

MOBILITY ENGINEERING

AUTOMOTIVE, AEROSPACE, OFF-HIGHWAY

A quarterly publication of **SAE** INTERNATIONAL and **SAE INDIA**



Jaguar Land Rover's Ingenium engine

Tata's luxury group debuts
advanced engine family

Aero engine wear

Oil debris monitoring

New look inside

Screens, cameras for touch control

Volume 1, Issue 5

December 2014



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46 Oil debris monitoring in aero engines **AEROSPACE PROPULSION FEATURE**

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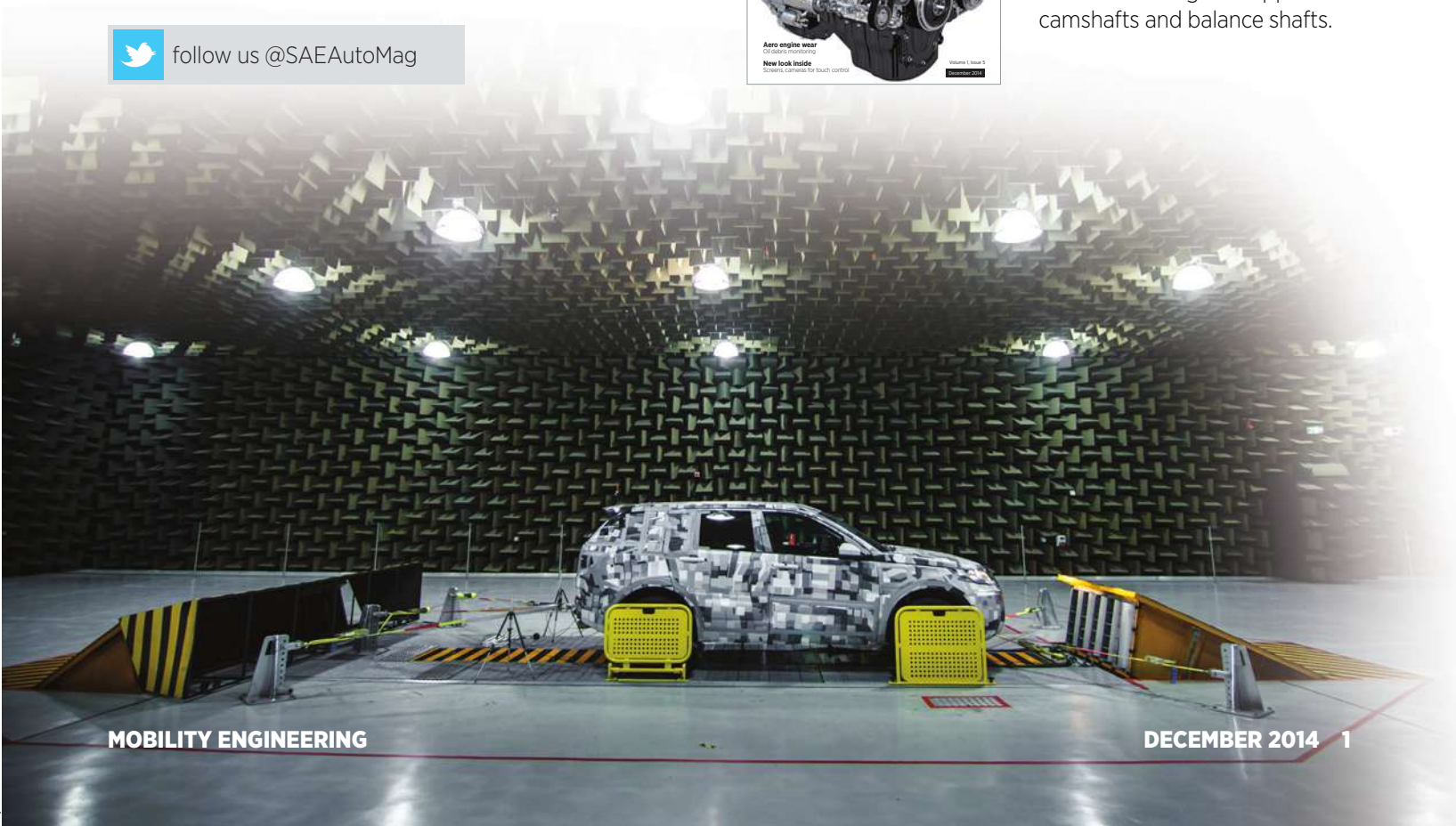
Video inputs are another option showing up on displays that increasingly offer touch control.

Cover

Jaguar Land Rover’s all-new Ingenium modular, turbocharged gasoline and diesel engine range targets significant internal friction reduction by using rolling-element bearings to support camshafts and balance shafts.



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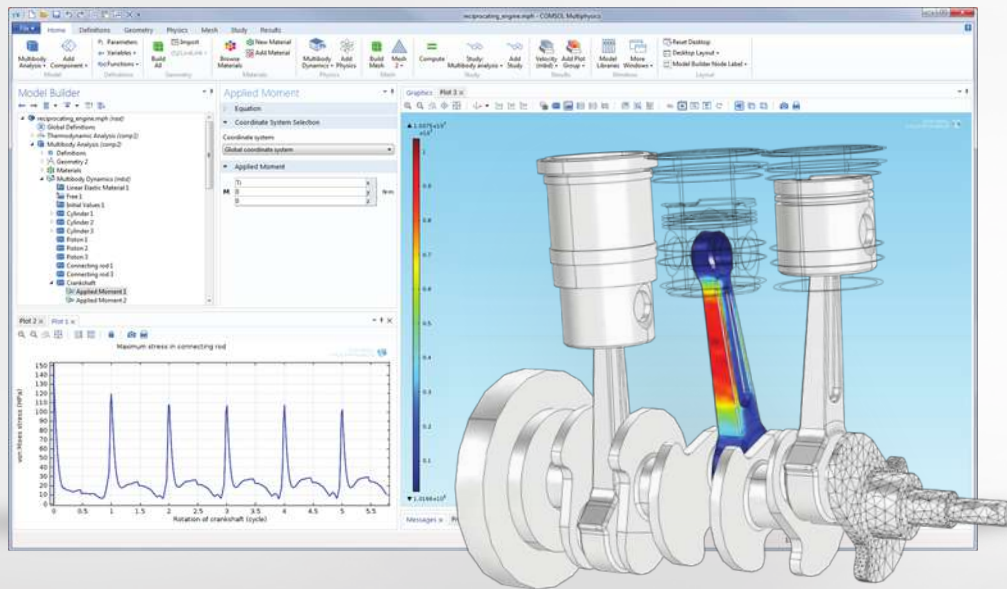
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MULTIBODY DYNAMICS: Model of a three-cylinder reciprocating engine with both rigid and flexible parts is used for the design of structural components.



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EDITORIAL

Kevin Jost
Editorial Director
kevin@sae.org

Asit K. Barma
SAE India Editor

C. V. Raman
ED, MSIL
CV.Raman@maruti.co.in

Arun Jaura
VP, SAEINDIA
arunjaura@gmail.com

Bala Bharadvaj
MD, Boeing R & T
bala.k.bharadvaj@boeing.com

Mathew Abraham
Sr. GM, Mahindra
ABRAHAM.MATHEW@mahindra.com

Venkat Srinivas
Special Director, Ashok Leyland
venkat.srinivas@ashokleyland.com

Jean L. Broge
Managing Editor
jbroge@sae.org

Lindsay Brooke
Senior Editor
abrooke@sae.org

Patrick Ponticel
Associate Editor
ponticel@sae.org

Ryan Gehm
Associate Editor
rgehm@sae.org

Matthew Monaghan
Assistant Editor
mmonaghan@sae.org

Zach Nocera
Editorial Assistant

Lisa Arrigo
Custom Electronic
Products Editor
larrigo@sae.org

Contributors

Kami Buchholz
Detroit Editor

Stuart Birch
European Editor

Jack Yamaguchi
Asian Editor

Steven Ashley
Dan Carney
Terry Costlow
Richard Gardner
Jenny Hessler
John Kendall
Bruce Morey
Jennifer Shuttleworth
Linda Trego
Paul Weissler

DESIGN

Wayne Silvonc
Art Director

Brian Fell
Senior Designer

Ryan Pristow
Senior Designer

William L. Schall
Graphic Artist

Lucy Matyjaszczyk
Graphic Artist

SALES & MARKETING

K. Shriramchandran
SAE India
No.1/17, Ceebros Arcade
3rd Cross Kasturba Nagar
Chennai
India 600 020
(T)91-44-42152280
(E) ddg@saeindia.org

Marcie L. Hineman
Global Field Sales Manager
+1.724.772.4074
hineman@sae.org

Emerging markets not about to disappear

The term “emerging markets,” credited with being created by a **World Bank** economist in 1981, has really only been part of the common vernacular for a couple decades or so, and really only gaining major traction in the last decade. There are many variations of the term, and even more definitions. Essentially though, an emerging market is a country that is still in a development, or transitional, stage in terms of its economy. Thus, the regions tend to be going through plenty of change, and are very dynamic. But most important is that most of the growth opportunities available today are in emerging markets.

During the “Efficiently Engineering for Global Markets—Meeting the Emerging Market Product Challenges” Executive Panel at October’s **SAE Commercial Vehicle Engineering Congress**, the panel’s moderator, **Cummins’** Sean Milloy, also pointed out that some emerging markets are actually quite a bit larger than developed or mature markets.

“For example, the heavy-duty truck market in China is as large or nearly as large as the rest of the world combined,” he said. “Sales were at about 760,000 units in 2013, while in North America, India, Europe, Latin America, and the rest of globe, were about 880,000. So China has about 45% of the global heavy truck market. It’s already huge, but it’s undergoing a lot of change. Another example, China has about 35-40% of the global total construction equipment market. It’s not only developing in the sense that it’s growing, but also in the sense that it’s changing.”

Part of what entails that “change” has to be on any product developer’s radar. In terms of construction equipment, China’s largest segment is in the mid-market, or what panelist John Jullens, Partner, **Strategy&** (formerly **Booz & Co.**), referred to as the “good enough” segment. Premium equipment is about 5% of the market, and low-end equipment about 15%, leaving 80% of the massive China market in the “good enough” segment.

“‘Good enough’ is a phrase that is misleading in that it implies that ‘good enough’ is easy. All you have to do is develop a cheap version, de-content and dumb things down. That’s not the case,” said Jullens. “In reality, it often requires products that have been specifically designed from the ground up to meet Chinese mid-market customers’ unique needs, and must be supported by completely different business

models. In this sense, ‘good enough’ isn’t good enough at all, and many MNCs [multinational corporations] will find it quite challenging to become competitive in the Chinese mid-market.”

To be successful, Jullens suggested, commercial vehicle MNCs need a different business model, and mind-set, and he offered some “success factors.”

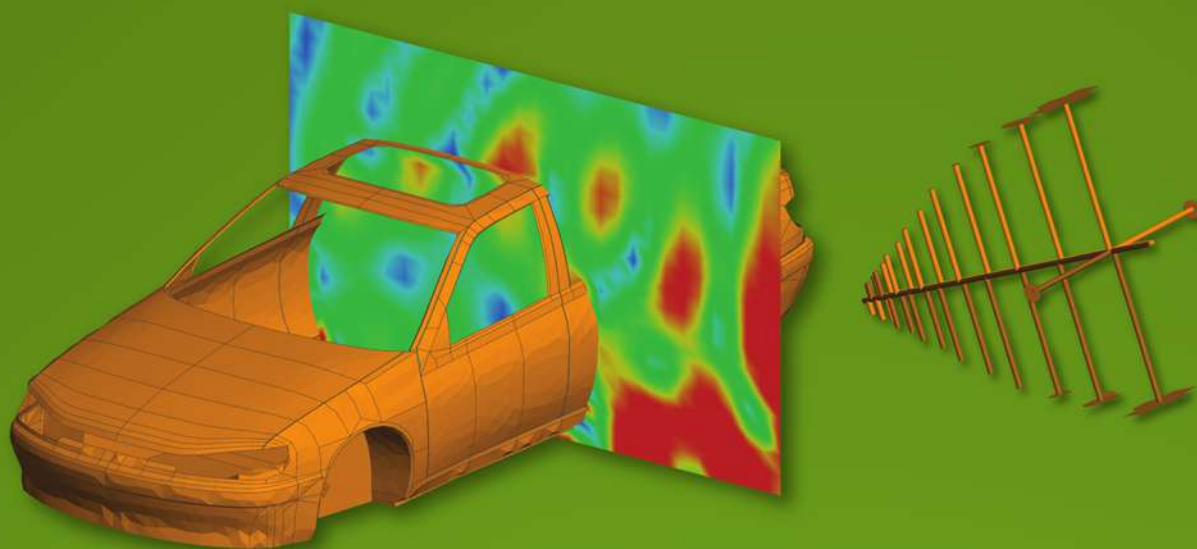
- Rethink the business model to support unique entry-level market requirements
- Develop “low-priced” products specifically designed for mid-market customers, as opposed to merely introducing “low-cost” versions
- Transfer core activities to narrow cost gaps with domestic entry-level market competitors
- Consider entering into partnerships with local suppliers
- Consider developing a multi-brand strategy to successfully operate across premium and entry-level market price points
- Develop cost-effective ways of sales by employing multi-format dealerships including vehicle supermarkets and brokers
- Ensure that management is capable and sufficiently empowered to enable fast decision making and sensitivity to local market requirements
- Ensure that HQ has at least a basic understanding of each emerging market’s unique business and regulatory context.

Overall, Jullens emphasized that the traditional MNC strategy of merely introducing low-cost versions of world-class products will not be sufficient to compete in emerging markets. That said, to become (or remain) truly competitive, developers and engineers must keep an eye out for trends to stay ahead of what products will be needed to meet future emerging-market requirements, and not just chase what is needed there today.

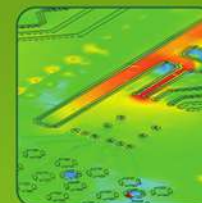
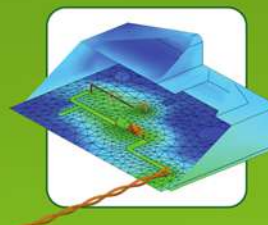
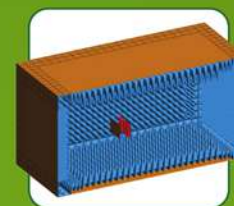
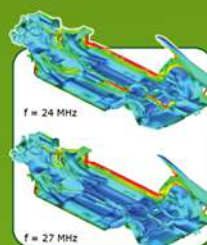
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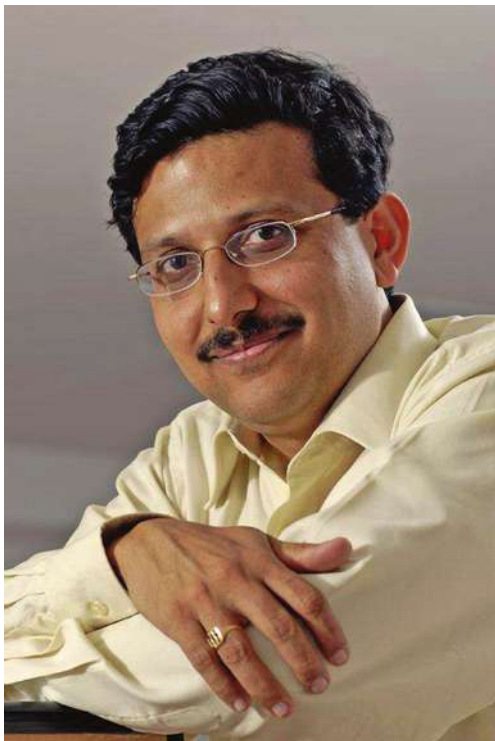
Altair Engineering India Pvt. Ltd.

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FOCUS

To the next orbit of growth

SAEINDIA's new team, now firmly in place, is embarking on to the 'next orbit of growth' toward the Vision 2020 set forth by past leaders. I am happy to share with you the results of the tireless efforts of all my team members, section leaders, Operating Board members, and staff in supporting me to formulate the Presidential Policies for the financial year 2015. The core team members, cross-functional teams, boards, and sections discussed and deliberated on the identified core areas of focus for growth this year and pledged to implement the formulated action plan. The exercise was done with the true spirit of the 'Power of One' in formalizing the way forward, to propel the organization to the next orbit of growth.



Dr. Aravind Bharadwaj
President, SAEINDIA

Earlier in July, we were fortunate to host Daniel Hancock, 2014 SAE International President, during his 10-day visit to India. All three verticals conducted value-added programs during the SAE President's visit. SAEINDIA's Off-highway Board had an event July 22 in Pune on "Futuristic Technologies and Orbit Shifting Business Strategies for Indian Off-highway Industry." The one-day workshop found some interesting and useful derivatives like differentiating market drivers through new technologies, disruptive and collaborative business models, and ideas to set

an ecosystem for availability of efficient skill-sets and talents for the industry.

This was followed by an Aerospace Board conference on "Propel High with Project Management" jointly with the Project Management Institute of India on July 24 in Bangalore. The event saw the industry's top thought-leaders like Dr. V K Saraswat, Dr. Kota Harinarayana, and Dr. Bala Bharadvaj sharing their best practices in project management to the young and energetic audience. SAEINDIA Automotive Board, led by Dr. Arun Jaura, conducted a unique Blue Ribbon CEOs' Conclave on July 25 in Chennai. At this conclave, CEOs and business heads of automotive OEMs and component manufacturers shared their experience and thoughts on "Business Practices for Next Generation Mobility." The discussions covered many aspects of business practices such as ethics and values, diversity, talent development, partnerships for holistic development, smart mobility for masses, and inclusive strategies.

As highlighted earlier, each event truly set a new benchmark in addressing the needs and concerns of mobility professionals. SAEINDIA Southern Section initiated a unique concept of Knowledge Round Table (KRT) in actively engaging members within individual companies. KRTs of each company will ensure regular knowledge-sharing forums within the group through lectures, technical discussions, and other activities. KRTs in **Mahindra** Research Valley, **Renault-Nissan**, **UCAL**, and **WABCO** were inaugurated. President Hancock was kind enough to inaugurate the largest KRT at MRV, and delivered the first expert lecture.

The Aerospace Board conducted an international workshop on Integrated Vehicle Health Management (IVHM) for aerospace applications on Oct. 17, 2014, in the side lines of SAE IVHM committee meetings. The SAE President-elect for 2015, Dr. Richard Greaves, inaugurated the workshop and delivered his address to the industry experts and young practitioners from the Indian aerospace industry. Senior experts on aircraft maintenance and diagnostics and prognostics from Europe and U.S. participated in the event sharing their experience and thoughts to set the trend for IVHM in India.

Later this year, all the boards of SAEINDIA will be working on an action plan formulated under the Presidential Policies to ensure enhanced value delivery to the membership population.

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SAEINDIA

News

SAE International 2014 President visits India

SAE International 2014 President Daniel Hancock visited India from July 21-30, 2014. The Boards of SAEINDIA and Sections conducted various activities across India during the visit of the Presidential Delegation.

The visit started off with a one-day workshop on “Futuristic Technologies & Orbit Shifting Business Strategies” for the Indian Off-highway Industry conducted July 22, 2014, at ARAI, Pune by SAEINDIA Off-highway Board along with SAEINDIA Western Section.

Embarking on its objectives under Vision 2025, the SAEINDIA Off-highway Board organized the workshop to set a new trend on technologies and business strategies for enhanced leverage on emerging-market opportunities, promotion of new technology trends, and innovative business models.

The workshop consisted of expert keynote sessions and panel discussions focusing on the following four identified quadrants for growth:

- New technology to differentiate and drive the market
- Effective collaboration between stakeholders and value chain partners
- Disruptive and innovative business models to cover the base of the pyramid
- Create an ecosystem for efficient skill-sets and talent development

The welcome address was later given by Hancock. He explained the role of SAE in the international arena related to technology, research, and spread of scientific approach among engineering communities, colleges, and school students. He highlighted his role in SAE over the past 40 years in various initiatives such as Baja SAE and A World In Motion. The SAE



SAEINDIA members from various off-highway companies like John Deere, Eaton, JCB, PTC, TAFE, and Cummins participated in the “Futuristic Technologies & Orbit Shifting Business Strategies” workshop.

President also detailed how SAE is able to implement scientific temperament amongst professionals and student communities.

SAEINDIA members from various off-highway companies such as John Deere, Eaton, JCB, PTC, TAFE, and Cummins participated in the workshop.

The event was sponsored by John Deere and Eaton, and ARAI provided the location. On July 21, a special dinner was hosted by SAEINDIA Western Section in honor of the visiting SAE International delegation.

Bangalore: July 24, 2014

SAEINDIA Aerospace Board and Bangalore Section conducted a one-day workshop on “Propel High with Project Management” for the Indian Aerospace Industry in association with Project Management Institute (PMI) on July 24, 2014, at Bangalore.

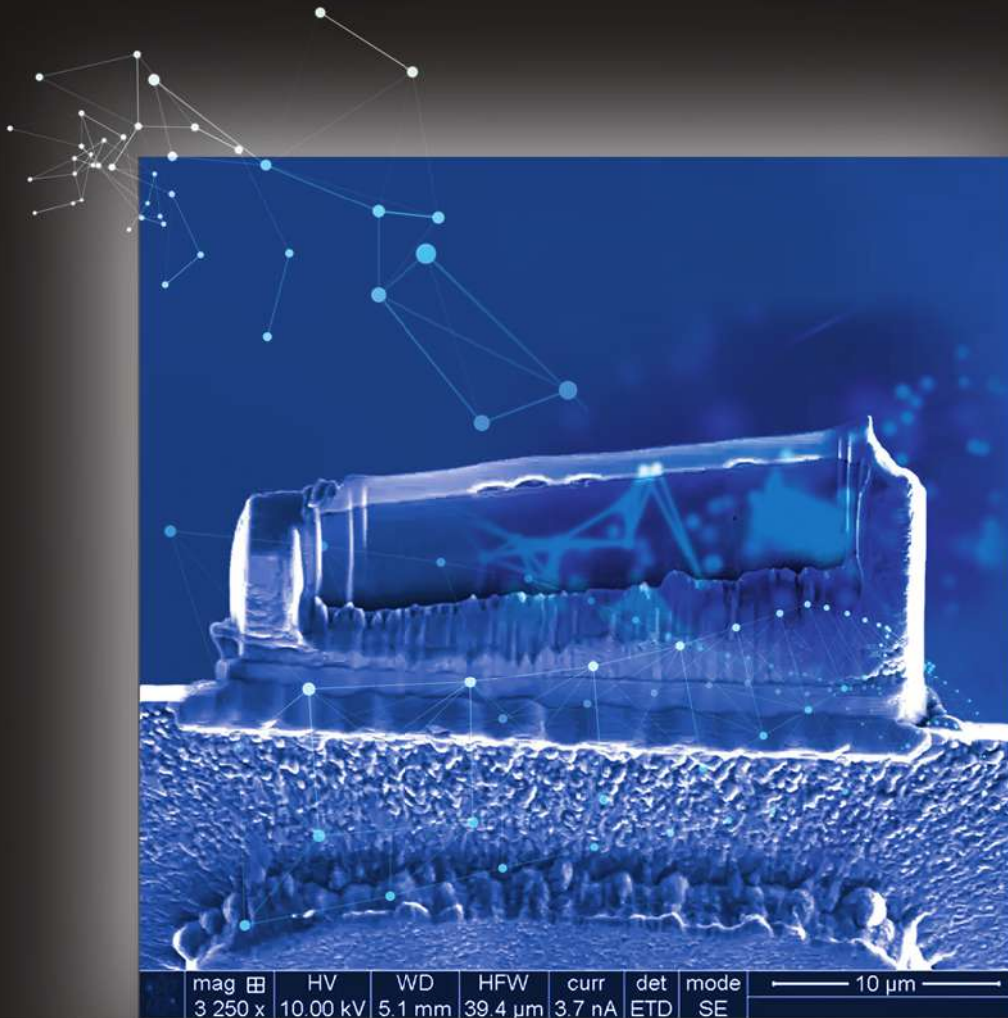
Members from various aerospace companies and defense establishments from India participated in the workshop. The workshop was inaugurated by Dr. V. Saraswat, former Secretary to the Defense Ministry (R&D) and presided over by Mr. Hancock. Dr. Saraswat delivered the welcome address, and the keynote was delivered by Dr. Bala Bharadvaj, Chair, SAEINDIA Aerospace Board, and Dr. Suresh, VSSC.

Dr. Saraswat spoke of India’s contribution in defense programs in this country and stressed that we should be proud of our achievement in the A&D sector. He spoke about the importance of project management in all these programs and various indigenous A&D programs in the country. Saraswat highlighted the development of missile programs, electronic warfare systems, light combat aircraft, and advanced light helicopter programs in the country. Challenges in technology, R&D, vendor management, system integration, concurrent engineering, and project management were highlighted in detail for the benefit of delegates represented by various A&D industry.

Dr. Bharadvaj’s keynote address presented an overview of the aerospace industry and its growth potential. He explained that projects in aerospace are long, complex, multi-dimensional, and technologically challenging. He stressed leadership vision, integrity, good communication, ethics, empathy, and competency to have successful project management. Very



SAE International 2014 President Dan Hancock (right) is honored by the SAEINDIA Off-Highway Board.



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SAEINDIA

News



SAEINDIA Aerospace Board and Bangalore Section conducted a one-day workshop on “Propel High with Project Management” for the Indian Aerospace Industry in association with PMI on July 24, 2014, in Bangalore.

aptly, Dr. Bala gave an insight into Indian project management capabilities over the centuries in various programs such as the Taj Mahal, Tanjore Temple modern day infrastructure, and engineering programs in the country.

During a panel discussion titled “Role of Project Management in Engineering for Aerospace,” Moderator Mr. Damodaran Subramanian, Senior VP, **Safran Engineering Services**, and panelists Dr. Kota Harinarayana and Dr. DS Kothari, DRDO Chair, **ADA**; Mr. Shyam Chetty, Director, **CSIR-NAL**; and Mr. Ravishankar Mysore, VP, Engineering for Global Engg Center, **UTAS**, discussed the following key points and expressed their views based on their rich experiences:

- Integration of technologies in long-term projects such as aerospace
- Adoption of newer technology despite longevity of the projects
- Investment in process, people, and motivation of the project teams
- Cultural aspects of saying “no” when it is required
- Involvement of Indian teams from the initial phase of the global projects
- Different roles of a project manager and technical manager
- Constant training on newer approaches, technology, and mentoring.

During the panel discussion titled “Experience in Aerospace Manufacturing—A Project Management Perspective,” moderator Mr. Vasanth Kini, MD, **Titanium Industries**, and panelists Mr. Sridhar Ramachandran, Vice President & GM, **Indo-US MIM Tec Pvt Ltd**; Mr. Naresh Palta, CEO (A&D), **Maini Group**; Ms. Stanis Jovita, GM-Engg Ou, **Cyient**, presented their views in implementation of project management principles both in the manufacture of mechanical components and electronic systems. The following points were highlighted and discussed:

- The principle of project management in public sector.
- Difference in licensed production and indigenous developed production.
- Certification is a challenge for Indian companies—NADCAP, AS9100.
- Technical managers focusing on technology but not on program management.
- Importance of supply chain, Risks in logistics, 5W & H.
- Manufacturing in avionics and pricing the product.
- Obsolescence management and minimum order quantity.

The keynote address was given by Dr. B. N. Suresh, Vikram Sarabhai distinguished professor at **ISRO** (Indian Space Research Organisation) HQ. Dr. Suresh gave a very clear view of the successful implementation of project management principles in Indian Space Program from the initial days. He highlighted the role of ISRO in bringing together R&D, big and small private players in executing various projects under ISRO’s leadership. He categorically mentioned the need of roles and responsibilities of various stakeholders in every program using the three tier non-conformance management. He also stressed the importance of trust and transparency.

Chennai: July 25, 2014

SAE President Hancock inaugurated the SAEINDIA Knowledge Round Table (KRT) of Mahindra Research Valley on July 25, 2014, during his visit to Mahindra Research Valley (MRV) near Chennai. KRT is an initiative to engage SAEINDIA members within each company in new knowledge sharing initiatives and activities.

Hancock visited the Mahindra Technical Academy (MTA) at MRV and delivered the first expert lecture at the MTA. Close to 250 SAEINDIA members from Mahindra Research Valley attended the inaugural function and the lecture.

While expressing his gratitude for the SAE President’s visit to India, Dr. Aravind Bharadwaj, President, SAEINDIA, also gave special thanks to Mr. Balasubramanian, Chairman of Southern Section and Mr. Parvez Alam, champion on this unique initiative from the Southern Section.

SAEINDIA Automotive Board led by Dr. Arun Jaura conducted a unique blue chip event “Blue Ribbon CEO’s Conclave” at the Taj, Chennai on July 25, 2014. Mr. Hancock inaugurated this conclave and appreciated the participation of the leaders and captains of the Indian industry.

At this first-ever conclave, 20 CEOs and business heads from OEMs and vendor partners were present to show their continued support to SAEINDIA and share their thoughts and



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SAEINDIA

News



SAEINDIA, PMI INDIA, and SAE president Dan Hancock after the lighting ceremony prior to the “Propel High with Project Management” event in Bangalore.

experiences about “Business Practices for Next Generation Mobility.”

The discussion was not limited to, but covered four major aspects: Doing Business Right: Ethics and Values, Diversity, Talent Development; Leveraging Innovation and Business Practices, Public-Private Partnership; Socio-economic Partnerships for Holistic Development; and Integrating Smart Mobility for Masses: Inclusive Strategy (Urban Development, Energy Providers and Policy Makers).

Chennai: July 28, 2014

SAEINDIA Southern Section conducted an event to kick off the “A World In Motion” (AWIM) activities for the year at the Maharishi Vidya Mandir School in Chennai. Mr. Hancock, during his speech, appreciated the efforts of all SAEINDIA members and volunteers in successfully establishing the AWIM program in India. All volunteers who contributed to the AWIM activities were recognized in the presence of the SAE International President by the chairman of the Southern Section. The function was also graced by the presence of Dr. Govindarajan, past Chairman of SAEINDIA Southern Section and a stalwart of SAEINDIA.

