SAE INTERNATIONAL

UPDATE

NEWS & INSIGHTS FOR MOBILITY PROFESSIONALS

Dr. Bala Bharadvaj

Dr. Mingchao Guo

Dr. Yichao Guo

Mr. Steve Holland

Dr. Heejung Jung

Held in the highest esteem

Fifteen engineers cement their mobility industry legacies by being elected SAE Fellow.

Prof. Dr. Hiroshi Kawanabe

Dr. Imad Khalek

Dr. James McCarthy Jr.

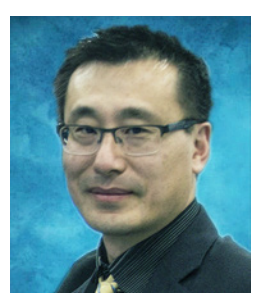
Dr. Eric D. Pomraning

Mrs. Jennifer Rumsey

Dr. Riccardo Scarcelli

Mr. Scott Schmidt

Dr. Greg Shaver



Dr. Gavin Song

Ms. Rhonda Walthall

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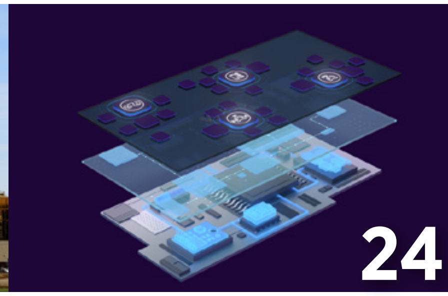

On the cover

Introducing the 2021 class of SAE Fellows.

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Mission inspires the quest

The quest for meaning drives many human beings. It differentiates our species from other living beings.

What about the meaning for an organization? The closest you will find is a "mission statement." No matter if you work for a large organization or a small one — or even if you form a new startup in pursuit of your entrepreneurial dream — having a compelling mission statement is critical. Read the mission statement of any business or organization, public or private. They are generally aspirational, and purport to present a benefit to society. What these statements truly mean is not always understood by many. Even among those who understand and can recite the mission statement verbatim, how this translates into their daily work isn't always clear. This is where connecting the mission to strategy and operations becomes critical.

Some mission statements are so lofty that they serve only as feel-good lines. Some are so detailed that, aside from a few, most people don't remember what it actually says or means. Some drive inspiration, others cause perspiration.

A well-designed mission statement stands the test of time. Notice I said "well-designed," not "well-crafted." The latter is easier to achieve.

How do you design a mission statement that truly stands the test of time? Being clairvoyant isn't necessary, but there are many things an organization can do. The best mission statements, in my experience, share the following traits:

A) Meaningfully brief

You want the mission statement to be short enough to be memorable and meaningful enough to appeal to a broad cross section of internal and external stakeholders. Avoid complex words, esoteric terms, and obscure phrases. The mission statement should ideally evoke emotional vesting for both experienced and new employees alike, while being positively memorable for all others.

B) Identifies the benefit

The mission should clearly identify what is the ultimate benefit that the world, society-at-large, or even a target group would get from the organization pursuing its mission. The best mission statements identify who and what would benefit with unmistakable clarity. All stakeholders, particularly the markets that the organization targets, should agree that the benefit cited in the mission is truly valuable.

C) Identifies the means

Identifying the benefit without the means can make a mission statement appear too ethereal or idealistic. After all, every organization must operate within a focused framework of opportunities and market-justified position it seeks to carve out for itself. The means is how the stated benefit will be realized. Including the means makes a mission statement grounded.

D) Ever forward-looking

The best mission statements have an ever-fresh hue, making them inspirational and aspirational at the same time. A mission statement that can do this both for this year and for the next 100 years is not easy. Such a timeless mission statement envelops generations of technological and societal advancements in the future. The challenge here is to achieve this while complying with B) and C) above, which themselves are subject to market forces.

E) Call for action

A mission statement should serve as a clarion call for action. It should preferably have an action verb that can be used to drive strategy and conveys a sense of momentum.

F) Unconstrained specificity

This may sound oxymoronic. People are attracted by specificity, as it provides clarity and encourages deeper convictions among those who are inspired by such a mission. Yet, a mission statement that is too specific risks limiting the growth potential of the organization and risks becoming obsolete as markets, society, and technologies evolve. Achieving specificity without hampering constraints is a key goal.

G) Internally and externally consistent

It is disconcerting to have a mission that meets all the above criteria and yet is not consistent with the DNA

SAE International

At a February meeting, SAE President Sri Srinath explained to staff his plans for carrying out SAE's mission in 2022.

of the organization. This also refers to the cultural dimension that doesn't get as much visibility in the quest to draft a "perfect" mission statement. Having a great mission without supportive organizational and cultural frameworks is like designing a great car with serious manufacturing defects.

SAE International's mission statement, "Advance mobility knowledge and solutions for the benefit of humanity," is an example that scores well on all the above traits. Our mission remains ever fresh, ever inspiring, and ever forward-looking. More than 115 years since our inception, our organization is still guided by these words. Every strategic plan that our organization develops is anchored by our mission.

Diversity, equity, and inclusion (DEI) is an important focus area for most organizations today, and many have DEI policy statements or strategies in place. What works best, in my opinion, is when the organization's mission is intimately tied with DEI. In SAE's case, our mission covers "humanity" right in the statement. There are few things more inclusive or diverse than all of humanity. Equitable access to all mobility knowledge and solutions is an implied goal in our mission. Not all mission statements allow for DEI to be naturally covered, but having that as an organic objective is inspiring.

A mission statement represents the organization's quest for meaning. Much like an individual's quest for meaning, it is a "spiritual" endeavor because you are capturing the spirit of the organization in one phrase. If it doesn't, it is worth casting aside the current mission statement that doesn't meet all the criteria and starting afresh to develop a new one. This is not easy work but may be necessary in some organizations, as a mission that is meaningfully connected to why it exists is fundamental to all strategic planning.

The right mission statement for an organization isn't developed from one executive retreat. Neither is this a "project" of a "task force" or a "steering committee." A truly worthy mission statement takes time to develop, alternating between deep introspection by the leaders and wide consensus seeking with a diverse group of stakeholders, including those who have been part of the organization during the pivotal moments of its history.

The process is messy, and at times chaotic, but the outcome will be beautiful.

How do you know you have it? Much like Michelangelo's David, you know you have it where there is nothing left to chip away or add. In practical terms, you will have it when everyone who reads or hears the mission statement feels it resonates with them in some deep way that makes them want to be part of the organization, whether they joined 30 years ago or is interviewing for a new position now. ■

Dr. Raman Venkatesh, COO, SAE International, wrote this article for *Update*.

Regulatory CO_2 emission standards are needed for BEVs

BEVs don't have tailpipes and, as a result, they erroneously register as zero CO_2 under today's regulations.

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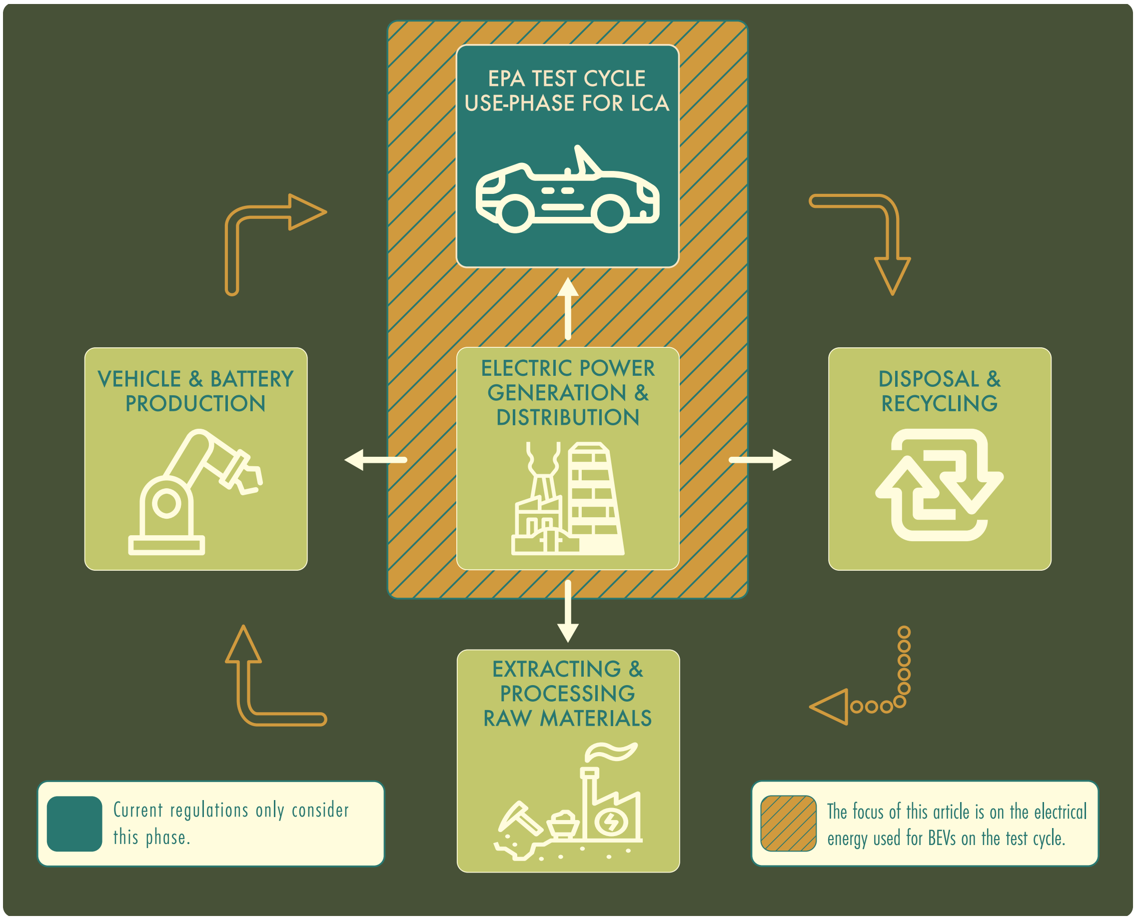
The original EPA certification test procedures from the 1970s were developed to regulate criteria pollutants exhausted from vehicle tailpipes and fuel economy of internal combustion engines. At the time, this made sense—liquid-fueled internal combustion engine vehicles (ICEVs) dominated the market, there were very few battery electric vehicles (BEVs) available, and CO_2 was not yet regulated as a greenhouse gas (GHG). Fast forward to today, and we still regulate based on the tailpipe alone. But this once-logical methodology no longer adds up. BEVs don't have tailpipes, and as a result, they erroneously register as zero CO_2 under today's regulations. (Please refer to an article I wrote in the August 2021 issue of *Update*).

Classifying BEVs as "zero emission vehicles" is simply not correct when you consider the entire system, which includes electrical power generation and distribution. All the elements of lifecycle analysis (LCA), as shown on page 7, must be considered to fairly compare the CO_2 emissions of BEVs to ICEVs or even hybrids. After all, the planet doesn't care where the CO_2 comes from; it only cares that it's in the atmosphere. Therefore, the essential question our regulations should address is this: What is the total CO_2



Johnson and Senecal

All the elements of Life Cycle Analysis (LCA) shown in the figure must be considered to fairly compare the CO2 emissions of BEVs to ICEVs or even hybrids.

impact (wherever it may come from) per mile driven for a given vehicle? Unfortunately, our current regulations, not designed with BEVs in mind, are asking the wrong question—the tailpipe is only part of the story.

We won't try to tackle the entire LCA in this article, but we will comment on one of the larger contributions to a BEV's climate impact that is missing from today's regulations: emissions from the electricity generated to charge the battery.

For a thorough definition of LCA, read the sidebar on page 8.

Electricity generation must be included if we hope to have a technically fair way to certify and account for BEVs in our efforts to reduce the carbon footprint from driving.

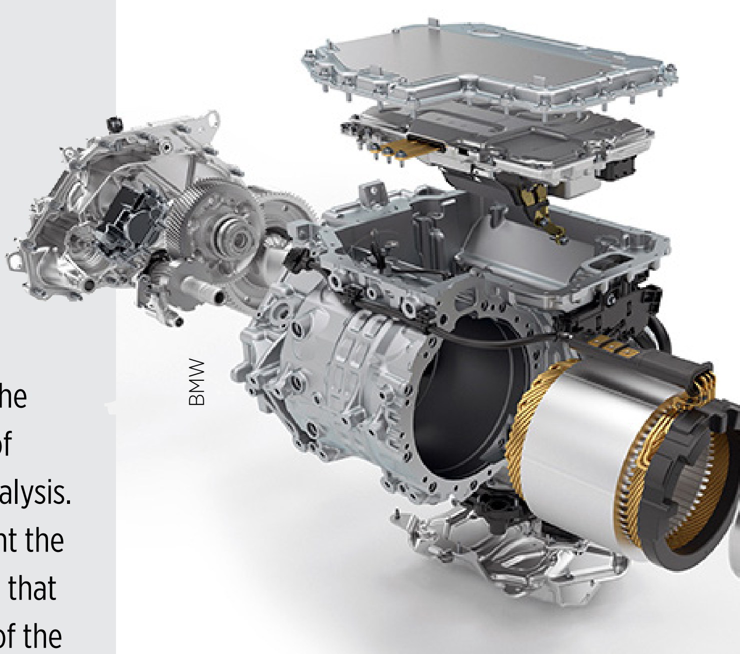
How do we do this? Accounting procedures need to be developed for electric vehicles that include generation. A proper method in today's regulatory framework would account for the CO_2 emissions associated with the energy consumed over the vehicle certification test cycles. Test cycles today already determine the energy consumed by the vehicle. Combining this measurement with the equivalent CO_2 emissions from the electrical grid used to charge the vehicle (e.g., g CO_2/kWh), the CO_2 emissions in g/mile for the test cycle can be calculated.

