using software and algorithms to look at all the conditions that are happening to the machine while it's working—the loads, the speeds, and changes in [conditions] in terms of the powertrain."

The Shuttle Shift feature enables directional shifts without slowing engine speed or using the inching pedal. An available Autoshift system allows programming shift points to best match requirements of specific applications.

A Cat C13 ACERT Tier 4 Final engine replaces the C11 used in the predecessor model, providing up to 8% more power and torque.

Operator-assist integrated technology

The 14M3 features a range of integrated technology solutions that aim to improve operator performance and productivity while reducing operating costs. The fully scalable, factory-integrated Cat GRADE with Cross Slope is one example. The system allows operators to maintain desired cross slope by automatically controlling one side of the blade.

"A lot of the work that motor graders do is simple slope control," said Porter. "Throughout the day there are many common slopes that operators will use... They know what side of the road they're working, they might want a 4% crown, 6% shoulders and 20% ditch slopes. You can program up to nine preset sloped targets on a Caterpillar grader," which is patented and exclusive in the industry, according to Porter.

A new, larger Message Display fully integrated into the front dash provides better visibility to the cross slope performance screen and in direct line-of-sight to the blade. Whether operators use cross slope in the automatic mode or as manual indicate-only, they have a clear view of critical slope information required during operation. The display was previously positioned on the right-side B-post.

Cat Advanced Control Joysticks allow the operator to manipulate any Cat GRADE or AccuGrade blade control system while maintaining control of all other machine and implement functions. The advanced joysticks also can be configured for use with auxiliary functions, such as snow wing control for snow removal operations. They come standard with Cat GRADE with Cross Slope or can be ordered as a stand-alone attachment.

The joysticks were brought to market specifically for the M Series 3 motor graders.

"The best part about these controls is we're taking the automated blade control buttons and switches that used to be at the base of the joysticks and integrating them into the main controllers," Porter explained. "So operators can keep their hands on the joysticks during operation, they have full control of the machine, full control of the blade, and now they have full control of the automatics—whether they're using Cross Slope, AccuGrade Sonic, Laser, GPS or Universal Total Station."

The newly patented Stable Blade feature is a "first-of-its-kind" anti-bounce system for a motor grader. It detects and minimizes machine bounce by automatically controlling the throttle during operation, with no operator intervention required. The system helps eliminate rework, saving time and reducing fuel burn.

"This is the [technology] you should be most excited about," said Porter.

Stable Blade works with a sensor in conjunction with the engine and the Electronic Throttle Control feature, similar

A new, larger Message Display fully integrated into the front dash provides better visibility to the screen in direct line-of-sight to the blade. It was previously positioned on the right-side B-post.

to adaptive cruise control. "The system says, 'Okay, you want to run 1800 rpm in 4th gear, lock it, sit back and run your blade,'" he explained. "As that sensor feels the harmonic bounce about to occur, it will decelerate your machine automatically, slow you down until stable, and then modulate your acceleration back to your intended target. It happens before the cutting edge ever damages the surface—that's the key."

Caterpillar tests found that the Stable Blade system can reduce bounce by 35% and save up to 14% in fuel burn by eliminating rework.

Another patented and exclusive technology is Auto Articulation, which combines two functions into one by automatically articulating with steering input. This feature, which was based on customer feedback, improves maneuverability and performance in tight working spaces, enhances operator comfort and reduces fatigue.

"Even though the M Series motor grader definitely made advancements in terms of articulation—it used to be a separate lever on the conventional systems, on an M Series it's a simple twist of the wrist—customers [asked us] to make it simpler," Porter said. "So with a toggle switch, you can now have both—as you steer it with that joystick left and right, the hitch will follow."

As with the Advanced Control Joysticks and Stable Blade technology, Auto Articulation is retrofittable to any existing M Series grader in the field.

The 14M3 motor grader and other "heavy metal," along with additional Cat Connected Technologies for machine control and monitoring, were highlights of hte company's display at the recent ConExpo-Con/Agg 2017 in Las Vegas in two exhibit areas totaling 60,000 ft^2:

Ryan Gehm

Power and more underscore 2018 Toyota Camry

2018 Camry revealed by Toyota president Akio Toyoda at 2017 Detroit auto show.

The best-selling car in America for the past 15 years breaks its mold with a new platform and powertrains. Things have changed with **Toyota**'s 8th-generation flagship sedan and the legacy of being simply a "standard sedan" has been blown up.