SAEINDIA Southern Section activities were presented to the visiting SAE International President. The initiatives of the section were very much commended by Mr. Hancock. Following the event, South Mag was distributed to those in attendance.

New Delhi: July 30, 2014

The SAEINDIA Foundation Awards ceremony was conducted by SAEINDIA Foundation along with Northern Section in New Delhi on July 30, 2014, during Mr. Hancock’s visit to SAEINDIA Northern Section. Members were recognized for their distinguished contribution to the industry and activities of SAEINDIA. The chief guests for the event, Mr. Vikram Kirloskar, President, **SIAM**, and Mr. Hancock delivered their congratulatory message to the award winners. The event was attended by prominent leaders such as Dr. K Kumar and Mr. Balraj Bhanot along with leaders of SAEINDIA Northern Section Mr. R Dayal, Mr. I V Rao, and Mr. C V Raman.

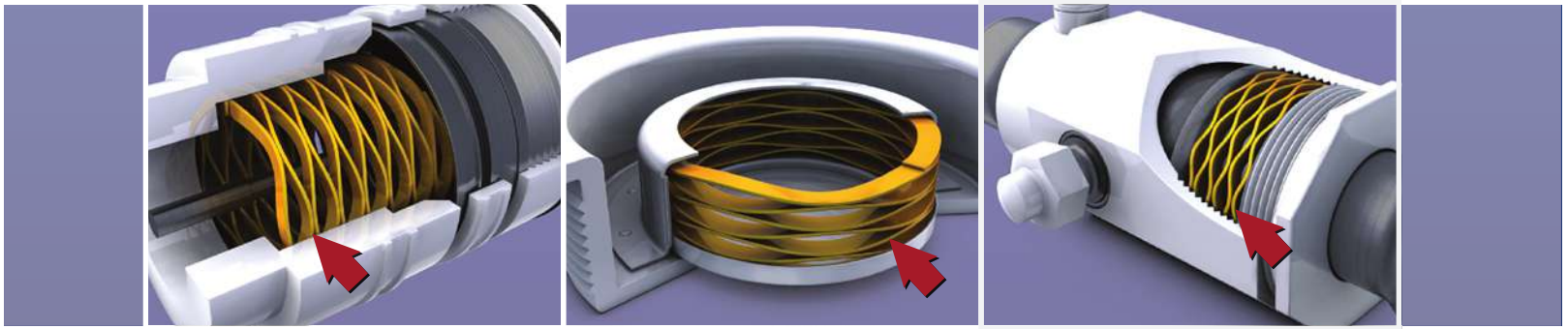
The Winners of SAEINDIA Foundation Awards:

- Life Time Achievement Award : Dr. R Mahadevan
- Roll of Honor : Mr. Rakesh Sood
- Guru Awards : Dr. S Thirumalini, Dr. K C Vora, Prof. S Majji
- Champion Awards : Mr. Prateek Bansal (Northern section), Mr. Parvez Alam (Southern Section)
- Engineer of the Year Award : Mr. Ashesh Anil Shah (Tata Motors), Mr. Avnish Gosain (Maruti Suzuki)
- Student of the Year Award : Mr. Ankur Wadhwa (Jamia)
- Kalpana Chawla Award : Ms. Charul Chadha, Ms. Archika Singh Poria, Ms. B Sharmila

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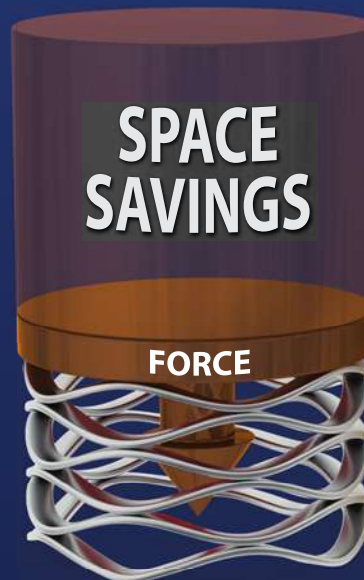


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SAEINDIA

News

SAEINDIA formulates plan for improvement

For the last decade, few trends have captured the world's attention as much as the so-called rise of the rest—a spectacular economic/political/intellectual emergence. **SAEINDIA** is all set to devour the power of oneness. Two days of strenuous effort and untiring buoyancy of the new Managing Committee has been set to propel SAEINDIA to the next orbit at the convergence of the Presidential Policies deployment. The defined major tasks were analyzed and debated about 30 days before the convergence by the identified cross-functional teams and operating teams. The activity was followed as business planning to bring alignment, clarity, and participation of all concerned, and thereby facilitate achievement of stretched targets in a smart, systematic, and professional manner.

While commending the dedicated efforts of past presidents, Managing Committees, other senior leaders, members, volunteers, and staff for their contribution in the evolution of SAEINDIA as a respected professional society in the country, President Dr. Aravind Bharadwaj explained the policies considered relevant, prioritized them with the present time frame, and essentially identified areas of improvement. In addition to the normal focus areas for any society—sustenance through member engagement—the following are the prioritized areas for improvement:

- Enhance relevance of activities to members
- Reduce non-value-adding expenditures
- Increase member engagement
- Improve creation of knowledge
- Develop guidelines for unified working among SAEINDIA sections and divisions.

The importance of deploying these five policies through strong, inclusive, and innovative deployment to arrive at executable actions was explained by Dr. Bharadwaj and Mr. Selvamani.

Cross-functional teams (CFTs) were formed, headed by leaders of SAEINDIA, to write the policy stories on the above prioritized areas. Execution stories were prepared by the Operating Boards and Section Committees.

All the stakeholders ensured, through proper deliberations and discussions, the alignment between the execution stories and the policy stories prepared by the CFTs based on the identified priority areas of focus, and formulated the plan. All senior members of the CFTs, Managing Committee, Operating Boards, Section Committees, and staff pledged to work on the formulated action plan.

BAJA SAEINDIA

BAJA **SAEINDIA** was a dream come true under the mentorship of Dr. Pawan Goenka, Executive Director and President, Automotive & Farm Equipment Sectors, **Mahindra Group**, who supported the idea, brought together a capable team, and initiated the event at the land facility of NATRiP (National Automotive Testing and R&D Infrastructure Project) in Pithampur. The next BAJA SAEINDIA event will be conducted in February 2015. Participation in the event is increasing year by year covering almost every university all over India. It began with 27 colleges in 2007 and now 325 colleges from all states compete. This year will be an international event, which is go-

ing to be more competitive for the Indian students. 122 teams were selected for the main event after the virtual round of BAJA SAEINDIA, which happened in August at Gujarat Technological University, Ahmedabad. This includes 12 BAJA teams, which is a new initiative by the committee. Teams will take to the tracks using electric motors and batteries. Because the February event is international, the tracks are transformed to a higher level. Through each passing year, BAJA SAEINDIA has seen an exponential growth with more than 2500 participants. BAJA is just not a competition anymore; it is a revolution growing day by day, where only the fittest will survive.

Building on world-class capability in manufacturing

IACC, TIE, and SAEINDIA Bangalore section organized a successful event titled “Building World-Class Capability in Manufacturing” on June 6, 2014, at the Hubli Deshpande Centre BVB college campus. Smt. K Rathna prabha (IAS), Additional Chief Secretary, Commerce and Industry Department, government of Karnataka, and Sri M. Mahaeshwar rao. (IAS) Commissioner of Industrial Development and Director of Industries and Commerce, Government of Karnataka, spoke during an Interactive session with various industries on how to make the North Karnataka region a global manufacturing Hub in upcoming years.



Members of the Karnataka government speak at the “Building World-Class Capability in Manufacturing” event.

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SAEINDIA

News

SAEINDIA Northern India Section student convention

On Sept. 13, 2014, SAEINDIA Northern India Section (SAENIS), in association with **MNIT Jaipur**, organized its first student convention in Rajasthan—a new beginning, particularly for this region. Over 841 students from 16 colleges and universities including MNIT Jaipur, **SKIT Jaipur**, **JECRC University Jaipur**, **Anand International Engineering College Jaipur**, **Poornima College of Engineering**, Jaipur, **JECRC**, Jaipur, **JECRC-UDML**, Jaipur, **GEC**, Ajmer, **IIT Jodhpur**, **RIET Jaipur**, **LNMNIT**, **VIT**, **Manipal University**, Jaipur, **MLVTEC Bhilwara**, **PITS Sikar**, and **Rajdhani College of Engineering**, Jaipur, participated in the convention.

Workshop series

Futuristic Technologies and Orbit Shifting Business Strategies

A one-day workshop on “Futuristic Technologies and Orbit Shifting Business Strategies” was jointly organized by SAEINDIA Off-Highway and SAEINDIA Western Section on July 22, 2014, in **ARAI**, Pune. The objective was to enhance and leverage from emerging market opportunities through futuristic technology, effective collaboration, and disruptive and innovative business models. As the Indian economy is poised to take off to the next level in the following decade, the off-highway industry needs to work on a paradigm shift in terms of technology development and new business models with greater benefits to the stakeholders in the value chain. Off-highway can also look to increased contribution to the GDP from agriculture and infrastructure industry.

Emissions and Our Environment

As part of a workshop series, a one-day workshop on “Emission and Our Environment” was jointly organized by ARAI and SAEINDIA Western Section at ARAI, Pune on Aug. 28, 2014. Dr. Suresh S Iyer, Research Associate in the Department of Mechanical Engineering at **Pennsylvania State University**, USA and Dr. K. C. Vora, Sr. Dy. Director & Head of Academy at ARAI, Pune, headed the workshop.



Attendees of the “Emissions and Our Environment” workshop.

A World in Motion

A World In Motion (AWIM) program is an international event of **SAE**, which brings together teachers, students from different technical institutes, and industry volunteers in one platform for exploring physical science by addressing the essential concepts of science, technology, engineering, and mathematics (STEM) among the school children. The program is structured in a seasoned manner so as to develop scrutiny and impel the future generation to pursue careers in STEM by bringing their daily experiences into AWIM classrooms. The curriculum of the program incorporates a workshop for teachers, students, and industry volunteers known as the Master Teacher Training Program.

Material Testing Using a Digital Image Correlation

A one-day workshop on “Material Testing Using a Digital Image Correlation,” jointly organized by ARAI, SAEINDIA Western Section, and Lavisio took place at ARAI, Pune on Aug. 12, 2014. Dr. Robert Littlewood, Applications Engineer at LaVision, Singapore; Arun Raj, Regional Sales & Support Manager – India, LaVision, Singapore, oversaw the workshop.

Advance Driver Assistance & Active Safety

A one-day workshop on “Advance Driver Assistance & Active Safety,” jointly organized by ARAI, SAEINDIA Western Section, was held at ARAI, Pune on Aug. 12, 2014. The speakers for this workshop were as below:



Attendees of the “Advance Driver Assistance & Active Safety” workshop.

- **Mr. A. V. Mannikar:** Sr. Dy. Director & Head, Safety & Homologation Laboratory and Passive Safety Laboratory, ARAI, Pune.
- **Mr. Jitendra Shah:** Research Engineer at Ford Research Centre Aachen GmbH Germany.
- **Mr. Pratyush Khare:** Head of Integrated safety center at TATA Motors, Pune.

Economics of Fuel: Complete Vehicle is the Key

SAEINDIA Northern India Section (SAENIS) organized a one-day seminar in association with AVL on “Economics of Fuel: Complete Vehicle is the Key” on July 18, 2014, at Hotel Leela Ambience, Gurgaon. The seminar focused on engine, combustion, emission measurement and testing, fuel economy improvement, and related areas. The seminar took a close look at future emission trends in India and Europe and how better fuel economy can be achieved through calibration. Also discussed was the future of hybrid technologies in India.

Engine Failure Investigation and Analysis seminar

SAEINDIA, along with SAE International, organizes a seminar on “Engine Failure Investigation and Analysis” by Mr. Robert Kuhn on Nov. 10-11, 2014, in Chennai and Nov. 13-14, 2014, in Pune. Mr. Kuhn is an expert with years of experience and demonstrated expertise in the subject of engine failure. He is also part of the eminent panel of SAE in the International Lecture circuit.

CAE for Powertrain Application

A three-day workshop on “CAE for Powertrain Application,” jointly organized by ARAI, SAEINDIA Western Section, and ANSYS was held at ARAI, Pune from July 7-9, 2014. The speakers for this workshop included:

- **Dr. S. Manivasagam**, Chief Delivery Officer for **Onward Technologies Limited**, Pune
- **Sanjeev Bedekar**, TSFE (Thermal Science Functional Excellence) leader at **Cummins Research and Technology India (CRTI)**, Pune.
- **Mr. M. A. Patwardhan**: Dy. General Manager at Computer Aided Engineering Laboratory at ARAI, Pune.
- **Mr. Sandeep Shetty**: Sr. Technology Specialist at ANSYS India.
- **Mr. Santosh Kotalgi**: Senior Technology Specialist in the Support & Services organization at ANSYS FLUENT India Pvt Ltd.
- **Mr. Priyank Jain**: Sr. Technology Specialist in Support & Services organization at ANSYS FLUENT India Pvt Ltd.
- **Mr. Jayesh Muthyal**: Senior Technology Specialist in the Support & Services organization at ANSYS FLUENT India Pvt Ltd.
- **Mr. Sourabh Shrivastava**: Technology Specialist at ANSYS India
- **Mr. Mahendra Joshi**: Technology Specialist at ANSYS India
- **Mr. Rahul Phadke**: Technology Specialist with ANSYS India
- **Mr. Sampat Kumar**: Deputy Manager, PTE, ARAI.



Attendees of the “CAE for Powertrain Application” three-day workshop.

Multi Axis Testing: Improving Durability of Automotive Components

A one-day workshop on “Multi Axis Testing: Improving Durability of Automotive Components,” jointly organized by ARAI, SAEINDIA Western Section, and Moog was held at Hotel Mapple Emerald Delhi on July 15, 2014, at Hotel Radha Regent Chennai on July 16, 2014 and at ARAI Pune on July 18, 2014. The speakers for this workshop were as below:

- **Mr. Craig Lukomski**: Engineering Manager for Moog’s test market in Plymouth, MI
- **Mr. M. R. Saraf**: Sr. Deputy Director & Head of Department of Structural Dynamics Laboratory (SDL) and Automotive Material Laboratory (AML) at ARAI, Pune.



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24 January 2015

CALL FOR REGISTRATION

PROGRAMME SCHEDULE

| | SIAT 2015 | SIAT EXPO 2015 |
|-----------|--|---------------------------------|
| 21 Jan.15 | Inaugural Session & Technical Sessions | Inaugural Session & Exhibition |
| 22 Jan.15 | Technical Sessions | Exhibition |
| 23 Jan.15 | Technical Sessions & Valedictory Session | Exhibition |
| 24 Jan.15 | | Technology Theatre & Exhibition |

REFERENCE TECHNICAL BULLETIN

Reference Technical Bulletin comprising of technical articles, advertisements, etc. will be published to commemorate SIAT 2015. It will provide an opportunity for sharing various technical advancements in automotive technology. Technical notes, case studies, product information, etc., are invited for inclusion in this Reference Technical Bulletin. For more details, please contact: Mrs. A.A. Baikerikar, DD, IMPC, Tel: 020-30231640 E-mail : siat2015-trb@araiindia.com

CALL FOR REGISTRATION

Invitation for online registration of delegates, delegate fee is payable in Online/Cash or through Demand Draft made in favor of "The Automotive Research Association of India", payable at Pune, India. The first 200 delegate registrations received with payments will receive SIAT 2015 Merchandise. Log on to <http://siat.araiindia.com> for online enrollment. Registered delegates will be entitled to participate in the Symposium, Exhibition, Luncheons and Cultural Programmes. They will also receive Symposium Proceedings and Delegate Kit.

CALL FOR STUDENTS POSTERS

Poster competition for students under the categories of 1) Emission, 2) Safety and 3) Noise, Vibration and Harshness (NVH). For more details, please contact: Mr. Vijay Pankhawala, General Manager, BDCP, Tel: 020-30231133, Mobile: 9975492659, email: pankhawala.dts@araiindia.com

SIAT EXPO 2015

A grand exposition of automotive technology, products and equipment pertaining to Auto Industry, is being organized concurrent to SIAT 2015.

The exposition will attract automotive OEMs, Tier - I, Tier - II and Tier - III suppliers, equipment providers, CAD/CAM/CAE tool providers and other service providers to showcase their products and service capabilities. This time over 165 exhibition stalls are available for booking.

This exposition is open to all automotive personnel and interested individuals and will be an excellent opportunity for promotion of business and dissemination of information.

For Registration, Correspondence, Please Contact:

Dr. K. C. Vora

Sr. Deputy Director & Convener, SIAT 2015

Email : siat2015@araiindia.com ■ vora.pga@araiindia.com

Tel.: +91-20-3023 1240 / 1190

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H. A. Nakhawa

Deputy Director & Coordinator, SIAT EXPO 2015

Email : siatexpo2015@araiindia.com

nakhawa.ecl@araiindia.com

Tel : +91-20-3023 1275

IMPORTANT DATES

| DESCRIPTION | LAST DATE |
|---|-------------------|
| Receipt of Abstracts | 30 April, 2014 |
| Acceptance of Abstracts by Evaluation Committee | 16 June, 2014 |
| Receipt of Draft Manuscripts | 31 July, 2014 |
| Receipt of Final Papers | 15 November, 2014 |

DELEGATE FEES*

| Category | After 1st October 2014 |
|---|------------------------|
| Author(s) (first author only) | Rs. 7,000/- |
| Non-SAE Indian Delegate(s) | Rs. 13,000/- |
| SAEINDIA Delegate(s) | Rs. 12,000/- |
| Indian Delegates (Group Discount for more than 10 delegates from same company) | Rs. 11,000/- |
| Foreign Author(s) (first author only) | US\$ 500 |
| Foreign Delegate | US\$ 800 |
| Foreign Delegates (Group Discount for more than 3 delegates from same company) | US\$ 700 |

- * Service Tax extra. Currently 12.36% and will be charged at actual as applicable.
- Delegate fee is payable in cash or through Demand Draft drawn in favour of "The Automotive Research Association of India", payable at Pune, India.
- Registered delegates will be entitled to participate in the Symposium, Exposition, Luncheons and Cultural Programmes. They will also receive Symposium Proceedings and Delegate Kit.

TECHNOLOGY THEATRE

Those interested in showcasing their technology in the auditorium, may contact: Mr. S.N. Datar, DGM, BDCP. Tel: 02030231134, Email: datar.dts@araiindia.com

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| (Specified Category) | (Open Category) | |
| <ul style="list-style-type: none"> Best International Paper Best Indian Paper on Environmental Pollution Best Oral Presentation Innovation Award sponsored by ARAI through SAEINDIA Foundation | <ul style="list-style-type: none"> First Prize Second Prize Third Prize | <ul style="list-style-type: none"> First Prize Second Prize Third Prize |

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Industry NEWS

Promising outlook for India's premium-motorcycle market

The market for premium motorcycles in India is forecast to grow at a compound annual growth rate of more than 30% in the period 2014 to 2019, according to **TechSci Research**. The market research firm notes that a key target for such products



The 2014 Harley-Davidson 750 Street was designed and engineered for global, urban-dwelling customers (<http://articles.sae.org/12639>). Market dynamics changed significantly in 2010 when the U.S. company began assembling motorcycles in India, avoiding heavy import duties and associated high price tags.

is what it calls "high net worth individuals" (HNIs). The total number of HNIs is expected to increase by 115% over the next decade. The firm further notes that motorcycles in the 500- to 800-cc segment have especially great growth potential in the premium motorcycle market in India over the next five years because of their "better maneuverability compared to motorcycles [of more than 800 cc]," and as such they are more suitable for rough Indian roads.

New WABCO India plant supplies advanced braking for heavy trucks

WABCO Holdings Inc. recently opened its fifth manufacturing facility in India, located in Lucknow. The new plant will supply advanced braking technologies, including antilock braking systems (ABS), actuators, and a range of braking valves, for multi-



WABCO inaugurated in September its fifth manufacturing facility in India. Pictured (from left to right): Rajnish Julka, Plant Head - Lucknow, Tata Motors Ltd.; Jacques Esculier, Chairman and CEO, WABCO; P. Kaniappan, Vice President, WABCO India; Leon Liu, President, Truck, Bus and Car OEMs Division, WABCO; and Vijeyandra Pandian, Indian Administrative Service and Additional Managing Director, Uttar Pradesh State Road Transport Corp.

ple global heavy truck and bus manufacturers operating in India. The new 479,000-ft² (45,000-m²) facility currently employs around 150 people. WABCO expects to employ about 300 people when the factory reaches full production capacity by the end of 2015. "As a strategic Tier 1 supplier, WABCO continues to support **Tata Motors** in the development and delivery of...innovative technologies that help improve the safety and efficiency of Tata trucks and buses on India's roads," said Rajnish Julka, Plant Head—Lucknow, Tata Motors Ltd., at the inauguration ceremony. WABCO's four existing plants include two in Chennai, one in Jamshedpur, and another in Pantnagar.

U.S., India to collaborate on Mars exploration, Earth-observing mission

While attending the International Astronautical Congress, **NASA** Administrator Charles Bolden and K. Radhakrishnan, Chairman of the **Indian Space Research Organisation (ISRO)**, met Sept. 30 to discuss and sign a charter that establishes a NASA-ISRO Mars Working Group to investigate enhanced cooperation between the two countries in Mars exploration. They also signed an agreement that defines how the two agencies will work together on the NASA-ISRO Synthetic Aperture Radar (NISAR) mission, targeted to launch in 2020. The joint Mars Working Group will seek to identify and implement scien-



An artist's concept of NASA's Mars Atmosphere and Volatile Evolution (MAVEN) mission is shown. Launched in November 2013, the mission will explore the red planet's upper atmosphere, ionosphere, and interactions with the sun and solar wind.

tific, programmatic, and technological goals that NASA and ISRO have in common regarding Mars exploration. The group will meet once a year to plan cooperative activities, including potential NASA-ISRO cooperation on future missions to Mars. Both agencies have newly arrived spacecraft in Mars orbit—NASA's Mars Atmosphere and Volatile Evolution (MAVEN) spacecraft and ISRO's Mars Orbiter Mission (MOM). One of the working group's objectives will be to explore potential coordinated observations and science analysis between MAVEN and MOM, as well as other current and future Mars missions. The joint NISAR Earth-observing mission will make global measurements of the causes and consequences of land surface changes. Potential areas of research include ecosystem disturbances, ice sheet collapse, and natural hazards.

Tata AutoComp, Magna team to develop CV seats in India

Tata AutoComp Systems Ltd. and **Magna International Inc.** recently entered into a 50:50 joint venture agreement to provide seating systems to the Indian commercial vehicle (CV) and bus industries. According to a Magna spokesperson, these seats will be newly designed, developed, and manufactured in India for the India market—not current “off-the-shelf” products. “Depending on the wants and needs of the JV’s future customers, it’s possible for new innovations or industry-firsts to be included,” the spokesperson shared. The timeline for the JV, which will be headquartered in Pune, Maharashtra, is still to be determined, he said, and will be based on customer needs.

“Seating systems in commercial vehicles have not yet evolved in India,” Arvind Goel, President and Chief of Operations and New Technology, Tata AutoComp, said in a statement announcing the JV. “With the rapid increase in infrastructure, we envisage more and more vehicles plying long distances. In such a scenario, the safety and comfort of both driver and passengers is paramount. Through this JV, we intend to address this increasing need of the industry.” The JV in India is an important part of Magna Seating’s global growth strategy, according to Deepak Nagaraja, Vice President of Magna Seating. “We believe this market offers a great deal of opportunity, and we look forward to working together with Tata AutoComp to capitalize on the potential,” he said in the statement.

Saab selected by AAI to deploy A-SMGCS at five airports

The **Airports Authority of India (AAI)** has selected **Saab** to deploy Advanced-Surface Movement Guidance & Control Systems (A-SMGCS) at five airports in India. The Saab A-SMGCS will enhance situational awareness and runway safety at these growing airports. Saab will be deploying its A3000 A-SMGCS, Saab multilateration, and SR-3 Surface Movement Radars (SMR) to Ahmedabad, Amritsar, Guwahati, Jaipur, and Lucknow Airports. The A3000 A-SMGCS will fuse multilateration and SMR surveillance data to provide air traffic controllers



The A3000 A-SMGCS provides precise situational awareness and advanced conflict-detection and alerting capabilities that improve runway safety.

with precise surveillance of the airports’ runways and taxiways, along with the identification of aircraft. In addition, the A-SMGCS will feature Safety Logic runway incursion detection and alerting algorithms to provide controllers with advanced warnings of potential runway incursions. The A-SMGCS will also include functionality for Airport-Collaborative Decision Making (A-CDM) initiatives. Previously, Saab had deployed A-SMGCS to Chennai, Kolkata, and Mumbai Airports and an A-SMGCS, multilateration, and SMR to Indira Gandhi New Delhi Airport.

India, all countries can dramatically reduce CO₂ emissions, study says

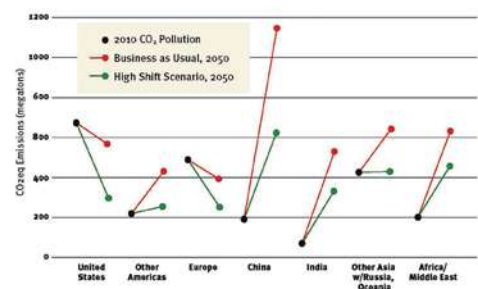
More than \$100 trillion in public and private spending could be saved between now and 2050 if the world expands public transportation, walking, and cycling in cities, according to a recently released report by the **University of California-Davis**, and the **Institute for Transportation and Development Policy** (a U.S.-based nonprofit, nongovernmental organization focused on sustainable transportation). Additionally, reductions in carbon dioxide emissions reaching 1700 megatons per year in 2050 could be achieved if this shift occurs.

Further, an estimated 1.4 million early deaths associated with exposure to vehicle tailpipe emissions could be avoided annually by 2050 if governments

require the strongest vehicle pollution controls and ultralow-sulfur fuels, according to a related analysis by the **International Council on Clean Transportation** included in the report.

Doubling motor vehicle fuel economy could reduce CO₂ emissions by an additional 700 megatons in 2050. The UC-Davis report, A Global High Shift Scenario (<http://photos.ucdavis.edu/albums.php?albumid=478293>), is the first study to examine how major changes in transportation investments worldwide would affect urban passenger transport emissions as well as the mobility of different income groups. The findings should help support wider agreement on climate policy, where cleanup costs and equity between rich and poor countries are key issues. The authors calculated CO₂ emissions and costs from 2015 to 2050 under a business-as-usual scenario and a “High Shift” scenario where governments significantly increase investments in rail and clean bus transportation, and provide infrastructure to ensure safe walking, bicycling, and other active forms of transportation. In India, CO₂ emissions are projected to leap from about 70 megatons today to 540 megatons by 2050, because of growing wealth and urban populations. But this increase can be moderated to only 350 megatons under the High Shift scenario by addressing crucial deficiencies in India’s public transport system.

Total CO₂ Pollution From Urban Passenger Transportation



TECHNOLOGY

Report

AUTOMOTIVE POWERTRAIN

JLR's all-new 2016 modular engines feature roller-bearing cams, balance shaft

Jaguar Land Rover (JLR) recently unveiled fundamental details of its all-new turbocharged modular gasoline and diesel engine range designed for high levels of efficiency and performance, that will play a major role in the company's new-product assault through 2019. The first engine in the Ingenium range, as it is called, will enter production early next year in Jaguar's all-new 2016 XE mid-size sports sedan.

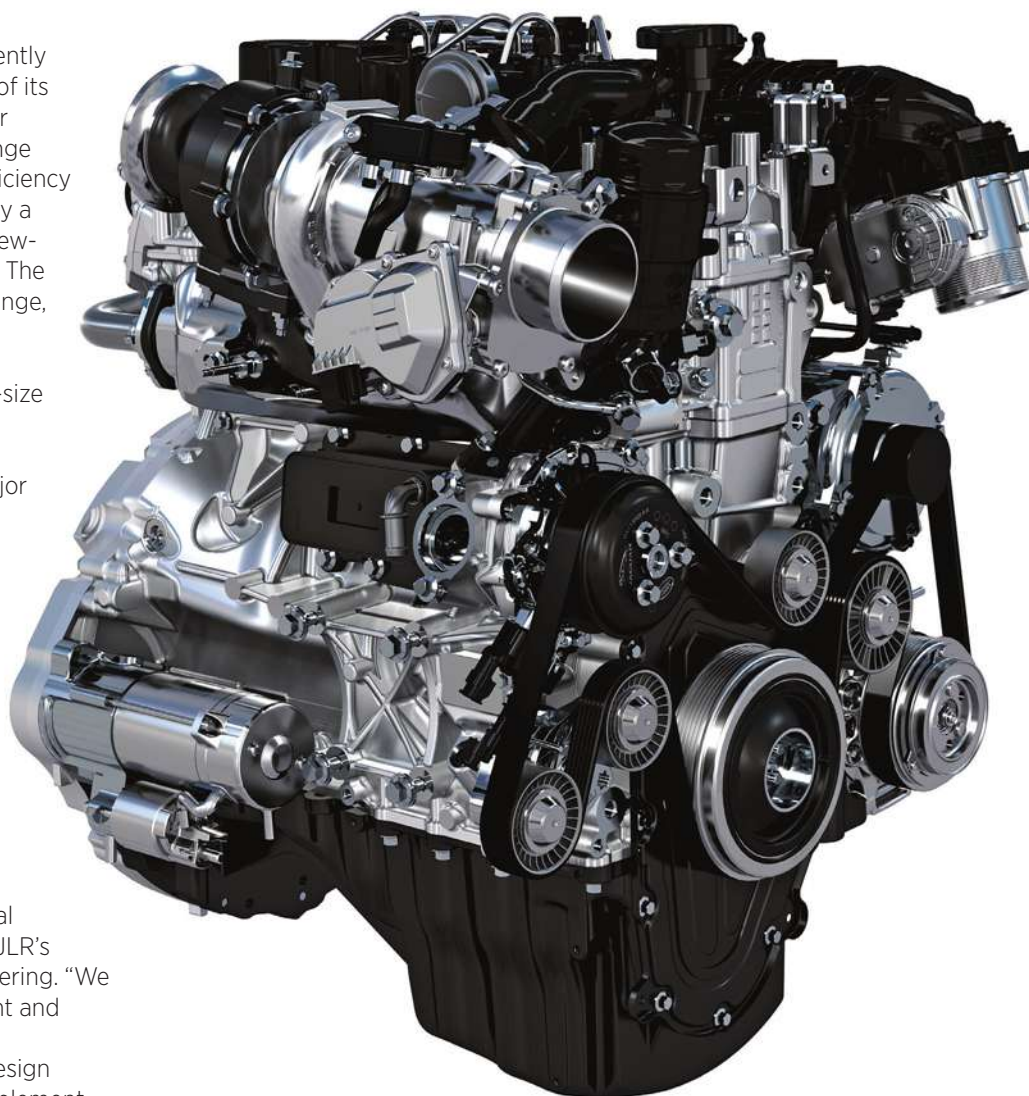
The automaker plans to introduce what it terms "a major new car" every six months, with up to 50 "major production actions" (including hybrid variants) over the next five years. Some £3.5B is scheduled to be invested on product creation.