Of course, the devil is in the details. How we convert the used battery energy to CO_2 will have a major influence on the outcome. The quickest way to perform this conversion would be to use the emission rate from the U.S. average electricity mix (which according to the EIA in 2020 was 386 g CO_2/kWh). But while this approach is easy, it can suffer from large errors (see Holland et al., Proceedings of the National Academy of Sciences, 2022 and Burton et al., SAE International Journal of Electrified Vehicles, 2022). Instead, we advocate for a regional approach based on total demand response (including demand from adjacent regions) to determine the appropriate emission rate, as outlined by Burton et al. (SAE International Journal of Electrified Vehicles, 2022). This methodology is baselined with current data and could consider future projections of the electrical grid. However, as it is difficult to predict the future, and considering that liquid fuels for ICEVs will also become greener over time, we caution against including too much projection in the conversion. The methodology and data the standards use to convert the electrical energy at the plug to CO_2 could be updated periodically (e.g., every five years).

This change in the approach to BEV regulations needs a technical investigation by an independent committee that is not tied to industry or government because of the implications of the change. We think this study can best be

What does life cycle analysis mean?

As described by Senecal and Leach in their book ***Racing Toward Zero: The Untold Story of Driving Green*** (2021), LCA is a methodology that accounts for the environmental impact of a product or process across all of its phases from creation to disposal. For a car, this starts with the raw materials needed to make the vehicle (and its fuel) and any processing required. It continues with the manufacturing and distribution of the vehicle and its components. Next comes the use-phase of the vehicle—the phase that is typically considered for analysis. However, we must broaden our scope to take into account the fuel the vehicle uses and any processing and distribution that fuel may require. Finally, we must consider the disposal of the vehicle and its components.



Cutaway of BMW's latest d-drive system, now in its fifth generation.

carried out by the National Academies (NA) Board on Energy and Environmental Systems (BEES). A recent NA Report discusses scenarios of GHG regulations for the electricity sector in the context of the light-duty fleet (2021 report titled "Assessment of Technologies for Improving Light-Duty Vehicle Fuel Economy 2025-2035"); however, what is outlined in that report is based on emission caps or emission rates from standards. We support an approach that uses the actual electricity emission rates from charging as a result of the regulatory test.

Several statements of task that could be considered in our proposed study are:

1. LCA studies of electrified and internal combustion engine vehicles to optimize future GHG emission reductions in the light-duty transportation sector.
2. The technical approach to account for CO_2 emissions from BEVs in the EPA certification process to meet Federal emission standards.
3. The implication of electrified vehicles to the consumer over the life cycle of the vehicles.
4. The geographical locations and types of use where BEVs will best optimize GHG emission reductions and be optimal for consumers.
5. The likely growth of the various types of electrified vehicles in the 2025 to 2040 time frame.

Nissan

With its seminal Leaf EV, Nissan was an early advocate of bi-directional charging for a variety of V2G functions.

By performing this study, and ultimately implementing its results into vehicle regulations, we hope to have a much more equitable comparison of the climate impact of various powertrain technologies. This will significantly benefit both the planet and the consumer as we move toward decarbonizing transportation. ■


This article was written for *Update* by John Johnson, Presidential Professor Emeritus, Michigan Technological University, and by Kelly Senecal, Visiting Professor, University of Oxford.

SAE and Ohio Aerospace Institute Sign memorandum of understanding

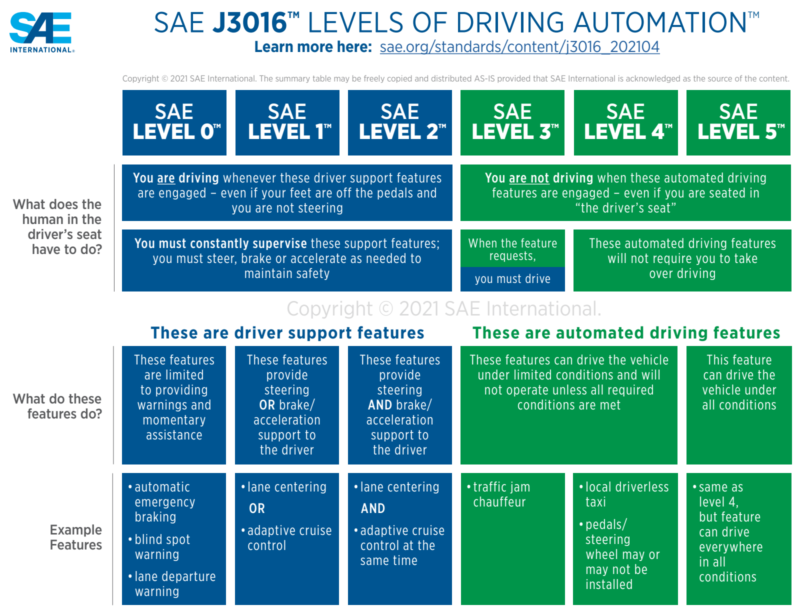
SAE International and the Ohio Aerospace Institute (OAI) are pleased to announce the signing of a memorandum of understanding (MOU) to collaborate and cooperate in areas of mutual interest serving the members of both organizations with a key focus on promotion of aerospace standards related activities. The collaboration will also explore areas for partnering on cross-member communications including events, training, pre-professional education and membership, bringing greater value to the aerospace industry.

"SAE International is delighted to establish this partnership with OAI. With a history of technical leadership in SAE standards committees from industry, government and research in a region spanning the birth and future of aviation, we look forward to continuing to partner with Ohio's aerospace sector to promote consensus standards and technical knowledge, encourage professional development and draw mutual member benefits," said David Alexander, director, aerospace standards, SAE International.

"OAI is excited to work with SAE International to help educate organizations about the latest requirements and standards. The goal of our partnership is to help manufacturers become more competitive in the aerospace supply chain; and introduce information to interested students. It is a pleasure working with the knowledgeable and professional individuals at SAE International. We look forward to a successful long-term relationship," said Kim Holizna, director global development & programs, Ohio Aerospace Institute.

The Ohio Aerospace Institute is a nonprofit 501(c) 3, the first NASA associate collaborative institute chartered to foster relationships between industry, education and works with government agencies. Within the organizations 32 years of experience in aerospace research, education and workforce development, while building and managing collaborations, consortia and public and private relationships. The organization will soon launch the Ohio Aerospace Industry Association, further connecting businesses, government and academia to streamline and improve supply chain management. For more information, visit OAI's website at www.oai.org. ■

SAE International intensifies efforts to protect intellectual property



SAE International

SAE International, in the course of serving its mission to advance mobility knowledge and solutions for the benefit of humanity, creates numerous copyrighted works and owns various trademarks, patents, and other valuable intellectual property (IP) rights related to its technical standards, publications, training courses and many additional products in the aerospace, automotive, and commercial-vehicle industries and allied technology domains. SAE considers its IP in these areas among its most valuable assets and is increasing its efforts to protect it.

"With the vast amount of advanced technical content SAE produces, SAE's IP portfolio is growing significantly and we invest considerable resources on it," said Raman Venkatesh, executive vice president and chief operating officer, SAE International. "As violations are discovered, we work with our internal legal team, as well as outside counsel when necessary, to work towards an amicable solution that advances our mission while protecting SAE's IP."

SAE's J3016™ Levels of Driving Automation is an example of SAE IP that is often used and referenced by other organizations. SAE permits this chart (shown above and here) to be used freely, so long as it is used as-is and appropriate attribution is given to SAE.

When referencing a level in this chart, SAE should be included as a prefix. The proper use would be SAE Level # or SAE International's Level #. Simply calling 'Level #' or 'L#' are in violation of SAE IP policy.

"SAE was recently notified that an organization had improperly created and distributed a derivative work based on SAE's J3016 Levels of Driving Automation chart," said Greg Bradley, SAE general counsel. "We took swift and appropriate action to ensure that the improper use was resolved, and will continue to do so."

For complete details of SAE's IP policy, please click here. ■

SAE International

Jennifer Rumsey is one of two women in the 2021 class of SAE Fellows. Here she speaks at COMVEC 2019.

Held in the highest esteem

Fifteen engineers cement their mobility industry legacies by being elected SAE Fellow.

In their own ways, each engineer in SAE International's 2021 class of Fellows has made a positive, distinct, and sustaining mark in the mobility industry.

"SAE Fellows—and the contributions they make to the ongoing vibrancy of the mobility industry—warrant special recognition and our deepest reverence," said Nicole Iorfido, the SAE staffer who managed the SAE Fellows program. "And there's no greater and lasting honor in the world of mobility engineering than being elected SAE Fellow. The distinction ensures that the names and impact of these individuals will forever be revered within SAE and the larger mobility engineering community."

"That said," she added, "SAE is a foward-looking organization. It's my feeling that SAE Fellows are a credit not only to industry's past, but also to its future.

In the 2021 class, 15 SAE Fellows were cited for their achievements in the automotive sector (11), the commercial vehicle sector (2), and the aerospace sector (2)—although there are varying degrees of industry overlap for certain Fellows.

Implemented in 1977, the SAE Fellows program has honored a total of fewer than 1,000 individuals over the years since, "making it a distinction eminently worth celebrating," Iorfido said. "Typically, each

SAE International

For each COMVEC event (2021 shown), James McCarthy invites four Eaton student interns to make presentations reporting on their research.

new class of SAE Fellows is recognized as part of a reception/dinner/ceremony event held in conjunction with the subsequent year's WCX World Congress Experience in Detroit. COVID-19 made it impossible to hold the ceremony in 2020 and 2021, but we are locked in and moving forward with the exclusive affair on April 4."

Read on for the citations of each 2021 SAE Fellow.

Dr. Bala Bharadvaj,
Boeing Research Technology India

"In recognition of inspirational leadership, collaborative research, and service to the community for the advancement of engineering and technology for aerospace applications."

Nominated by Dr. Richard W Greaves

Dr. Mingchao Guo
FCA US LLC

"Dr. Mingchao Guo has developed CAE modeling and analysis methods and techniques for automobile structure and joint fatigue with consideration of nonlinearities. He has made substantial contributions to the SAE community and publications in the areas of material modeling and testing, structural strength and durability, lightweight metals, and composites."

Nominated by Dr. Yung Li Lee

Dr. Yichao Guo
Stellantis NV

"Dr. Guo is well recognized for his crucial role in the evolution of automotive on-board diagnostics (OBD). He is not only the author of tens of influential invention patents and technical publications, but also a contributor to the advancement of OBD technology throughout SAE."

Nominated by Dr. Zhe Wang

Mr. Steve Holland
Principal Consultant

"Steve Holland's technical/leadership efforts helped launch GM's OnStar Proactive Alerts, a landmark IVHM system deployed on millions of GM vehicles. He has been a leader in SAE's IVHM standards and is chair of SAE's HRCS Consortium. He developed the first vision-guided robots in the automotive industry."

Nominated by Mr. Tim Felke

Dr. Heejung Jung
University Of California Riverside

"Recognized for his expertise and work in vehicle emissions for new emissions standards and new emissions measurement methods. He is also recognized for his expertise, work, and leadership in vehicle cabin air quality."

Nominated by Dr. Chris Mi

Prof. Dr. Hiroshi Kawanabe
Kyoto University

"Prof. Dr. Hiroshi Kawanabe is distinguished in his understanding and modeling of the in-cylinder, non-uniform turbulent combustion process, based on data obtained by laser diagnostics, etc. He has established novel numerical models such as diesel combustion sub-models for computational fluid dynamics, and a simplified 1-D diesel combustion model for engine systems."

Nominated by Dr. Yasuo Moriyoshi

Dr. Imad Khalek
Southwest Research Institute

"Dr. Imad Khalek is a recognized world expert in measurement of particle emissions from combustion sources. His work on dilution, partial flow, filter media, and PEMS has been incorporated into CFR Part 1065. His catalytic stripper technique has been incorporated into the EU regulations."

Nominated by Dr. David B. Kittelson

Dr. James McCarthy Jr.
Eaton

"Conserving fossil fuels & reducing emissions by innovating across the vehicle powertrain including engine development (common rail fuel injection, valvetrain, EGR & air management), aftertreatment systems and vehicle NVH while demonstrating technologies to meet upcoming standards starting in 1998 at 4.0 g/hp-hr NOx to 2027 at 0.02 g/hp-hr NOx."

Nominated by Dr. Dan Williams

Dr. Eric Douglas Pomraning
Convergent Science Inc.

"Recognized for his leading role in the creation of advanced computational fluid dynamics software used for the design of cleaner and more efficient propulsion systems. Dr. Pomraning is a world leader in developing turbulence and combustion modeling approaches for reacting flow devices."

Nominated by Dr. Kelly Senecal

Mrs. Jennifer Rumsey
Cummins Inc.

"For advancing innovative diesel power systems, emissions control, and efficiency technology; influencing the diversification of Cummins' product offerings; charting the company's path to a decarbonized future; leading a Fortune 150 company during a period of crises; and remaining focused on the well-being of employees, the business, and our environmental impact."

Nominated by Dr. Donald Stanton

Dr. Riccardo Scarcelli
Argonne National Laboratory

"Dr. Scarcelli has optimized advanced combustion concepts with low-carbon and no-carbon fuels like natural gas and hydrogen via high-fidelity simulations leveraging high performance computing. Recently he has developed predictive models for advanced ignition systems for high-efficiency engines which are being transitioned to industry demonstrating impact. Dr. Scarcelli has also provided 10+ years of excellent service to SAE, as a lead session organizer and chair at multiple SAE events, and recently as a vice chair of the Engine Combustion Committee, therefore enormously contributing to the SAE mission."

Nominated by Dr. Sibendu Som

Mr. Scott Schmidt

Automotive Manufacturers Equip Compl Ag

"Scott Schmidt's professional and SAE leadership accomplishments have strengthened the SAE Mission and Vision in vehicle and highway safety, mobility access, and engineering education. Without Scott, ground vehicles would clearly be less safe and accessible; his innovations in developing and sustaining student engagement in SAE programs would not exist."

Nominated by Mrs. Emily Reichard

Dr. Greg Shaver

Purdue University

"Prof. Greg Shaver has performed ground-breaking research on internal combustion engines, hybrid-electric powertrains, and vehicle automation systems. His work on novel control strategies, especially on variable valve actuation, is highly valued by both industry and regulatory agencies and has had a major impact on the design of next-generation commercial engines."