"We don't want to just stay in that [standard sedan] position, so that was our driver to make an unprecedented change," Masato Katsumata, global chief engineer of the 2018 Camry, said in an interview with *Mobility Engineering* following the car's world debut at January's Detroit auto show.

Creating a car that would elicit fun and excitement for the driver was a key goal.

"This was not just another typical, conventional full model change," Katsumata said about the approach of the engineers who had a hand in developing a midsize car with more advanced technology—and unexpectedly performance—than the current Camry.

The Toyota New Global Architecture (TNGA) set the stage for a highly revamped Camry. With TNGA, said Toyota Motor Corp. President Akio Toyoda, "Our engineers were able to accommodate the new design's low center of gravity and the extreme sculpting of the sheetmetal."

Primary vehicle dimensions are a 111.2-in (2824-mm) wheelbase, 191.3-in (4859-mm) overall length, 56.7-in (1440-mm) overall height and 72.4-in (1839-mm) overall width. All but the height dimension have increased in comparison to the current Camry.

Camry will be offered with an all-new 2.5-L "Dynamic Force" 4-cylinder gasoline engine paired with an equally new Direct Shift 8-speed automatic transmission. This next-generation 4-cylinder spotlights higher torque, higher power and lower fuel consumption in the "total-use" range. And this high-output powerplant is reported to have 40% thermal efficiency, a claim Toyota also recently made about the 4-cylinder engine powering the Prius hybrid.

The 2018 car also will be available with a 3.5-L V6 with D-4S fuel injection, as well as a next-generation Toyota Hybrid System variant. Unlike the current Camry Hybrid's trunk-located battery pack, the 2018 model's power pack is under the rear seat. The hybrid system's CVT offers a new Sport Mode setting that enables the driver to feel smooth, quick simulated "gearshifts" via the simulated 6-speed sequential shift transmission.

The 2018 Camry is slated to reach dealerships in late summer 2017.

Kami Buchholz

I.D. Buzz: VW's latest future-look Microbus

It's a **VW** Microbus for future generations, an electric van capable of fully autonomous driving. But at this point, it's only a concept.

"We want to re-ignite America's love for Volkswagen. And we are fully committed to the future of mobility—smart, sustainable, affordable—that is the new Volkswagen," proclaimed Dr. Herbert Diess, Chairman of the Board of Management for the Volkswagen Brand.

Sharing the stage with the Volkswagen I.D. Buzz electric van concept during the automaker's 2017 Detroit auto show press conference, Diess said the Volkswagen brand's North America EV parade begins in 2020 with the launch of a completely new vehicle architecture. The 2025 goal is to sell one million EVs annually.

"The I.D. Buzz here on stage is one of the concepts we are examining," Diess said.

VW's new Modular Electric Drive Kit, VW's modular vehicle architecture for EVs known as MEB, underpins the I.D. Buzz. The 129.9-in (3299-mm) wheelbase electric van's all-wheel-drive system has a claimed total output of 369 hp. There is an electric motor on each axle. The vehicle has a 111 kW·h battery,

The VW concept I.D. Buzz made its world debut at the 2017 Detroit auto show. (Kami Buchholz photo)

delivering an EV range estimated at up to 270 mi (600 km) on the U.S. driving cycle.

Befitting its intent as a fully autonomous driving vehicle, the I.D. Buzz has an unconventional cabin that includes a touch-sensitive steering wheel and an augmented-reality head-up display. The HUD enables navigation directions or other important information to be projected as a virtual image 23 to 49 ft (7 to 15 m) ahead of the vehicle. The concept van's front seats can be electrically unlatched and rotated 180° to face the rear seats.

Tomasz Bachorski, Technical Development, Head of Interior Design, said the I.D. Buzz's seats are more than a place to sit. The second-row seatbacks can be folded to form a table, while the third-row seats can become a bed. "It's really easy, really friendly, because life outside is complicated enough—so the interior here is easy-to-use," he said.