Ingenium's design "is configurable and flexible for longitudinal and lateral architectures and for front, rear, and all-wheel drive, together with auto and manual transmissions," said Ron Lee, JLR's Director of Powertrain Engineering. "We can vary cylinder displacement and cylinder count."

Hybridization was also a design "must" for the engine, to complement the emphasis on very strong low-end torque, high power output, low emissions (the aim is sub-100 g/km CO₂ for the diesel AJ200D launch version) and the ability to power convincingly both the company's on and off-road, premium products.

JLR is releasing no specific output figures at present, but in terms of torque alone it needs to match or better the 500 N·m (367 lb-ft) of Mercedes-Benz's highly successful 2.1-L bi-turbodiesel and the Volkswagen Group's similar figure (but over a wider rev range) from its new 2.0-L diesel bi-turbo unit.

Both single- and twin-turbo boosting solutions from Mitsubishi and



JLR's new Ingenium engine: gasoline and diesel versions have about 30% component commonality. Piezo injector technology is not used.

BorgWarner will be used.

Lee said the most significant plus to ensure Ingenium would meet JLR's needs was its "clean sheet" creation, enabling every aspect to be created precisely to meet the company's needs and the requirements of varying global legislation. The engines' design allows them the ability to be updated with emerging technologies.

The engine due in the new XE weighs up to 80 kg (180 lb) less than a typical current equivalent. Particular emphasis has been placed on achieving

exceptionally low internal friction, which is described as being 17% less than a current 2.2-L diesel.

"Roller bearings are used on both the cam and balancer shafts instead of conventional machine bearing surfaces," said Lee. "We have simplified the cam drive to reduce the length of the primary chain and replaced some of the traditional sprockets with gears, so reducing moving parts to offset friction."

The engine has a computer-controlled oil pump to match exactly the amount of oil required according to speed and



Ron Lee, JLR's Director of Powertrain Engineering, extols the benefits of a "clean sheet" design for the company's Ingenium engine program, which he oversees.



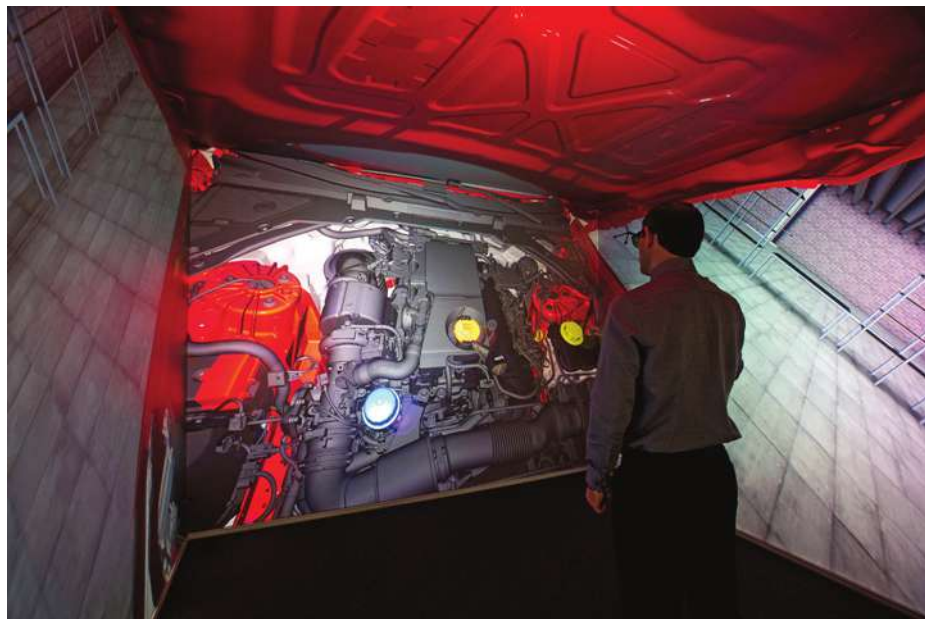
Jaguar is making no comment about a three-cylinder Ingenium unit, but Group Engineering Director, Dr. Wolfgang Ziebart, expects electric motors to get bigger and more powerful with ICE's getting smaller. The "only way" for a premium car manufacturer like JLR to achieve a double-digit emissions fleet average is via hybridization, he indicated.

conditions of the vehicle. It also has a computer-controlled variable water pump to vary coolant flow through the engine, based on temperature, speed and ambient temperature: "That, in combination with a split- or twin-cooling system, means the engine can be warmed very quickly to reduce emissions and to heat the cabin," Lee explained.

Other aspects of Ingenium's base architecture include bore significantly offset to the crankshaft, and switchable electronically-controlled piston cooling jets used to maximize the efficiency of the oil system.

Initially, it will be built in four-cylinder form. Jaguar is making no comment about a triple but Group Engineering Director, Dr. Wolfgang Ziebart, indicated that he expected electric motors to get bigger and more powerful with ICE's getting smaller. The "only way" for a premium car manufacturer like JLR to achieve a double-digit emissions fleet average is via hybridization, he indicated.

So efficient might its new hybrids become, that JLR believes it can make very significant advances in closing the gap with pure electric solutions in terms of efficiency when range is factored in and all environmental aspects of electric



CAVE view of installed Ingenium engine. Ease of servicing and component replacement has been part of JLR's underhood design targets.

drive, including the generation of electricity at source, are considered.

The heavily patented Ingenium engine has undergone 72,000 h dyno testing and 2 million miles of real-world road testing as of July 2014. It will be built in an all-new £500 million factory in Wolverhampton, U.K., using the latest

generation, highly flexible CNC systems. Jaguar executives also recently said Ingenium production also is planned for a new China engine factory.

Stuart Birch

TECHNOLOGY Report

OFF-HIGHWAY POWERTRAIN

Isuzu takes high-level approach to T4F solutions

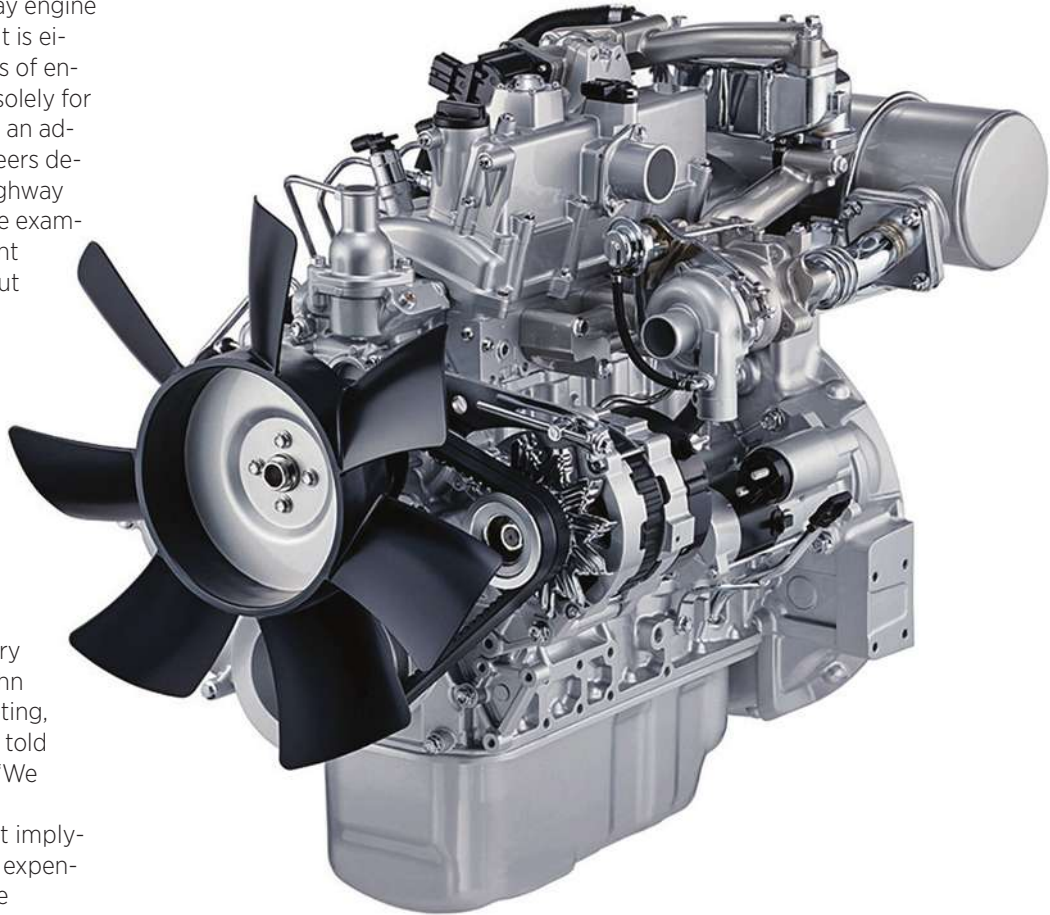
Depending on which off-highway engine manufacturer you're talking to, it is either an advantage that its teams of engineers design specifically and solely for the off-highway industry, or it is an advantage that its teams of engineers design for both the on- and off-highway industries. In this case, it is a rare example of both sides of the argument being just about right. And to put a little twist on one side of this argument, it's not such a bad thing either to design for multiple geographical markets, at least in terms of the long run.

"In terms of our design criteria, fuel economy and noise are at very high levels, which doesn't always match the U.S. demand, but which certainly matches the Japanese and European demands as fuel is very expensive in those markets," John Dutcher, Director, Sales & Marketing, **Isuzu Motors America**, recently told *SAE Off-Highway Engineering*. "We expect that to change."

Unfortunately, Dutcher is not implying that fuel is going to get less expensive outside of the U.S., but more expensive inside, and thus making fuel economy more of a design incentive for all the off-highway engineers who have barely been able to catch a breath since meeting Tier 4 Final (T4F) demands. And in fact, Isuzu is one of the companies already on its way to improved fuel economy compared to Tier 4 Interim engines via the elimination of a diesel particulate filter (DPF) (and thus dosing) on its recently released T4F engines.

Fuel economy will essentially no longer be an issue unique to on-highway applications, and neither will noise. "Most of our off-highway engines are derivatives of Isuzu's truck engines, and on-highway demands are much, much more strict, particularly on noise," said Dutcher. "So we have an inherent benefit when we apply one of those engines to industrial because it maintains that low noise level."

Possibly even more than an emphasis on fuel economy, Isuzu engineers have a very high interest in maintenance-free designs. "Our engines are engineered for



Isuzu's 4LE2 and other Tier 4 Final production engines can be customized to a "customer's exact requirements" while maintaining what it believes will be a maintenance-free experience for end users.

worst-case scenario environments, so maintenance will be minimal. Specifically, our DOC should be good for the life of the engine without maintenance," said Dutcher. "Our high-volume catalyst originated with our truck business and it was re-packaged for robust off-highway and industrial applications. We have a long history with that on-highway technology, so we're pretty confident it's going to be a good solution."

To make integration easier for customers, Isuzu will be "offering an engine-mounted exhaust catalyst, so the OEM doesn't have to make design and validation decisions for that system," said Dutcher. "We deliver the engine package preassembled and prevalidated, so the equipment maker is not responsible for that, and that saves them time, effort, and cost. Of course,

it's not a one-size-fits-all, but it is a one-size-fits-many. The packing is compact and logical, and it can be applied to a wide variety of applications."

Does such technology transfer go the other way; that is, from off- to on-highway? Dutcher would not discuss any specifics on what Isuzu's on-highway engineers may have learned from the off-highway team. But if off-highway engineers have been able to eliminate the DPF while meeting regulations, maybe it's just a matter of time before DPFs disappear from trucks as well.

Jean L. Broge

ENERGY

A look inside lithium-ion batteries

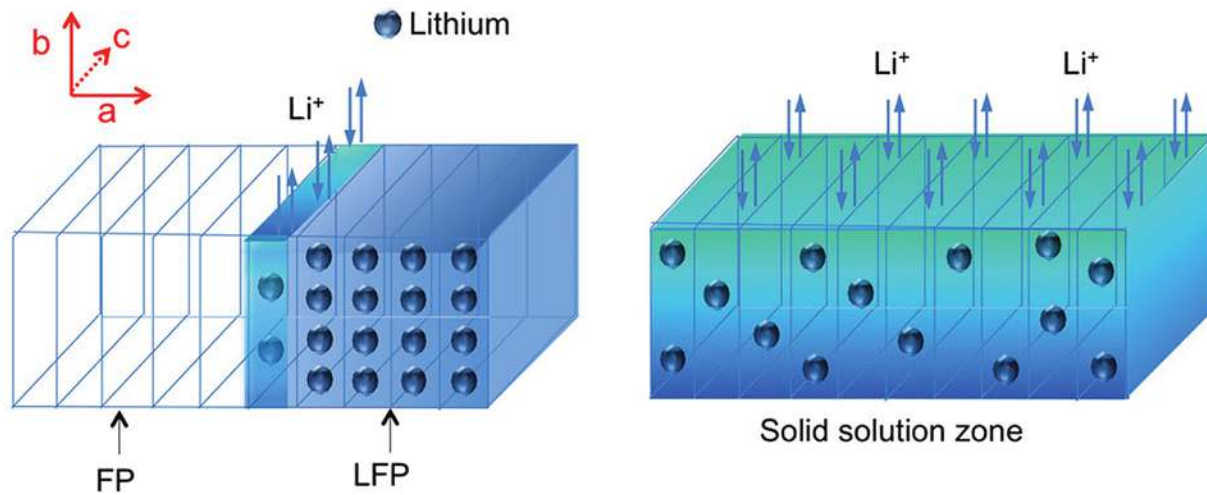


Diagram illustrates the process of charging or discharging the lithium iron phosphate (LFP) electrode. As lithium ions are removed during the charging process, it forms a lithium-depleted iron phosphate (FP) zone, but in between there is a solid solution zone (SSZ, shown in dark blue-green) containing some randomly distributed lithium atoms, unlike the orderly array of lithium atoms in the original crystalline material (light blue). This work provides the first direct observations of this SSZ phenomenon. (MIT)

A group of researchers from MIT say they have observed the inner workings of a type of electrode widely used in lithium-ion batteries, and may be able to explain “the unexpectedly high power and long cycle life of such batteries.” The group consists of MIT postdoc Jun Jie Niu, research scientist Akihiro Kushima, Professors Yet-Ming Chiang and Ju Li, and three others.

The electrode material studied, lithium iron phosphate (LiFePO₄), is considered an especially promising material for lithium-based rechargeable batteries; it has already been demonstrated in applications ranging from power tools to electric vehicles to large-scale grid storage. The MIT researchers found that inside this electrode, during charging, a solid-solution zone (SSZ) forms at the boundary between lithium-rich and lithium-depleted areas—the region where charging activity is concentrated, as lithium ions are pulled out of the electrode.

Li says that this SSZ “has been theoretically predicted to exist, but we see it directly for the first time,” in transmission electron microscope (TEM) videos taken during charging.

The observations help to resolve a longstanding puzzle about LiFePO₄: In bulk crystal form, both lithium iron phosphate and iron phosphate (FePO₄, which is left behind as lithium ions migrate out of the material during charging) have

very poor ionic and electrical conductivities. Yet when treated—with doping and carbon coating—and used as nanoparticles in a battery, the material exhibits an impressively high charging rate. “It was quite surprising when this [rapid charging and discharging rate] was first demonstrated,” said Li.

“We directly observed a metastable random solid solution that may resolve this fundamental problem that has intrigued [materials scientists] for many years,” said Li, the Battelle Energy Alliance Professor of Nuclear Science and Engineering and a professor of materials science and engineering.

The SSZ is a “metastable” state, persisting for at least several minutes at room temperature. Replacing a sharp interface between LiFePO₄ and FePO₄ that has been shown to contain many additional line defects called “dislocations,” the SSZ serves as a buffer, reducing the number of dislocations that would otherwise move with the electrochemical reaction front. “We don’t see any dislocations,” Li says. This could be important because the generation and storage of dislocations can cause fatigue and limit the cycle life of an electrode.

Unlike conventional TEM imaging, the technique used in this work, developed in 2010 by Kushima and Li, makes it possible to observe battery components as they charge and discharge, which can

reveal dynamic processes. “In the last four years, there has been a big explosion of using such in situ TEM techniques to study battery operations,” said Li.

A better understanding of these dynamic processes could improve the performance of an electrode material by allowing better tuning of its properties.

Despite an incomplete understanding to date, lithium iron phosphate nanoparticles are already used at an industrial scale for lithium-ion batteries. “The science is lagging behind the application,” Li said. “It’s already scaled up and quite successful on the market. It’s one of the success stories of nanotechnology.”

“Compared to traditional lithium-ion, [lithium iron phosphate] is environmentally friendly, and very stable,” said Niu. “But it’s important for this material to be well understood.”

While the discovery of the SSZ was made in LiFePO₄, “The same principle may apply to other electrode materials. People are looking for high-power electrode materials, and such metastable states could exist in other electrode materials that are inert in bulk form...The phenomenon discovered could be very general, and not specific to this material,” said Li.

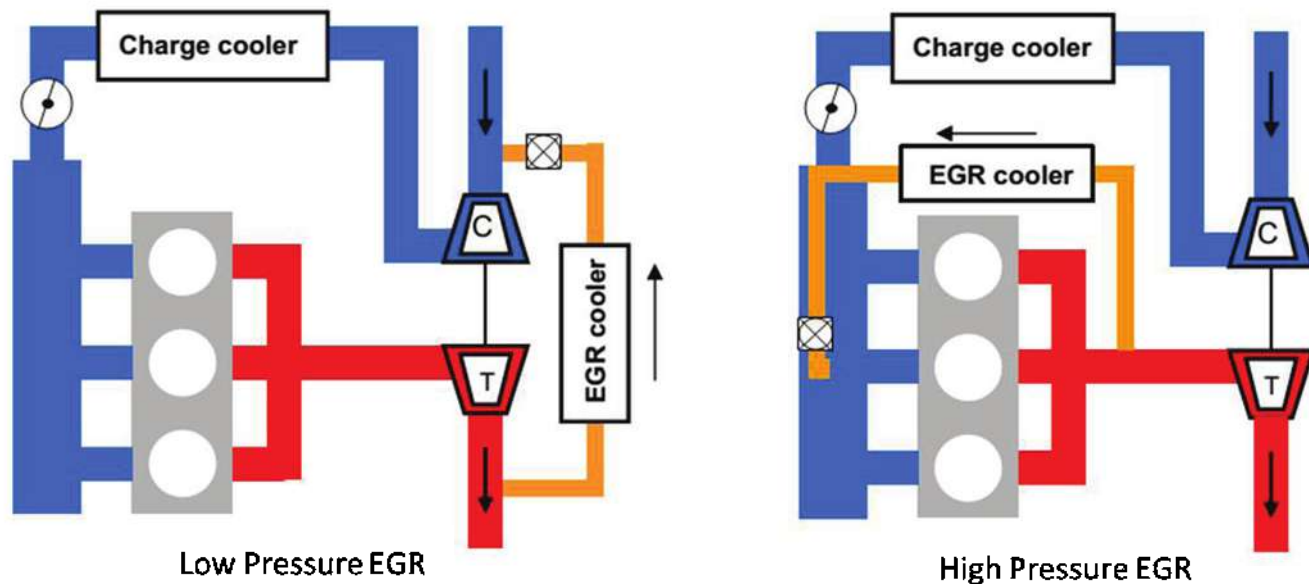
The research was supported by the **U.S. National Science Foundation.**

Jean L. Broge

TECHNOLOGY Report

AUTOMOTIVE POWERTRAIN

Cooled EGR shows benefits for gasoline engines



Two common cooled EGR system configurations tested by Mahle Behr on a 1.2-L gasoline engine.

"EGR [exhaust gas recirculation] systems now in use on diesel engines were used to meet emissions regulations. In gasoline engines, we think they are an ideal way to meet stricter fuel economy standards," explained Martin Bauer, Development Director for engine-mounted components at Mahle Behr USA, in an interview with *Automotive Engineering* magazine.

EGR systems divert some of the engine-out exhaust gas and mix it back into the fresh intake air stream. Mixing exhaust with the intake air lowers combustion temperatures and rates. This improves emissions by reducing the formation of NO_x. It also reduces the knock limit, providing better fuel economy through higher compression ratios and/or spark advance.

Cooling the exhaust before mixing it into the intake stream in a special heat exchanger further improves emissions and the knock limit. Bauer estimates that cooled EGR could improve the average fuel economy from 2% to 5%, as measured on current drive cycles used by regulatory agencies.

"We especially see improvements from cooled EGR for downsized gasoline engines that are turbocharged and use direct injection," he said. That is because such engines are designed to

run at higher loads and speeds. That is the operating region knock limit, and mixture enrichment seriously affects fuel economy.

Another potential application is engines used in hybrid electric vehicles. Typically, these Atkinson-cycle engines also run at high loads and speeds, though they are not typically turbocharged or use direct injection.

To better understand the benefits from cooled EGR, Mahle Behr ran a series of tests on a three-cylinder 1.2-L turbocharged direct-injection gasoline engine with a 9.3:1 compression ratio. The test engine produces 120 kW (161 hp) peak power and 286 N·m (211 lb·ft). The engineers compared two types of cooled EGR: a high-pressure system that diverts exhaust before it powers the turbocharger turbine, and a low-pressure system that diverts exhaust from downstream of the turbocharger turbine.

The cooled EGR device is a laser-welded fabrication similar to those the company supplies to diesel applications. It measures 2 x 1.5 x 8 in (51 x 38 x 203 mm) and typically weighs 1.4 lb (0.63 kg). The unit is constructed of corrosion-resistant 300- or 400-grade stainless steel.

"We found that the low-pressure cooled EGR showed improvements over

the entire speed/load operating map," said Bauer, with a maximum improvement at the highest speed and load of 9% better fuel economy. The high-pressure cooled EGR showed even better maximum reduction, with 18% better fuel economy at the highest speed and load.

However, he tempered this finding by saying that the average fuel economy as measured on four different drive cycles (NEDC, WLTP, Artemis, and MPT-HLC) was actually better for the low-pressure cooled EGR.

"We predict that the newer driving cycles, such as WLTP or Artemis, will have higher shares of high load and high engine speed, meaning cooled EGR will provide benefits in better fuel economy as a result," he said.

Bruce Morey



TECHNOLOGY Report

OFF-HIGHWAY ELECTRONICS

Joysticks increase safety and reliability while reducing weight

Joysticks are evolving rapidly, improving ergonomics to help improve operator efficiency and increase safety and reliability. The controllers are helping increase safety and linking to networks to simplify wiring harnesses to reduce weight.

"More degrees of freedom of joystick handling are being offered in a single joystick," said Kirk Lola, Business Development Manager at **Parker Hannifin's** Electronic Controls Division. "Offering four degrees of freedom in a single medium-handle joystick improves operator efficiency by allowing more functions to be controlled without the operator having to remove their hand from the joystick."

A key way to enhance operator productivity is to reduce fatigue by reducing the amount of movement necessary to accomplish tasks. Software is a major contributor in this trend. Programmers are now altering the degree of movement with software that adjusts to the task being performed. Operators have more precise control at some times and more speed at others, for example.

"We do extensive work with profiles governing how much a joystick moves vs. the command on the output," said Michael Olson, Engineering Manager, Electronic Components at **Danfoss Power Solutions**. "For example, say a joystick application requires high sensitivity when the machine first moves, followed by greater command later in operation. We can adjust the profile to make it easier for the operator to feel both the fine and larger movements required by the application."

The wiring for these manual controls is also changing. The trend to networking is being followed to trim the size of wiring harnesses. However, this design change must often be done in conjunction with enhancements in ruggedization requirements.

"We are seeing a movement to CAN-based switches/ keypads," said Christopher Kolbe, Sales & Marketing Vice President at **HED**. "OEMs are looking at ways to reduce wiring, and CAN-based switches are perfect. In addition, customers are renting more and more



Software lets Danfoss joysticks perform differently for different tasks.

equipment. This equipment get pressure-washed frequently so the sealed CAN keypads that are IP69 rated are much more robust."

Design strategies also focus on the growing need to improve safety. Reducing the potential for failures that can endanger humans or equipment is an important aspect of human-machine interface development. For some, the focus goes beyond reducing failures to ensuring that inputs weren't accidental.

"Many recent advances in joysticks have revolved around safety," Olson said. "We're building double redundancy into switches. We sometimes use two different technologies to read the switch to validate that the switch was actually pressed before the function will happen. With double redundancy, even if the joystick gets bumped, we can determine whether the hand was in the position it should have been so we know that the movement was intended or unintended."

Terry Costlow

AUTOMOTIVE ELECTRONICS

Broader data sharing for connected transportation will require widespread collaboration

As populations in sprawling urban areas rise, commuting will become a bigger challenge. Connected cars are likely to leverage connectivity to help commuters reach destinations using different modes of transportation, further driving development teams to collaborate more extensively within their companies and with outsiders from many fields.

In the future, executives predict that cars, buses, and trains will all share data to help travelers best manage their transportation needs. One top executive feels that connected vehicles need to be part of a vast network of all transportation options that will provide data that commuters can use to decide whether to travel, then how to reach their destination.

"I believe all forms of transportation need to be on the same network; the car is one element in the environment," **Ford** Executive Chairman Bill Ford said at the recent ITS World Congress in Detroit.

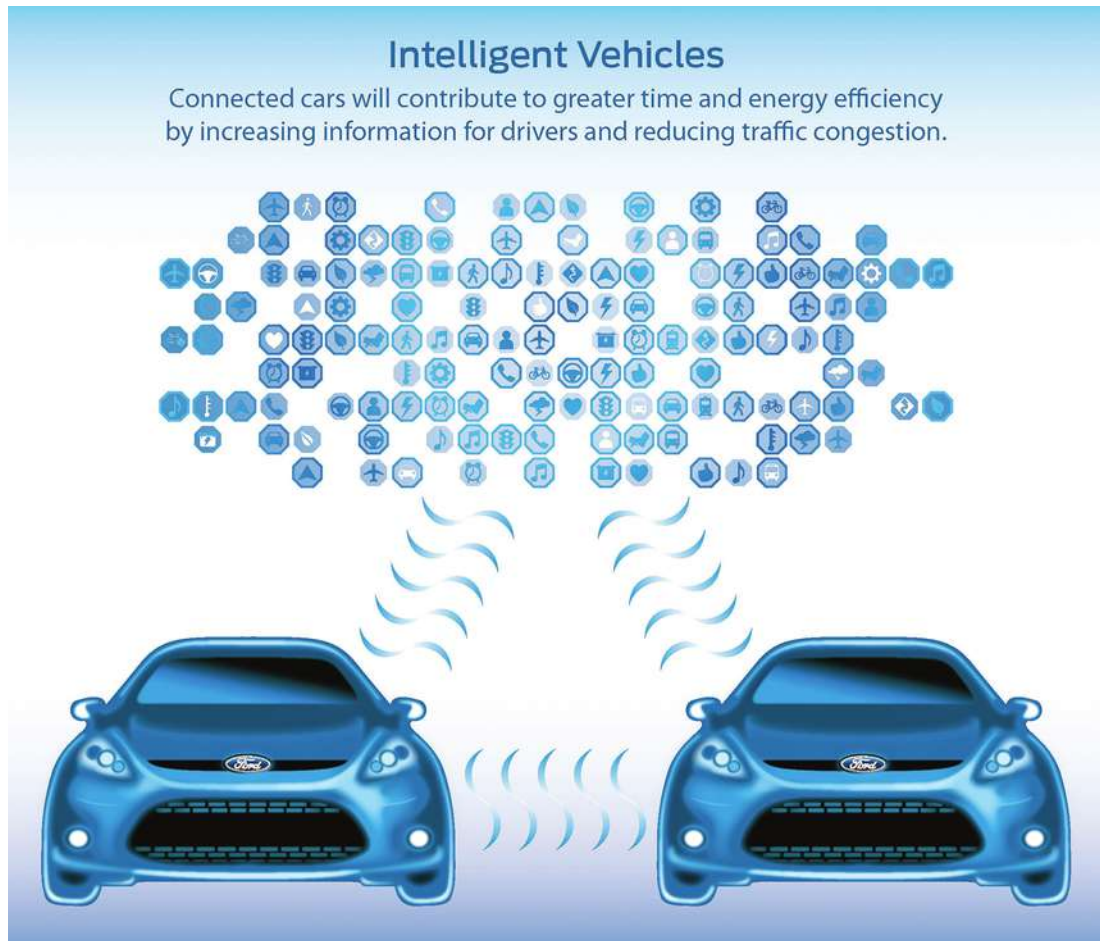
Public transportation managers note that with one comprehensive network, commuters would have enough data to pick their mode of transportation. Sometimes, they could decide to reschedule appointments to account for travel times.