Nominated by Dr. Dan Williams

Dr. Gavin Song

Ford Motor Company

"Dr. Song is recognized for his significant contribution to CAE innovative methodologies on 1) fuel tank — innovating the methodology to integrate the transient dynamic durability analysis under proving ground conditions with Arbitrary Lagrangian-Eulerian algorithm to simulate fuel sloshing with fuel and fuel vapor interaction; 2) body and chassis — analyses of durability, NVH, safety, and optimization, which have good correlation with testing and weight-saving. He consistently shows technical leadership in organizing CAE technical sessions for 16 years, CAE technical panel discussions, and live seminars at SAE world events."

Nominated by Dr. Pranab Saha

Ms. Rhonda Walthall

Collins Aerospace

"In recognition of her career achievements, extraordinary contributions, and distinguished leadership in the field of prognostics and health management for aircraft, impacting the landscape of PHM in the aerospace industry through her service to SAE andPHM Society, and achieving regulatory acceptance of PHM."

Nominated by Dr. Richard W Greaves

Farewells

News has reached SAE International of the passing of the following SAE members.

Keith Armstrong, 23 years of SAE membership

Norman Beachley, 52 years of SAE membership, SAE FELLOW

Tom Birch, 18 years of SAE membership

Brian Cohen, 1 year of SAE membership

Albert Ebi, 55 years of SAE membership

Arthur Gardiner, 47 years of SAE membership

Eduardo Godinho, 25 years of SAE membership

Chuck Greening, 8 years of SAE membership

Steven Hahn, 29 years of SAE membership

Juan Herrera, 44 years of SAE membership

Frank Jamerson, 52 years of SAE membership

Richard Johnson, 41 years of SAE membership

Steve Kraus, 55 years of SAE membership

William Kreider, 63 years of SAE membership

Joe Latas, 50 years of SAE membership

Loren Mathews, 46 years of SAE membership

Neil Newman, 63 years of SAE membership

Larry Peiffer, 51 years of SAE membership

George Piness, 71 years of SAE membership

William Stebbins, 64 years of SAE membership

James Swain, 47 years of SAE membership

James Swanson, 48 years of SAE membership

Jeff Swanson, 45 years of SAE membership

Mark Sztenderowicz, 39 years of SAE membership

Rolland Westra, 60 years of SAE membership

Steven Wittau, 16 years of SAE membership ■

Past SAE president passes away

Ronald K. Leonard was the SAE president in 1998. At the time of his recent death, he had been an SAE member for 55 years.

Only a few of SAE International's presidents had a formal education in agricultural engineering. Leonard was one of them. At Deere, he eventually became the senior division engineer of the cotton harvesting division. Later at Deere, he became director of worldwide agricultural tractor & component engineering. ■

TECH FOCUS: **SOFTWARE**

"A seminal moment…was Tesla's decision to allow for over-the-air updates."

-Dr. Rahul Razdan

IN THIS SECTION

EMBEDDED SYS IN THE AGE OF

The popular SAE Edge Report, "Unsettled Issues Regarding Autonomous Vehicles and Open-Source Software," explored the emerging role of software and specifically open-source software in autonomous vehicles. This trend is actually part of a much longer and deeper trend of the infusion of electronics into a larger range of embedded systems. In this article, we will explore these broader trends and the impact on SAE's home markets in the aerospace and automotive space. These general lessons also apply to a broader range of markets such as commercial vehicle, industrial, defense, and medical.

Electronics historical mega-trends

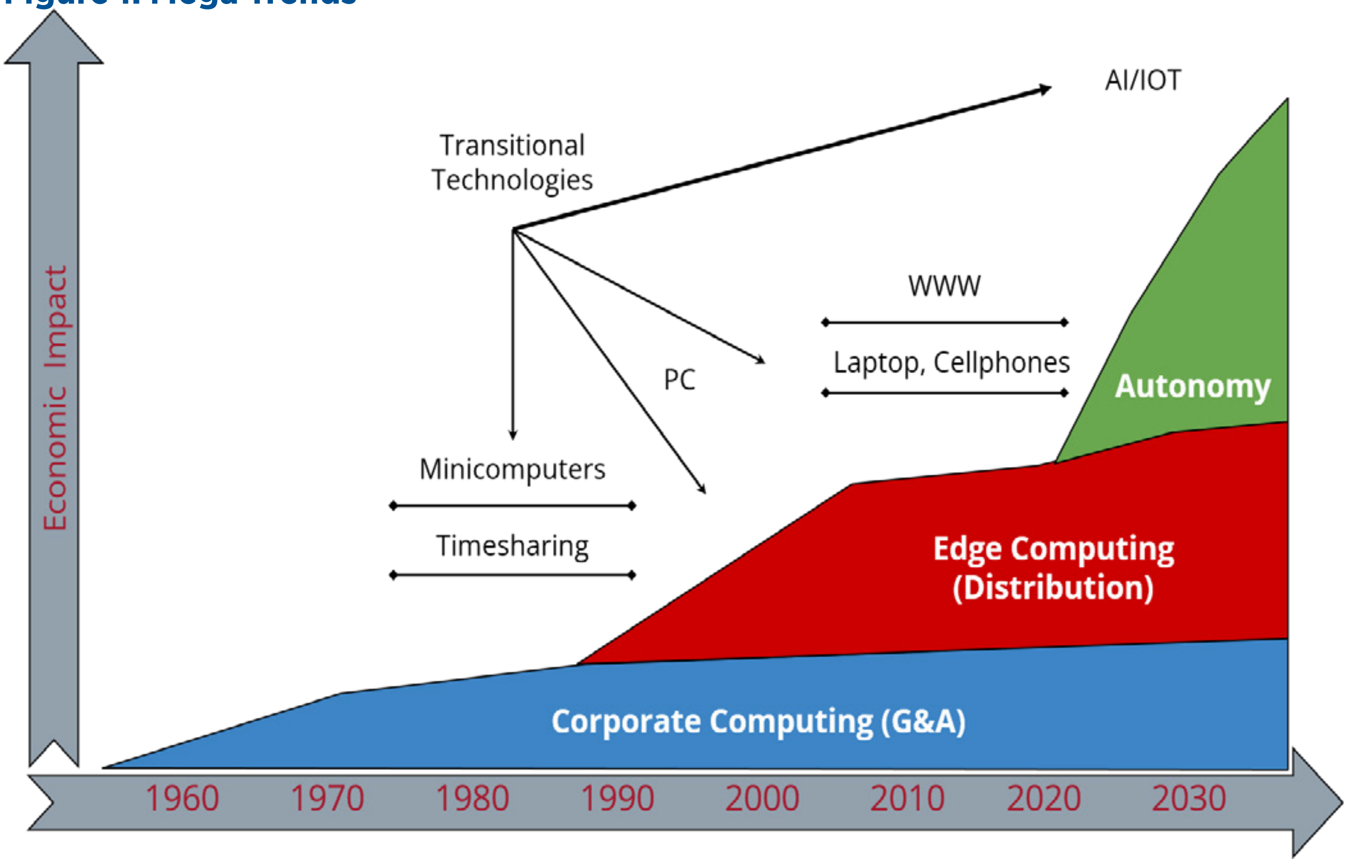
Before starting, a bit of historical analysis is required. Over the last 70 years, computing solutions have fundamentally shifted major parts of the world economy. As shown in blue (Figure 1, page 19), the

ABOUT THE AUTHOR

Dr. Rahul Razdan is a seasoned scientist and business executive who has had significant roles in the world of academia, startups, and fortune 500 companies. Currently, he is the founder and chief technical advisor for Anew Design Systems and he runs an active research institute (www.razinstitute).

TEM DESIGN CHALLENGES OPEN-SOURCE AND AI

Figure 1: Mega Trends



Dr. Rahul Razdan

first wave of electronics consisted of centralized computing and the leaders in the field included companies such as IBM, Digital Equipment Corporation, Wang, and others. Fundamentally, these technologies provided productivity solutions for the administrative (G&A) functions for the global business enterprise. With this shift, the finance, human resources, and administrative functions of global business were disruptively impacted. Gone were the days of a sea of admins doing paperwork.

The next wave consisted of edge computing devices (red in Figure 1) such as personal computers, cell phones, and tablets. With this capability, companies such as Apple, Amazon, Facebook, Google, and others could add enormous productivity to the advertising and distribution functions for global business. Suddenly, one could directly reach any customer anywhere in the world. This mega-trend has fundamentally disrupted markets such as education (online), retail (ecommerce), entertainment (streaming), commercial real estate (virtualization), health (telemedicine), and more.

Today, we are at the beginning of the next major disruptive cycle caused by computing. This cycle consists of embedded sensory devices (sometimes known as Internet of Things), local intelligence systems (sometimes known as machine learning), and global intelligence (sometimes known as cloud resources). Broadly called AI/IoT, these three technologies are in the process of disruptively impacting nearly every market segment where in-field sensing with computation can solve interesting problems. Medical, mining, agriculture (land or ocean), space operations, and of course autonomous vehicles are examples.

The sheer size of these mega-trends have driven significant investments resulting in order-of-magnitude acceleration of innovation and development of significant supply chains. For electronics, the critical industry is semiconductors where the combination of technology innovation (Moore's Law) and investments ($billions) has delivered massive functionality. As a result, today, semiconductor makers can easily build billions of devices onto a single chip.

How does one manage billions of entities in a design process, and how about the cost of doing so?

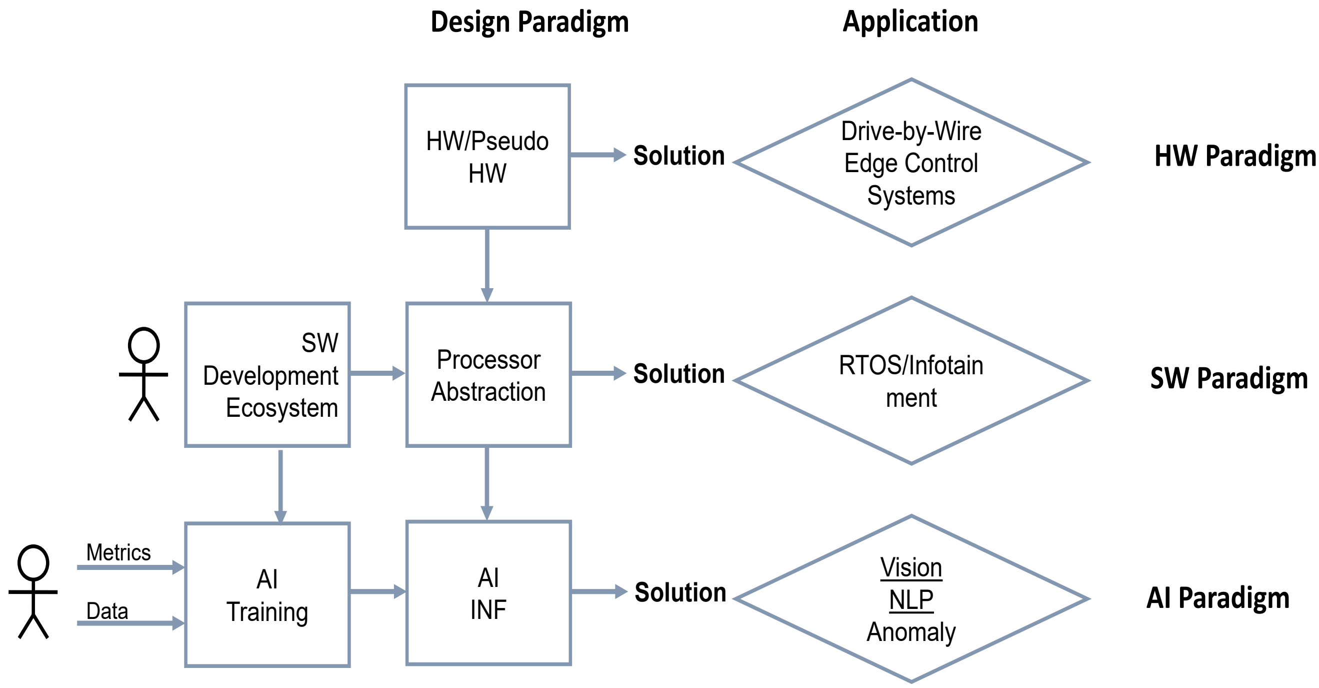
Akin to building a city, designing a modern high-end semiconductor chip is an expensive technological challenge. To manage the complexity of design, a multi-billion dollar industry called electronic design automation (EDA) was created. To manage cost, the semiconductor industry has developed the idea of platforms — that is, devices which are generic and can be customized for end market function (the birth of software).

To date, the drivers of all of this work have been the corporate and edge mega-markets described in the image on page 19. Traditional embedded markets ranging from aerospace to industrial systems have benefited from innovations from the traditional consumer markets. However, since the semiconductor supply chain is optimized for the consumer market, the result has also introduced significant challenges of managing a supply chain (allocation, obsolescence and reliability) where one is a minor participant. These supply chain topics are discussed extensively by the author in a series of articles in EPSNews, a publication focused on electronics procurement and supply chain as well as on the Anew website (www.anew-da.ai).

System design and embedded systems

Traditionally, embedded design has largely taken a closed system point-of-view. That is, at the point-of-

Figure 2: Technology Platform Design Shifts



Dr. Rahul Razdan

design, the overall function and components of the product are fixed as the product transitions from design to manufacturing. Especially for safety critical systems, this model has had a great deal of utility, but with the significant tradeoff of operating on the lagging edge of innovation.

However, the formation of semiconductor computing platforms is disrupting this model significantly. Figure 2 (above) shows the significant transitions which have occurred and the transitions to come. In this design typology, the world is transitioning through three distinctive paradigm shifts of electronics system design: hardware (HW), software (SW), and artificial intelligence (AI).