Kami Buchholz

I.D. Buzz cabin can be reconfigured in several ways, while exterior dimensions are: 194.5-in length, 77.9-in width, and 77.3-in height.

2018 Ford F-150 diesel aims to exceed 30 mpg

Besides its new 3.0-L diesel option, the 2018 F-150 gets a new 3.3-L gasoline V6 and various exterior front-end changes to better differentiate models within the series.

With two key 30-mpg enablers for the F-150 already in production—an aluminum body structure and 10-speed transmission—**Ford** Truck Engineering now brings the final piece of the technology puzzle: a 3.0-L turbodiesel.

Combined with standard stop-start, the first-ever diesel-powered F-150 will be shooting for an **EPA** fuel economy rating that exceeds 30 mpg—the Holy Grail for full-size trucks—when it enters production later this year as a 2018 model.

Ford announced the long-rumored diesel F-150 on Jan. 8, ahead of its 2017 Detroit auto show press conference. The news comes just weeks after CEO Mark Fields said the company also will build a hybrid-electric F-150 in the 2020 timeframe—not to mention revive the midsize Ranger pickup and Bronco SUV.

The 3.0-L PowerStroke V6, based on Ford's proven 'Lion' family developed in-house for group use when Ford owned **Jaguar Land Rover,** currently is offered in several JLR models. The 84 x 90-mm bore/stroke engine features a compacted-graphite iron (CGI) cylinder block and aluminum DOHC heads. It is expected to enable the Dearborn automaker to claim best-in-class fuel efficiency for its highest-volume and most profitable model. The diesel also will be a significant step toward getting the F-150 into federal CAFE compliance for MY2025, which mandates a minimum 30-mpg highway/23 city rating for vehicles with a minimum footprint of 75 ft^2 (7 m^2).

Presently, **FCA**'s **Ram** 1500 with optional 3.0-L V6 turbodiesel and 8-speed **ZF** automatic is the class leader, rated at 27 mpg highway/20 city/23 mpg combined. No diesel or gasoline midsize pickup currently sold in North America achieves 30-mpg highway, either.

Ford's most fuel-efficient 2017-model F-Series is the standard-payload 2wd with 2.7-L twin-turbo EcoBoost gasoline V6 and 6-speed automatic, rated at 25 mpg highway/19 city. Trucks with the 3.5-L twin-turbo gasoline V6 and 10-speed 10R80 automatic co-developed with **GM** are rated at 25 mpg highway/18 city.

Complementing the diesel as the new standard engine in the 2018 F-150 lineup is a 3.3-L direct-injected, naturally-aspirated gasoline V6. Ford engineers expect it to achieve an **SAE** rating of 282 hp (210 kW) and 253 lb·ft (343 N·m), same as the incumbent 3.5-L V6. There's also a "second generation" 2.7-L EcoBoost V6 with reduced internal friction and improved robustness.

The 5.0-L V8 also benefits from "significant upgrades for power and torque" according to Ford. The V8 also will be paired with the new 10R80 transmission.

2018 F-150s receive new grilles, headlamps and bumpers aimed at differentiating the various models within the series, along with six all-new wheel designs from 17 in to 22 in.

Lindsay Brooke

All-new 2018 Ford Expedition hits big-SUV segment with aluminum body, 10-speed automatic

Known internally by its U553 program code, the 2018 Expedition leverages F-Series architecture and AL construction.

New rear Advanced Cargo Manager system was designed in-house at Ford.

When **Ford Motor Co.** leadership made the bold decision to invest in aluminum body structures for its F-Series pickups, they made sure the Expedition was integrated into the product plan. The resulting 2018 Expedition, unveiled February 7 in Dallas, shows the fruits of that wisdom.

Still riding on a separate hydroformed-steel ladder frame (itself redesigned and CAE-optimized for greater strength and lower mass), the new eight-passenger SUV sheds up to 300 lb (136 kg) compared with the incumbent model. The mass reduction enabled Ford engineers to move to a single-solution powertrain format—the 3.5-L turbocharged V6 with auto stop-start and 10R80 10-speed automatic. No V8! Reducing curb weight also allowed the addition of a large panoramic sunroof system, typically a significant mass penalty.