"The problem is not that commutes are five minutes or one hour longer, the problem is not knowing," said Klaus Schierhackl, a Director of **ASFINAG**, Austria's toll collection agency. "If you know the commute's one hour longer, you can plan accordingly."

However, creating this large network is no small feat. Transit agencies, transportation departments, and automakers will all have to agree on communication protocols. They will also have to ensure that information is up to date at all times. Synchronizing this info is another facet of the technical challenges.

"We need a network of solutions, stitching things together to address different travel solutions," said James

TECHNOLOGY Report



Ford envisions plenty of communication between cars and a wide range of transportation management systems.

Buczowski, Director, Global Electrical/Electronic Systems Engineering, at Ford Motor Co. "We need seamless transitions to keep things operating at the same time."

Creating this broad network is likely to further extend the number of cooperative efforts undertaken by automakers. The shift to telematics is among the factors that have prompted many OEMs to work more extensively with a broad range of third parties. Vehicle-to-vehicle communications, which use 5.9-GHz dedicated short range communications technology, may well become another.

"We need to collaborate," said Jon Lauckner, CTO at **General Motors**. "We also need standards, not only in automotive folios but in other folios. Standards are especially important for the 5.9-GHz frequency. We all have to be working on the same frequency for vehicle-to-vehicle communications or we'll get a Balkanized mess, like in the charging infrastructure when everyone installed different equipment until the **SAE International** put some standards together."

Some of these cooperative efforts will require changes in the way OEMs operate. As automakers try to leverage the rapid changes of Web-based communications, there's a fair chance that they will be working with startups or companies that are far smaller than Tier 1s.

"If we are going to be successful, we have to work with small companies," Bill Ford said. "We can't overwhelm them with requirements or overburden them with requests."

OEMs will also have to tighten the links between teams throughout the enterprise. Infotainment and telematics systems may have to communicate with safety systems to ensure that drivers are protected even if they are distracted, for example. Similar interactions will be needed if vehicle-to-vehicle communications systems call brakes and steering into action.

"Connected vehicles have a huge impact throughout the industry," Buczowski said. "We need to break down barriers within the organization, groups that have never worked together have to share information. This is true

within the company and without. We need to move from a components view to systems engineering, looking at everything."

While automotive developers will focus on technical issues, legislators will play a role in the development of large transportation networks that include public agencies. Legal issues such as who owns data will have to be determined.

"The technical solutions are out there," said Ananth Prasad, Secretary, **Florida Department of Transportation**. "Getting the public policies we need around those technologies is a difficult challenge. Where the public policy ends and the private sector begins is in question. The lines are blurred."

Terry Costlow



AEROSPACE AVIONICS

Rockwell Collins and Elbit show off F-35 Gen III helmet at Farnborough



Speaking to his own experience, F-35 Chief Test Pilot Al Norman said at Farnborough that the new helmet gives him “the choice of what I see, the choice of what to do. When I plug in my HVI [helmet vehicle interface] cable, I truly become one with the aircraft.”

The F-35 Gen III Helmet Mounted Display System (HMDS)—developed by **Rockwell Collins ESA Vision Systems, LLC**, a joint venture between **Rockwell Collins** and **Elbit Systems Ltd.**—which is said to provide “unprecedented situational awareness (SA) for fighter pilots,” will be delivered to **Lockheed Martin** for software integration into the F-35 aircraft in the next two or three weeks, it was announced at the Farnborough Air Show. The Gen III HMDS will be integrated into Low Rate Initial Production 7 for the F-35 program.

The F-35 Gen II HMD was demonstrated at the Rockwell Collins booth at the air show in July.

“This helmet changes the paradigm for the display of information to fighter pilots,” said Phil Jasper, Executive Vice President and COO, Government Systems, for Rockwell Collins. “It is the first to have a fully integrated head-up display, which gives pilots all the critical information they need on the helmet’s visor. Pilots who have flown this new system have provided positive feedback about their ability to respond faster with reduced workload, resulting in an enhanced ability to complete missions successfully.”

“The HMDS provides F-35 pilots with the most advanced digital night vision and head tracking capabilities available today,” said Raanan Horowitz, President and CEO, Elbit Systems of America. “Providing an accurate and readable virtual HUD with high resolution night vision, combined with low latency, is essential to the execution of the F-35 complex missions during day and night operations.”

The state-of-the-art HMD features a biocular 40x30° field-of-view, high brightness and high resolution display, with integrated digital night vision. When fully integrated with the aircraft sensors and systems, the HMDS heightens the F-35 pilot’s SA. The HMDS displays the distributed aperture system (DAS) imagery from Northrop Grumman, which gives pilots the ability to see through the structure of the aircraft for a 360°

view as well as a direct picture of the ground beneath them.

Speaking to his own experience, F-35 Chief Test Pilot Al Norman said the new helmet gives him “the choice of what I see, the choice of what to do. When I plug in my HVI [helmet vehicle interface] cable, I truly become one with the aircraft.”

The system provides a lightweight HMD, with optimized center of gravity and maximum comfort for reduced pilot fatigue. Everything about the F-35 Gen III HMDS is designed to enhance the fighter pilot’s precision, efficiency, and safety, while reducing the overall cost of the program, says Rockwell. The Gen III

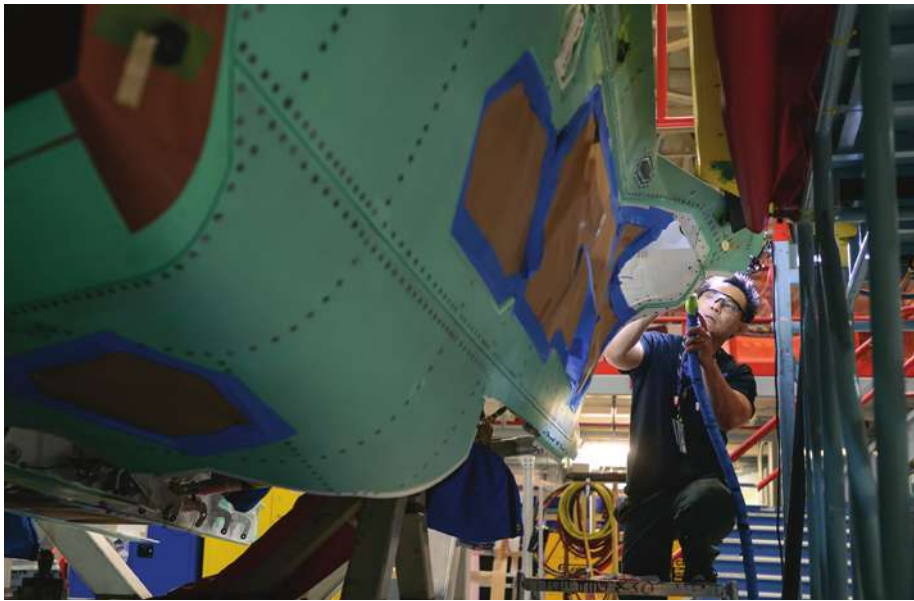


“The HMDS provides F-35 pilots with the most advanced digital night vision and head tracking capabilities available today,” said Raanan Horowitz, President and CEO, Elbit Systems of America.



TECHNOLOGY

Report



A Northrop Grumman technician puts finishing touches on the center fuselage section of the F-35 prior to delivery to F-35 prime contractor Lockheed Martin. (Northrop Grumman)

design includes improved optics, image device and backlight, along with enhanced head tracking capability and

the next-generation Night Vision Camera, providing equivalent performance to ANVIS-9 NVGs (night vision

goggles).

Norman said the system eliminates the need to decide when or if to wear NVGs, "turning night into day. It's like having six eyeballs [due to the plane's six cameras]. Everywhere I am I have my symbology with me." He added that pilots can use either the stick or the touch-screen glass to change the option of their view and amount of information from the helmet.

Rockwell Collins was responsible for the overall HMDS performance and the helmet-mounted display components, and Elbit was responsible for the night vision cameras, helmet tracking, and display processing components.

To date, more than 160 HMDS units have been delivered to Lockheed Martin. The HMDS generations have logged more than 15,000 hours of test flights on the F-35.

Jean L. Broge

AUTOMOTIVE INTERIORS

Climate control engineers face new CAFE test

Automotive climate control engineers are working to wring increased efficiency not only from the refrigeration system, but from every peripheral too. Yes, there are CAFE (corporate average fuel economy) credits that can be claimed for specific engineering features from a U.S. EPA menu, but cars and light trucks will have to earn them by passing a new EPA validation test: AC17. And with the industry facing regulatory dictates for electric drive vehicles (EVs) from California and some northeastern states, reducing the detrimental effect that climate control operation can have on vehicle range may be equally critical.

AC17 is on a complex phase-in schedule that starts with reporting only, to give industry some time to iron out wrinkles. It's a more real-world test than the basic A/C idle test in present use.

However, efficiency contributions of upgrades are small, and individual ones may be within the tolerances of test repeatability. It is hoped that along with overall results of all upgrades, certain segments of the complete AC17 test will



The AC17 test for manual temperature control system starts with full-cold and high-blower settings, then switches to midpoints at first idle of the SCO3 test.

show significant improvements that can be attributed to particular upgrades, such as improved performance during the high demands of initial cool-down.

Test initially is optional

AC17 was developed by the EPA in conjunction with **USCAR** (U.S. Council for Automotive Research, the Detroit Three

research consortium) with input from the **California Air Resources Board** (CARB). Like any brand-new test that introduces many variables, AC17 is getting considerable analytic attention.

The test is optional to the A/C idle procedure for 2014 through 2016, so the industry can learn its nuances. Automakers will begin sending AC17 data to the EPA in the 2015 calendar year, showing results for efficiency improvement from reduced reheat, increased recirculation, pulse-width modulated blowers, and internal heat exchangers. Because of AC17's complexity, only one vehicle from a platform must be tested.

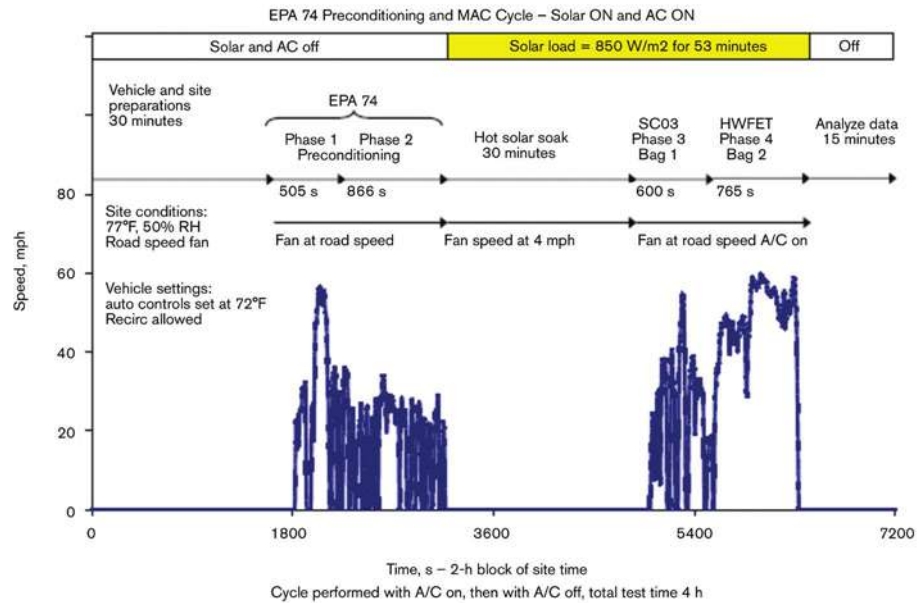
The A/C idle test is basically 10 min of A/C on, 10 min off, within an ambient temperature range of 68-86°F (20-30°C). Results are compared against a calculated standard—i.e., the difference in CO₂ g/mi between A/C on and A/C off. If too great, reduced (or potentially no) credits are allowed. Large engines tend to show a much smaller increase in load at idle from A/C vs. a small engine (V8 vs. four-cylinder). At present, manufacturers can use either the A/C idle test or AC17. But credits initially are “gifted” with AC17, which should promote its use.

Phase-in

The phase-in schedule begins with the 2014-16 model years. EPA's CAFE credits (in the form of CO₂ g/mi) are a maximum of 5.7 g/mi fleet average. Manufacturers report either A/C idle test data (every configuration of vehicle or engine displacement), or results of AC17 on one configuration per platform. If the manufacturer chooses the AC17 option, it gets full credit just for reporting results. A manufacturer can “bank” some credits from early use of a low-global-warming refrigerant.

In the 2017-19 phase, EPA's CO₂ g/mi and NHTSA's gal/mi both apply. Basically equivalent for CAFE, they are 5.0 g/mi (0.000563 gal/mi) for cars, 7.2 g/mi (0.000810 gal/mi) for trucks. AC17 must be used, but again, reporting results for one configuration per platform earns full credit. Total A/C credits (to 2025) for efficiency upgrades and using low-global-warming refrigerant are 18.8 g/mi for cars, 24.4 g/mi for trucks.

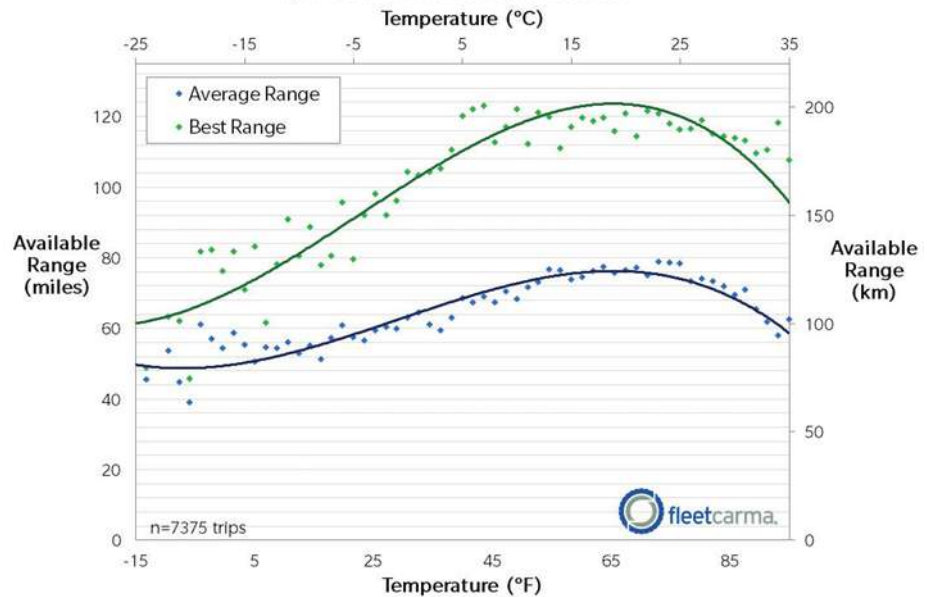
In the 2020-25 phase, CAFE credits are unchanged but AC17 enforcement begins. It is mandatory on one configura-



AC17 is done twice, starting with A/C-off preconditioning, followed by solar loading, then versions of SC03 and highway tests, first with A/C on, then A/C off.

Nissan Leaf: Range vs. Temperature

Spanning All Model Years in the FleetCarma Database



FleetCarma study of ambient temperature effect on Nissan Leaf range, with the upper curve reflecting best results, lower curve representing average range.

tion per platform with the efficiency technologies and one baseline vehicle (without). The baseline need not be identical; in fact could go back as far as 2014 and be combined with engineering analysis. AC17 results must equal or exceed CAFE menu credits, or credit is lowered to reflect improvement shown.

AC17, performed at 25°C (77°F) and 50% relative humidity, incorporates ver-

sions of EPA window sticker tests, beginning with Federal Test Procedure 74 (part of FTP 75 city test, basically the preconditioning section), followed by 30 min of solar loading (850 W/m²), then SC03 (assortment of speeds and acceleration rates) and the highway test, in a 2-h procedure. AC17 is performed twice (first with A/C on, then A/C off), for total test time of 4 h.

TECHNOLOGY

Report



The Mitsubishi i-MiEV climate control panel is fully manual, and a study shows a large difference in EV range for normal vs. maximum settings.

Specific manual A/C strategy

However, even something seemingly as straightforward as turning on the A/C is anything but. With Automatic Temperature Control, the system is set for a particular temperature: 22°C (72°F). Although many systems have a proprietary control algorithm, particularly if the default is ECO mode, this approach is believed to yield significantly comparable results. However, manual A/C requires a different strategy: full cold for temperature and high blower speed, with temperature and blower speed turned to midpoint settings at first idle on SCO3, targeting a center register air outlet temperature of 55°F (13°C). This isn't intended to be equivalent to the ATC operation.

EPA based the CAFE credits on research performed during an **SAE International** Cooperative Research Group's I-MAC (improved mobile A/C) study of 2005-08. In that program, the EPA and the **National Renewable Energy Laboratory** (NREL) aimed to identify a 30% improvement in system efficiency and a 30% reduction in cooling loads (plus 50% reduction in leakage).

AC17 testing to date has demonstrated reasonable repeatability for conventional cars and light trucks—to within 2.0 g/mi, or about 0.6%. However, comparable repeatability isn't quite there yet for hybrids, primarily during SCO3, which involves greatest use of the hybrid system.

There are CAFE credits for solar/thermal technology (glazing, seat and cabin ventilation, and reflective paint). Solar/thermal credits are capped at 3.0 g/mi for cars, 4.3 g/mi for trucks. Off-cycle credits are available for thermal control/energy usage improvements, including idle stop, aero, waste heat recovery, high-efficiency lighting, and active engine and transmission warm-up. Including solar/thermal, hybrids, plug-in hybrids, and EVs, credits are capped at 10 g/mi for a manufacturer's fleet.

AC17 solar loading tests show solar film/glass has a significant effect on CO₂ emissions in comparative evaluations, both in SCO3 and highway tests. On a **Dodge Avenger**, the film produced a 12 g/mi difference (430.4 vs. 442.4 g/mi) vs. no film in an SCO3 test, and a 5.3 g/mi difference in the highway test (251 vs. 256.3 g/mi).

NREL solar load activity

NREL has been particularly active in real-world testing of solar control film, glass and paint, and the effect of vehicle pre-ventilation—primarily with the objectives of improving EV range. It cited data on the **Mitsubishi i-MiEV** that indicated a drop of 46% in Max Cool, 34% in A/C Normal. It also referred *Automotive Engineering* to a study by **FleetCarma**, a fleet data-logging company that showed the **Nissan Leaf** range averaged 75 mi (121 km) at 65°F (18°C) and dropped to 58 mi (93 km) at 95°F (35°C).

NREL tested two **Ford Focus** EVs, provided under a cooperative agreement with Ford, with one vehicle a control. The other was fitted with solar control film on all glass surfaces. The cars were hot-soaked from sunrise until noon. Average interior air temperature reached 121.3°F (49.61°C) without the film, 111.7°F (44.28°C) with the film, with ambient at 77°F (25°C) at noon.

The laboratory then began a 20-min simulated-drive cool-down in max A/C and measured A/C energy savings at 48.9%. Cabin air temperature equivalency (to within 1.2°F/0.7°C) was established by lowering blower speed on the film-fitted Focus, which reduced evaporator capacity (and compressor power required, to produce the energy saving). This is apparently a maximum “because of the A/C settings, extended soak with full solar load, and a 20-min simulated drive that weights the thermal transient fairly high,” NREL's John Rugh said.

A separate pre-ventilation test during plug-in, immediately prior to drive-off, was made by NREL, and it pointed to another way to reduce A/C electric use to increase EV range. It used a Focus blower and ducts to purge cabin air following a similar hot soak, and cabin temperatures were lowered 12.6°F (7°C) within 15 min, at a cost of just 0.08 kW-h. Extending pre-ventilation to 30 min doubled energy consumption but lowered cabin temperature only an additional 1.8°F (1°C). A/C energy savings from a 20-min cool-down were estimated at about 50%.

Paul Weissler

TRUCK INTERIORS

Connectivity and safety converge in Delphi Tech Truck



Delphi premiered versions of its full-color, high-resolution, and entirely reconfigurable vehicle cockpit instrument panel displays during IAA 2014.

Building upon the convergence of two of the three pillars making up the theme of safe, green, and connected commercial vehicles at Delphi's display at the IAA Commercial Vehicles event in Hannover, Germany, the company unveiled reconfigurable clusters and wireless device charging technologies as part of its second-generation "Tech Truck."

"Safety is paramount," said Jeff Owens, Chief Technology Officer at Delphi, while describing the bookends that were part of his company's themed display at IAA. "Our objective is zero accidents because that means zero fatalities. In the next 10 years, we are going to see extraordinary things that happen with safety and connectivity in vehicles. These two areas are certainly converging, but they must do so safely and must be done efficiently, and we have to pro-

vide future-proof solutions. Delphi is one of the few commercial vehicle suppliers who can take connectivity to the next level and integrate that with safety."

Reconfigurable clusters

As greater amounts of information are being made available to on-highway commercial vehicle (CV) drivers such as vehicle health data, infotainment information, and critical safety warnings, driver distraction is a growing concern on the global roadways.

Traditional instrument clusters are now being replaced by reconfigurable clusters, which provide CV manufacturers with an answer to the increased consumer demand for connectivity without compromising safety. Delphi says that this will give drivers a clear indication of what is going on with the vehicle.

Delphi premiered versions of its full-color, high-resolution, and entirely reconfigurable vehicle cockpit instrument panel displays during IAA 2014. One of the options on these reconfigurable clusters enables the driver to change and personalize the content of the cluster. This allows for mass customization suited to individual preferences.

Crucial driver information is displayed within a 20° field-of-view and with photorealistic 3D graphics. The design allows flexibility for styling, functionality, and information content. The ability to personalize content based on driver preferences provides an opportunity to help customers create brand differentiation. Delphi believes that its experience in this domain will create opportunities for the company to provide a fully integrated cockpit for its customers.

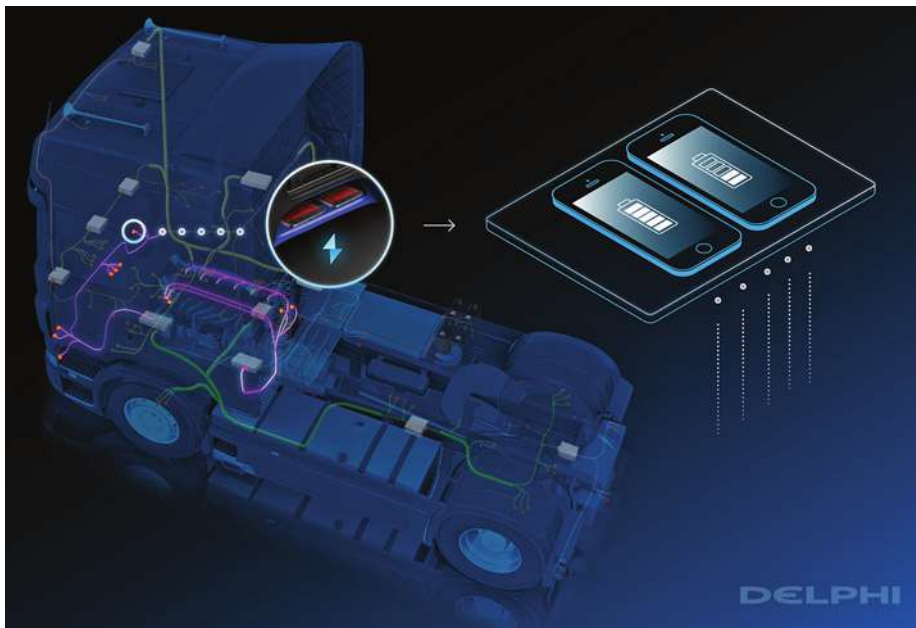


Crucial driver information is displayed within a 20° field of view and with photorealistic 3D graphics.

TECHNOLOGY

Report

The ability to personalize content based on driver preferences provides an opportunity to help customers create brand differentiation.



Delphi's Wireless Device Charging System creates a cordless environment for high-efficiency, hands-free charging, which helps reduce distraction caused by drivers fumbling to connect their devices while driving.

"The objective is to create a customized and cost-effective design," said Owens.

'Always online'

Commercial vehicles of the future will be "always online," and the latest integrated cockpit solutions from Delphi are aimed to help make drivers more productive through its infotainment and driver interface solutions.

The reconfigurable clusters play a part in this equation in allowing CV drivers to stay connected and informed of customer and vehicle data, traffic updates, weather, and more. The increased volume of in-vehicle information and customers' demand for customization requires a high degree of content

management depending on the driving situation.

Delphi's technologies and designs were conceived to deliver critical information to drivers with maximum safety in mind. The goal is to combine innovation with a building-block strategy that offers high-value products designed to meet the specific needs for cost optimization, durability, and CV-specific applications.

"It's all part of that future technology that will keep drivers safe," said Owens.

Wireless device charging system

"And to help make drivers' lives a bit easier and a little less cluttered, we are demonstrating our wireless device

charging system for the phones and tablets that the driver may bring into the cab," shared Owens during IAA.

Commercial vehicles rely on a number of mobile devices for communication, entertainment, and safety. Delphi's Wireless Device Charging System creates a cordless environment for high-efficiency, hands-free charging. It eliminates clutter associated with multiple charging cords in the cabin, which helps reduce distraction caused by drivers fumbling to connect their devices while driving.

Delphi is a strong participant in the wireless power standards organizations such as **SAE International**, and says it is committed to providing customers with the systems that meet their specific requirements. Delphi's Wireless Device Charging System is ready for market introduction.

Owens explained further: "With the desire of the consumer, and certainly the driver, to bring their digital lifestyle into the cabin, and with all the opportunity for additional information to make their ride more efficient and more productive, it also has the opportunity to add more distraction. This is where we think the connectivity space and the safety space converge—where you put active safety implementations on the vehicle, at the same time allowing information to be gated to the driver at the appropriate time when it's a low workload kind of environment. So we are trying to provide the kind of technology where even if the driver could be distracted, the vehicle never is and maintains the safety of the commercial vehicle space."

Greg Muha

TRUCK CHASSIS

Ashok Leyland develops bimetal brake drum to improve heat dissipation, reduce weight

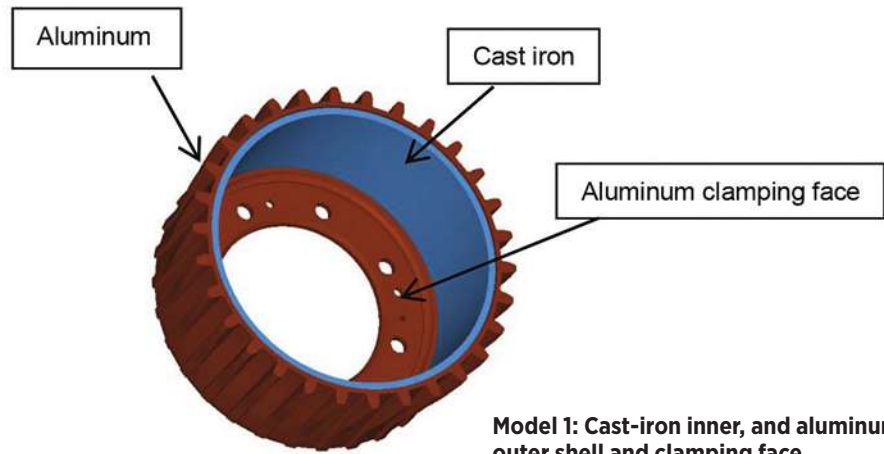
To achieve weight savings in vehicles, OEMs and component suppliers are increasingly using ultra-high-strength steel, aluminum, magnesium, plastics, and composites. One strategy is to develop components using a multi-material concept. **Ashok Leyland** researchers used this approach when developing a bimetal brake drum with cast-iron inner ring and aluminum outer shell. Two different design configurations were proposed and made, both resulting in significant weight savings compared to a conventional gray cast iron brake drum, with similar or better performance.

The researchers presented their study as part of the “New Design Concepts for Medium and Heavy Truck Steering and Braking Systems” technical session at the **SAE 2014 Commercial Vehicle Engineering Congress**, which took place October 7-9 in Rosemont, IL.

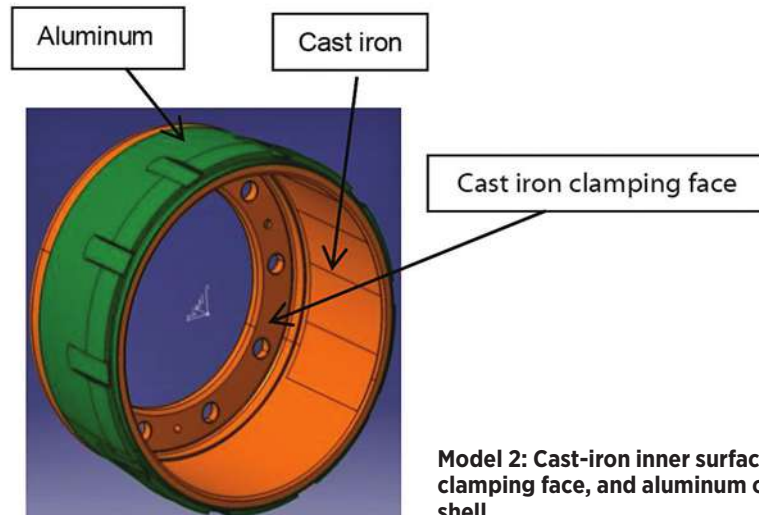
One of the major drawbacks of drum brakes is that they are more sensitive to brake fade because they are not capable of dissipating the generated heat. During braking, friction between the brake drum and lining increases the temperature to 315°C (600°F). The excessive temperature rise damages the lining material severely.

To determine the thickness requirement of the cast-iron inner shell and Al outer shell, a detailed CAE analysis was carried out for the two designs. Model 1 consisted of a braking surface in cast iron and outer shell with fins (for better heat dissipation) and clamping face in Al. In Model 2, the braking surface and clamping face were cast iron and the outer shell was Al. The 3-D models of the brake drum were created using **Dassault Systèmes’ CATIA**.