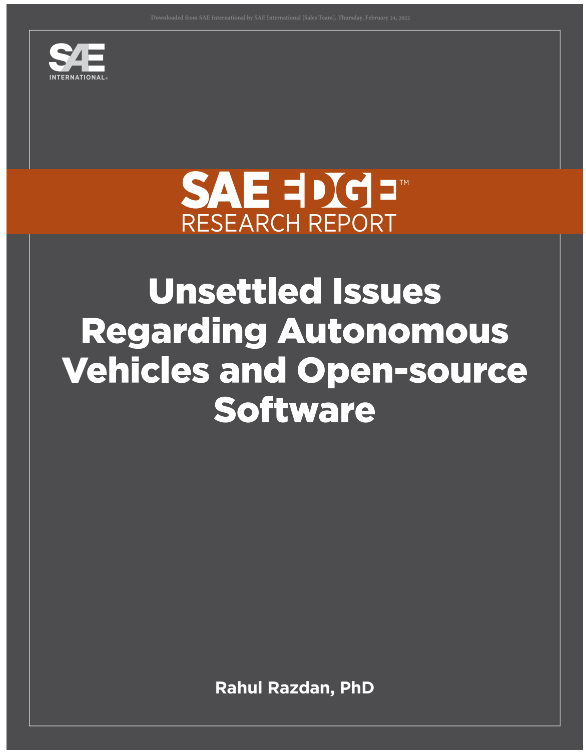
HW Paradigm

In the HW Paradigm, the system design specified the specific functionality of the electronics embedded system. Design primarily consisted of using standard parts or "Pseudo HW" devices such as microcontrollers or field programmable gate arrays (FPGAs) to build concrete system solutions. In automotive and aerospace systems, the underlying communication, sensor, and control systems for the device were often built with this methodology in mind. Conventional EDA design methodologies supported this paradigm reasonably well with the so-called printed circuit board (PCB) physical design process from companies such as Cadence Design Systems, Siemens (old Mentor Graphics), and Altium. In addition, the product lifecycle management (PLM) capabilities from companies such as Parametric Technologies (PTC) or Dassault Systemes helped to manage the whole product configuration.

SW Paradigm

In the SW paradigm, the system design enables the use of the processor abstraction (computer architecture) to gain access to massive amounts of functionality from the software ecosystem. The processor abstraction allows the developers of software to maintain and leverage their investment across a large number of implementation platforms.

This critical property of the processor abstraction allows for deep investments and associated returns. Further, a combination of commercial and open-source ecosystems can provide enormous capability and at the same time allow for the crowd sourcing of innovation from a wide variety of sources. It is not unusual to find many vertical embedded applications where the SW provides the majority of the value. Finally, the SW abstraction has its own ecosystem of tools such as compilers, operating systems, loaders, device drivers, and board support packages.



The acceleration and magnitude of value provided by the SW paradigm is at a scale that in many cases, embedded system designers must start with the selection of the SW ecosystem and build the rest of the system around that decision. In the past, embedded system designers often “snapshotted” the software stack, but with the tradeoff of missing ongoing innovation. Today, increasingly embedded systems are building processes for field updates of the software stack. A seminal moment in this paradigm was Tesla’s decision to allow for over-the-air updates.

From a system design point of view, the SW paradigm introduces significant complexity because one must manage two independent ecosystems that operate at a different cadence. The process of mapping design intent to underlying components is difficult due to this lack of coordination and the massive complexity of the components. The problems become even more difficult when viewed from a product lifecycle point of view because the SW paradigm introduces constant additions to the supply chain and release points. Managing this complexity is a focus for most embedded design teams.

AI paradigm

Recent advancements in machine learning (a key subdomain of AI) have enabled the harnessing of sensors to build intelligence on the edge. With these capabilities, sound can be interpreted as language (NLP), video can lead to object recognition (vision), and there are many more applications.

This AI/ML paradigm is built on top of another abstraction above the processor called the AI model (CNN, Transformer, etc). There is a compile path (training) with a run-time flow (inference). For AI, the data is used to produce the algorithm, so there is a requirement to manage the training data in a similar fashion as software code in the past.

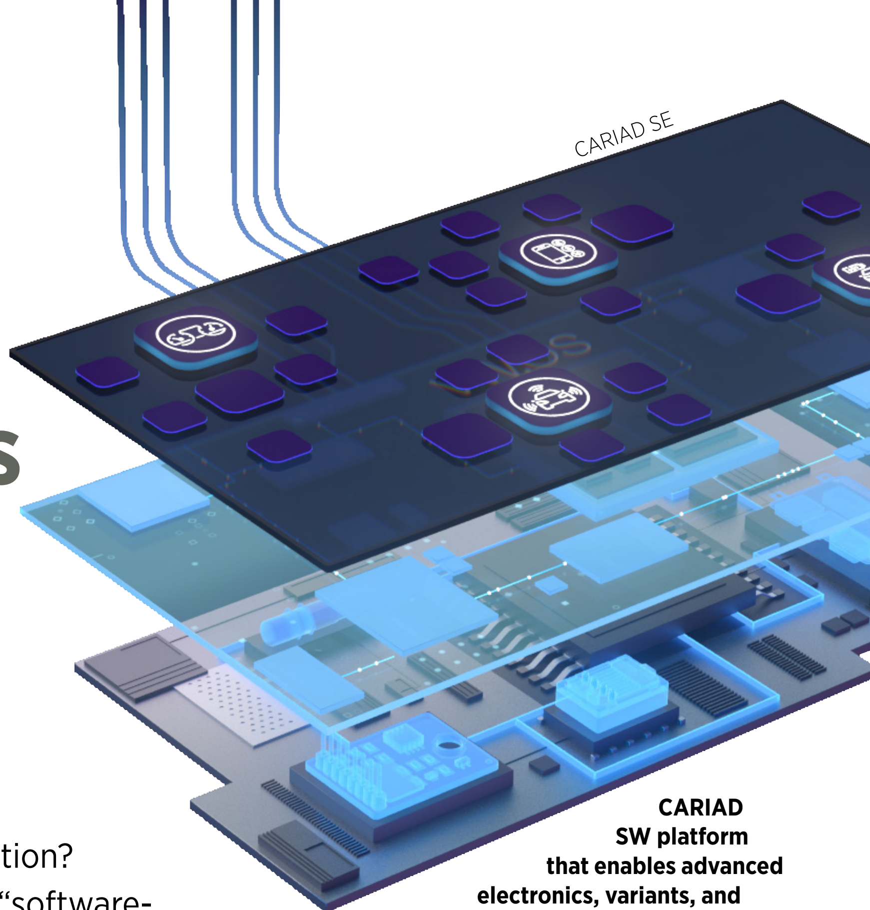
From a system design perspective, AI/ML is at the center of most of the interesting applications in embedded systems, with key focus points around autonomy, cybersecurity, and safety systems. The AI Phase adds another independent ecosystem onto the system designer plate which is independent from the HW and SW phases and operates at its own cadence. The data/training cycle updates can range from being tied to SW release cycles to near continuous operation. Today, traditional EDA systems do not consider the AI paradigm.

Where does this leave the embedded design space ?

The traditional HW paradigm is well understood by the embedded design community, and there are strong enabling tools from the EDA and PLM communities. As OEMs such as Tesla have shown, a highly leveraged SW paradigm can be very powerful to enable both functionality and innovation. However, the critical enabling tools from EDA and PLM struggle with managing the SW paradigm. Specifically, the fundamental processes for design discovery, mapping of function to component, component selection, and lifecycle management of the product must be upgraded. Finally, the AI paradigm is at the forefront of embedded system design and, largely speaking, there is no real capability available from the EDA and PLM sectors to enable these capabilities.

Overall, the SW and AI paradigms have the promise to enable the third mega-wave of capability for the benefit of the world. However, these fundamental shifts in system design methodology must have the critical enabling technologies in EDA and PLM to deliver on the promise of these technologies. ■

Finding challenges and solutions for mobility software at scale



CARIAD SW platform that enables advanced electronics, variants, and innovative applications.

Is software the technology or the solution?

We read a lot these days about the "software-defined car," a term that suggests software is the solution. It's a term that defines a car, the value of which is more than 50% determined by software-enabled attributes and features. But if software is the solution, what is the technology that produces it?

A lot goes into the final "runnables," which read data and control actuation of vehicle features: user studies, requirements, design, prototyping, coding, modeling, simulation, and verification. As we can imagine, it is easy to get lost when we develop for all automotive feature trends in parallel.

I am fighting for engineering excellence in automotive since 2008. I have been an SAE member since 2012 and value the organization's knowledge exchange tremendously. Today, I manage a competency center for software development at CARIAD SE, the software house of Volkswagen Group.

CARIAD is a new organization, but with a very different business case than most new organizations, like startups. Startups in automotive, but also in many other industries, begin with a focused product scope. For them, the number of features in development are limited.

At CARIAD, we cover the full scope of the CASE (connected, autonomous, sharing/

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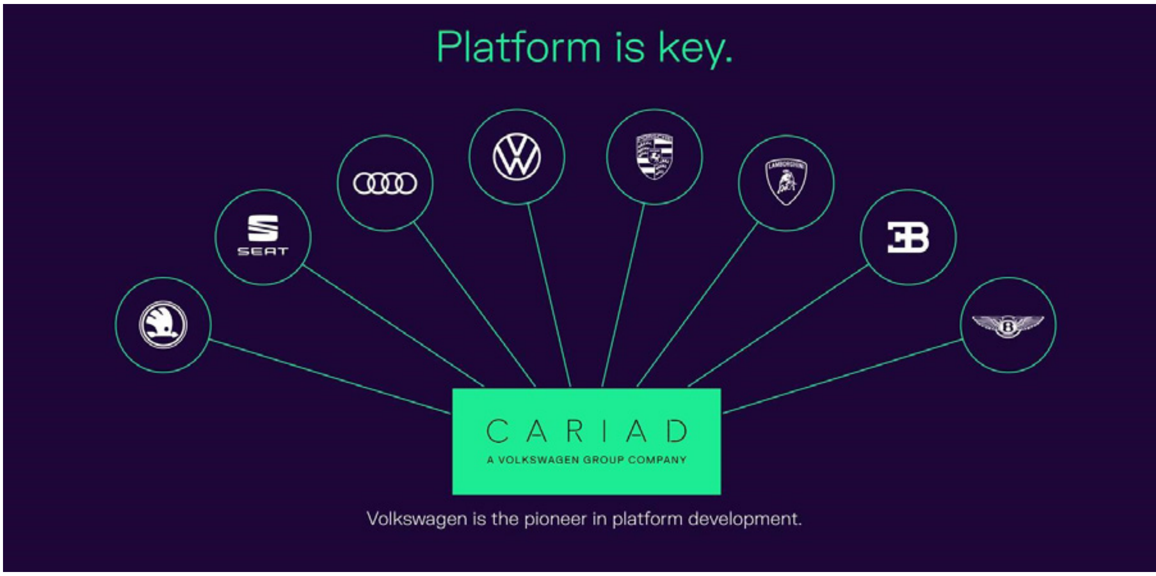
Eight-year SAE member Fabian Koark wrote this article for *Update*. He manages a competence center for software development at CARIAD SE, the software house of the Volkswagen Group.



CARIAD SE

CARIAD is a solution partner for all Volkswagen brands.

subscription, electrification) trends for all Volkswagen vehicle brands. Features for connectivity are developed in parallel with features for autonomy, shared services, and electrification. Here we have an environment in which engineering excellence for the software-defined car is not optional.

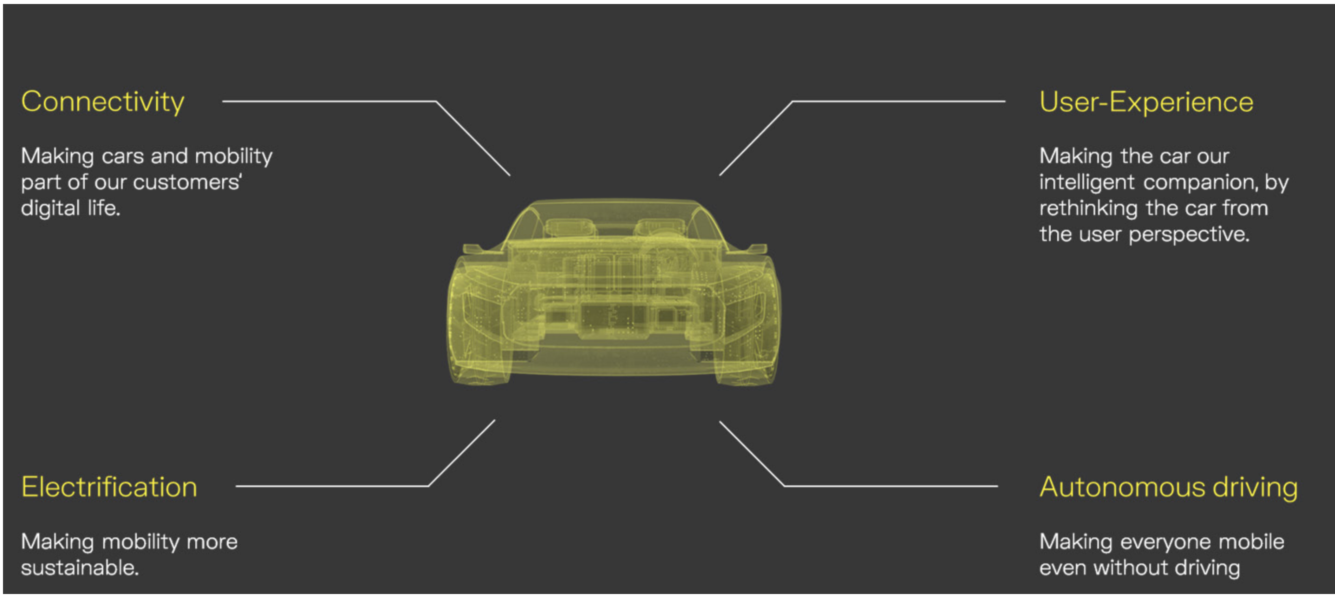
But the question remains: How do we get there?

The value of the question

To answer this HOW, we need to emphasis the value of questions. Why? Because in a complex environment, the best answers require research methods rather than engineering methods, which tend to solve one problem fast without evaluating all options.

Automotive software development is a complex environment for multiple reasons. The real-time behavior increases the impact of weak software at any time. Automotive software faces many dependencies. Once automotive software works, the tester wants more. The specified features change and increase — so-called feature creep. In other software-defined products, the project scope is often focused on one next product launch. Not so in automotive. While a project — today we call it a solution train — begins with one target vehicle, many vehicle variants are added to the same program.