Chief Engineer Todd Hoevener smiled broadly when asked recently by *Mobility Engineering* if he expects significant fuel economy gains with the lighter vehicle. "Typically we're happy with mass parity compared with the outgoing vehicle, due to added feature and safety content. But losing the 300 pounds enabled us to grow the vehicle size a bit," he noted.

The 2018 vehicle will be built in both short and long (Expedition Max) versions, the latter measuring 12 in (305 mm) longer; both are available in XLT, Ltd. and Platinum trim packages. Compared with the outgoing 2017 truck, the new Expedition has a 3-in (76-mm) longer wheelbase, is 4-in (102-mm) longer overall, and is 1-in (25.4-mm) wider overall.

Hoevener, a 15-year veteran of Ford Truck Engineering, claims it is the first full-size SUV to feature a sliding second-row seat. The tip-and-slide functionality improves access to the third row even with a child safety seat in place. The power-folding third row seat now reclines. Second- and third-row seats offer pushbutton fold-flat functionality. The interior design team designed a clever and useful storage-shelf "Cargo Manager" system for the luggage space behind the third-row seat. "That was done entirely in-house by Ford," Hoevener said.

With the rear passenger seats folded down the cabin will accommodate a 4x8-ft (1.2 x 2.4-m) sheet of plywood with the liftgate closed. Ford Large SUV

While "floating" roofs are the current trend in SUVs, Expedition customer clinics demanded body-color C-pillars rather than blacked-out ones, said exterior chief George Bucher.

marketing manager Craig Patterson claims the new vehicle has two times the interior "cubby space" than its predecessor. He noted that the development team extensively engaged in UX (user experience) research with current Expedition owners and even visited their homes to observe daily usage.

The 2018 Expedition is one of the first North American products to utilize Ford's new CAN-3 electrical architecture, Hoevener added. Engineers added a dial-type electric transmission shifter in the center console which saves interior space. An electronically-locking rear differential is offered, as is continuously-controlled suspension damping. Rear suspension is independent.

Body design and surfacing were optimized for improved aerodynamics, explained George Bucher, the veteran exterior design lead. The truck's A-pillars are "faster" than the current model's, a result of using much of the F-Series front architecture. Expedition's aero package includes standard active grill shutters and extensively modeled exterior mirror mounts with subtle concavity on their vertical surface to minimize the "helicopter effect" of turbulent air in that area, Bucher noted.

"This program has a lot of wind tunnel and CFD time in it," he said. "Todd's body engineering team was great to work with—they gave us almost everything we wanted!"

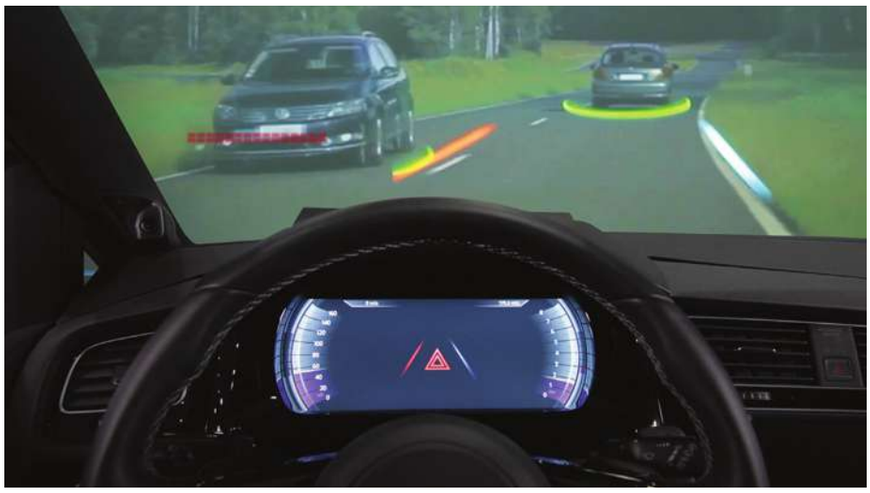
The vehicle is available with a 4x4 driveline that features a 2-speed transfer case and Terrain Management Assist. "Our customers value towing capability in extreme conditions—ever try to pull a boat out of the water?" he asked. "Having low range is a necessity."