A detailed contact model was developed between the liner and brake drum cast-iron surface. The second-order tetrahedron element was selected for fine meshing. The brake drum hub seating face was clamped in vertical direction, and variable pressure was applied in the leading and trailing contact area. Based on the simulation, high stress was observed in the fillet radius of the inner surface and clamping face of Model 1. The thickness was increased slightly to



Model 1: Cast-iron inner, and aluminum outer shell and clamping face.



Model 2: Cast-iron inner surface and clamping face, and aluminum outer shell.

meet the stress limit. In Model 2, high stress was not observed in high-pressure conditions.

The bimetal brake drum was then developed via a conventional casting process and validated via dynamometer test rig. The test was conducted at three different brake lining temperatures. The drum was rotated at a speed of 60 km/h (37 mph). The 0.2 g braking torque was applied by brake lining to stop the vehicle. The test was conducted for 1000 stops.

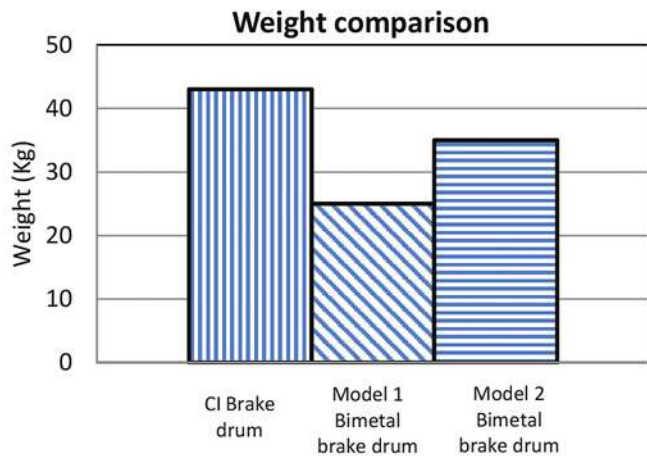
The final chemical composition was analyzed using a spectrometer. The hardness measurement revealed that the secondary phases were not formed in both the inner and outer shells—an indi-

cation that the inner ring material property was like that of the conventional brake drum material.

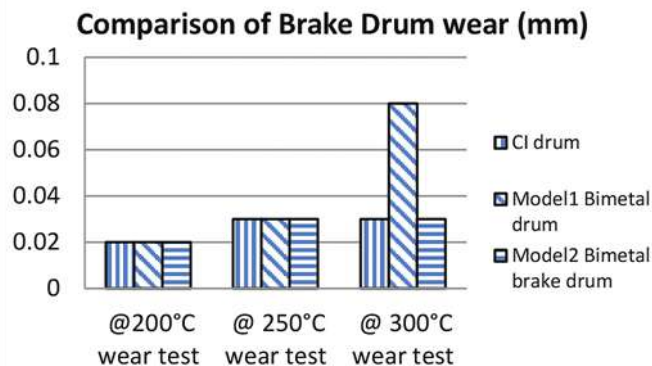
Mechanical properties such as proof strength and Young’s modulus were measured as per **ASTM E8** standard, and thermal properties and density were also measured. Based on the mechanical properties analysis, the bimetal brake drum material inner-surface properties were observed as similar to conventional brake drum properties. The lining and drum wear pattern also were similar to the existing system design.

Furthermore, the weight was reduced by 42% in Model 1 and by 26% in Model 2 compared to a conventional brake drum. The weight reduction directly as well as

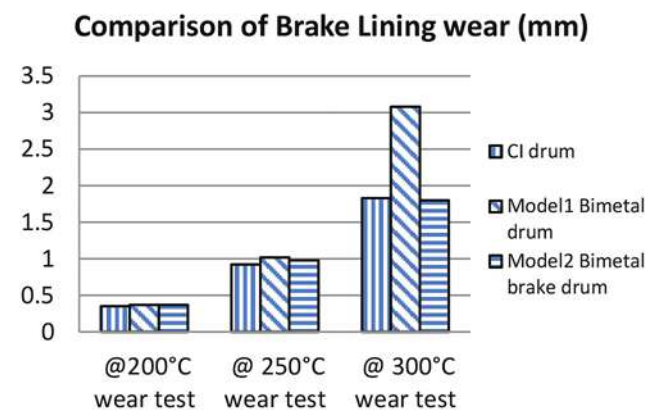
TECHNOLOGY Report



Weight comparison of conventional vs. bimetal brake drums.



Comparison of brake drum wear.



Comparison of brake lining wear.

indirectly improves performance of the axle system; it improves the tire life, and unsprung mass reduction marginally improves fuel efficiency. In addition, it reduces braking distances with less brake pedal pressure.

Three optimized locations were identified near the brake lining and drum contact zone to measure heat dissipation. In three different temperature conditions—200, 250, and 300°C (400, 500, and 600°F)—it was clearly shown that the Model 1



Dynamometer testing of bimetal brake drum.

brake-drum temperature was 50% lower than the conventional cast-iron brake drum. Model 1's outer surface fins increase the cooling rate; the fin design itself improves the heat dissipation rate 33%.

Model 2's heat dissipation rate also was higher than the gray cast iron brake drum. The better heat dissipation rate in the bimetal brake drums reduces the thermal stress and reduces the tire temperature because of high thermal conductivity aluminum in the outer surface.

The initial and final thicknesses of the brake drum and the lining material were measured after completing the tests at three different temperatures. The bimetal brake drum wear was equal to the conventional cast-iron brake drum wear at 200 and 250°C. In both cases, the wear rate of lining and bimetal brake drum was equal to the wear rate of conventional brake drum/lining.

In addition, based on the microstructure analysis, the secondary phases were not observed after the aluminum outer surface castings. In 300°C test conditions, a crack was observed in the Model 1 bimetal brake drum mounting area. The crack propagates throughout the thickness of the brake drum in radial direction; the drum distorted and eccentricity of the brake drum was changed to increase the wear rate in both brake drum and brake lining material.

In visual observations of the brake drum surface, minor scoring marks were observed, indicating that wear severity was low after the 1000 stops. In brake lining materials, the worn surface wear track depth was very low and wear debris was not observed.

As a result of this study, development of the bimetal brake drum has been taken forward for vehicle-level performance analysis and implementation.

This article is based on SAE International technical paper 2014-01-2284 written by Sunil raj of Ashok Leyland Technical Center and S Ravi Shankar of Ashok Leyland Ltd.



TECHNOLOGY Report

AUTOMOTIVE MATERIALS

Graphene composites for cars

Soon after **University of Manchester** physicists Kostya Novoselov and Andre Geim discovered the “wonder material” graphene—one-atom-thick sheets of carbon that are a 100 times stronger and much lighter than steel—researchers started incorporating it into polymer composites in the hope of creating materials with greatly improved physical properties.

Nearly a decade later, efforts to fabricate practical graphene composites continue apace, but the technology is still in its infancy. Recently, however, a pioneering project began to develop novel graphene-based nanocomposites that one day could truly revolutionize the automotive industry. The 18-month, \$1.1-million iGCAuto research collaborative, which is funded by the European Union’s 10-year, billion-euro Graphene Flagship program, aims to make high-performance graphene composites that could reduce the weight of car structures by one-third or more.

Advanced composite materials are widely viewed as a promising way to make vehicles more fuel-efficient and lightweight, but low-mass vehicles tend to perform less well in collisions. So new approaches must be found to enhance the crashworthiness of composites. Graphene composites may be able to fill that role.

The new iGCAuto consortium comprises a half-dozen research groups at

the **University of Sunderland** in Britain, **Centro Ricerche FIAT** in Italy, **Fraunhofer ICT** in Germany, **Interquimica** in Spain, and two Italian specialist R&D entities, **Nanesa Srl** and **Delta-Tech SpA**.

Lightweighting with graphene

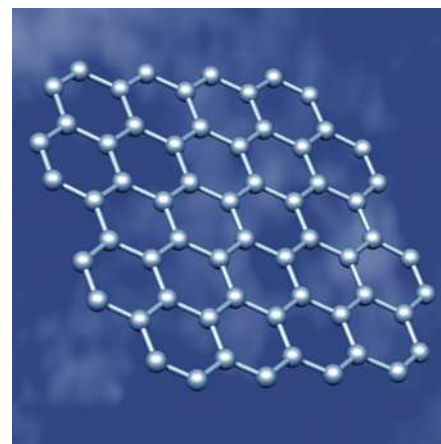
“Graphene has tremendous applications for the automotive industry, and using it to enhance the composite materials in cars has considerable potential,” said Ahmed Elmarakbi, Professor of Automotive Engineering at Sunderland, who wrote the original iGCAuto proposal.

What distinguishes the iGCAuto collaboration are its novel approach and lofty aims.

“We plan to develop a new way to use graphene to enhance polymer composites that we hope can save as much as 30% to 50% in automotive structural weight—the chassis and body-in-white—compared to today’s steel cars,” Elmarakbi said. “In five or six years that improvement could even reach 70%.”

The resulting components could not only lessen weight, but also could feature substantially thinner cross sections as well.

The graphene-based material will be investigated, modeled, and designed to provide improved strength, dimensional



Graphene is a one-atom-thick sheet of carbon that is a hundred times stronger than steel. (University of Manchester.)

stability, thermal behavior, and flame retardance. Fewer smoke emissions is another goal, as is superior durability—properties that would boost vehicle and occupant safety.

The research team plans to exploit a novel nanocatalyst and unique graphene-based nanocomposite materials that were developed by Egyptian scientist Sherif El-Safty, Chief Researcher at Japan’s **National Institute for Materials Science**, Elmarakbi said. “Although we’re at a very early stage and still have to fully prove the concept, I am growing more confident that our collaboration will be fruitful.”

Lightweight GRAPHENE based materials for structural applications

Graphene nanocomposites for integrated sensors

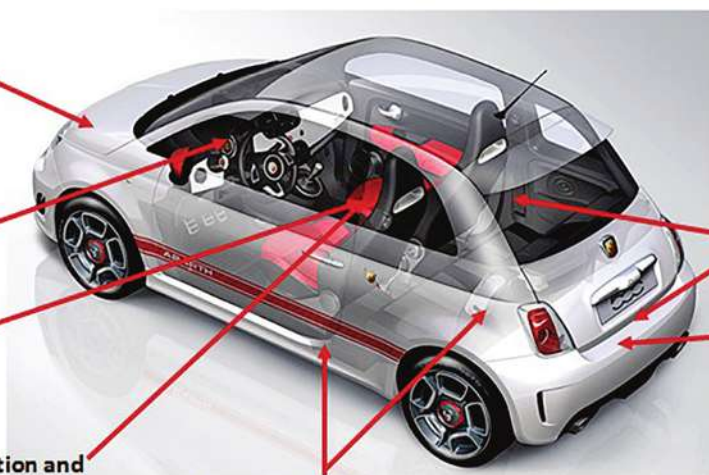
Functional textile

Sensors for pollutants detection and safety

Smart adhesives

Nanostructured TE materials (cooling/heat recovery)

Nanofluids (friction/thermal management)



FIAT researchers see numerous potential automotive applications for graphene.



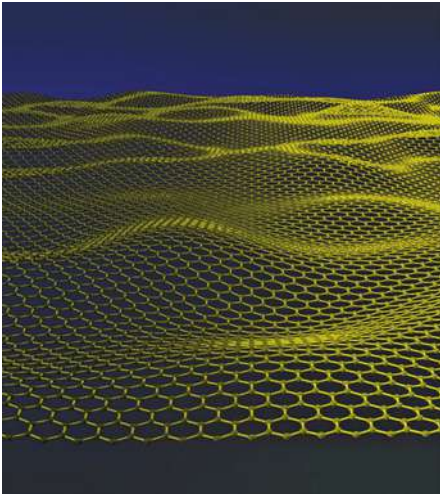
TECHNOLOGY Report



Ahmed Elmarakbi, Professor of Automotive Engineering at the University of Sunderland, wrote the iGCAuto proposal.



Sir Konstantin Novoselov, who co-invented graphene, won the Nobel Prize for his work. (University of Manchester)



Graphene, the “wonder material,” is composed of a chicken-wire arrangement of carbon atoms. (University of Manchester)



New, more efficient methods to produce graphene flakes have been developed recently at Trinity College, Dublin. (University of Manchester)

El-Safty will not directly take part in this work, but will continue working separately on similar projects.

The multi-national team hopes to develop an enhanced polymer matrix with a modified chemical composition in which the atomic positions and bonding are changed to obtain different physical properties. “Once we achieve that, we will add graphene oxide to form a composite that has better energy-absorption characteristics—microcracking, fragmentation—which should provide improved impact dynamics in collisions and under severe loading,” Elmarakbi said. “Essentially, we’ll functionalize the surface of the graphene oxide to alter the interaction between the oxide and the enhanced polymer.”

New design and production

The iGCAuto members also intend “to change the way composites are manufactured,” Elmarakbi said. “We are currently evaluating different processing concepts, including random dispersion of the reinforcement within the polymer and oriented lay-up processes.”

“Our goal is to combine these novel materials concepts with the latest safety design approaches through the development and optimization of advanced ultra-light graphene-based polymer materials, efficient fabrication and manufacturing processes, and life-cycle analysis to reduce the environmental impact of future vehicles,” Elmarakbi stated. Minimizing costs will be another key

objective. In the EU proposal process, the maximum cost allowed for mass reduction was about \$24 for each kilogram. Preliminary studies indicate that “we may be able to do it without compromising costs.”

Graphene R&D

“This project strengthens our effort to take graphene and related materials from the lab to the factory floor, so that the world-leading position of Europe in graphene science can be translated into technology, creating a new graphene-based industry,” said engineer Andrea Ferrari, Director of Britain’s **Cambridge Graphene Center** and Chair of the Graphene Flagship’s Executive Board.

“The first experiments with graphene composites occurred in 2006,” he said, “but the research is still in an early phase.” Many fundamental issues still need to be addressed such as processing routes and orientation, but the initial niche applications are appearing. “For example, a line of **Head** tennis rackets that are made of graphene composites are being used by Novak Djokovic and Maria Sharapova.”

Production of graphene itself recently received a boost when a research group at **Trinity College**, Dublin, led by professor of chemical physics Jonathan Coleman, discovered how to make graphene in a liquid process that is suitable for large-scale production.

“People previously made graphene in small quantities using brute-force methods on graphite, but these methods were



TECHNOLOGY Report



The European Union will spend one billion Euros over the next decade to bring graphene research to the commercial market. (University of Manchester)

inefficient,” he said. “We found that you can produce graphene in a kitchen blender, using fluidic shear to rip the flakes off graphite—a technique that received some public notice a couple of months ago.” Graphite, the ‘lead’ in pencils, is essentially a stack of graphene

layers.

“We developed a more practical method in which graphite is first mixed with a solvent (usually water) and soap,” Coleman explained. Then ultrasonic agitation is used to shear off flakes, somewhat like “pressing the side of a deck of

cards to slide them off.” The differential shear forces strip graphene flakes, layer by layer, using relatively little energy. “We have licensed that method to a company,” he noted, adding that the liquid exfoliation technique “works with any two-dimensional material.”

Graphene, it turns out, is just the first and best known of a family of so-called two-dimensional (2D) materials—ultra-thin substances that have large lengths and widths, but very small heights. “We know of some five-hundred 2D materials,” Ferrari noted, including silicene, germanene, boron nitride, silicon carbide, rare earths, transition-metal chalcogenides and halides, and synthetic organics.

“The structural applications of graphene hold lots of promise,” he said. Mechanical reinforcement of polymer composites is a “big opportunity for graphene. Even small additions can yield a doubling or tripling of the physical properties.”

“I would go so far as to say that if we don’t have significant applications of graphene composites within five years it would be a big problem for the entire field.”

Steven Ashley

OFF-HIGHWAY MATERIALS

Monolayer PA6 a promising solution for SORE fuel tanks and permeation compliance

Since January 2012, fuel tanks fitted to new small off-road spark-ignition engines must comply with permeation requirements set out in the Environmental Protection Agency (EPA) regulation 40 CFR 1060. Permeation emissions from the tanks may not exceed 1.5 g/m²/day in tests carried out at 28°C, or 2.5 g/m²/day at 40°C. The barrier performance of the tanks cannot degrade over time, and it must retain this emission performance for the life of the equipment.

The EPA regulation 40 CFR 1060 is part of a complete set of regulations issued in 2008 on the exhaust and evaporative emissions of fuel tanks for small engines used in handheld power equipment, riding mowers, walk-behind mowers, generators, non-fixed marine tanks, ATVs, utility vehicles, and personal watercraft.

Traditionally, Small Off-Road Engine

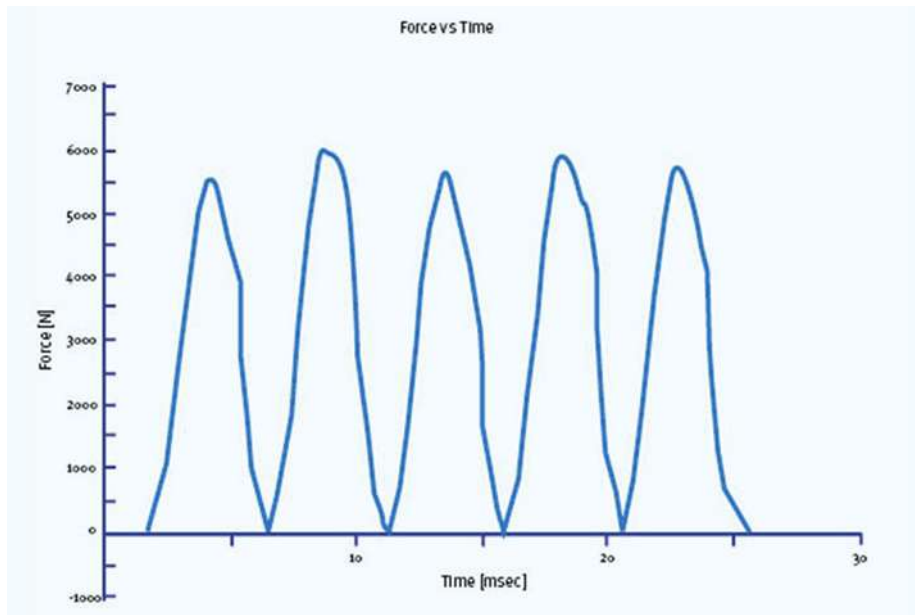


DSM Akulon Fuel Lock grades meet CARB requirements (which are even tougher than the EPA’s) on permeation in SORE fuel tanks. These grades, which contain additives that increase impact resistance while also improving barrier, can be processed by extrusion-blow molding, injection-blow molding, roto molding, and injection molding. The latter types are used for producing tanks in two pieces, which are then joined together by vibration or hot-plate welding techniques.



TECHNOLOGY

Report



Impact behavior of a monomaterial PA6 SORE fuel tank system, tested using ISO 6603-2 test method for the determination of puncture impact properties of rigid plastics, in the form of flat specimens. The flat specimens were taken out of 2.7-L blow-molded tanks having a wall thickness of 2.05 mm (0.08 in). The falling weight test was carried out at -40°C.

(SORE) fuel tanks have been blow molded in high-density polyethylene (HDPE). However, HDPE on its own does not meet the new stringent permeation regulations. Typical HDPE tanks emit 25 to 30 g/m²/day, more than 15 times the allowable limit.

So tank manufacturers have been looking for new solutions. It goes without saying that they would prefer a solution that costs as close to the original one as possible. Several solutions are currently available on the market, including post-treatment of HDPE tanks with fluorination, blends of HDPE with polyamide nanocomposites, EVOH (ethylene vinyl alcohol) barrier layers in a multi-layer co-extrusion with HDPE, and so-called monolayer systems. In this last category, solutions of polyamide 6 (PA6) and also of acetal resin are now available. All these alternative solutions differ from each other in various ways, not only in their barrier properties and costs, but also in process stability, quality control, and impact resistance of the tanks.

Processing stability, quality control, and cost

It is clear that the simpler the process is, the less costly it is likely to be and the easier it will also be to maintain quality control. At the same time, consideration

needs to be given to the state of the technology. EVOH barrier layer co-extrusion is, for example, well-established in the production of large fuel tanks for automobiles. Not surprisingly, it is also seen as a possible barrier solution for SORE fuel tanks. However, the two markets are quite distinct, and multi-layer constructions might be considered too costly for SORE applications, where production volumes are lower. Capital costs are high, and recycling excess material back into the process is only possible as an extra layer in the co-extrusion process.

Fluorination has been in use for even longer, but the extreme toxicity and corrosive nature of the gaseous fluorine used in the process requires the use of dedicated, offsite fluorination centers. This means that molded tanks need to be shipped to the center, fluorinated, and then returned to the molder for tank fittings before finally being sent to the OEM. This extra handling is not only costly, but also requires significant coordination and timing to assure OEMs receive treated tanks in time for their production needs.

As a batch process, the use of nanotechnology additives to HDPE for evaporative emission remediation has the advantages of being able to use blow-

molded HDPE as the primary material and the cost of use is attractive. Effectively dispersing the needed nano layers in the HDPE requires very high attention to additive amounts and extreme control of the processing temperatures. Temperatures that are either too high or too low can result in tanks that behave like neat HDPE—very high permeation characteristics. Again, this property is almost impossible to assess in a production process.

Fluorination may require more rigorous ongoing quality testing than continuous ones. Fluorinated HDPE has also been shown to lose its barrier performance during normal use of the equipment.

Use of nanotechnology certainly appears very interesting, but it is still little used on a commercial level, and the barrier properties it achieves are more susceptible to process conditions than is the case with other monolayer solutions. As a result, particularly close attention needs to be paid to process and quality control.

PA6 shows promise

Of all commercially available solutions to reach the EPA permeation requirements for SORE fuel tanks, monomaterial PA6 technology scores the highest when it comes to the combination of permeability, process stability, mechanical properties, and costs. PA6 has an inherently high barrier to hydrocarbons; permeation rates do vary between specific grades, but at least one commercial available solution, uniquely developed specifically for SORE applications, has a permeation rate that is less than 20% of the EPA limit.

Perhaps the most significant characteristic of Akulon Fuel Lock (DSM Engineering Plastics' trade name for its emission remediation PA6 material) is consistently low permeation rates for ethanol-containing fuels. Since the material is inherently permeation resistant, it is insensitive to changes in processing. The permeation rate has been shown to be well below the regulatory limits, even for wall thicknesses that are half of current HDPE tanks.

In addition, the material is relatively straightforward to process, so tank producers can expect to obtain a reliable and durable barrier that shows the same

performance over many years. The ability to use 100% regrind without compromising in processing stability and material performance results in an even further decrease in cost. Impact resistance tests show good results even at -40°C (-40°F).

PA6 also has the advantage that, with no modifications to hardware, it can run on equipment originally intended to process HDPE. Its mold shrink values are very similar to those of HDPE, and polyamide compounds for fuel tanks have been successfully processed using injection molds, blow molding equipment, and hot plate and vibration welding equipment that were originally used for HDPE.

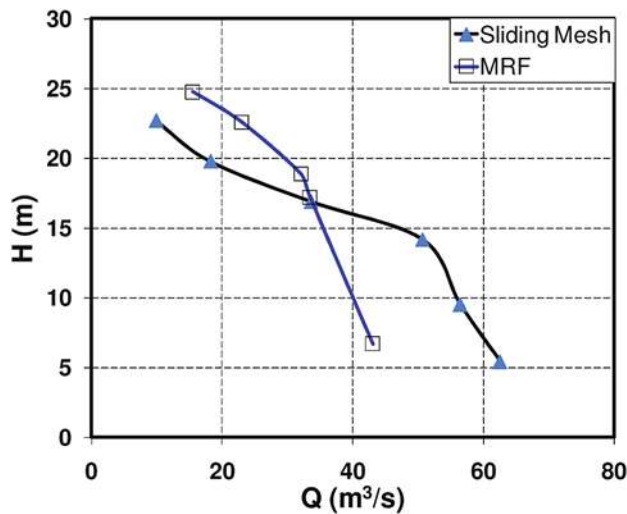
Production of monomaterial polyamide 6 tanks is also recycling-friendly; 100% production regrind has the same melt viscosity as the virgin material. The dynamic melt rheology and sagging performance are the same for the virgin and the 100% regrind material.

Various solutions are now commercially available that meet EPA permeation requirements for SORE fuel tanks. Each has its own merits, but overall, latest monomaterial PA6 technology scores the best when it comes to the combination of barrier, mechanical properties, long-term reliability, process stability, and system cost. With specially developed compounds, processors have the opportunity to produce thin wall tanks that still meet the EPA and **California Air Resources Board** (CARB) evaporative emission regulations.

Karen Scholz, PhD, Research & Technology Manager Europe for Consumer Goods at DSM, and Mark Schierson, MSc, Business Development Manager at DSM, wrote this article for SAE Off-Highway Engineering.

AEROSPACE SIMULATION

Tata Technologies researchers use CFD to predict cavitation in liquid ring pumps



The CFD predicted pump performance curves using the steady state MRF and the transient sliding mesh approaches are shown. The results show a considerable difference in the characteristic curve obtained using the two approaches.

Liquid ring pumps are used in aircraft fuel systems in conjunction with main impeller pumps. These pumps are used for priming the pump system as well as to remove fuel vapor and air from the fuel. Prediction of cavitation in liquid ring pumps is important as cavitation degrades the performance of these pumps and leads to their failure. As test-based assessment of cavitation risk in liquid ring pumps is expensive and time consuming, recent approaches have been to assess and predict the risk of cavitation using CFD methods with the goal to quicken the design process and optimize the performance of these pumps.

CFD models have demonstrated the ability to be used as a cost-effective tool to analyze cavitation phenomenon in pumps for the aerospace industry. Pump reliability is of utmost importance in both commercial and military fixed wing and rotary wing aircrafts due to their need of vapor or air free fuel that is required to be supplied to their engines at all flight missions. As liquid ring pumps serve the function of removing fuel vapor and air from the fuel, their reliable functioning plays a critical role in determining the safe operation of aircrafts during flight. As cavitation has the potential to severely limit the operability of these liquid ring pumps and in severe cases may lead to their structural failure, accurate prediction of cavitation in liquid ring pumps is

extremely important to design these pumps for safe operation.

The cavitation phenomena occur in regions where large pressure drops cause the local pressure to fall below the vapor pressure resulting in formation of vapor bubbles. Typically for pumps, cavitation occurs in the suction side of the pump blades that in turn results in a reduction of effective area of blade thereby diminishing the efficiency of the pumps. The formation of vapor bubbles and their subsequent bursting creates pressure impulse on the blade surfaces, which leads to vibration and fatigue induced structural damage, leading to pump failures.

Researchers from **Tata Technologies Ltd.** used steady state Multiple Reference Frame (MRF) methodology and the transient sliding mesh methodology to assess cavitation, pump performance, and Net Positive Suction Head (NPSH) in liquid ring pumps using **ANSYS-Fluent** CFD software.

Results of the research show a considerable difference in the characteristic curve obtained using the two approaches. The results obtained using the MRF approach show a sudden slope change in the performance curve when the flow through the pump exceeded $30\text{ m}^3/\text{s}$. This unphysical behavior that is not observed in the transient sliding mesh attests to the possible inaccuracy that could result when simulating cavitation using the

TECHNOLOGY Report

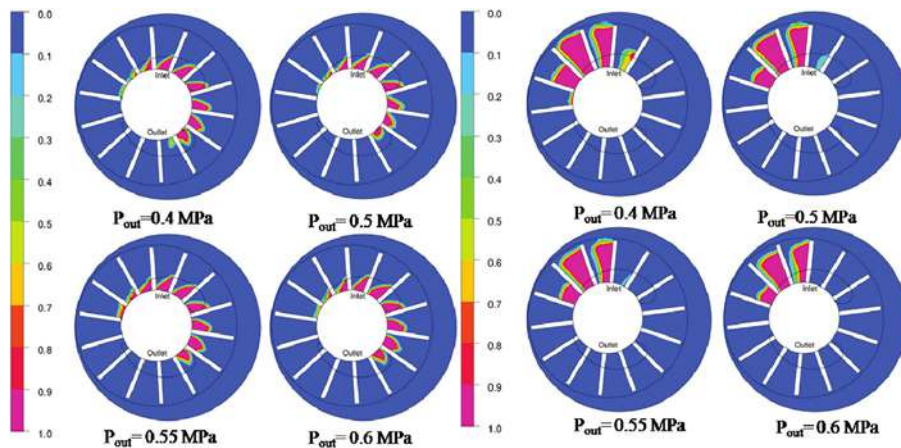


Figure 1: The predicted volume fraction of fuel vapor at pump mid-section using the transient sliding mesh (left) approach and steady state MRF (right) approach are shown.

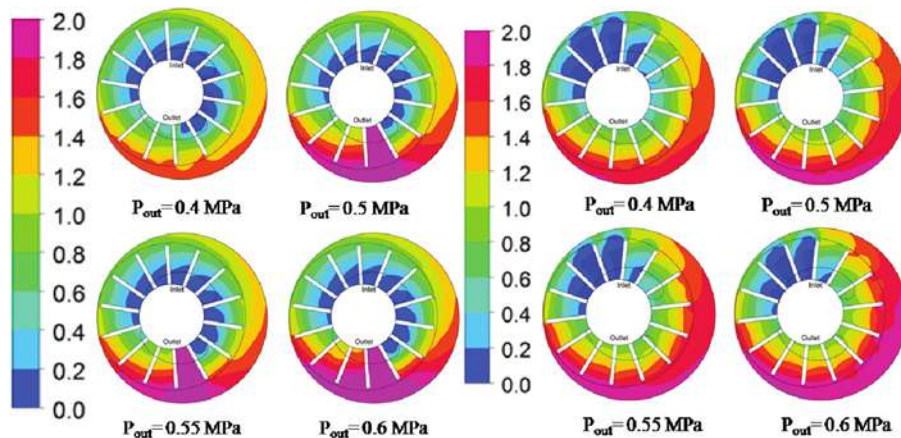
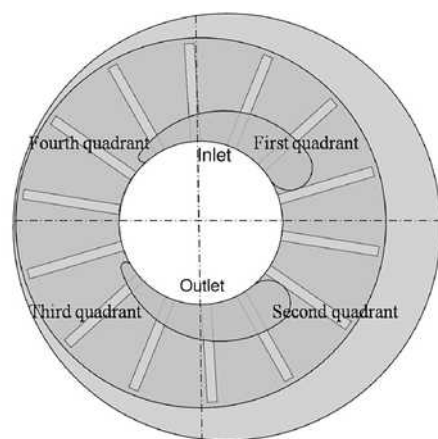


Figure 2: The predicted pressure distribution (MPa) at pump mid-section using the transient sliding mesh (left) approach and steady state MRF (right) approach are shown.