In such and environment, immediate analyzing, dissecting, and patching every challenge that surfaces is not always successful. Imagine you have a big onion. but just need a little bit of it for your first course. You can cut out a wedge, right to the core. Or you can peel off one layer. The peeling does not reveal the core, but it leaves the residual system as a whole. No risk of drying out and falling apart, while taking away exactly what we need now. The cut to the core does not stop the cutting as you need to



CARIAD SE

Rethinking the software-defined car.

process the whole onion while losing focus on your first dish. In agile software, we call that the MVP (minimum valuable product). Given complexity and the wrong tactics, an engineering organization cab easily lose its focus. Encouraging questions can help maintain that focus. We software engineers easily align behind open questions once they are defined.

We take it like a scavenger hunt, from strategy down to the core of our technology. What is our goal this year, this week, today? Why was our mood not the best yesterday? How can we increase our fun and productivity? What do we not yet know about the software development scope? Which of all known design patterns will solve the requirements in the best way? How do we measure software's quality? What is the technology leader doing to resolve this issue?

Strong software engineering organizations establish systems to capture these questions without the immediate need to answer them, as not every question has the same value at any given point in time. Remember the onion: If we spend resources on answering the first question immediately, we might not get to the most innovative question for a long time. It takes some cultural modeling to establish such a behavior. We software engineers are often proud, so encourage us to share the questions we have no answers for — or we will keep them for ourselves.

But let's not stop this discussion on just the cultural level of software engineering — after all, SAE Internationa is a global organization. Let's take a deeper look at the complexity of automotive software engineering today, defined by real-time behavior, dependencies, feature creep, and variants.

Real-time vs. time-critical

Many industries think they release real-time software. But we need to distinguish between real-time and time-critical systems. The main difference between real-time software and time-critical software is the tolerance level for latency. Where in real-time systems, latency will cause harm to health and property, latency in time-critical systems will cause bad user experience. In a nutshell: Latency in real-time systems can be lethal for the user, latency in time-critical systems can be "lethal" for the product success.

The distributed functionalities in automotive require many channels with their characteristic delays. Not just the functional but also the communication design with fitting payload patterns need to be considered. A method and skill set, which is barely taught in academia. In the latest years, centralized domain architectures were promoted to simplify this complexity. Working in these new domain architectures makes us smarter. We now know centralization does not come without real-time challenges. Good software design needs to show the limiting resources in electronics, no matter if in 1 or in 10 ECUs (electronic computing units). A smart approach in agile software development is to plan 2 micro phases — 2 stages of the same capability. In the first phase, we make the feature work; in the second phase, we freeze the functionality and make it run lean and efficient. Therefore, we can call these phases also innovation and industrialization sprints.

To support all phases and sprints, a complete and evaluated software architecture is key. Just with the different views of such a software architecture, dead code and waste of resources can be avoided in the later deployment. But what is a complete and evaluated software architecture? Standards like ISO26262 and ASPICE give us some quality criteria. Additionally, we are well advised to increase the software design competence with methods such as ATAM (architecture tradeoff analysis method) to lead the competition of real-time software performance.

Where the money is

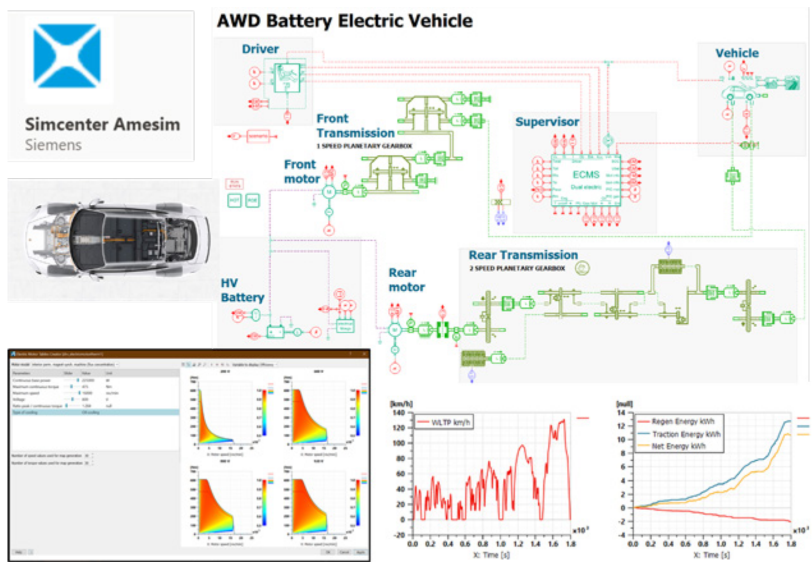
Automotive software development is complex, as explained before. No surprise, it requires a lot of effort and expense. The only way to finance advanced automotive software engineering is to sell many, many cars. To sell more cars with the same software, it is necessary to produce many vehicle variants with a high level of software re-use. Re-use in platform, layered and modular designs are key. We need to embrace the best practices which are behind the modularization rules of AUTOSAR and OSI layers. Every violation of given modularization rules can be tolerated — e.g., as complex drivers — but will increase the risk of "dead" code on the device. Dead code that provides no value but still consumes storage and runtime resources. ■

Engineering software: enabler of integrated mobility

What is the “sauce” that enables all the subsystems required to execute such a product? One ingredient is engineering software.

Electrified, automated, and connected. These are the main thrust areas of development in mobility to reduce emissions, crashes, and congestion. Mobility products featuring these technologies are highly integrated systems.

Sophisticated electric motors, power inverters, high-voltage batteries, and thermal systems are coupled with advanced sensors monitoring the chassis, the propulsion system, and the world around the vehicle. The vehicles are linked to communicate with other vehicles, infrastructure, and



Siemens

Example Siemens AMESim full vehicle-powertrain vehicle model used in Michigan Tech’s xEV technical elective courses.

more — all feeding into real-time control of optimal energy management, driving dynamics, and interactions with traffic infrastructure. What is the “sauce” that enables all the subsystems required to execute such a product? One ingredient of that sauce is engineering software.

The design complexities of individual components and the multi-factorial interactions between subsystems in modern and future mobility products are beyond the reach of simple analysis and rudimentary synthesis. Those currently working in any facet of mobility product execution know that a software package exists that is targeted specifically to the design and optimization of a certain component or feature of the vehicle — e.g., electric motor electromagnetics, drive-

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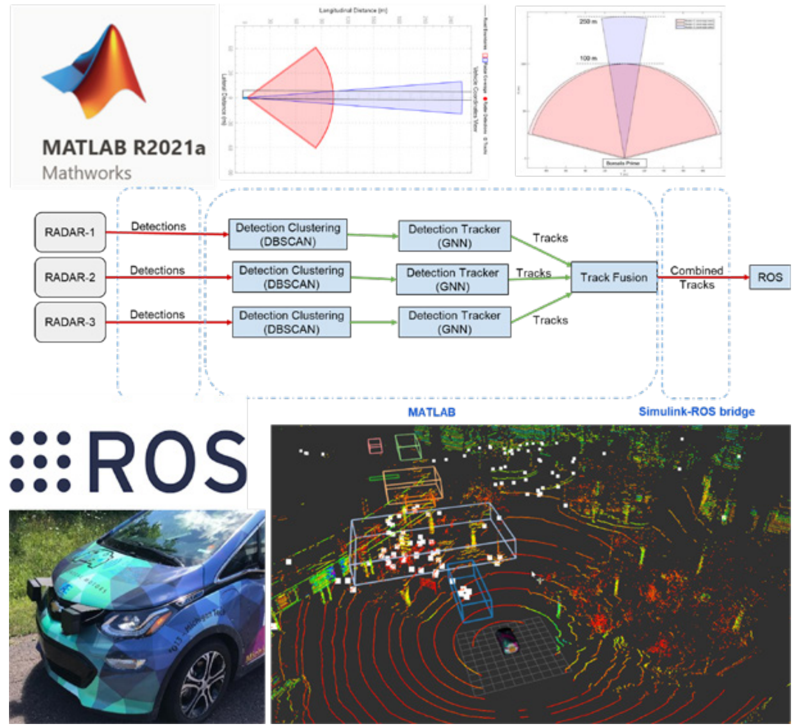
quality assessment, etc. Some engineering software is broad, covering many facets of mobility product engineering — e.g., a suite that provides for data processing and/or mining for AI/ML to ADAS analysis and autonomous vehicle code generation. Other software facilitates the creation of a highly detailed plant model for dynamic analysis to determine mechanical loads and hardware design requirements to creation of control algorithms and calibration. More and more, co-simulation and linking of engineering software is happening to reduce development time, costs, and pre-production hardware such as mule and prototype vehicles. In the eyes of engineering management — or, more accurately, corporate leadership — product development needs to proceed entirely on a virtual basis with highly correlated and representative models. An idealistic objective is the training of current and new engineers in a culture of virtual-based product engineering with limited hardware availability. But how do we get there?

After nearly a decade at General Motors in various roles within powertrain engineering, the "call" to train the next generation of engineers came. And I answered.



MathWorks

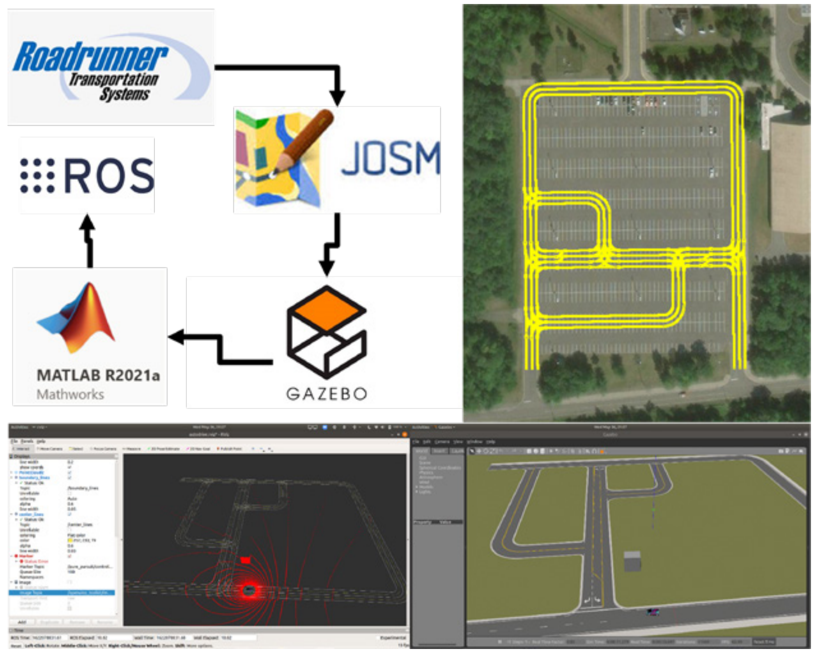
Integration of engineering software to create RADAR based object detection code for use in Autonomous Vehicle competition.

Transitioning back to my alma mater, Michigan Technological University, the focus was to teach and train young engineers to be force multipliers in the mobility sector based upon what I learned and experienced in my professional career. When I joined Michigan Tech in the fall of 2016, the mechanical engineering curriculum was already well into a transformation to include more engineering software and experiential hands-on engineering labs. The focus was to create a holistic approach that promotes a solid understanding of fundamental physics and engineering principles that are then applied to solve complex and open-ended design problems that don't have a single solution that allows one to "circle the answer." Engineering software tools from MathWorks, Altair, Siemens, Ansys, etc. are incorporated into certain courses to illustrate the synthesis, analysis, design, optimization, or acquisition of test data to correlate or enhance model-based design per requirements. An underlying goal is not to make the students experts in any single one of these particular engineering software platforms, but rather to show the utility they provide as tools that fit into engineering highly integrated and optimized mobility products. Specifically, the recipe calls for five main ingredients:

1) very specific requirements
2) multi-disciplinary engineering teams
3) virtual and digital tools
4) large data sets manipulated with AI or ML
5) lean amounts of validation hardware or resources before SORP

To provide context of engineering software applied in engineering education, two examples will be explored: a two-course technical elective sequence in mobility system electrification and a collegiate design competition to develop an SAE Level 4 autonomous vehicle.

The design and analysis of electrified vehicle powertrains are highly complex, with



RoadRunner, JSOM, Gazebo, MathWorks

Creation of road network in parking lot for autonomous vehicles using engineering software.

numerous system interactions to achieve best performance per requirements. Michigan Tech's introductory and advanced courses in vehicle electrification were redesigned to use both Siemens AMESim modeling environment and MathWorks MATLAB to rapidly analyze subsystems and full-vehicle powertrain systems for energy consumption, dynamics, and controls. The two-course sequence walks the students systematically through each subsystem with simple and detailed models that are then built into a range of electrified powertrain architectures where the interaction of controls and energy consumption are explored. The overall objective of the courses is to show the iterative process that comes with tradeoff studies aimed at optimized hardware and controls in the xEV space to achieve reduced emissions without compromised vehicle-level dynamic performance.

Michigan Tech is one of a number of participating universities in SAE-GM's AutoDrive Challenge I and II.

Execution of the competition is not possible without the use of engineering software tools. An SAE Level 4 autonomous vehicle is simply too complex to engineer without using software to analyze sensors and to develop perception and path-planning algorithms, to name a few challenges. To illustrate Michigan Tech's use of engineering software to assist in engineering an autonomous vehicle, the inclusion of RADAR as an object-detection system was created from a combination pg collected data in ROSBag, simulated data in MATLAB/Simulink, and the repurposing of generic object-detection algorithms to use auto coding to directly create software for implementation onto the autonomous vehicle compute platform. Multiple engineering software tools are employed to successfully create and field the object-detection algorithm, which is then paired with vehicle path planning and dynamic control.

Like many other universities, Michigan Tech lacks a dedicated, limited-access vehicle dynamics area or skid pad to test and validate an autonomous vehicle's control and capabilities. To get around this limitation, Michigan Tech AutoDrive students use numerous engineering software tools to create a road network onto a parking lot to validate the vehicle's control and navigation. Roadrunner was used to create the road network and infrastructure, which was then exported into Java OpenStreetMap, which was then in turn exported into Gazebo to generate the maps necessary for deployment to the test vehicle using ROS for control. In this case, a series of software steps that are part of the AutoDrive Challenge and made available to the universities in the competition was used to overcome a resource constraint and provide a solution for validation of our competition vehicle.

Engineering software is vital to making complex mobility solutions function. Integration of engineering software into engineering curriculum is as vitally important to engineering education as it is to actually engineering the products and solutions.