Ford claims its latest SUV features over 40 "innovations." We didn't count nearly that many (if you could call them genuinely innovative) but the long list of electronic safety, comfort and convenience items includes a claimed "class-exclusive" enhanced active park assist; wireless charging for mobile devices; up to 10 WiFi hotspots with up to 50-ft (15-m) range; dual-headrest rear seat entertainment and an optional 12-speaker B&O audio system.

The cabin has 12-V power points, six USB chargers and a 110-V outlet. SOP starts in late 3Q17 at the Kentucky Truck Plant in Louisville.

Lindsay Brooke

Visteon tests augmented reality HUD for Level 4 autonomy



A halo around an oncoming car and other graphic overlays are shown on the AR HUD in Visteon's VW Golf demo vehicle, which also has an exterior forward-facing camera and two driver-facing cameras.

Augmented reality (AR) head-up displays are emerging as critical equipment for **SAE** Level 4 autonomous driving, where the operator must completely trust that the vehicle's ADAS sensors and cameras are monitoring and accurately recognizing its surroundings.

Mobility Engineering recently experienced a proof-of-concept demonstrator vehicle fitted with **Visteon**'s latest AR HUD system, at the supplier's Van Buren Twp., MI, headquarters. On the 2015 VW Golf R's windshield, graphics are superimposed over the driver's real-time sight line to indicate objects detected near the vehicle's path. The system also displays relevant driver information, such as lane departure warning, and navigation guidance.

With a 10 x 4-degree field image, the windshield AR HUD is nearly twice the size of those used on current production vehicles, company engineers claimed. Images are projected 33 ft (10 m) from the driver's eyes in comparison to the typical 6.5 ft (2 m) distance.

The system was designed to display sensor information "in a relevant and comprehensive manner in the driver's field of view," noted Patrick Nebout, Director of Advanced Technologies. He noted that the demo vehicle was developed by engineers at Visteon's technical center in Cergy, France.

Driver-facing interior cameras, located in the A-pillar and the rearview mirror, monitor the operator. They trigger audible and visual alerts to rouse a distracted driver, explained Mike Eichbrecht, a member of Visteon's North American technical sales group. "For instance, if you're looking down at your cell phone, an audible tone and LEDs lets you know that something in the car's vicinity, such as a bicyclist beside the road, needs your full attention," he said.

Nebout believes that an AR HUD will be the fastest, easiest and most effective interface for informing the driver of what the vehicle's sensor array has detected (i.e., moving objects, stationary obstacles, the road lane) as well as the optimum path to follow.

Over the next two years, Visteon's AR HUD vehicle demonstrator will gain capabilities. Improved optics will allow significant increases in the field of view and the size of the image, expanding the scope of driving-environment information, Nebout said.

"Visteon is also developing artificial intelligence technologies," he added, "that will allow more natural and efficient HMI and will optimize the image positioning in accordance with the dynamics of the vehicle."

AR HUD systems also have been in development at Visteon competitor **Continental AG** since 2014.

Kami Buchholz

COMPANIES MENTIONED

AD INDEX

David Moseley, Director, Powertrain, CAE Crash & Safety for electric-vehicle startup Lucid Motors, believes engineering ICEs or EVs isn't all that different. (Image: Lucid Motors)

David Moseley: EV or ICE, "It *is* all physics"

As Director, Powertrain, CAE Crash & Safety for electric-vehicle startup **Lucid Motors**, David Moseley may hold one of the most intriguing—and possibly even most-envied—jobs in the auto industry. Moseley discussed the not-really-so-different aspects of EV and internal-combustion engineering, why a powertrain's still just a powertrain—and why he ponied up his own money for a deposit on Lucid's Air electric luxury sedan.