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

steady state MRF approach.

Typically cavitation occurs near the hub surface, and investigation of the pressure distribution in the hub area is important to understand and analyze the cavitation phenomenon. Cavitation occurred in the first, second, and fourth quadrant of the hub. The cavitation region extends from around 0° to 50° and from around 270° to 360° . The results show the appearance of pressure spikes that coincide with the fluid compression and subsequent ejection through the outlet port. The pressure spikes result in an implosion or collapse of the vapor bubble, which is formed during the cavitation process. The large magnitude of the pressure spikes, value of which is as much as 2.25 MPa for the pump configuration considered in this study, creates pressure impulse load at the impeller surfaces, which may lead to structural failure. Furthermore, the cyclic nature of the pressure impulses leads to

fatigue of the impellers that further expedites their structural failure.

To compare the results obtained using the steady state MRF approach and the transient sliding mesh approach, the volume fraction distribution at the pump mid-section plane are shown in Figure 1. These distributions of volume fraction and pressure are shown for varying values of outlet pressure ranging from 0.4 MPa to 0.6 MPa. The results demonstrate that cavitation occurs in the region between the inlet and the outlet port along the direction of rotation of the impeller. Furthermore, the results show that the cavitation area shrinks with an increase in outlet pressure. The distribution of the vapor fraction shows the accumulation of liquid fuel around the periphery due to centrifugal forces and the accumulation of the vapor bubbles in and around the hub region as these regions experience the low pressure regions that lead to cavitation.

The vapor fraction distribution predicted by the MRF approach indicates an unrealistic unphysical location of cavitation. The MRF model predicts that the cavitation occurs near the inlet port which is physically unrealistic.

Figure 2 shows the distribution of absolute pressure at the pump mid-section plane as predicted by the transient sliding mesh and the steady state MRF methodology, respectively. As expected, there are regions of lower pressure near the inlet port and regions of higher pressure near the outlet port.

The results indicate that though the computation efforts are cheaper for the steady state MRF model, the results obtained are unphysical. The computationally expensive transient sliding mesh approach results in realistic predictions. Due to unavailability of experimental data, a quantitative validation of the sliding mesh approach for cavitation prediction could not be performed, but the trends observed in the results show promise in this approach as compared to the MRF approach. Further investigation along with experimental validation would be required to refine the prediction fidelity of the transient sliding mesh based cavitation model for liquid ring pump applications.

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

AUTOMOTIVE SIMULATION

Ferrari changes course on track simulation software

The departure of Luca Cordero di Montezemolo after 23 years as Chairman of **Ferrari**, signals the likelihood of many changes at **Modena**. One of them, just revealed, is the mid-racing season switch by its **Formula One** team to new simulation software, which supplements the limited track testing permitted under **FIA** rules.

It has selected a system from U.K. driving simulation software specialist **rFpro**, which specializes in modeling the world's Grand Prix circuits to deliver what the British company terms "new levels of realism and response speed".

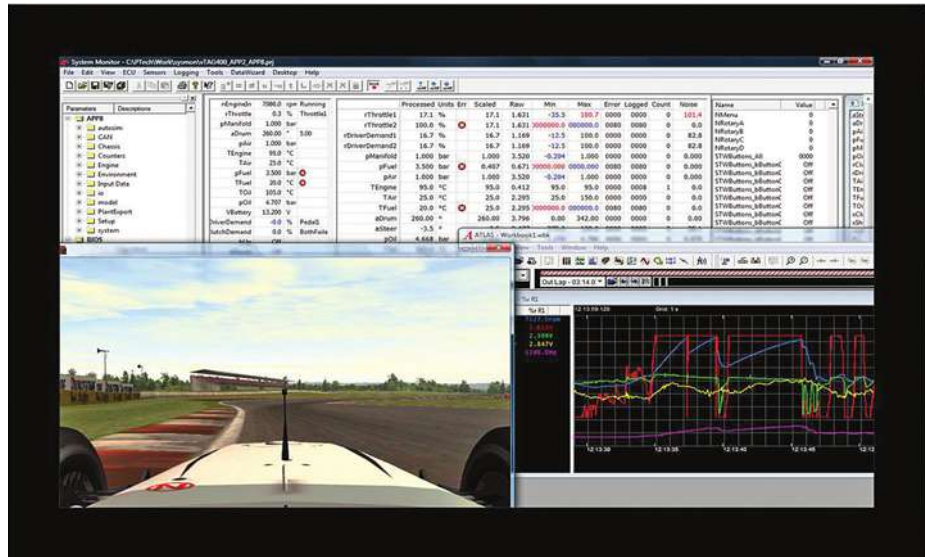
The change to rFpro's TerrainServer product was implemented following extensive evaluation by Ferrari engineers. Ferrari's Giacomo Tortora, responsible for F1 Vehicle Dynamics, says: "I think Ferrari's tests are the most demanding faced by any vendor. We tested video bandwidth and latency, road surface data quality, and visual accuracy for the digital circuit models. The trial of rFpro was so promising that we immediately put it to use in production-intent applications within our F1 team."

At Ferrari, "production-intent applications" describes engineers' ideas (typically aerodynamic refinements) being simulated before manufacture.

Ferrari's decision to change operational software mid-season, and risk simulator downtime disrupting the engineering development schedule, underlines the scale of the performance improvement available, said rFpro Technical Director Chris Hoyle.

To be fully effective as an engineering development tool, DIL (driver-in-the-loop) simulation software must reproduce the track surface in minute detail and respond to dynamic inputs faster than the driver can detect; rFpro claims that its TerrainServer product is the first simulation package to fully satisfy both requirements. It was selected by Ferrari after "an exhaustive evaluation process," says Hoyle.

Explaining the importance of highly accurate simulation software, Tortora stressed that not only is it essential that the circuit model capture the road surface accurately but also that it is validated to ensure that the vehicle



Ferrari F1 has switched to rFpro simulator software.

model is running on the same road surface as the real car.

"The way in which TerrainServer captures every LiDAR scanned datapoint within the tire contact patch, and integrates them all to provide our vehicle model with accurate road input, improves correlation with our measured data and also feels more realistic for the driver," he says.

Ferrari runs multi-channel stereo projection, so it wanted minimal system

latency to ensure the fastest possible refresh rate. Tortora adds: "rFpro is able to deliver the maximum video bandwidth, in stereo, at very high refresh rates with just a single frame of latency between our vehicle model and the projectors."

It was the system's speed that was a key to Ferrari's decision, Tortora said, describing the video bandwidth as probably an order of magnitude greater than a traditional solution.



Ferrari F1 Vehicle Dynamics engineer Giacomo Tortora says of the selection of rFpro: "I think Ferrari's tests are the most demanding faced by any vendor."



Chris Hoyle, Technical Director of rFpro, says that as well as motorsport, his company is focusing on the mainstream production automotive industry for its simulation software.

TECHNOLOGY Report

Hoyle said that as well as its position as a supplier to top motorsport teams, rFpro is now focusing on the mainstream automotive industry, with the opportunity to meet a wide range of requirements and to provide technology that could broaden simulation software applications.

The ability to simulate a vehicle's dynamic behavior accurately, with DIL, makes it feasible to assess extreme situations such as those encountered

when testing advanced driver assisted system (ADAS), ESP, and other control systems designed to affect the dynamic behavior of the vehicle.

"The motorsport industry is well known for being early adopters of new technologies to find competitive advantages, but we believe that it's our production automotive clients that will benefit the most from our technology. That technology allows them to reintroduce the human test driver into

the model-based development process, even for highly dynamic emergency maneuvers when ADAS systems become active."

He claimed that the company's current clients are experiencing reductions of up to 30% in costs incurred in development as a result of integrating rFpro's software, by facilitating human testing considerably earlier in the development cycle.

Stuart Birch

AUTOMOTIVE SIMULATION

Renault applies model-based systems engineering to dual-clutch transmission

Car manufacturers are facing various and sometimes contradicting constraints such as energy efficiency, high performance, driving comfort, reliability, and safety. In a global context, they must also adapt driveline designs to different markets. Therefore, **Renault** must handle a variety of powertrain designs. Moreover, due to increasingly intelligent systems, mechanical and controls system design cycles are more and more linked. A common system mock-up is needed.

Renault has implemented model-based systems engineering (MBSE) to manage these challenges as well as to reduce development cycle and costs. With MBSE, design and integration problems are solved earlier, the number of prototypes and test benches are reduced, and cross-team collaboration is improved. The MBSE approach allows Renault to evaluate, throughout the development phases, the key attributes of the complete vehicle including the engine, transmission, actuators, and chassis.

Renault recently extended its MBSE approach to include a new dual-clutch transmission (DCT) and controls strategies validation and optimization.

The DCT, developed by **Getrag**, is being integrated into C-segment vehicles such as the Renault Mégane or Scenic, and will be widely applied to other vehicle ranges. The new DCT includes seven gears. Wet clutches allow for increased torque capacity up to 300 N·m (221 lb-ft).

The DCT enables gear pre-engagement when another gear is already engaged and drives power. The gear



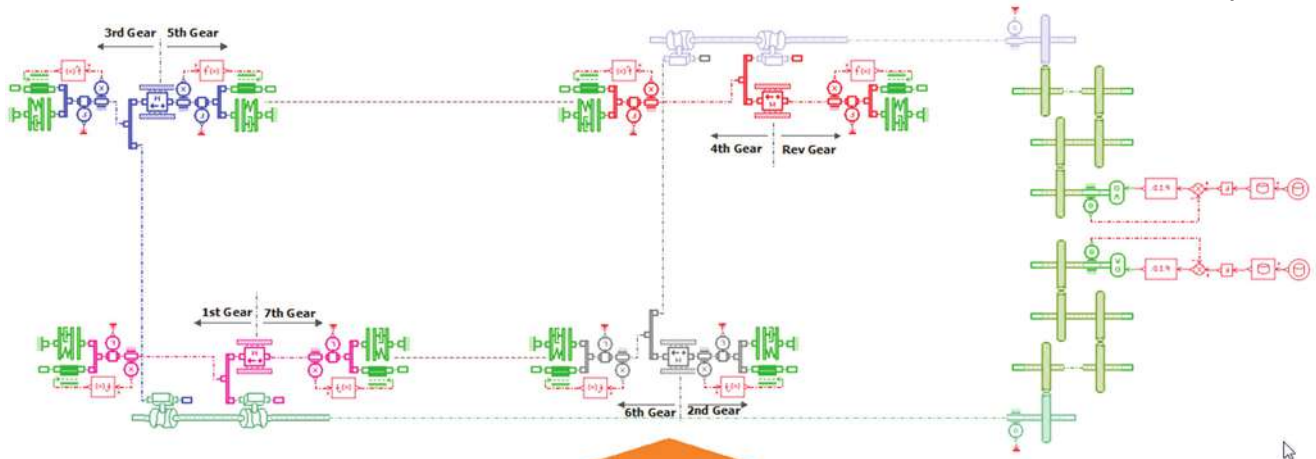
Renault is equipping its conventional vehicles with a new seven-gear dual-clutch transmission, developed by Getrag.

shifting is limited to clutch switching, without significant engine torque reduction. It makes the whole gear change faster, smoother, and more comfortable than a standard automated manual transmission. The engine control unit just needs to manage a slight torque drop by controlling the fuel injection in diesel engines or spark advance in gasoline engines.

The internal DCT command relies on electrohydraulic actuation for clutches and electromechanical actuation for shifting gears. The electrified command

decreases the gearbox's global power consumption, and it is mandatory when gears are shifted without available engine power (for instance, stop-start applications).

To address different steps of the design V-cycle, Renault must carry out numerous analyses to integrate the gearbox with the various engines and chassis. To cope with multiple simulations addressing different levels of assumptions, Renault has opted for LMS Imagine.Lab Amesim software from **Siemens PLM Software** as the simula-



tion platform for multi-domain modeling. Using LMS Amesim, various levels of models can be built depending on user constraints and needs: parameters availability, level of details and accuracy, fast simulation constraints, real-time capabilities, etc.

For the DCT project, Renault has used two levels of models addressing the complete drivetrain:

- Level one model: actuators are assumed to be ideal (excepting delays). This model remains simple and accelerates simulations for controls development and validation. It can be used for real-time applications, such as hardware-in-the-loop or software-in-the-loop to help software development.

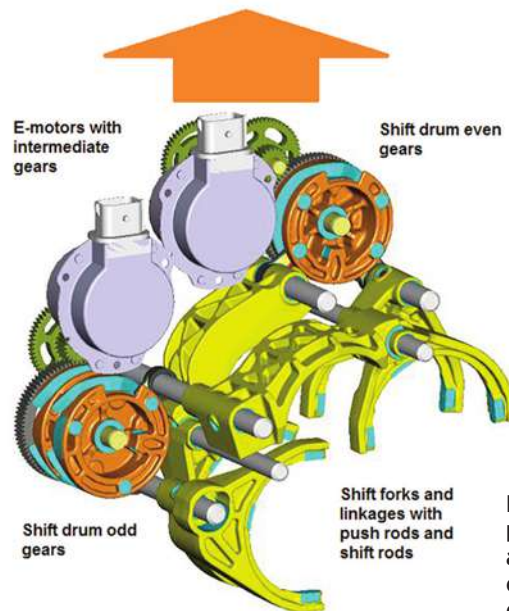
- More detailed model: mechanical actuators geometry (barrels, connected finger, etc.) is replicated in the model to accurately compute contact forces between components. Main lines and consumers are included within hydraulic circuits that are pressurized by electropumps for clutch actuation. The speed of electropumps is regulated by the control logic to control pressure on the clutch pistons. This model was built to perform deeper analysis related to transmission actuation control and design.

These models help engineers understand the power flows between all subsystems and components as well as some drivability aspects.

Two types of validation were performed to demonstrate the models' capabilities and accuracy:

- Functional validation confirms very simple scenarios such as correct gear shifting and providing the right actuator's responses to the requests.

- Experimental validation compares measurements and simulation results



Models help engineers understand the power flows between all subsystems and components, including electromechanical and electrohydraulic actuators.

with various variables such as gearbox in-shaft speeds, side-shafts torques, vehicle longitudinal acceleration, engine speed, or actuators' positions.

Functional model validation is an important stage in the modeling workflow. This step makes sure that the system will have the right type of behavior and functionality. Then, model correlation with experimental data lets Renault check simulation capabilities.

System simulation is used at Renault throughout the V-cycle for different applications. At the beginning, system simulation is applied to select the best system architecture and evaluate how a solution helps answer customer requirements. Then, simulation is used to evaluate high-level controls laws as well as calibration of actuator regulations to estimate the influence of different controls calibration on the gear shifting quality.

For the DCT project, approximately

60 requirements have been translated into scenarios. Then, the scenarios were simulated to validate virtually that the system and its controls fulfill the requirements. This early evaluation enabled Renault to isolate, understand, and solve several minor bugs and logic design issues that could have become critical if identified later on. Moreover, prototype testing can be accelerated by applying simulation during the pre-validation stage of the controls logic.

In addition, MBSE helps engineers quickly evaluate new designs or controls logic improvements—for example, to reduce fuel consumption with a good balance between the NVH response and drivability.

This article was written for Automotive Engineering by Vincent Talon of Renault and Nicolas Sabatier and Patrice Montaland of Siemens PLM Software.

Oil debris monitoring in aero engines

In a gas turbine engine, small particles or “chips” are generated at the point of wear, serving as an advanced warning that catastrophic failure will occur if the wear is not addressed. Health monitoring systems, such as oil debris monitoring, are used to find these small particles so that the wear can be resolved before it’s too late.

The aviation gas turbine engine has evolved considerably since its inception in the 1920s. From improved materials to withstand higher turbine inlet temperatures to lightweight bladed compressor disks, the gas turbine engine of today is more complex than ever before. It is this increased complexity that has warranted special means to ensure that high levels of reliability and performance are maintained throughout the life of the engine.

The life of a gas turbine engine is typically limited by that of its rotating components that undergo wear due to friction, vibration, and mechanical loads. The lifespan of these components may be represented by a “bath-tub” curve (see Figure 1).

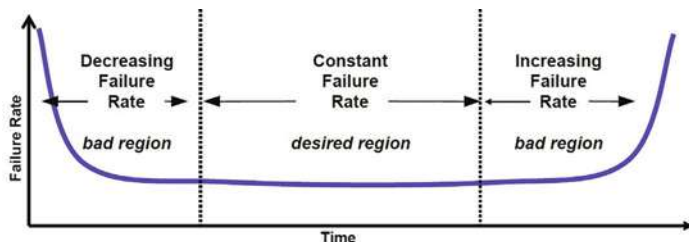


Figure 1: The life of a gas turbine engine is typically limited by that of its rotating components that undergo wear due to friction, vibration, and mechanical loads, demonstrated by this bathtub curb.

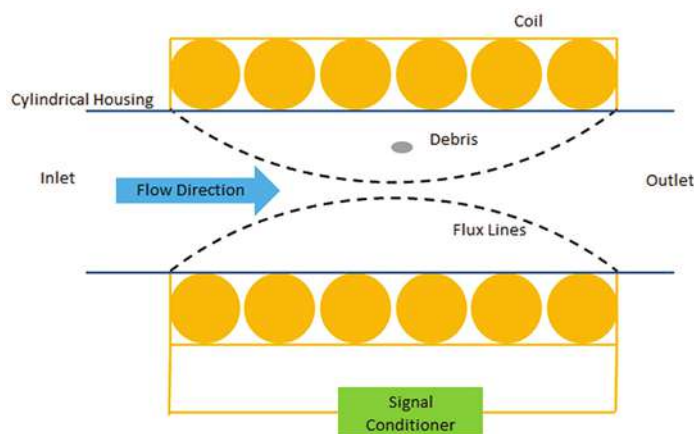


Figure 2: Cross-sectional schematic of inductive flow-through sensor.

A high failure rate is observed initially which corresponds to “infant mortality” of the components. With time, the failure reduces to a constant rate which denotes the useful life of the component followed by eventual wear-out at the end of the lifespan.

Any failure in the dynamic machinery would begin with small particles or “chips” that are generated at the points of wear. These serve as a precursor to catastrophic failure that would occur if the wear was not addressed in a timely manner. The nature of the wear directly influences the shape and size of the chip that is generated. For example, cuboidal platelets would typically be produced by normal rubbing wear while rolling contact fatigue might result in formation of spherical debris particles.

The lubricating system ensures that a thin film of oil is maintained between parts undergoing relative motion. Any wear particles generated would be carried away by the oil towards the sump. By monitoring the oil line for evidence of these particles, the objective of health monitoring of the components would thus be achieved. Hence the phrase “oil debris monitoring” is typically used to describe such a system.

The role of flow-through and accumulating sensors

Flow-through sensors mount on the oil line and detect debris through non-contact means without interrupting the flow. Inductive debris monitors are the most popular sensors that fall under this category. Figure 2 shows a simple cross-sectional schematic of an inductive sensor.

A coil is wound around a cylindrical housing through which the oil is made to flow. Any debris in the flow-path will interrupt the magnetic flux lines and cause a change in voltage across the coil. Ferrous/non-ferrous particles are distinguished based on the phase of the voltage induced in the coil. This signal with appropriate processing could be fed to the engine control unit to determine the next course of action.

Current trends in flow-through sensor technology

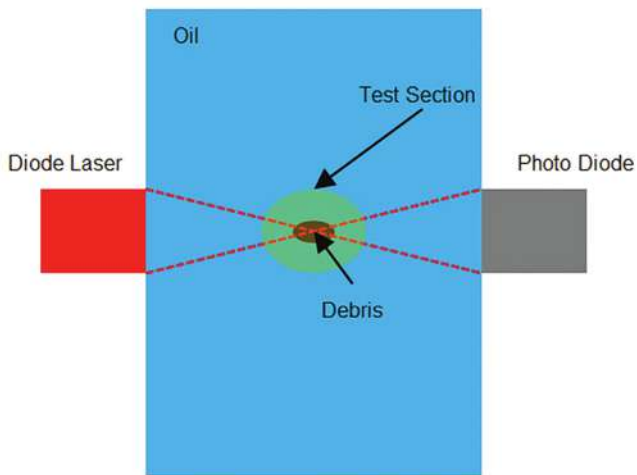


Figure 3: Schematic of optical flow-through sensor.

involve using acoustic or optical techniques to detect particles. The key advantage being that they are independent of the material properties of the particle (see Figure 3).

A coherent laser is transmitted through the oil and the shadow of any debris present is recorded onto a photo diode. Apart from obtaining count statistics, each resulting image is analyzed for the shape and structure of the particles as well.

The perennial disadvantage with these acoustic and optical systems, however, is that there is the risk of wrongly counting bubbles as particles. Any break in the homogeneity of the oil in the test section would potentially register a false indication of debris. Advancements in signal conditioning would be required to implement it in flow-through scenarios where both debris and gas bubbles are transported by the oil.

Accumulating sensors detect and capture debris for root cause analysis. They employ a magnet within the oil flow-path to attract ferromagnetic debris and retain them. Indication may be achieved by capturing it such that an electrical circuit is bridged and a signal is thus generated. Examples of these systems are the Smart Zapper brand of Electric Chip Detectors manufactured by **Eaton**.

A more advanced accumulating sensor is the centrifugal separator for capturing debris, as shown schematically in Figure 4.

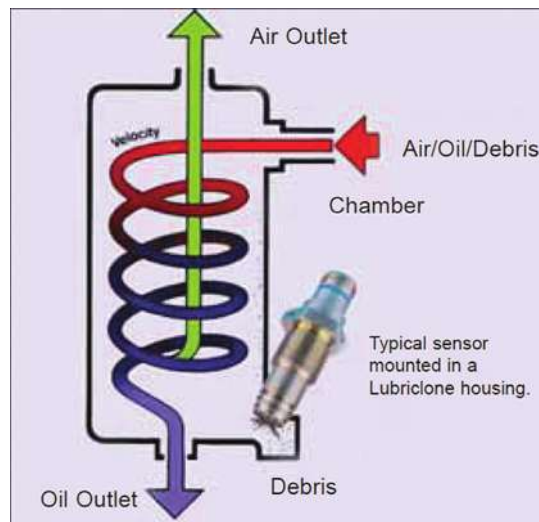


Figure 4: Schematic of three-phase separator used for capturing debris.

A by-product of lubrication is the entrainment of air by the oil into the system. The oil and air along with any ferromagnetic debris enter the separator tangentially. The debris and oil being the denser components in the mixture are thrown towards the walls while a central column of air is formed. The oil and debris are carried to the outlet by the downward swirl while the air is vented from the top. A magnetic sensor is installed in a peripheral port such that the ferromagnetic debris is captured and indicated. In this manner, the debris (solid), oil (liquid), and air (gas) are separated effectively and so the separator afore described is more specifically referred to as a 3-Phase separator. The Lubriclone brand of products made by Eaton is of this type.

Current advancements and the need for development

Increased performance demands on bearings have prompted a migration to ceramic or hybrid designs. In addition to being lighter than its steel counterparts, ceramic bearings are self-lubricating and corrosion resistant with excellent electrical insulation properties. To monitor wear on these bearings, a magnetic approach would not work. Optical and acoustic technologies that are independent of debris material would be the way forward in detecting these particles.

In addition to non-metallic debris

monitoring, engine health monitoring systems of today are driving the need for real-time monitoring where information regarding the size and shape of the particle may be received and acted upon during operation. An acoustic sensor for example could be developed to relate the size of the particle to the strength of the reflected signal by the particle. Ferromagnetic particles are proportionately as “big” as the voltage they induce in the coil of a magnetic sensor.

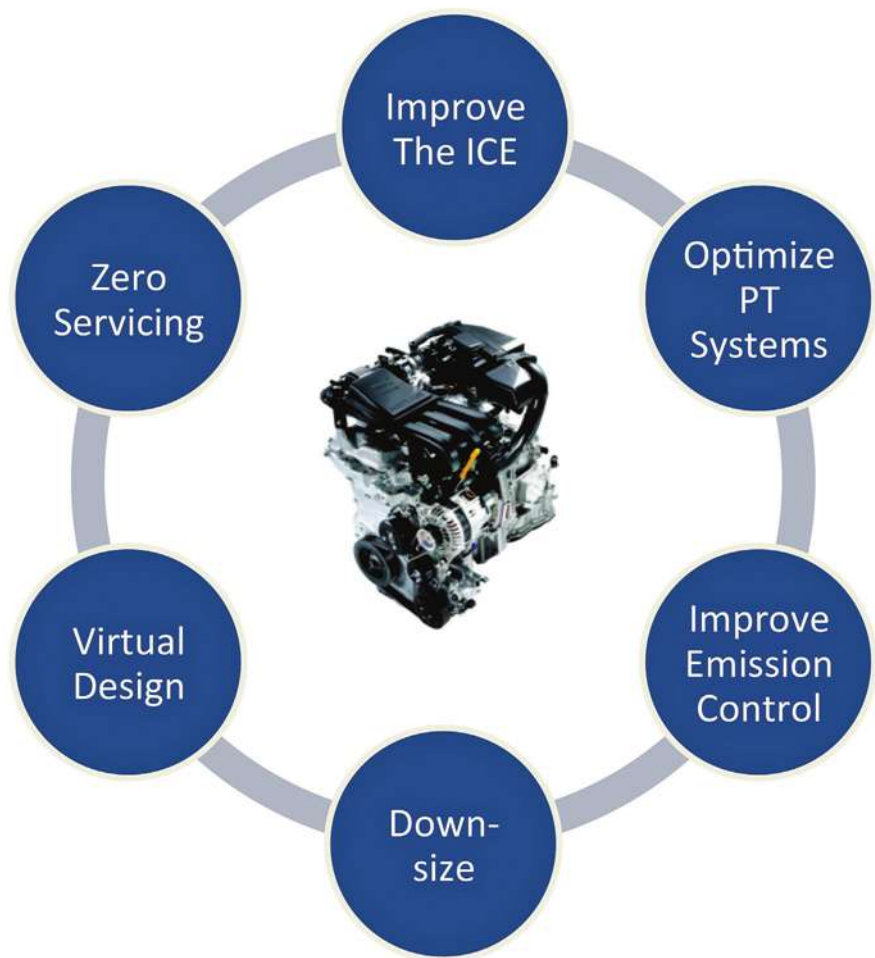
In either case, the objective may only be achieved with significant advancements in the signal conditioning and its qualification for airworthiness. ■



This article was written for *Mobility Engineering* by Anant Kumar, Sr. Engineer, Aerospace - Fluid and Electrical Distribution, Eaton India Engineering Center, Pune.

Indigenous powertrain development

Customer needs and expectations on drivability, fuel economy, and safety have pushed Indian and multinational OEMs to think about the development of powertrains and gearboxes for local needs with global standards.



The powertrain in India can trace its roots back to **Standard Motor's** Rover SD1, **Hindustan** Ambassador, **Premier Padmini**, **Maruti Suzuki**, **Ashok Leyland**, **Tata Indica**, and **Mahindra**. Globalization brought **Honda**, **Hyundai**, **Toyota**, **GM**, and others to the country. During the last two decades, the mobility of India has been improved by the development of Golden Quadrilateral and other infrastructure measures. Global exposure of Indian and technological evolutions necessitated the need and demand for more power from personalized transportation.

Environmental impact, global warming, and health hazards brought the global greenhouse emissions norms and lead to stricter control on automotive powertrain. These tough emissions norms made Indian OEMs look at outsourcing powertrain development for more competent, quick, and proven solutions with better technology and lower risk. The emissions norms also lead to better power, fuel economy, and comfort through reduction of NVH.

Market potential, Indian banking systems, and credit offerings were stabilizing the country's economy with continual growth which made

international car makers offer a technology on par with global standards. Technically advanced manpower and lower costs made India a global house for small and compact cars as well as powertrain. Market maturity and stabilized growth with cultural developments raised the customer expectation and impacted local developments leading to low cost, high quality, reliable solutions. These were the primary needs for the indigenous development of the powertrain and automotive technologies suiting the local conditions of cost and the harsh environment.



The current state and how to move forward

Indigenous powertrain development demands vision influenced by top management involvement, competency, perseverance, risk mitigation, and product development process. Investments requiring design, development infrastructure including engineering skills and exposure with industry and academia participation to deliver the best.

With the current state of OEM's demand for involvement of global design houses, technology suppliers need high-level coordination from local teams to get the best out of the powertrain. They hope to learn the process and procedures of making powertrains to stricter emissions norms and higher reliability with increased technological content (micro-hybrids, start-stop, etc.). For many years engineers in India have been in a constant learning phase, due to continuous pressure on staged implementation of the stricter emissions norms. Engineers as a team should aspire to take more risk with indigenous development leading to competency development and innovation at a lower cost.

Development of indigenous technology requires competency building and innovation under a continuously improving process and engineering standards. Competency building measures can be enhanced through continuous knowledge sharing thorough systematic behavior adhere to culture that may be an imitation of standards and processes of global design houses or JV partners that may delay the implementation due to cultural conflict.

Product development process (PDP) plays an important role in creating technologies and product for a need. This enforces not only product design, but also supplier development at a required level by understanding the process capabilities and current SWOT (Strengths, Weaknesses, Opportunities, and Threats) of the existing suppliers. In fact PDP brings a clear picture of the current state and

the improvement required over time.

Competency building through a frame work which leads to a system-wise (air intake, exhaust, engine mechanical, performance, emissions, etc.) core-team of engineers with enhanced knowledge base would help to not only address the current product development but also help improve efficiency and reliability of a particular system throughout the development process, as well as in field problem solving.

Innovation is the by-product of competency building through continuous efforts. Need and knowledge generate innovation. Innovation is a mindset that leads to competitive advantage. At this stage, indigenous India powertrain needs an orbit-shifting innovation through transformation.