Michigan Tech is not a microcosm relative to engineering software and the digital transformation happening in engineering education. Nearly all engineering curricula have, or are in the process of incorporating, more software into courses, design projects, and collegiate design competitions. The success of engineering education and our "product" (more engineers) is predicated on stronger relationships with engineering software companies and industry to understand needs on digital engineer training. The tools of yesterday's engineer — slide rule, pocket calculator, calipers, mechanical pencil, etc. — have been replaced by sophisticated engineering software and simulation conducted on tablets and, ever more so, on the cluster or cloud to create the optimal electrified, automated, and connected mobility products of tomorrow. ■

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Transformational changes in automotive software.

The pursuit of error-free, safety-critical automotive software

Over the past two decades, automotive embedded software grew tremendously — to millions of lines of code — with the evolution of software-based features in the vehicle. As software content grew, software development processes and methods also evolved to maintain efficiency and enable the release of software features in a reasonable amount of time. With safety criticality of automotive embedded software at top of mind, the industry established very efficient development, validation, and verification methods. Model-based systems engineering (MBSE), model-based design (MBD), automatic code generation (ACG), and testing methods became ubiquitous, and various standards such as ISO 26262, AUTOSAR were created to provide guidance.

Now, the industry is taking another huge leap in evolution of vehicle software. Industry trends such as automated driving, advanced driver assistance systems (ADAS) systems, connectivity, and electrification are all influencing the software evolution. Additionally, competitive pressure within the industry is requiring a very short turnaround of software-driven features. To meet these requirements, over-the-air (OTA) software

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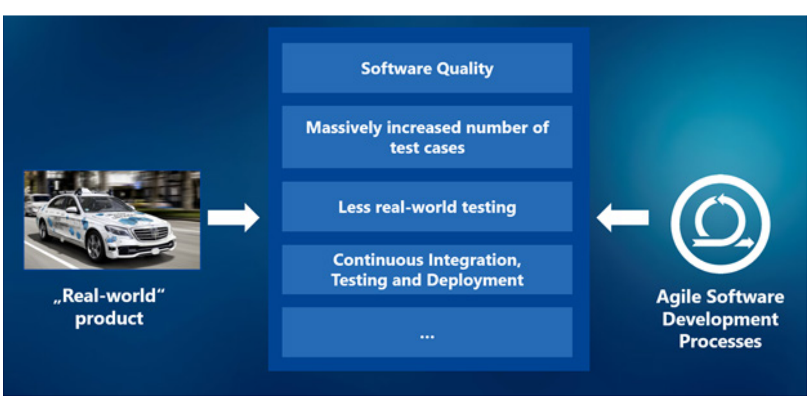
updates are becoming essential.

Autonomous driving/ADAS systems based on artificial intelligence (AI), machine learning (ML), and dozens of sensors on board the vehicle require a newer data-driven development methodology for automotive applications. The amount of data required for the training of AI for perception of the vehicle environment, and for validation and verification of this software, is tremendous. This large amount of data and the extent of computing necessary for validation and verification of software require a large computing infrastructure that is only feasible through high-performance computers (HPC) or a remote cloud-based infrastructure.

Connectivity to both internet information, vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (v2x) communications, and OTA updates is bringing the element of cybersecurity to the software. This adds another layer of complexity to development and testing, as well as adherence to appropriate security standards.

The changes described above have completely transformed the vehicle software development process. Conventional, classic waterfall development processes are evolving to an agile, continuous integration/continuous deployment (CI/CD) methodology. We can summarize this transition as



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Key challenges in modern automotive software development.

"embedded systems are being developed with IT methodologies."

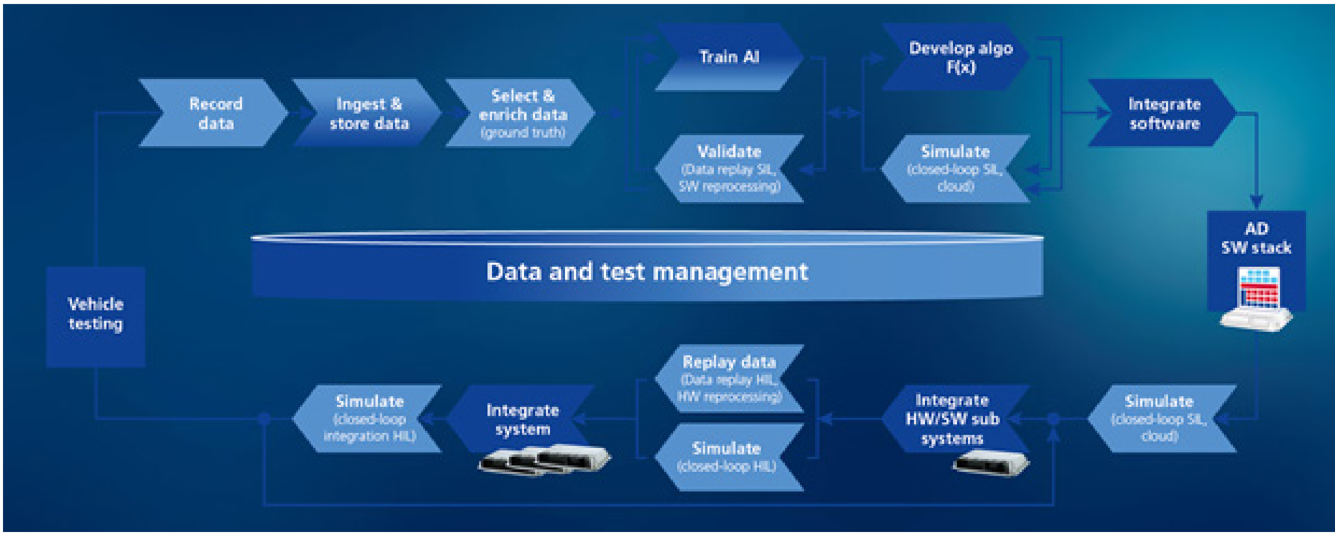
With these massive changes to the software content and development process, the industry is facing several challenges to ensure that it can maintain software quality of these safety-critical applications while keeping costs low. With the large number of new features and complications arising from autonomy, the testing required to validate safe operation has grown exponentially.

Conventional methods of on-road testing are severely limiting in this new era. Factored into all this complexity is the continuous development of software, which requires continuous feature-level and vehicle-level testing.

Some of these challenges are now being addressed by adapting new methodologies, new software architectures, new software development and testing tools, a cloud-based infrastructure, etc.

Data-driven development

Autonomous system development is based on using machine learning and artificial



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Data-driven development of automated driving system software.

intelligence technologies. The conventional MBD process was often based on the requirements driving software development and testing processes. While requirements are still defined, the software application for the perception of the vehicle environment is based on sensor data. The overall process is shown in the image above.

Broadly, this data-driven process can be grouped into five main stages as:

- Data collection and enrichment
- Machine learning and software development
- Continuous integration/continuous deployment
- System integration and testing
- Vehicle testing
- Data collection and enrichment

The foremost step in the process is to collect the data from the operational design domain (ODD) of the vehicle with intended sensor configurations. Sensors like camera, lidars, and radar generate a large amount of data per second, and therefore the data logging and storing of this data require specialized equipment like dSPACE AUTERA. This system provides a bandwidth of up to 50 Gbit/s and storage of up to 32 TB per unit. Backed by powerful, easy-to-use programming and a graphical user interface - RTMaps AUTERA provides all the capabilities for engineers to capture data to meet their needs. Another software component, RTag, provides an easy means to add metadata to

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Graphical user interface, RTMaps and AUTERA.

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Data enrichment with UNDERSTAND.AI tools.

the captured data for ease of sorting and finding appropriate data for further use in the development process. Additionally, the AUTERA family of products provides necessary upload stations to move the captured data to cloud.

This raw data is further enhanced to make it suitable for the machine learning process for identification of the vehicle environment and entities around the vehicle. Annotation, anonymization, tagging, labeling, etc., are some of the methods of enriching the data. Various software tools and methodologies are available for this process.

Machine learning and software development

Advanced features for automated driving — such as sensor fusion, perception, path planning, etc. — are combined with the overall conventional software for HMI, body, chassis, and powertrain controls in the software development process. The key components of automated driving are developed using the data-driven development process for machine learning parts of the perception layer. Here, the software with neural networks is trained to understand the reality of the surrounding that is perceived from the fused information provided by the sensors. A software-in-the-loop (SIL) methodology is used to validate these algorithms.

Since this process is complicated, it's important to use appropriate tooling that can break down the process into manageable steps: prepare, simulate, and validate. This is offered with dSPACE SIMPHERA, which is user-intuitive and simple.

This is a continuous process. Since this is the most important step in the process and has a large variability of scenarios, it requires very intensive validation. Both the training and validation parts of this process are computationally intensive and need a lot of data. For testing purposes, the real data is augmented with synthetically generated data for completeness of testing. To support the computation requirements, a cloud-based environment, as provided with SIMPHERA, becomes essential.

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dSPACE SIMPHERA – scenario-based testing of aautonomous driving systems.

Continuous integration/continuous deployment

Given the large amount of software and need for expedited, updated software delivery, the automotive industry is embracing the agile methodology extensively. In this process, the software features are delivered with a much higher cadence and integrated into the overall software all the time. Using tooling like Jenkins, the process is structured to deliver a continuous pipeline of validated software packages for the vehicle.

System integration and testing

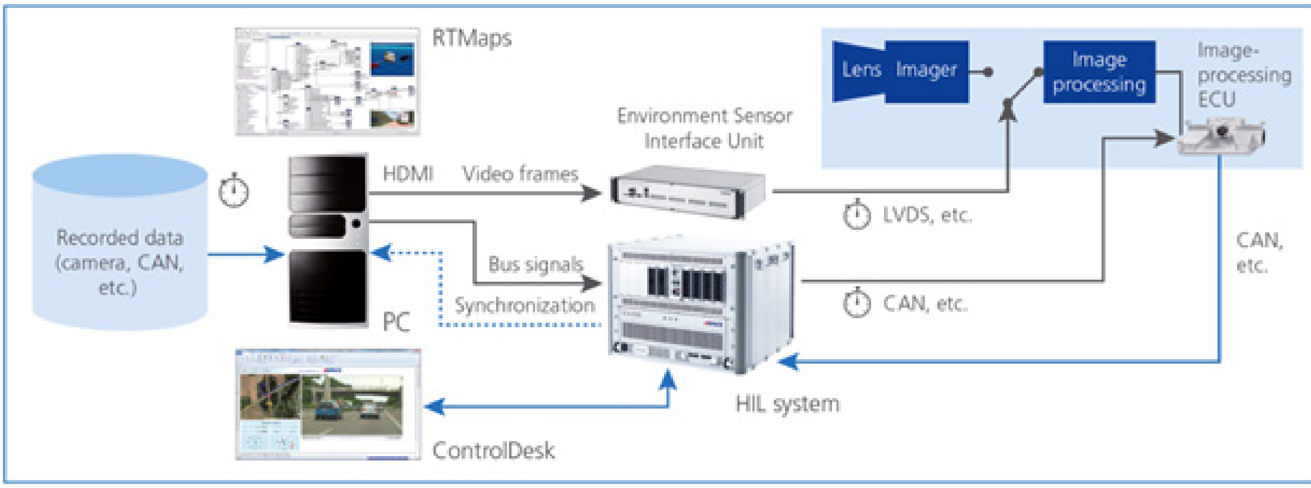
This is one of the key steps in the development process where the validated software and the intended ECU hardware are integrated. The overall system of multiple cameras, electronic control units (ECUs), etc., becomes a reality and is available for testing. Even after all the software is validated, key aspects of testing (e.g., for physical faults, timing effects arising from multiple asynchronous systems, data issues, sensor failures, communication errors) can only be validated during this phase of integration testing. So, while software-in-the-loop (SIL) testing is crucial and augments the process to make the software more reliable, hardware-in-the-loop (HIL) testing is very critical to perform prior to releasing the software for in-vehicle testing. There is no substitute for this step, even in the most advanced testing processes for development of safety-critical systems. Shown on page 36 is an example setup of an open-loop testing of camera sensor and image-processing unit.

Vehicle testing

Finally, the software must be validated in the intended vehicle together with the overall electromechanical systems, combined and fine-tuned to the desired user experience the OEM hopes to deliver to its customers. This step is also crucial to identify additional data and test cases for validation. All the feedback collected through this testing is then fed back into the development process.

Strategic decisions and implications

The strategic decisions made for the product development process and infrastructure will



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Hardware-in-the-loop testing of camera systems with dSPACE SCALEXIO.

reverberate in an organization for a long period of time. It will impact the success of the company and its promise to deliver the best products to its consumers. Key implications of these decisions are:

- Efficiency throughout the product lifecycle
- Agility in development
- Product quality
- Customer satisfaction

Talent and workflow management for product development are acknowledged to be among the greatest challenges. Additionally, the development of complex and safety-critical products will require simulation to be leveraged as a major aspect of the work process. Therefore, the toolchain and workflow choices that impact the efficiency of the development process are very critical.

New techniques, such as the ones proposed for a hybrid test infrastructure with real and simulated test scenarios, will continue to evolve. Infrastructure choices will influence the adoption of new work processes like agile development. Toolchains must be open to be integrated into the overall product development processes for continuous development and integration. As a result of continuous development and the integration of processes, testing can eliminate errors early on. dSPACE tools feature open-architecture APIs, making integration easy with toolchains composed of many agile software development third-party tools for requirements management, etc.

Conclusion

With an appropriate toolchain and methods, OEMs can be assured of their capabilities to develop error-free, complex, safety-critical products. Using simulation, difficult-to-replicate test scenarios can be validated in the safety of the lab environment. With this capability, and with testing early in the process, development costs can be contained. ■

Car designed using Siemens' Xcelerator.

Siemens

The virtual twin

You have been asked to design a new product. Your mind starts to work… How can you design the product so that it will be useful and fulfilling its requirements? How can you reduce the amount of time needed for the design? How can you reduce the design cost? How can you design it so that people will love it? How can you control the cost of product improvements during the product lifetime? Virtual twin's approach will help with these questions. In a sense, this is nothing new from a concept perspective. We have been doing it for hundreds if not thousands of years. A house builder has a concept on how to design a building through relevant expertise and experience in his mind. What is new are the computational tools that extend our minds million-fold. With these computational tools we can track thousands of parts that make a modern car or plane possible, test how they would behave without ever building a physical prototype, optimize and track them through product lifetime. This is well beyond what a single mind can do. Virtual twins are making the impossible possible, they enable the magic behind products like Tesla Model S, Apple iPhone, or Dyson Vacuum. So, how is it done?