Should the auto industry step away from the term "powertrain" and shift to "propulsion" as the march toward electrification continues?
I'm happy to keep calling it a powertrain–as far as I am concerned it's just the sequence of energy transformations from source to tractive effort, whether ICE, fuel cell, battery/motor or [Star] Trek-y warp-drive. I don't think we need a unique term for each manner by which this is achieved. What I positively like about the term "powertrain" in this context is the picture it generates in my mind of a line of carriages, a sequence of matched components working in harmony to deliver passengers to their destinations.

We're always intrigued by discussion of the parts-count delta between IC vehicles and EVs. Does this meaningfully ease the product-development and bill-of-materials processes?
In truth, it probably only serves to make the ambition of creating both a car and a car company barely feasible for a startup—rather than utterly insane!

More seriously, this goes to the heart of how one develops a product as complex as a car in the context of a startup company. The big picture is that you don't need all that many people and you need to scale their number progressively as the vehicle design develops. Too many people, too soon, perversely acts as a brake on progress: tentacles of premature design begin to grow, which are hard to sever and begin to limit the design.

I suppose you could say that a mature organization can make good use of a wider range of engineering skills effectively, as systems and precedents are available to enable a wider range of people to contribute. Without these protections, a small company like Lucid is more dependent on the excellence of its individual engineers.

Understanding and managing these issues well ends up being far, far more important than the parts-count difference in the vehicle between ICE and EV.

Without direct emissions, is the broad task of achieving the full range of regulatory certifications for an EV considerably less complicated?
I'm not really able to quantify where the balance of complexity between the ICE and BEV systems will eventually lie as EV technology matures. I can promise you that we've faced some pretty deep challenges and deployed some sophisticated methods. Whether its 3D X-ray tomography of an individual lithium ion cell as it fast-charges, or a 40-million-element model of a fine oil mist as it cools a stator end-winding, there is an enormous amount to learn and significant science and engineering in developing an understanding of EV powertrain development. Remember that there is no simple mapping between battery/fuel tank and controller-motor/engine—an EV powertrain is a very integrated and sophisticated system.

So I am prepared to admit, if it salves anyone's pride, that it's easier to develop a new BEV powertrain than it is a cutting-edge ICE powertrain, whether for emissions targets or other attributes. I'm not completely sure this is true—but whatever.

Regarding the current state of battery development, should we expect a "mature" kind of development timeline for the foreseeable future, or a potential "game-changer" chemistry or other breakthrough?
Well, first of all there is cell chemistry. This is the starting point: transforming chemical to electrical energy. Since reading the Ladybird book of "Magnets, Bulbs and Batteries" at the age of six or seven, and tearing open a battery to extract an anode and cathode to insert in a juicy lemon, I've always thought of this as something like witchcraft. Fortunately, Lucid has a world-class cell-technology team that works in partnership with our cell suppliers [**Samsung SDI**] to develop the range of attributes that Lucid is looking for with each application.

Even in the relatively short time that I have been involved with this process, I have seen how much progress has been made in the cells available to us. It seems to me that our cell-supply partners have a range of incremental ideas available and as soon as we were able to offer consistent direction and support, they rapidly produced improvements. For example, in fast-charge resilience we have seen a 200% gain when compared with the position 12 months ago. So I have a sense

that there is plenty of scope for improvement in that "mature technology" sense.

There also is an enormous gradient of demand to pull new technologies forward—it is simply not environmentally possible to satisfy the growing demand for transportation based on the personal oxidation of hydrocarbons. So it seems very likely to me that human ingenuity and the rich varieties of available chemistries will yield disruptive cells in response to this demand gradient.

What about drive/traction motors? Lucid's are proprietary, I understand. What might make a "bespoke" motor design better than something already developed and in production from a motor manufacturer?

In Lucid's case, it's never been about acquiring a bespoke design, in the sense of believing that our vehicle is so very different from any other that only a uniquely-designed motor will do. It is certainly true that we could not buy a motor like our own, but that is not the philosophical justification for developing an in-house unit.

First, we should note how closely-integrated the whole EV powertrain system must be. The technology and winding of the motor is very much linked to the current levels in the inverter and the cell technology, topology and mechanical design of the battery—which all is tightly linked to the thermal management of the vehicle. Then the mechanical design of the transmission must be integrated with that of the motor for maximum efficiency. And everything must be tightly packaged and tuned for installation in the vehicle to serve the space experience of the passengers. Finally, none of the design principles of any of these components are yet matured in their automotive applications to the point where there is anything like a consensus on their optimal features, or even an accepted genealogy of options.