Future state

Indigenous powertrain development in the future should have local teams working with global knowledge leading to less dependency of the global design houses. The experienced engineers gathered with a young energy team should have a defined methodology for competency building and continuous skill improvement.

Needless to say the globally used tools and practices are available and already in use by powertrain developers. This could be a starting point for success and orbit-shifting behavior.

1D simulation tools confirm the design, where it could be built by 3D design capabilities leading to a local product development and verification prototype (mechanical and design validation) at lower costs and reduced development time.

Another aspect of indigenous technology development could be related to a critical part prototype development, where the maximum learning attained should be shifted to the home ground rather than abroad for product-development cycle time reduction and risk mitigation methodologies. It is seen now the globalization of niche technologies of

3D printing, tool and die-making are available in India through global players which could accelerate the learning processes.

Measure of success

A successfully developed indigenous powertrain would have reduced involvement of global design firms, leading to competency development. It would lead to the existence of a collaborative model with the global design firms for technological advancements (BSG, electric vehicles, GDI, etc.). It is an important parameter to avoid global design houses to solve the current problem. A locally competent team leads to development of cost-effective technologies leading to innovation and products which could be compared at a global level. The cost of the product could be reduced due to more home-grown ideas and potential suppliers used.

Advantages include an increased product understanding in terms of performance, reliability, and NVH leading to customer satisfaction at affordable cost. Additionally, a greater contribution to the product-development cycle time reduction is possible.

Indigenous powertrain development in India must have competent system-wise teams at OEMs working collaboratively with design houses and international suppliers for technological advancements for the local needs. Ideally there would be indigenous design houses providing knowledge, design, and collaboration with globally competent subject matter expertise to fulfill the need of a global powertrain for India at an affordable cost. ■

This article was written for *Mobility Engineering* by Meenakshi Sundaram, General Manager, Powertrain Engineering, Hinduja Tech Limited (formerly Defiance Technologies Limited), Chennai & Member, Management Committee, SAE India Southern section; Vignesh Jayenthiran, Engineer, Powertrain, Hinduja Tech Limited.



The next wave of crash simulation

As computing speed has improved and software itself has made significant speed and performance gains with each release, modeling tools are now quick enough to build high-quality, large, high-detail vehicle models in a very efficient manner.

by Matthew Monaghan

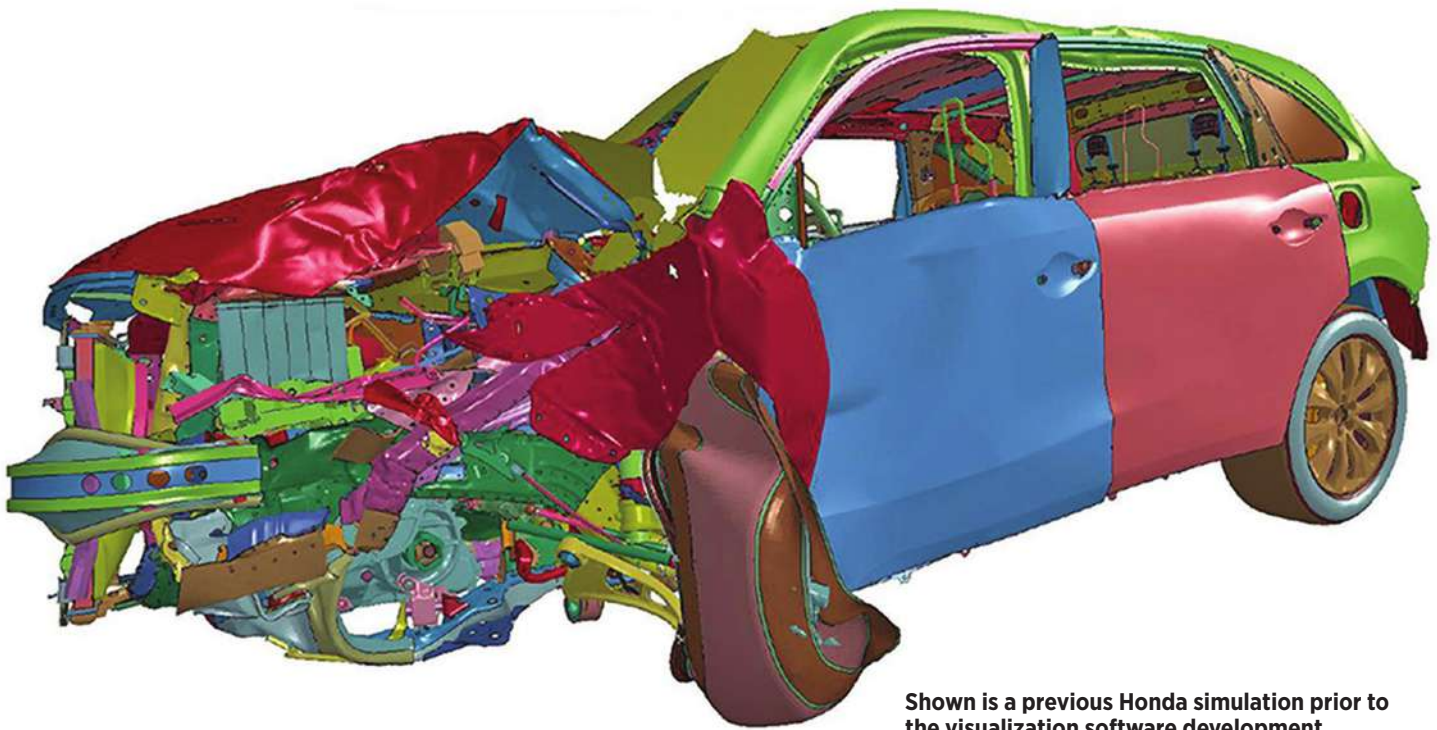
Shown is a Honda R&D Americas Inc. crash simulation visualization as a result of its co-development with 3DXCITE.



Although most vehicle crash tests are typically done at 35-40 mph (56-64 km/h), the speed at which crash *simulations* are run continues to accelerate. As computing speed continually improves, engineers are able to perform more investigative

studies and explore alternatives relating to weight, materials, and performance.

“We’re always searching for speed, accuracy, robustness, and the quality of the results,” said David Mason, Vice President Global Automotive, **Altair**. “There are trade-offs



Shown is a previous Honda simulation prior to the visualization software development.

amongst those, so if we make some assumptions we can run the simulation faster. Computers keep getting faster each year, so we're able to model more and more, but we can make some assumptions and they can run the simulations faster. If we want to be more accurate then the simulation takes longer to run and it lessens the amount of simulations we can do in order to try different countermeasures, etc."

Speed has always been at the forefront of development for Troy, MI-based Altair Engineering Inc., which in 2010 was among the first software providers to compress the time required to mesh, assemble, and simulate a full-vehicle crash finite-element model to just 24 h.

"As the speed of computers has come along and the performance of the software itself has continued to make significant speed and performance gains in each release, it's just become a point in time where the modeling tools are quick enough so you can build these high-quality, large, high-detail models in a very efficient manner and then you can solve them also. The OEMs typically are looking to solve within an overnight cycle."

Ken Bonello, Senior Manager, Vehicle Safety Performance Integration, **General Motors**, can attest to the growth of high-performance computing power and the impact it has had on the ability to build more complex and more detailed FE models.

"As an example, maybe 10 or 12 years ago, a finite-element crash model may have consisted of a million elements, and today for a typical vehicle crash model we're in the 3 million to 5 million element model range, depending on the specific vehicle," Bonello said. "The level of detail that we're able to apply and the computing power that we

have is enabling us to run these crash simulations literally overnight."

Gaining confidence

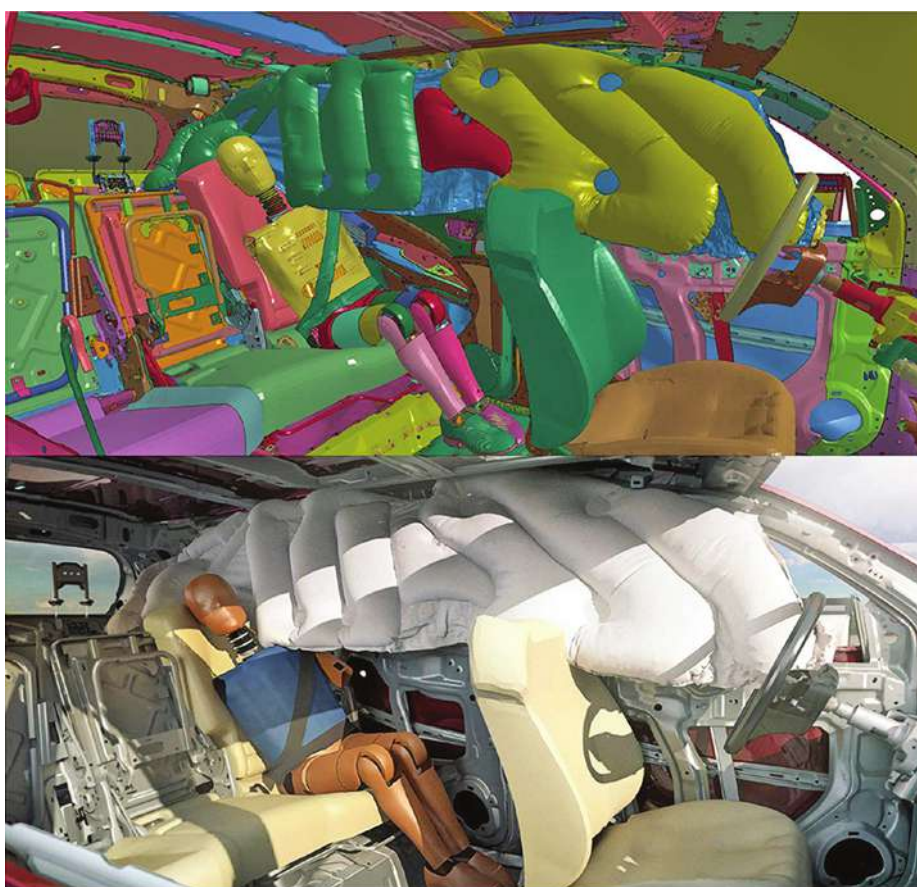
Confidence in virtual models continues to improve, and manufacturers such as GM are now often only running a physical test at the end of a program to get final confirmation/validation of performance, rather than running continual loops of testing, which is both expensive and time consuming.

However, new tests such as the **IIHS** small overlap front crash test, first introduced in 2012, have proved challenging for mini and small cars and midsize SUVs. Therefore, additional learning and development are required to be able to predict the physical performance with the same confidence as more established test conditions.

"There's a case where the vehicle impact is in a way that's different than the way we've designed the main energy-absorbing structure of the vehicle," Mason said. "So you see a lot of use of high airbags to help in that case. You need very accurate airbag modeling, which models the whole process—the firing mechanism, the filling of air, and how that bag deploys geometrically within the vehicle over time—so we put a lot of work in our FDM method in order to improve the accuracy of that airbag deployment throughout all phases of it."

With an added emphasis on lightweighting to meet new CAFE (Corporate Average Fuel Economy) standards, automakers are expanding the use of nontraditional materials. High-strength steels, aluminum, magnesium, and composites are playing a larger role in vehicle structures, therefore a lot of research is currently being done

The next wave of crash simulation



A before (top) and after (bottom) view of Honda's use of a new 3-D, crash-simulation visualization technology.

to predict the failure mechanism within the material and accurately simulate it.

"There's a lot of work going into getting accurate prediction of composites," Mason said. "As you see

automakers trying to lightweight and using some of these new materials, it's requiring a lot of work on the software side to make sure that we can predict with the same accuracy and robustness those materials vs. the traditional

mild steels of the past. They want to build more accurate models and still develop them in the same amount of time."

Accurately modeling the connection of these materials, either through welding, bolted joints, or adhesives, is important when determining the cause of a failure in a crash event. Software providers are updating connection modeling techniques and material models for more accuracy.

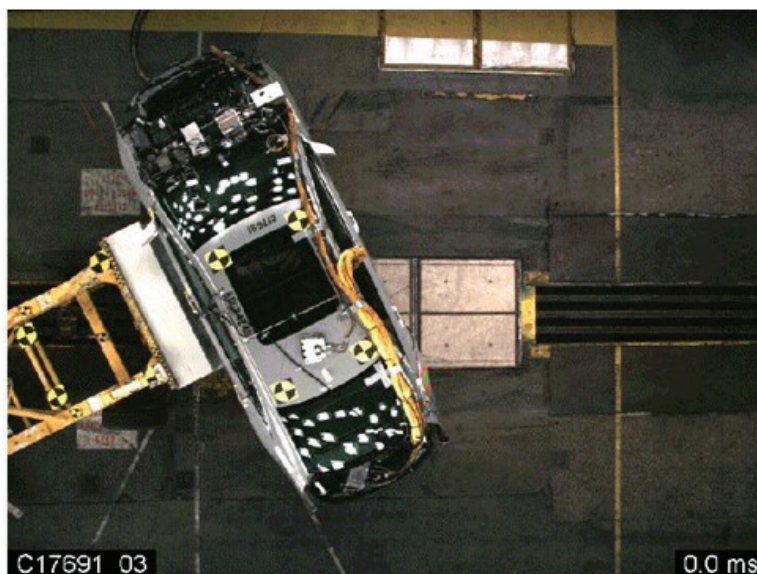
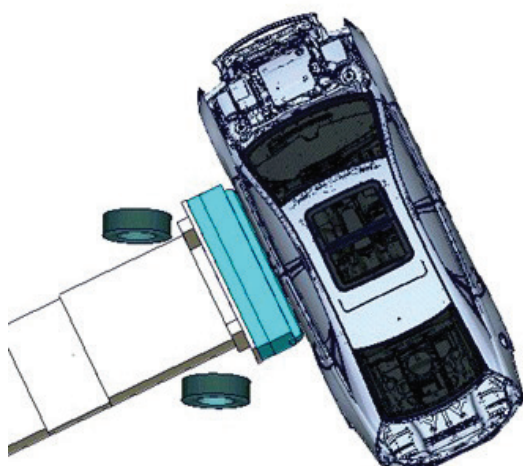
"The modeling of the joints is very important for us to be as accurate as possible," Bonello said. "We do need to pay specific attention to accurately capturing the weld locations and understanding weld capacity for the different types of materials we're using in our vehicles."

Making sense of massive models

As models become larger and more detailed, the number of elements within a vehicle model is expected to climb from the tens of millions to hundreds of millions.

"To do that, we're required to have a highly parallel efficient solver," Mason said. "Up to thousands of cores being used on the computer side, which is very challenging from a software perspective to take advantage of that."

As models become more complex,



A comparison of CAE simulation and test film footage of the 2013 Cadillac XTS undergoing side NCAP testing.



The 2014 Chevrolet Spark was the only vehicle in the Insurance Institute for Highway Safety minicar segment to earn a Top Safety Pick rating in 2014 model year testing (2013 model shown). Spark's safety structure makes extensive use of high-strength and ultra-high-strength steels and includes 10 standard airbags.

it becomes increasingly important to be able to understand exactly what is happening during a crash simulation. With this in mind, **Honda** recently pioneered a new 3-D, crash-simulation visualization technology as a plug-in to DeltaGen, the visualization solution of **Dassault Systèmes' 3DXCITE** (formerly **RTT**).

"With finite element, you're looking at 100 time steps within a crash sequence; it's like 100 photographs as that car is going through the crash event, and each of those time steps represents between 1 GB and 1.5 GB of data," said Tim Ventura, Senior Manager of Business Development, Dassault Systèmes. "So when you look at 100 time steps, you're looking at 100-150 GB of data. To take it into a visualization environment, that's truly the major challenge."

The visualization software, co-developed by Honda R&D Americas Inc., takes the output from LS-DYNA and renders it in a 3-D presentation, enabling engineers to more easily study the results of a crash simulation, test different design approaches, and implement design changes.

"When you look at the rudimentary models, their predictive analysis they feel they're 90-95% accurate with their models," Ventura said. "When

you add shadow, light, and definition through the use of the colors, they start to see some deflections and reactions that they don't normally see in those models. It creates, for them, a very good engineering tool to really analyze as much of that event up front as possible with high definition."

Honda engineers are able to manipulate the rendering, rotate the view in any direction, and strip away parts of the vehicle to isolate a section or component for more thorough analysis. The crash barrier can also be rendered transparent in the virtual environment so the immediate effects of a crash can be viewed from multiple points of view, including the driver's seat.

"The elephant in the room for them was when they went into a management meeting, they had these key milestones where they would sit down and look at all of the elements of the predictive analysis on the crashworthiness side of things," Ventura said. "What they were finding was they would spend a lot of time in those events and really half the people would truly understand what was going on or cared about what was taking place in those events. So they wanted a better way of doing a more interactive review process with their

management teams that kept them engaged in what they were actually talking about. So instead of talking about charts and graphs, they wanted to treat it as if I was grabbing their hand and walking them through the entire crash event with a real model."

Honda R&D has been utilizing LS-DYNA non-linear crash simulation technology since 1998 as part of its new-model development process and has used the technology to help develop new safety designs, including its Advanced Compatibility Engineering (ACE) body structure.

"Past efforts at creating this kind of highly realistic rendering involved weeks of concentrated effort by engineers and rendering specialists and would result in a single simulation with fixed viewing parameters," said Eric DeHoff, Technical Leader for CAE in the Crash Safety Group of Honda R&D Americas Inc. "With this new technology we can create and manipulate the simulation at the push of a button, and we can do it in hours instead of weeks."

Video of the visualization software in action and commentary by DeHoff can be seen at http://youtu.be/vd7_RN48AHY. ■

Business jets bounce back



The Dassault 7X was the first of a new Dassault generation of sophisticated fly-by-wire executive jets.

The business jet segment suffered badly from an extended economic downturn but is now seeing a new generation of airplanes becoming available, introducing features and technologies that are the equal to, and in some cases superior to, jets in airline service.

by Richard Gardner

The business jet market has a resilience all of its own. While defense spending has sharply declined, the commercial sector is overflowing with multi-thousand order backlogs. But if business jet orders can tail off dramatically and then bounce back so quickly, what accounts for this collective long-term immunity to volatile market demands?

One answer is competition.

There are now so many manufacturers of business jets in the world there are niche markets within the sector that enable products to be offered for almost any need, from a private Airbus Corporate Jet (ACJ) A380 down to a four- to six-seat entry-level jet.

While the leading brands can supply a family of platform aircraft, the market is dynamic enough to also have space for new start-ups that do not require the same level of manufacturing infrastructure and corporate critical mass to bring new lightweight airplanes to market.

The main challenge for all-new designs is to keep the development timescale through to test and certification as short as possible, taking advantage of the latest design and manufacturing tools that enable rapid prototyping and the full exploitation of composite structural materials. This requires very tight management with a highly motivated team, with a good knowledge of what this sector's customers are looking for (and what isn't already available). Get this combination of factors right and

priced at a realistic level to break even, and with appropriate investment, a small project can breakthrough into big-time production numbers.

Worldwide business jet deliveries rose by almost 20% during the first three months of this year, with 154 aircraft handed over. The North American market remains the prime target with by far the largest number of private and corporate jets registered. This market recovered rather faster than in Europe, where the financial cold wind caused a drastic slowdown in the rate of business expansion and the replacement of older jets stopped almost completely.

The unresolved fiscal problems in the Eurozone means that it is unlikely that European operators will be able to fully exploit what is now available in the executive jet market, at least for the next few years. New sales to the former Eastern European countries had been growing at a faster rate, as were sales to Russia and China, but the deterioration in Western/Russian relations is unlikely to promote further sales in the short term.

French flair

In Europe, **Dassault Aviation** remains the leading producer of business jets, with its six-strong Falcon family setting the standard in terms not only of sales (2250 to date) but advanced technology. The latest in a continuous product line dating back to 1963 is the three-engine Falcon 8X, which was announced in May 2014 and which features a larger fuse-



The new Dassault 8X is a 6450-nmi ultra-long-range aircraft and is making rapid progress. In late July the wings, fuselage, and engines of the first aircraft were joined ready for the initial power-on and ground tests. First flight is scheduled for early 2015, with first deliveries due at the end of 2016.

The flight deck of the Citation X+ features a new Garmin G5000 avionics package with four intuitive full color touch-screen LCD panels and three 14-in high-resolution displays, as well as fully integrated auto-throttles to reduce pilot workload, including fuel management.



lage and high-performance wings with an integrated **Honeywell EASy** flight deck with head-down displays, head-up displays, and a synthetic vision system (SVS), SmartView, that provides a high level of all-weather day and night situational awareness.

The 7X was the first of a new Dassault generation of sophisticated fly-by-wire executive jets incorporating the latest technology for discriminating “top end” customers, and has now been followed by the 5X and 8X. The SVS incorporates virtual representation of outside world features such as high ground, tall obstacles, and runways, fusing GPS navigational information and radar pictures overlaid with 3-D mapping from an onboard global database and electro-optical/night vision onboard sensors.

The new 8X aircraft is a 6450-nmi ultra-long-range addition to the family and is making rapid progress. In late July the wings, fuselage, and engines of the first aircraft were joined ready for the initial power-on and ground tests. It has adopted many of the advanced features of the Falcon 7X and 5X, including a fully digital fly-by-wire flight control system. It has the longest cabin of any Falcon, offering improved comfort and new competition at the upper end of the market. The 8X wing is 600 lb lighter than the airfoil on the 7X and its design gives Falcons advantages in aerodynamic efficiency, robustness, and maintainability.

Powered by three **Pratt & Whitney Canada PW307D** engines, with 5% more thrust than similar engines fitted to the 7X, the 8X is due to make its first flight in early 2015, with first deliveries due at the end of 2016.

Meanwhile, the twin-engine Falcon 5X started ground tests this summer and the first flight is expected in the first half of next year, entering service in 2017. This new aircraft, the largest Falcon to date, features in addition to a fully digital flight control system, a new design of wing “flaperon” that allows steep approaches at slow speeds. This enables the long-range aircraft to fly an intercontinental stage and then land at a relatively short air-strip, opening up many more direct point-to-point flights using secondary airfields.

Dassault Falcon Jet is a U.S. subsidiary of the French company and supports the Falcon family throughout the Americas and the Pacific Rim in Asia, including China. It also undertakes final fitting out of “green” airframes assembled in France and destined for customers in these regions.

Enter the fastest commercial jet

Earlier this year, **Cessna**, part of **Textron Aviation**, brought its recently certified mid-size Citation X+ to the Farnborough Airshow, making it the type’s first trans-Atlantic crossing in a normal business flight profile, with an average ground speed of 502 knot.

This new aircraft is extremely fast and exceeded Mach 1 during the certification tests, making it the fastest commercial jet currently available. It also has an exceptionally high maximum altitude capability of 51,000 ft, above the standard commercial air lanes, permitting flights over many types of adverse en route weather.

Since the demise of Concorde supersonic scheduled flights a decade ago, trans-Atlantic flight times have been flat-lined, and so an improvement in overall timings will be welcomed by many high-value business customers. On its U.S.-Farnborough journey, the Citation X+ flew at between Mach 0.86 and Mach 0.88 cruising above 45,000 ft. Maximum non-stop range is 3408 mi and with a maximum speed of Mach 0.93, carrying 12 passengers.

The most noticeable external difference with this latest model is the addition of wing-lets, which enhance performance by allowing cruise at higher altitudes consuming less fuel and enhancing takeoff and landing at either higher altitude airports or in high temperatures. It is powered by two FADEC **Rolls-Royce AE3007C2** turbofans.

The cabin has a dual-zone temperature control system to keep pilots and passengers comfortable. The extended cabin is built up around an intelligent cabin management and

Business jets bounce back

entertainment technology solution integrated with the avionics and electrical systems. The Cessna Clarity system provides passengers with individual touch screens that control cabin lighting, window shades, temperature, and entertainment and communications options.

Garmin supplies its Synthetic Vision Technology on the primary flight displays giving virtual views of runways, terrain, traffic, and obstacles. The flight deck features a new Garmin G5000 avionics package with four intuitive full color touch-screen LCD panels and three 14-in high-resolution displays, as well as fully integrated auto-throttles to reduce pilot workload, including fuel management. The auto-throttle is integrated with the flight-management system and automatic flight-control system for computer control of engine thrust. This system can be engaged prior to takeoff roll to control fuel flow throughout the duration of the flight, or it can be disengaged for manual throttle operation.

Cessna has also been giving its other established models a “refresh” to increase their sales prospects. This includes the Citation Sovereign and the FAA-certified Citation CJ3+, which features a new seven-seat cabin and incorporation of the Garmin G3000 flight deck. The Cessna Latitude is a new model in the superlight category and is presently well into its flight test program aimed at certification and first deliveries in 2015.

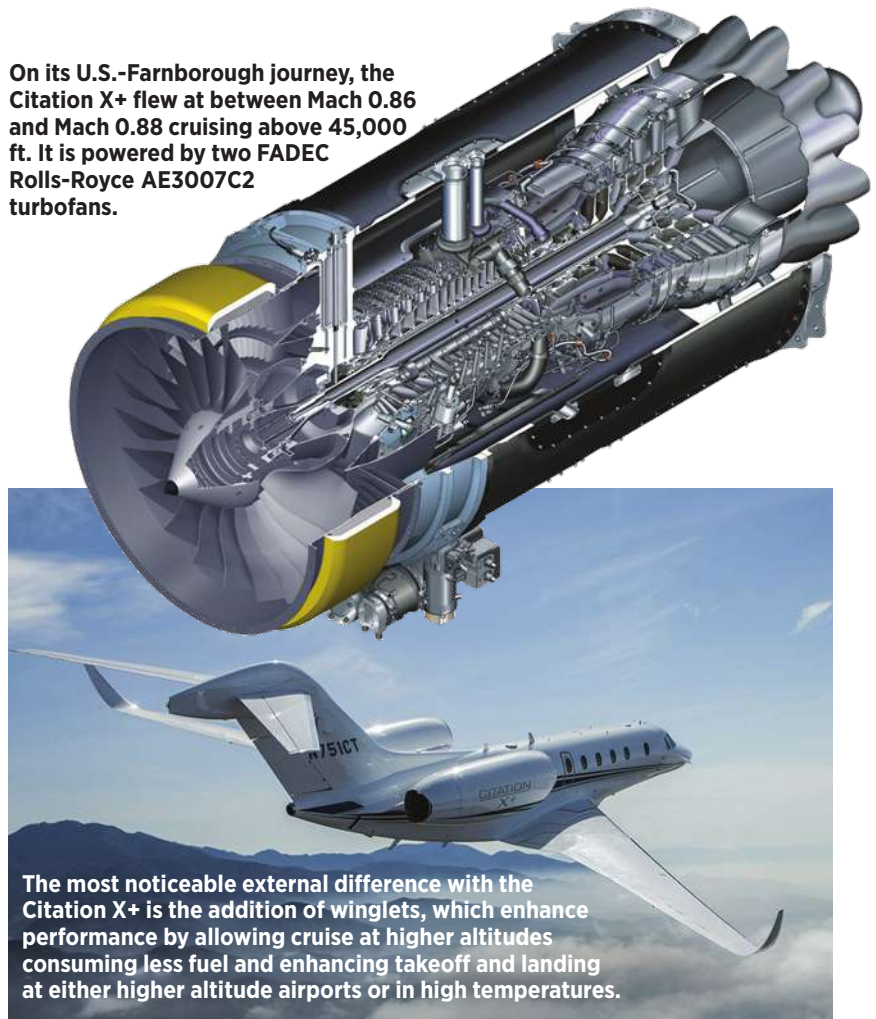
Powered by two P&WC PW306D engines, the nine-seat Latitude features a wider and taller cabin than the Sovereign, but shares a common wing and rear fuselage. It also features the Garmin G5000 integrated flight deck and the Clarity cabin management system. Range is 2500 nmi and it can cruise at up to 45,000 ft at a speed of 440 knot.

This jet is to be joined in the Cessna product lineup by a bigger family member, the super mid-size Longitude, sharing the same main features, and cabin cross section, but will be 9 ft longer with two more powerful Snecma Silvercrest engines giving it a 4000-nmi range and 490-knot cruise speed. This model will become the company’s top-of-the-range offering.

Established leaders

Gulfstream has dominated the super mid-size and very-long-range segments for almost as long as they have existed. Over the years the format has evolved to incorporate regular upgrades in terms of avionics and communica-

On its U.S.-Farnborough journey, the Citation X+ flew at between Mach 0.86 and Mach 0.88 cruising above 45,000 ft. It is powered by two FADEC Rolls-Royce AE3007C2 turbofans.



The most noticeable external difference with the Citation X+ is the addition of winglets, which enhance performance by allowing cruise at higher altitudes consuming less fuel and enhancing takeoff and landing at either higher altitude airports or in high temperatures.



The under-development Bombardier Global 7000 will be powered by GE Passport 20 engines with 16,500-lb of thrust. It will fly 7300 nmi at Mach 0.85.

tions, with new models also offering longer range, higher altitude, and more cabin features.

New wings and winglets have transformed capability and the current models—the G280, G450, and G650—are maintaining their presence in these niche segments. However, they are certainly not alone and in more recent times serious competition for ultra-long range requirements has come from many different directions.

Bombardier has been suffering from high-profile delays with its CSeries, but in its portfolio of business jets it is making good sales progress with its growing family of Global Express models, as well as finding new applications for specialist versions of its popular Challenger 604 and completion of the certification for the latest super mid-size



About to enter service, the Embraer Legacy 500 is in the midsize category and the 450 the mid-light category, but both share a high level of commonality and a top speed of up to Mach 0.83.



For the corporate customer in need of a business jet with a wingspan of 262 ft, a cabin area of 5145 ft², and a range of 9756 mi, Airbus is offering the ACJ A380.



The Global 7000 interior will have four distinct living spaces with a standard capacity of 17 passengers.

Challenger 350, which replaces the successful and long running Challenger 300.

The 350 has two Honeywell HTF7350 engines giving the aircraft a range of 3200 nmi carrying up to 10 passengers at a speed of up to Mach 0.82. The cockpit is built around the Rockwell Collins Pro Line 21 avionics system. The company's superlight Learjet 75 and light Learjet 70 models have now entered the market and are being followed by the new mid-size Learjet 85. This has a largely composite structure and flight tests are now under way.