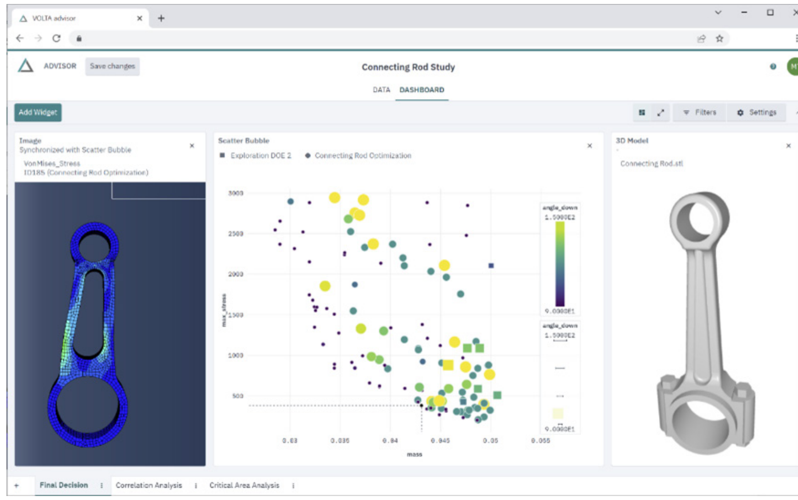
The technologies behind Virtual Twin are under constant evolution with occasional revolutions. For many years the focus was

ABOUT THE AUTHOR

Ales Alajbegovic, Ph.D., wrote this article for *Update*. He is chief executive officer of Four Elements Technologies. He spent his career developing and deploying Virtual Twin solutions for the world's largest automotive OEMs. He is a 16-year SAE member.

on combining the ability to design the product digitally while also evaluating its performance from multi-physics perspectives. How does one shape a car to minimize aerodynamic drag? Or design the iPhone so that it will not break when we drop it by mistake? Or design its antenna so that it can operate on 5G network? The answers to these questions require ability to simulate different physical phenomena, from fluid dynamics, structures, to electromagnetics. An excellent example of such tool is Siemens' Xcelerator. It consists of a comprehensive, integrated software portfolio that enables electronic and mechanical design, system simulation, manufacturing, operations, lifecycle analytics, and more. It manages product complexity while helping the companies gain competitive advantage. At its core is a virtual twin that seamlessly links virtual and real worlds.

There are many inputs into the product design requirements and finding the optimal solution is a serious challenge. Fulfilling only the required functionality is not enough. The requirements span weight, size, durability, cost,



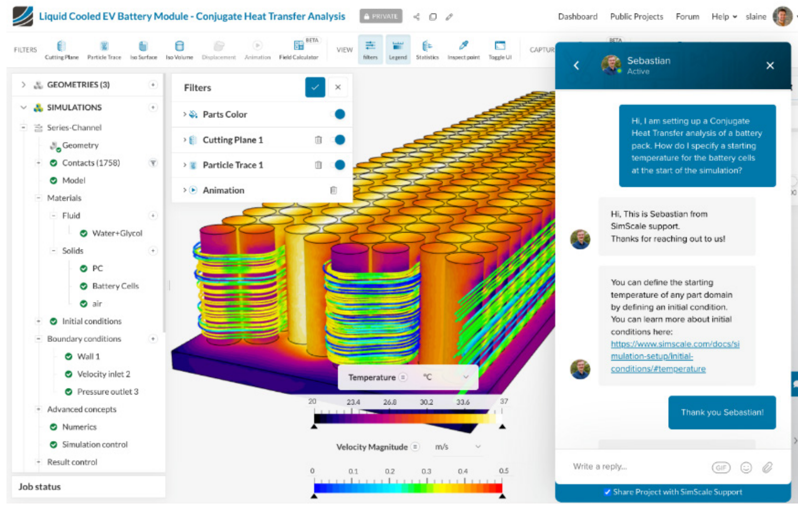
ESTECO

ESTECO VOLTA Advisor used to optimize the connecting rod.

manufacturing, all the way to esthetics. They cannot be fulfilled using physical prototypes, the cost and time for something like this is prohibitive. On the other hand, virtual twin approach enables efficient and affordable digital exploration of the design space. One can decide what are the relevant design parameters and then use optimization tools to find the optimal solution. Such design objectives can be tuned to individual perspective on what is important and can be used to fulfill certain brand image or achieve competitive advantage. A good example for such tool is ESTECO VOLTA Advisor, a web-based solution used to evaluate different parameters of the design space and help guide the design toward the optimal solution.

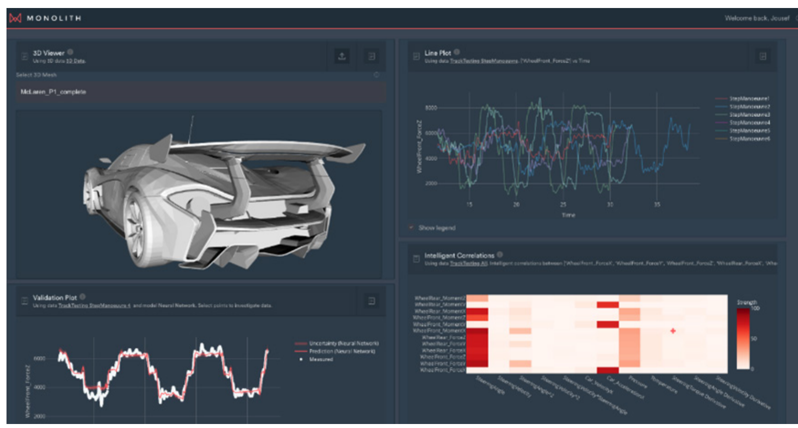
One of the main trends in the last few years is the use of the computational capabilities on the cloud. There are many significant advantages of doing this, from eliminating hardware costs to leveraging third parties for software maintenance. When done properly, there is no need for local software installations. All the work can be done from the web browser on any platform — PC, MAC, tablet, even mobile phones are possibilities. An example of a reliable cloud platform is SimScale which enables fluid flow, heat transfer, and structural simulations of the virtual twin while enabling seamless communications between the engineering teams and product support if necessary. There is no need for data transfers or working from a particular location. Everything can be seamlessly done on the cloud through the web browser - from geometry input, simulations, all the way to the design review with the engineering team.

Artificial intelligence and machine learning represent a revolution in the advancement of virtual twins. We are only at the advent of what will lead to orders of magnitude simulation speed-up while exploring design solutions that wouldn't be possible otherwise. We can only glimpse the advancements AI will enable in the not-so-distant future. However, the current capabilities and the speed at which they are being developed are a very clear indication that they will bring virtual twin to unprecedented levels. Working with virtual twins generates an enormous amount of data. Often in engineering work, majority of this data is ignored and practically lost because of our inability to process it. For



SimScale

SimScale cloud simulation environment used in battery design.



MONOLITH

MONOLITH — use of machine learning for the optimization of car aerodynamics.

ShapesXR

ShapesXR — use of Metaverse in the design of passenger space in a car.

example, aerodynamic simulations customarily generate billions of data points while engineers quite often use only a single value coming from such simulations – vehicle drag coefficient. Artificial intelligence and machine learning allow much deeper analysis of such data, learn from it in a way our minds simply cannot, and come to conclusions that will allow an aerodynamicist to operate on an entirely different level of understanding. This can and will lead to entirely new solutions and processes in product design. MONOLITH is on the leading edge of what can be achieved using machine learning today.

Another revolution in the advancement of virtual twins is Metaverse. It enables the creation of entire new set of interactive virtual universes where products are designed through collaborative teams that can cooperate from anywhere. Imagine interactions with virtual twins that will be perceived by our senses as real while also feeling a direct personal interaction with our colleague that might be physically on the other side of the globe. This will open creative possibilities that are literarily mind boggling. ShapesXR is pointing to such opportunities. They are already enabling such collaborations in creative design of car passenger spaces.

It is exciting to observe the current state and the ongoing development work of virtual twins. It is amazing how far we have come and what we can do today. Every day the products reach us that are a direct result of using virtual twins in action. At the same time, even the near future will bring us improvements that will lead to significant and impressive new possibilities. Our efforts in creating sustainable future and clean environment will benefit the most. ■

TECH FOCUS:
SOFTWARE

We hope this TECH FOCUS section was helpful to you. If you would like to comment on any of the articles in it, email us at **update@sae.org**. Use the same email address if you would like to submit an article for an upcoming *Update* FOCUS section; please refer to the editorial calendar below.

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How to use the SAE Mentor Program

Re-launched in fall 2021, the new and improved mentor program is an SAE member benefit that, for the price (free), is invaluable. We'd like to see more members get involved, both as mentors and mentees. Since the relaunch, several questions about the program have come up. Here are some facts about it.

- **The program provides a template of goals and a timeline –** this is a recommended template only, which you can choose to follow or not. Even if you do not follow the recommended steps, you can check steps off as you go along to show progress.
- **Mentees –** if you choose to self-match, you should look at mentors who match your goals, interests, technology-focus, etc. We would recommend you set up an initial meeting to get to know each other and make sure the mentor is who you are looking for. If not, you can choose to end the match early.
- **Mentors & Mentees –** if you are unable to complete a mentoring relationship, please check into the platform and let the other party know so you may both end the connection. We want to be courteous of other people's time.

SAE International

The latest mentor mixer included a Teams component.

- **Mentoring Connections –** schedule some time in-person (if applicable) or via virtual meeting. Sometimes a lot can be lost in writing, or be misunderstood. Make a checklist of goals and desired outcomes.
- Don't be afraid to end a connection if it isn't right for you! Not everyone is a good match. Time and energy are valuable, so make sure your mentoring connection is adding to your professional growth.

In addition to the one-on-one attention that a mentor-mentee relationship provides, the SAE Mentor Program also involves an occasional Mentor Mixer in Member Connection. The mixers have experienced and accomplished professional engineers answering questions and offering advice in text and/or in video. Check out the latest mixer, which was on Fear of Public Speaking. The event included a Teams discussion.

For more information or advice, be sure to look under the lefthand navigation bar under Help & Support → Help Resources. ■

YOUR MEMBERSHIP. **YOUR BENEFITS.**

MEMBERSHIP IN SAE INTERNATIONAL: **IT'S ALL ABOUT YOU**

BECOME A MEMBER TODAY AND BENEFIT FROM OPPORTUNITIES SUCH AS:

Member Connection connection.sae.org	Engage in discussions on the latest technical topics in the cross-sector Open Forum, share best practices, devise solutions to common challenges, and more.
Professional Development	Drive your professional development with free or deeply discounted courses, online seminars and events. Plus, take advantage of two free courses: *Standardization in a Competitive Environment* and *Introduction to the Automotive Ecosystem*.
Publications	Stay up to date with a subscription to an award-winning SAE industry magazine of your choice, plus a digital subscription to *Autonomous Vehicle Engineering*. In addition, enjoy a 10% discount on most SAE books, technical papers and standards.
Mentor Community	Share your expertise and provide inspiration to the next generation or seek guidance from a mentor yourself.
Events	Enjoy discounted registration on most SAE owned conferences, including SAE's flagship event, WCX.
Awards and Recognition	Advance in your career and earn recognition from your peers through more than 60 awards (many of which are for members only) across all mobility industries.
Leadership	Enhance your leadership skills through volunteer activities, board positions, and Section Officer Roles. Get recognized as an SAE Fellow – the highest grade of membership – given to long-term members who have made a significant impact on society's mobility technology.
Partner Discounts	Save more than the cost of your annual dues and support SAE development and programs through our partner program discounts on business services, insurance, travel, entertainment, gym memberships, and more.
The Career Counselor Series	Gain access to multiple videos on topics like stress management, public speaking, time management and more.
SAE Propel connection.sae.org/saepropel	Take advantage of SAE's engagement portal, where you can advance your career, guide the future generation and connect to the engineering community by signing up as a volunteer.
***Update* Enewsletter**	Stay up to date on current topics in mobility engineering with a members-only subscription to SAE's online newsletter, featuring SAE news, technical articles, and member content.
Sections	Become involved in your local SAE Section, and meet other engineers from your area who are working in the mobility technology field and keeping you up-to-date on the latest technical information. You also have the opportunity to serve on your section's governing board or committee.
Career Center	View employer job listings seven days in advance of the general public.

Visit **sae.org/participate/membership** for more information and to become a member today!

P20478404

The I/O Buffer Information Specification (IBIS) Open Forum releases new version

SAE Industry Technologies Consortia (SAE ITC) announced today that the IBIS Open Forum has approved version 7.1 of the IBIS Specification.

IC and module developers will now be able to supply I/O buffer capacitance and multi-die package and module interconnect models using Touchstone and IBIS-ISS (IBIS Interconnect SPICE Subcircuits). Several enhancements to the IBIS Algorithmic Modeling Interface (IBIS-AMI) improve modeling of equalization found in the latest high-speed DDRx interfaces. The IBIS-AMI "back-channel" link training protocol is enhanced to add support for statistical-based optimization of buffer equalization settings. Another new feature adds support for a simplified On-die Power Distribution Network (PDN) model. The new version includes other technical and editorial improvements offering a significant upgrade to IBIS version 7.0.

"This is the first time that IBIS has developed our syntax checking software, IBISCHK, in parallel with the specification editorial and approval process," said IBIS Open Forum Chair Randy Wolff. "The software will be made available nearly simultaneously with the release of IBIS version 7.1, aiding model developers and EDA tools to support IBIS version 7.1 compliant models more quickly. This concurrent development process improved the quality of the new Electrical Module Description (EMD) syntax, a highly anticipated interconnect modeling feature."

The new specification was approved on December 10, 2021 and is available at https://ibis.org/ver7.1/. The official IBISCHK parser software will be made available on the IBIS website for checking IBIS files for version 7.1 syntax compliance.