So from the outset, Lucid made a strategic decision that we would design every part of this critical sequence of items—including the motors—in house. This meant investing in truly world-class experts in each and every domain and providing them with the latitude to create together a single system with every component designed with regard to performance, system compatibility and vehicle packaging.

So describing our motor as "bespoke," as one might label a ball gown or Italian suit, makes Lucid's decision sound like a vanity or frivolous option. In reality, it's an expression of our CTO's [Peter Rawlinson] vision that our company will be technology-driven and develop a profound understanding of all the systems that define our USPs [unique selling points].

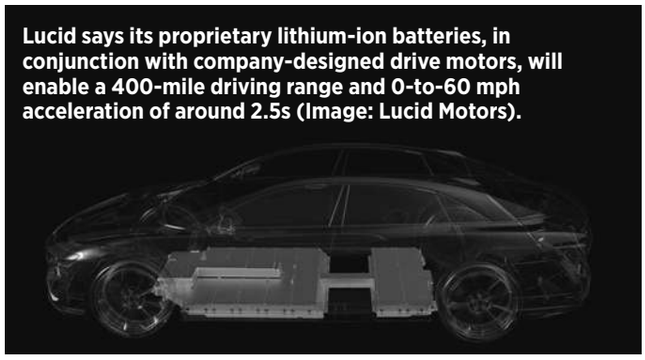
What might be the most significant challenge for an engineer with a work history in IC vehicles to switch to EV engineering?

A wide proportion of the specific engineering skills are identical: in chassis or body-in-white design. In restraints development or vehicle crash structures. EV engineering unlocks new opportunities and presents new challenges that you may not recognize and it's all too easy to continue with outdated assumptions. But the skills themselves remain directly applicable.

The biggest change is really in the design of the specific components of the powertrain itself. There is clearly a huge difference in this core technology set. I really, truly believe that it is all physics and a motivated and competent engineer can pick up the challenge of moving to a new discipline even in these areas. Letting go of the security that we feel we have by virtue of our established expertise becomes the biggest challenge for all of us.

Prototype of Lucid Air, a 1,000-hp, AWD luxury sedan the company plans to build in Arizona and begin selling in 2018 (Image: Lucid Motors).

Lucid says its proprietary lithium-ion batteries, in conjunction with company-designed drive motors, will enable a 400-mile driving range and 0-to-60 mph acceleration of around 2.5s (Image: Lucid Motors).



Perhaps in reality, the biggest shift required is whether to step out into the world of the new EV startups to learn this technology, or whether to bet on the growing in-house expertise of the established OEMs. That's more a question of your appetite for risk and reward—and I am talking about the intellectual rather than the financial opportunity.

Engineers dream of creating clean-sheet development processes. Have you at Lucid been able to do something perhaps you always wanted to do at previous companies but never had the opportunity?

For me, Lucid has been a fantastic experience. I have never previously had the privilege of working with the extraordinarily-concentrated pool of talent that Lucid has acquired. There is somehow an energy and expectation peculiar to the [San Francisco] Bay Area that creates a buzz about life and work. And absolutely, seeing a product growing before your eyes is quite extraordinary. It's enormously hard work.

But seeing the first alpha vehicle turn its wheels for the first time is an experience akin to giving birth. I really believe the Lucid Air is extraordinary in absolute terms, from any organization. There still is a great deal of work to do. But as soon as I had the opportunity to place my own deposit I took it – and I can't wait to drive my own Lucid!

Bill Visnic

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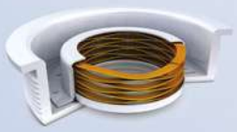

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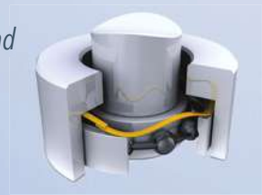

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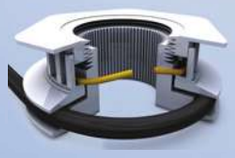

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