Powered by two P&WC PW307B engines, the eight-seat model comes right into the middle of the most hotly contested segment of the market, offering a 2600-nmi range with a top speed of 450 knot. As with its competitors, it is very well equipped in the cockpit area, being fitted with the company's Vision flight deck incorporating a Rockwell Collins Pro Line Fusion avionics system.

This flight deck design is also a feature on the emerging Global 7000 and 8000. These are new models in development that build on the market success of the original Global 5000 and later Global 6000 that offers extended range. They will become the largest members of the Bombardier executive jet family and expand its range flexibility out to just under 8000 nmi with a high Mach 8.5 cruise speed.

Brazilian festival

Embraer took a great leap a few years ago by launching its Phenom family of superlight executive jets. The result has been a runaway success, with this compact twin-engine jet soon achieving a significant slice of the market, and acting as an "entry level" for many operators requiring a modern technical solution in a minimum package that can still provide speed and comfort over a worthwhile range.

About to enter service is the Embraer Legacy 500, which has been in flight test since 2012. Its product line partner, the Legacy 450, which differs only in cabin length, is following twelve months behind, but is also now in the air. This is a new design and incorporates a digital flight control system, Rockwell Collins Proline Fusion integrated avionics system, and Honeywell HTF7500E engines.

The 500 is in the mid-size category and the 450 the mid-light category, but both share a high level of commonality and a top speed of up to Mach 0.83. The company regards these aircraft as potential market-leading offerings as they introduce fly-by-wire controls into this market segment for the first time.

The Embraer Executive Jet Division continues to sell limited numbers of its corporate and VIP versions of its regional jets, including the Lineage brand, and at the top end is expected to add an executive model based on the 2013-announced EMB-170 E2 family. This would compete with the ACJ and BBJ (Boeing Business Jet) directly, though trading internal capacity for operating economics with reduced fuel consumption.

The BBJ family, based on the 737-700 and -800, has carved a good slice out of the high-end corporate, VIP, and government segments but the outstanding demand for standard commercial Boeing 737s, which will be replaced by the 737Max later this decade, means that there is extreme pressure on deliveries for new airframes for fitting out as BBJs.

Boeing is also delivering special VVIP examples of the giant 747-8 and 787 models, which, along with similar executive conversions of the complete Airbus family of narrow and wide body airliners right up to the A380, demonstrates that there really are no upper limits to this high-prestige market. ■

Screens, cameras provide new look in cabs

Video inputs are another option showing up on displays that increasingly offer touch control.

by Terry Costlow



Linking cameras to displays helps Parker Hannifin improve safety and efficiency.

When predefined conditions are met, Eaton's displays can respond automatically.



Cameras and displays from HED give operators a view in hard-to-see areas.

Liquid crystal displays have rapidly gone from limited usage to mainstream, transforming human-machine interfaces (HMIs). Video images are being added to the diverse list of functions for these displays, which are also becoming input devices as touch technology gains acceptance.

Diversity is one of the key reasons displays are becoming a mainstay in HMI strategies. This versatility means that ease of use is a focal point for design teams.

“We’re integrating big screens into heavy equipment where operators haven’t used big screens or touch screens,” said Ingo Krueger, Business Unit Director, Cockpit & Mobility Systems at **IAV**. “It’s important to have operating menus set up in an intelligent way so operators can go through the settings and easily get what they need. Different modes can be set for different types of operations, such as when the vehicle’s in the field or on the highway.”

When multifunction displays are augmented with touch input, users can look at settings and adjust them or set points when alarms will sound. That helps protect vehicles as well as operators.

“For hydraulic functions, displays often are used to select or adjust the amount of power used during operation while providing information regarding fluid levels, temperatures, and pressures important for service diagnostics and maintenance,” said David Eckerd, Director, Product Management Director for Mobile Electronics at **Bosch Rexroth**. “Configurable messages or warning alarms may be triggered to warn an operator of pending problems and provide instructions regarding how to manage them.”

Picture this

Video images are the newest inputs being integrated into these displays. Pricing for rugged and compact cameras has declined rapidly as more passenger cars employ them. That’s helping video gain rapid adoption in large equipment where it’s hard to see some areas.

“We have found significant improvements in machine safety through the use of large display screens,” said Kirk Lola, Business Development Manager at **Parker Hannifin’s** Electronic Controls Division. “The addition of video input into the HMI screens has made a significant impact in machine safety. This allows the operator to see the area around the machine to help ensure that the area around them is clear.”

Going forward, more video functions will pop up automatically. Just as backup camera data is displayed when the vehicle is shifted into reverse, a crane or loader can be shown on the display when certain actions are being taken or when loads hit predetermined levels.

“As the sophistication of HMI technology increases, it is now possible to automate the way camera feeds are shown, ensuring the operator sees visual information that is critical to the task they are performing,” said Eddie Phillips, Marketing Manager of Electronic Controls & Software for **Eaton’s** Power and Controls Business.



IAV helps suppliers create programs that facilitate efficiency improvements.

Cameras can be especially helpful for hydraulic-powered operations, since actuators are often obscured from the operator’s view. Cameras are likely to play a major role in the drive to reduce accidents and injuries.

“When a hydraulic function is being operated that is not in clear view of the operator, a camera feed can be displayed so the operator can safely operate the vehicle,” said Christopher Kolbe, Sales & Marketing Vice President at **HED Inc.** “In addition, the display can show if the vehicle is on the edge of stability. For example, on an aerial work platform, the display can warn the operator that they are reaching an unsafe condition.”

Display and camera systems are evolving in other ways as well. Increased microprocessor capabilities make it possible to show information from a range of inputs, switching quickly when necessary. At the same time, these displays are being upgraded so LCDs can be used in even more environments.

“High processing power allows displays to increase graphics capabilities and show video, vehicle operator manuals, and split screen videos,” Kolbe said. “Sunlight readability is improving by integrating anti-reflective glass. More displays are IP67-rated/waterproof, allowing them to be mounted outside the cab.”

It’s polite to point

Displaying more information isn’t the only way displays are extending their influence. They’re quickly becoming a central element in control strategies. Touch technologies used on smart phones and tablets are being added to

Screens, cameras provide new look in cabs

cabin displays.

“Projected capacitive touch technology is now being incorporated into equipment designed for the off-highway market,” Phillips said. “Our VFX72 display uses the latest in projected capacitive touch technology as well as optical bonding to provide sunlight viewability.”

The ability to program display inputs is a significant benefit for equipment that is shipped globally. It’s fairly simple to do translations for anything seen on the screen, whether that’s a touch target, an alert, or the operator’s manual.

“One of the most significant changes in HMI software is the advent of the touch screen for operator interface and ability to support multiple languages,” Lola said. “The IQAN MD4 7-in display offers a touch screen display as well as the ability for the operator to select their language of choice if that language has been programmed into the display. This improves operator efficiency by presenting messages and information about adjustments and faults in their native language.”

Many designers are taking another step to link consumer technologies and off-highway equipment. Some

developers plan to provide connections between smart phones and the vehicle’s display. That lets operators see what’s on the in-cab display while they’re making adjustments to engines, PTOs, or other systems.

“Suppliers want to integrate with smart phones, but only for very specific tasks,” Krueger said. “On a large machine, where the operator’s often alone, it’s very helpful when they need to do something on the back of the machine. They can use the smart phone to see the information that’s on the dashboard display.” ■

Linux, Android, and tool chains drive software choices

Commercial technologies and the drive to improve safety are causing major changes in the human-machine interface (HMI) software that controls many functions on off-highway equipment. Programmers are turning to operating systems developed for the business and consumer world, while safety regulations help ensure that these technologies don’t reduce reliability or cause accidents.

These changes are occurring as HMIs become a central factor in OEMs’ strategies for differentiation. Though user interfaces are becoming more complex, there’s a growing focus on getting them to market quickly.

“Development time is being reduced because more OEMs are programming displays using development software that can program multiple vendor’s displays,” said Christopher Kolbe, Sales & Marketing Vice President at HED. “For example, most displays have a Linux-based operating system. Therefore, OEMs are using a generic development package so they can switch vendors without having to develop all-new software.”

Some suppliers are going to a popular consumer technology, looking at smart phone operating systems. Tools are a key driver behind this decision.

“You can use Android to run all the screens,” said Ingo Krueger, Business Unit Director, Cockpit & Mobility Systems at IAV. “That gives you the benefit of using the complete tool chain to develop software. That can be very convenient and it can help keep costs under control. If you use the tool chains for something like Android or other common alternatives, you can use model-based tools that make the software more stable.”

If programmers do opt to employ Android, its use will be limited largely to the displays and some minor aspects of the HMI. It’s doubtful that anything closely related to vehicle operations will be programmed atop the operating system.

“For safety-related functions, you don’t want to use Android,” Krueger said. “OEMs want to use dedicated operating systems to handle all safety-related tasks or very critical functions.”

That will eliminate many of the HMI tasks, particularly any aspect of the user interface connected with any safety-related tasks. HMI software is typically developed to high safety and reliability standards.

“The focus of HMI software development continues to be on safety certification,” said Michael Olson, Engineering Manager, Electronic Components, Danfoss Power Solutions. “We are continuously working to find better ways to reduce the impact of failures through software validation in combination with redundant hardware. Through software validation and redundant hardware, we can minimize a failure or make it known so that the machine stops when a failed device is detected.”

These safety regulations help ensure that problems that can cause injuries or equipment failure are unlikely. Functional safety standards set varying levels of safety based on the seriousness associated with problems in the field.

“The advent of Safety Integrity Level 2, or SIL2, controllers has made a significant impact in reducing the impact of failures,” said Kirk Lola, Business Development Manager at Parker Hannifin’s Electronic Controls Division. “Obtaining SIL2 certification allows the machine designer to use the certification and the reliability data to help design a SIL-compliant machine.”

As displays and HMI software evolve, it’s becoming easier for operators to set up their jobs. End users can set parameters for jobs they do regularly. Some HMIs even let users store these parameters and move them from vehicle to vehicle.

“Using sophisticated displays that have a powerful microcontroller allows operators the flexibility to automate routine functions using ‘wizards’ to script common functions,” said Eddie Phillips, Marketing Manager of Electronic Controls & Software for Eaton’s Power and Controls Business. “Displays like Eaton’s VFX70 also allow operators to store their machine preferences on a USB, allowing them to move their preferred settings from one machine to another across common machines in a fleet.”

Terry Costlow



Safety is a central factor for HMI developers at Danfoss.

Global VEHICLES

Discovery Sport introduces Evoque-based Land Rover



Discovery Sport is based on Range Rover Evoque powertrains and front end, with a new rear including a multilink rear axle.

Weight reduction has been an ongoing theme for **Land Rover** in recent years, with significant reductions for both the Land Rover Discovery and Range Rover. With the launch of the Discovery Sport, unveiled at the 2014 Paris Motor Show, Land Rover is extending the weight reduction theme with engine downsizing.

It's the first Discovery badged vehicle in a decade not to be offered with a V6 or V8 engine. In fact, the Discovery Sport has much more in common with the Range Rover Evoque, with which it shares powertrain options and many structural components.

Although the car has been launched with the 2.2-L four-cylinder diesel, which can trace its roots back to the company's days under **Ford** ownership, it's certain that replacement engines are on the horizon, now that production of a new family of **Jaguar Land Rover** turbocharged 2.0-L four-cylinder Ingenium gasoline and diesel engines is due to begin in early 2015. For now, the 2.2-L diesel is offered with power outputs of 150 hp (112 kW) for the eD4 and 190 hp (142 kW) for the sD4. A 2.0-L gasoline

engine is also available rated at 240 hp (179 kW).

The Discovery Sport structure is based on a steel monocoque, but with a

hood, roof, and tailgate formed from aluminum. A single-piece cross-vehicle magnesium beam is used, saving around 7 kg (15 lb) compared with a fabricated

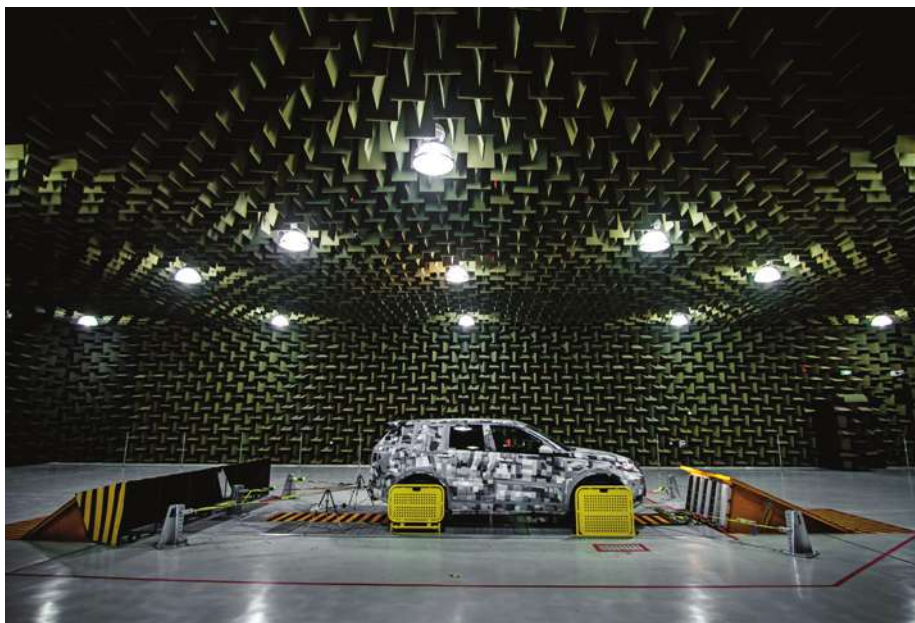


Land Rover claims an SUV first with the hood-mounted pedestrian airbag

Global VEHICLES



Hood, roof, and tailgate are manufactured in aluminum to aid weight reduction



Reduced NVH is one of the benefits of the new multilink rear axle.

steel alternative. Curb weight starts from 1765 kg (3890 lb).

A new lightweight structure is just one of the technical highlights. It's the first smaller Land Rover model to offer up to seven seats, or five plus two (5+2) seating as Land Rover describes it. To accommodate this, Land Rover has designed a new multilink rear axle.

The company claims a first in class for the hood-mounted pedestrian airbag,

fitted as regular equipment, along with Autonomous Emergency Braking (AEB). Although AEB is not yet mandatory for passenger cars in Europe, it will be impossible for new models to gain a five-star Euro NCAP rating in the future if the system is not fitted.

The AEB system uses a pair of stereoscopic cameras to sense objects ahead of the vehicle up to 80 m (262 ft) ahead. The cameras are mounted near the rear-

view mirror behind the windshield.

"When it monitors a potential collision risk, it operates between 5 and 80 km/h," said Cleaver. The system will give an audible warning and a visual warning in the instrument cluster or head-up display. "If the driver doesn't react, it pre-charges the brakes; if the driver still doesn't react, it automatically brakes the vehicle. Up to 35 km/h (21.7 mph), it will avoid a collision altogether and will mitigate collisions up to 80 km/h (49.7 mph)."

Four-wheel drive, using an electronically controlled **Haldex** center coupling, is the regular offering at launch, but this will be supplemented later in 2015 with a two-wheel-drive diesel-powered model badged eD4, with projected CO2 emissions of 119 g/km, measured on the New European Driving Cycle (NEDC).

The Haldex coupling will automatically decouple the rear differential in regular on-road driving, reducing frictional losses in the driveline. When other drive modes are selected using the Terrain Response system, the center coupling is automatically engaged. Four-wheel-drive Discovery Sports will have the choice of a **ZF** nine-speed automatic transmission or **Getrag** six-speed manual. Gasoline powered models are available with the ZF nine-speed automatic transmission.

"The main objective for us has been to develop a very compact SUV," Paul Cleaver, Discovery Sport Vehicle Program Director, told **SAE** Magazines. "A key priority was not to exceed 4.6 m (15 ft) in overall length. When you look at how this car compares with other premium SUVs, it's actually 39 mm (1.5 in) shorter than the Audi Q5, for example. If we look in the rear of the car, this is a 5+2 seater, with rear seats designed for teenagers and occasional use for adults.

"In terms of engineering, Discovery Sport is based off the Evoque platform. So the powertrain architecture, front end, transmission, driveline, all the technologies are based on Evoque, but everything from the heel board backwards is new, including the rear suspension system.

"We've got a new integral link rear suspension, which we have designed from scratch. The concept is the same as

we use on our bigger products, the Range Rover and Range Rover Sport. We've selected that system to afford us the space that we needed in the rear of the car to package the seats. So all the suspension is new and given that we've designed it from scratch, we've optimized NVH (noise, vibration and harshness) and dynamics.

"We've taken the opportunity to optimize those components from a weight perspective. The knuckle and the lower control arms front and rear on the suspension system are hollow cast aluminum components to take weight out of the vehicle.

"So a lot of the focus on the architecture has been around the back end of the car, firstly to get that very compact stance. Proportionally we wanted the car to be the way it is from a design perspective, but then if you look at the occupant package that we've managed to deliver with the +2 seats and the slide-and-recline second row seats, we didn't want to give anything away in terms of interior occupant space."

The second row seats can slide fore and aft through 160 mm (6.3 in). With the second-row seats set in the rearmost position, occupants have 1011 mm (39.8 in) of knee room, compared with 1025 mm (40.4 in) for the Range Rover Vogue. The wheelbase is 81 mm (3.2 in) longer than the Range Rover Evoque, while the car is 91 mm (3.6 in) longer overall than the Land Rover Freelander.

Land Rover claims that the Discovery Sport is the first SUV on the market to offer an external pedestrian airbag. The airbag has a volume of 110 L (3.9 ft³) and operates at speeds between 25 and 50 km/h (16 and 31 mph). Pressure sensors are located in the front fender, connected via a pressure tube. "When the system detects enough force on the pressure tube, the airbag is deployed within 50-60 milliseconds," said Cleaver. "The bag is deployed across the trailing edge of the bonnet and up and around the A-pillars."

John Kendall

Sikorsky's all-new Raider helicopter prototype is ready to fly



Sikorsky Aircraft has unveiled its S-97 Raider helicopter, the first armed reconnaissance rotorcraft featuring X2 technology. Its coaxial counter-rotating main rotors and pusher propeller enable cruise speeds up to 220 knot, more than double the speed of conventional helicopters.

Sikorsky Aircraft unveiled in early October the first of two S-97 Raider lightweight tactical helicopter prototypes. The Raider is targeted to fly by the end of 2014. In 2015 Sikorsky plans to offer the S-97 as a replacement for the U.S. Army's OH-58D Kiowa Warrior helicopter fleet.

The program began four years ago, and since that time military budgets have dramatically dwindled. It was no doubt to the benefit of the program that it was structured as 100% industry

funded to minimize funding risks. Sikorsky provided 75% of the investment, and 53 principal suppliers provided the remaining funding.

"Raider marks the first unveiling of a new relevant rotorcraft configuration in 30 years," said Mark Miller, Vice President of Research & Engineering at Sikorsky, a subsidiary of UTC. "We kept a close eye on lowering development, production, and support costs while increasing productivity and quality. We are looking forward to getting air under its tires and



The single-engine S-97 features a composite airframe and a maximum gross weight of slightly more than 11,000 lb. The cockpit will fit two pilots, seated side-by-side, and its cabin space will carry up to six troops, or additional fuel and ammunition for extended missions.

Global VEHICLES



Sikorsky turned on electrical power to the S-97 in May. At that point, the aircraft was about halfway through the assembly process.



Aurora Flight Sciences delivered the first composite fuselage—consisting of an integrated cockpit, cabin, and tail cone—for the S-97 in September 2013 at Sikorsky's Development Flight Center in West Palm Beach, FL.

expanding the envelope in flight test in the coming months.”

Based on the rotor coaxial design used in Sikorsky's X2 technology demonstrator, the S-97 features next-generation technologies in a multi-mission configuration (armed aerial scout or light assault). The X2 not only proved its capability to reach 250 knot, it also demonstrated low pilot workload and low acoustic signature for increased survivability, says Sikorsky.

Raider is expected to improve on the

X2 demonstrator by showcasing precision maneuvers in low flight speed, high g turning maneuvers at over 200 knot, hot day hover performance at altitudes up to 10,000 ft, and significant improvements in payload and flight endurance compared with conventional light tactical helicopters. Sikorsky cites that the S-97 will offer a 40% increase in payload and a 100% increase in endurance over conventional helicopters.

The fly-by-wire helicopter will feature counter-rotating rigid main rotor blades

for lift and forward flight, and a pusher propeller for high-speed acceleration and deceleration. The latter feature contributes to it achieving cruise speeds up to 220 knot, more than double the speed of conventional helicopters. Dash speeds are expected to be up to 240 knot or higher.

The single-engine aircraft features a composite airframe from **Aurora Flight Sciences** and a maximum gross weight of slightly more than 11,000 lb.

“The Raider fuselage was designed around a set of rigorous requirements necessary for this next-generation aircraft,” said Aurora President and COO Mark Cherry. “We applied our experience developing the composite main rotor pylon for the Sikorsky-built CH-53K heavy lift helicopter, and consequently our understanding of Sikorsky's design and manufacturing methodologies, to influence the Raider fuselage's preliminary and detailed designs, and subsequent development of the associated tooling.”

The cockpit will fit two pilots, seated side-by-side. For armed reconnaissance and light attack missions, the 36-ft long aircraft can carry a variety of sensors and externally mounted weapons, with the flexibility to house additional fuel and ammunition for extended missions. In a light utility or special operations



Global VEHICLES

configuration, the cabin will carry up to six troops.

It was just May when Sikorsky first turned on electrical power to the S-97 at Sikorsky's Development Flight Center in Florida, where the aircraft are being assembled.

The successful powering on meant that the cockpit multifunction displays and control display unit (CDU) were operational, as were the CDU controlled electronic circuit breakers. The aircraft then underwent electrical power and avionics Acceptance Test Procedures to complete the checkout of the remaining avionics, electrical, and flight control systems.

"The aircraft comes to life when power goes on," said S-97 Program Manager Mark Hammond. He also gave a shout out to several Raider suppliers that



In its last demonstration flight conducted in 2011 at the Sikorsky Development Flight Center, the X2 Technology demonstrator gave one last look at its technology in flight before officially being retired and transitioning to its first application, the S-97 Raider.

"played a critical role in achieving the power on milestone," including the **Sikorsky Avionics Product Center, Esterline-Korry, Esterline-Mason, United Technologies Aerospace Systems,**

Lockheed Martin, Garmin, Avionics Instruments, BAE, Honeywell, Pacific Scientific, Northrup Grumman, Meggitt, and LMS.

Jean L. Broge

Hitachi updates dump trucks with more comfort and serviceability features



The latest version of the Hitachi's rigid frame dump truck, the EH1100-5, includes improvements to the operator environment, increased machine serviceability, increased payload, and more remote monitoring capability.

Many legacy features are continued on **Hitachi Construction Machinery's** most recent version of its EH1100 rigid dump truck, the EH1100-5, such as the long-life and highly compressible NeoconE/ Helium suspension strut fluid, the roboti-

cally welded fully fabricated box section frame, the trailing arm front suspension, and the body floating hinge pin design. All those features are included on Hitachi rigid frame trucks regardless of size says the company.

The EH1100-5 also includes improvements to the operator environment, increased machine serviceability, increased payload, and more remote monitoring capability.

As with other large Hitachi mining



Global VEHICLES

The latest version of the Hitachi's rigid frame dump truck, the EH1100-5, includes improvements to the operator environment, increased machine serviceability, increased payload, and more remote monitoring capability.



trucks and shovels, the EH1100-5 is equipped with a 250-mm (10-in) LCD display to provide the operator with information regarding hauling performance and systems condition. Offsetting the LCD display to slightly right of the steering column allows the lowering of the dashboard in front of the operator for better visibility to the front of the truck. Communication via CAN bus allows rear view camera monitoring through the LCD display and reduces the amount of wiring required throughout the truck.

Two new safety features for the truck include the cab's ROPS (roll over protection structure) being redesigned to meet the requirements of using the EH1100-5 as a water truck and three-point seat belts being built into each type of seat Hitachi offers on the EH1100-5.

A mechanically hinged hand rail at the front of the cab can be positioned to provide the operator with optimum haul road visibility while the truck is in operation, or positioned to provide fall protection during cab area service. Operator noise exposure has been significantly reduced through the use of cab sound material and exhaust system modifications.

Many steering and brake system valves and test ports have been relocated from the mid-frame of the truck to the service deck for easier service and troubleshooting access. The steering filter is now located outside of the frame allowing service personnel the same ground level service access as is offered with the hoist filter.

The two high-capacity 12-V batteries have been moved to the front bumper for ground level access. Electronic maintenance and troubleshooting is available in various languages using the operators LCD in the cab.

Two body prop pins replace the single prop cable that has been the only means of propping the body up in the past. The 24-V relay box and circuit disconnect are located at ground level for easy service access.

For the market outside of North America, customers can choose between an **MTU** Series 2000 engine and a **Cummins** QSK23 engine. Within North America, the choice is limited to the Cummins QSK23 engine. The H6620A model automatic transmission offered by **Allison** offers improved shift quality, less shifting when empty, and upgraded components all resulting in longer life

before rebuild.

The EH1100-5 body is now designed to a volume of 41.5 m³ (55.6 yd³) and has a flat floor-plate for more control of material shed while dumping. The nominal payload recommendation for a standard equipped EH1100-5 is 63.5 t (70 ton)

The EH1100-5 rear wet disc brake assemblies now include an integral wet disc parking brake. While redesigning the rear wet brakes, Hitachi added brake surface area to increase service braking and retarder power.

Active traction control on the EH1100-5 has been refined to better control wheel spin in wet and muddy conditions resulting in improved haul cycle times and increased production.

All EH1100-5 trucks are equipped with a DLU (data logging unit). This allows remote monitoring of the truck via satellite, Wi-Fi, and Wenco.

Hitachi also now offers a speed limit feature that automatically restricts the truck top speed to a customer determined limit. This feature will automatically apply the retarder to control the set speed limit if the limit is exceeded while travelling downhill.

Jean L. Broge

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Q&A



Dr. Ken Washington is Vice President of Research and Advanced Engineering at Ford Motor Co. Appointed in August 2014, he leads Ford's worldwide research organization, overseeing the development and implementation of the company's technology strategy and plans.

Leading Ford's drive for innovation

Filling the void left by 32-year **Ford** veteran Paul Mascarenas, Dr. Ken Washington (**SAE** member, 2014), former Vice President of the Space Technology Advanced Research and Development Laboratories at **Lockheed Martin Space Systems Co.**, in August assumed the role of Vice President of Research and Advanced Engineering at the Ford Motor Co. Charged with overseeing the development and execution of the company's technology strategy and plans, Washington will pull from research and advanced engineering experience gained over the course of his 28-year career at Lockheed Martin and **Sandia National Laboratories** in the areas of nuclear engineering, information systems, super-computing, information privacy, and R&D space technologies. Two months into his post, Washington spoke with SAE Magazines editor Matthew Monaghan about his thoughts on technology transfer, innovation, and STEM outreach. For the transcript of the full interview, visit <http://articles.sae.org/13625>.

Coming from the aerospace and defense field, what was it about this position at Ford that made it appealing enough for you to make the switch?

I had been in aerospace and defense my whole career, so it was quite a surprise when I had the opportunity put in front of me. I quickly began doing a lot of research about the company, its history, the transformation that it went through, and its strategic focus, vision, and products, and the more I read the more excited I got. My experience over the last two months here has validated everything that I've read. It's a great company, and we make great products. We've got a solid plan that everybody understands and is working toward. How could you not like working for a company that has all that going for it? It's just been a really wonderful transition for me.

What has surprised you most thus far about the shift from space to automotive?

The most pleasant surprise has been the degree to which inno-

vation is really baked into the culture of the company. It's been in the DNA of Ford for a long time, and that's evident in how the leadership talks to each other, how we talk to people, and what we care about. [President and CEO] Mark Fields has been very explicit in talking about his focus, which is to have continuity of the One Ford plan and to accelerate that plan. The surprise for me is he follows that pretty quickly with the focus on innovation in everything we do, and it's a real pleasant surprise to have that laser-like focus on innovation. The challenge for me and my team then is to take that focus and fulfill the vision with real projects that are exciting, that matter, and make it into our vehicles and that create the building blocks for the future of our products.

Between autonomous technologies, alternative powertrains, lightweight materials, and in-car entertainment, how do you focus your resources?

The focus comes from having a clear understanding of where the company is going. The Ford plan is unchanged from when it was put into place some time ago. Mark's focus is to accelerate that plan. So how I translate into our priorities are the technologies that are aligned with that plan and where you can see the line of sight between the technology work that we're doing and the priorities for building high-quality, safe, green, smart cars, those are the projects that get the primary focus and attention.

The priorities that I've given myself coming into the role, as I've reviewed the whole portfolio, have been to really focus on some of the smart things that we're doing in terms of connected cars and mobility, and in the areas of green we're doing some work developing future powertrain solutions in the fuel cells. That has been an area where I really needed to put some focus and attention because it's going to be part of our future solution. There's been a lot of attention in driver-assist technologies. Behind the scenes, we've been doing research in taking that to the next level in terms of developing technologies that will enable a car to provide an autonomous vehicle experience. We're not ready to announce anything at this point, but we clearly have a very active research portfolio going on in that area.

You have a passion for STEM education, and one of the ways you mentioned about helping to address the issue is getting staff "engaged." What are the benefits of that engagement, and how do you proactively get your staff to take part?

When it comes to innovating in any space, it comes down to having the right talent on the team. The men and women that make up our workforce all understand that. It's very easy for me to be an advocate and executive champion for STEM because I think the entire workforce understands that it's just good business. As we look to hire new talent to bolster and continue to advance our team, having the right advocacy about STEM education simply enhances our pipeline of employees. It connects us with the right universities; it gets our message out to the community in a way that puts the Ford name in front of people who want to go into STEM careers. I'm looking forward to engaging on the STEM front and being a spokesperson for the company in that space.



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