An SAE Industry Technologies Consortia Program

For more information about the IBIS Open Forum, please contact info@ibis.org.

The IBIS Open Forum is an SAE Industry Technologies Consortia (SAE ITC) program. The IBIS Open Forum is the industry organization responsible for the management of the IBIS specifications and standards including IBIS, IBIS-AMI, IBIS-ISS, ICM, and Touchstone. The Open Forum meets every three weeks by teleconference. Membership is open to all interested companies. https://ibis.org/

SAE Industry Technologies Consortia (SAE ITC) is an affiliate of SAE International. ■

Drive-by-wire is subject of new SAE publication

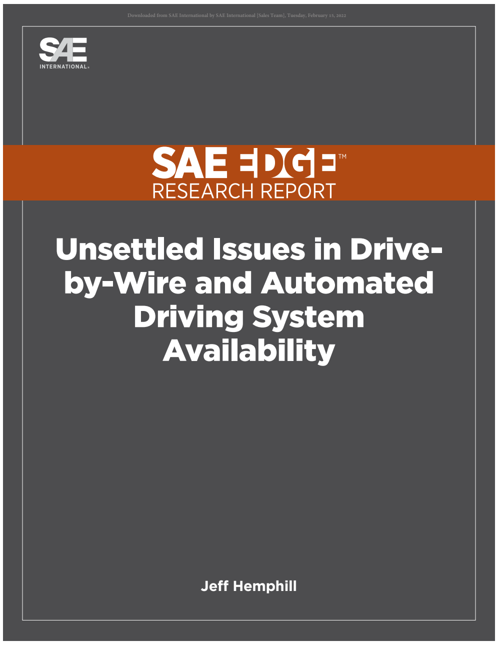
"Every day brings new automotive headlines regarding automated driving systems (ADS), which could lead many observers to think that autonomy is right around the corner."

Thus begins the introductory section of the new SAE EDGE Research Report, "Unsettled Issues in Drive-by-Wire and Automated Driving System Availability," authored by 2021 SAE President Jeff Hemphill. Completing the introduction, he writes:

"However, there are many unsettled issues. One such issue is availability, or how the vehicle behaves in the event of a failure of one of its systems, including those with the latest "by-wire" technologies. Handling of failures at a technical actuation level could involve many aspects: time of operation after first fault, function/performance after first fault, and exposure after first fault. All of these and other issues are affected by software and mechanical and electronic hardware (including connectors). In every system, changes to one component affect the functionality of others, so a systems approach is necessary.

"Availability is an issue in several environments with different implications. Vehicles at Levels 3, 4, and 5—on the continuum from Level 0 to full Level 5 automated driving features as defined by the SAE J3016 Levels of Driving Automation—are key to the discussion (Figure 1). Furthermore, these issues are being explored throughout the world, so there is an opportunity to share lessons and best practices from different regions.

"The term "by-wire" can encompass many automotive systems. At the highest level, systems have been described as "x-by-wire," but the more specific terms include "shift-by-wire," "suspension-by-wire," "throttle- or drive-by-wire," "steer-by-wire," and "brake-by-wire." The most crucial items for vehicle safety are brake-by-wire and steer-by-wire; these are the subject of much of this report." ■



SAE International

As Chief Technical Officer for Schaeffler in the Americas, Jeff Hemphill is responsible for research and new product development for automotive eMobility, transmissions, engines, chassis, as well as industrial components and systems. Hemphill is a former SAE president (2021).

Rumbaugh student winner

Dylan Konop is making a name for himself as a student member of SAE International. Wouldn't be a surprise if he does same as a professional member.

The Bradley University senior majoring in mechanical engineering has distinguished himself again by being named recipient of SAE International's Rumbaugh Outstanding Student Leader Award.

"Being named the recipient of the Rumbaugh Award is a very high honor, and I am grateful for the recognition it provides," Konop told *Update*. "SAE has been instrumental throughout my time in college and has provided me with numerous opportunities to learn and grow. From founding a collegiate chapter of SAE at Bradley to participating in their collegiate design series competitions, SAE has taught me skills and lessons that school doesn't teach in the classroom.

"Through this award, I will have the opportunity to continue to give back to a program that has given so much to me. Through a lifetime membership with SAE, I will be given the chance to help influence students in the same way I have been taught and mentored. Receiving the Rumbaugh Award means to me that I have grown and matured in a way — through SAE and the people closest to me- into an engineer that can have an impact on the world around me. It will empower me to empower others."


Thompson Photo Imagery

2021 Rumbaugh Outstanding Student Leader Award winner Dylan Konop is a Bradley University senior majoring in mechanical engineering.

About the overall impact SAE has had on him, he said:

"Through my time in college, SAE hasn't just been an organization that sets standards or sponsors publications. To me, they've been the teammates and support that have allowed me to participate in all

Dylan Konop

Bradley's Eco-Marathon/SAE Supermileage vehicle ('18-present).

types of activities that have positively impacted my education and my future. SAE has educated me through their industrial lecturer series and through their video presentations. They have offered me the chance to create relationships with a mentor, through their discussion boards, and through connection with our local professional section. And the opportunities haven't stopped there: I've written an article for MOMENTUM, offered my support and experiences through the 'Meet the Engineer' and 'Member Testimonial' video series, and been able to create a club that has truly allowed its members to develop both academically and professionally.

"But perhaps the most changing experience has been the opportunity to design and work on Bradley's Formula, Baja, and Supermileage SAE vehicles. Leading an academic and professional club is one thing, but conceptualizing and creating a competition vehicle is something entirely different. I'm extremely grateful for Liam Hughes and Holly Olson for their support through all the late nights and tough times.

"SAE has truly made an impact on me during my time at Bradley and look forward to being able to continue my work with them as I progress through school and into my career. Engineering in the real world is so much more than just equations and textbook knowledge, and that's where SAE bridges the gap. I would genuinely not be the student I am today or engineer I have the opportunity to become without the impact of SAE." ■

About the award

The purpose of the Rumbaugh Outstanding Student Leader Award is to identify and recognize an outstanding student leader of one or more SAE activities and, through the award, encourage a vision within the student to become an SAE leader during his/her adult career.

SAE student members will be nominated by their SAE faculty advisor who will provide a citation detailing the student's outstanding leadership skills during the past academic year. All nominees will meet the following criteria:

Student member of SAE who is about to graduate or has already graduated from a university or college in a technical field related to automotive engineering (This includes undergraduates and graduates.)

The student will have demonstrated outstanding leadership skills in one or more SAE activities during the academic year being concluded during the year of selection. (The purpose of this provision is to preclude an individual from being selected for leadership demonstrated solely in years prior to

SAE International

Max E. Rumbaugh Jr. (right) with the 2018 recipient, Greg Sawvelle (middle) and 2019 SAE president Paul Mascarenas at a 2019 SAE awards ceremony.

the year of his/her selection.) One recipient will be selected.

The recipient must have begun employment when selected.

Nominations will be judged based on SAE-related leadership activities during the year of nomination, and imminent support of SAE and its activities.

This award recognizes an outstanding student leader of one or more SAE activities and encourages a vision within the student to become an SAE leader during his/her adult career. Through a generous contribution from Max E. Rumbaugh Jr., past Executive Vice President of SAE (1986-2001), this award exemplifies his interest in encouraging leadership qualities and opportunities within the ranks of SAE supporters.

Established in 2012, this award is administered by the Rumbaugh Award Selection Committee and consists of a framed medal, a $750 honorarium, a lifetime professional membership in SAE and a trip to a major SAE meeting where the award is presented. ■

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JOB OPPORTUNITIES

SENIOR RESEARCHER, Warren, MI, General Motors. Research &dvlp Electronic Controls &Software (ECS) architectures, important enablers that allow automobile manufacturers to provide advanced features to customers in areas of major electronic growth in automotive sector such as automated driving, collision avoidance syss, vehicle connectivity, &on-board infotainment. Investigate new ECS sys architectures &technologies to enable deployment of exciting new functionalities. Contribute to design &evolution of powerful conventional, Battery Electric Vehicle &Autonomous Vehicle electrical &SW architectures to enable faster time to market for new features, products, &devices. Provide stable dvlpmt environment for SW features w seamless end to end connectivity, high-speed backbone communications, &highly efficient mechatronic layer of embedded devices. Interact w/ different project teams, R&D &Engrg, automotive cmpnts suppliers, universities, &start-up companies. Support continuous dvlpmt &refinement of electrical architecture strategy through R&D contributions &cross-functional collaborations. Conduct in-vehicle communication sys &network topology related research, technology injection &bench work. Ph.D., Electrical, Computer Engrg, or related. 6 mos exp as Engineer, Developer, Software Manager, or related, designing sys architecture including reqmts definition &implementation for smart grid-enabled smart device application for an Autonomous or Electric Vehicle, or related. Mail resume to Ref#1485, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

PRODUCT APPLICATION ENGINEER - ADDITIVE DESIGN & MANUFACTURING, Warren, MI, General Motors. Dvlp, validate, &release for production use parts, subsystems, &assemblies on psgr vehicles produced using additive manufacturing (AM). Analyze cmpnts within psgr vehicle Bills of Material to identify appropriate candidate applications for metals &polymers AM. Create business case anlys to support substitution of AM solution. Dvlp, &continuously refine detailed cost models of multiple AM technology modalities such as Laser Powder Bed/Multi Jet Fusion, &Fused Deposition Modeling incorporating factors such as capital amortization, raw material costs, labor operations cost, &post-processing operations costs. Coordinate w/ test labs detailed material characterization programs for metallic &polymeric AM materials, incldg multi-temperature tensile testing, density testing, microstructure anlys, strain-rate sensitivity testing, force-controlled high-cycle fatigue staircase tests, strain-controlled low-cycle fatigue tests, multi-axial impact strength, &various thermophysical properties. Use DFMEA, DRBTR, DFSS, GD&T engrg tools &processes to analyze &report product engrg designs. Bachelor, Mechanical or Automotive Engrg. 3 mos exp as Engineer, applying DFMEA, DFSS, GD&T engrg tools &processes to analyze &report product engrg designs, or related. Mail resume to Ref#1620, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

INDUSTRIAL ENGINEER, Brose North America, Auburn Hills, MI. Dvlp concepts &reqmts for new equipment considering ergonomic theories &standard MTM using TiCon software &SAP S&D&PP modules to optimize workplace design &production lines to produce mechatronic subsystems incldg rails welded assemblies &backrest welded assemblies for high volume mfg plant environments. Estimate required seat syss investment, workload assignments, mfg costs &schedules for new product industrialization. Review &define product designs &assess seat syss manufacturability incldg laser &Mig welding for serial seat syss production. Use DFM &DFA w/in simultaneous engrg process to achieve optimal design of products for cost efficient mfg processes &production lines. Coordinate preparation of facilities &infrastructure to receive new equipment through layouts created in AutoCAD following standard norms for layout creation on Brose Production Sys. Plan welding mfg tooling throughout product life cycle. Assure product &material qlty reqmts &GD&T at Brose plants in NA (measurements w/in prescribed GD&T) producing &addressing lifecycle assy processes of seat syss. Master, Industrial or Manufacturing Engrg, or related. 3 mos exp as Engineer or Graduate Research Assistant, researching or dvlpg mechatronic subsystem or mechatronic medical device, &defining or assessing manufacturability of mechatronic subsystem or mechatronic medical device, or related. Mail resume to Ref#626, Brose, Human Resources, 3933 Automation Ave, Auburn Hills, MI 48326.

DAIMLER TRUCKS NORTH AMERICA LLC SEEKS FINANCIAL PLANNING AND ANALYSIS SPECIALIST III in Fort Mill, South Carolina. This position will maximize the overall financial performance of Freightliner & Western Star Trucks by overseeing the reporting of New Truck sales and profit margins and providing analytical support in developing operating forecasts, plans and performance targets, among other duties. Requires Bachelor's in Accounting, Finance, Business Administration, or a related field of study, plus 6 yrs of exp. in the job offered or a related position. Alternatively, the employer will accept a Master's degree plus 4 years of exp. To Apply email resume to Anthony Long at tony.long@daimlertruck.com; reference job number DAI0000P92.

DEVELOPMENT ENGINEER-BATTERY (RECHARGEABLE ENERGY STORAGE SYSTEMS (RESS), Warren, MI, General Motors. Engr, dvlp &validate structural durability evaluation test methods &apply GMW testing standards to test &validate fatigue durability &safety of electric vehicles by conducting experimental tests &FEA on high voltage battery (RESS) cmpts to evaluate stress, strain, fatigue &vibration under field application. Use strain gages, accelerometers, &pressure transducers to collect strain, vibration, &pressure data from high voltage battery cmpts during operation to evaluate fatigue durability. Use iTest, Siemens LMS Testlab, National Instruments, Dewesoft &AVL Lynx tools for test data acquisition. Use MATLAB, Python, Siemens LMS Desktop advanced, DIAdem, &Concerto for data anlys &visualization of vibration data collected from lab &field tests. Perform FEA using Ansys to evaluate modal response of vibration test fixtures. Perform Power Spectral Density based vibration testing on prototype high voltage batteries using single &multi-axis shaker tables. Master, Mechanical or Automotive Engrg. 12 mos exp as Engineer, dvlpg structural durability evaluation methods to validate battery or powertrain durability or safety through experimental tests &FEA of battery or engine or engine related hardare cmpts for stress, strain, fatigue &vibration, or related. Mail resume to Ref#146-383, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

DAIMLER TRUCKS NORTH AMERICA LLC SEEKS COST MANAGEMENT ANALYTIC SOLUTIONS ARCHITECT in Fort Mill, South Carolina. This position will develop and market extended service coverage options and full-service contracts that provide customers with additional protection against potential losses due to engine and truck breakdowns, among other duties. Requires Master's in Management Information Systems, Information Engineering, or a related field. Also requires 2 yrs of exp. in data analytics and software development, which must include: exploratory data analysis; associated tool Tableau; manipulating structured and unstructured data with SQL and R; developing and testing statistical models using R; and leading the development of software. To apply email resume to Rachel Rawson at Rachel.Rawson@dailmertruck.com; reference job number DAI0000PBF.

JOB OPPORTUNITIES

CONTROLS DESIGN ENGINEER, Milford, MI, General Motors. Design, dvlp, test, implement &calibrate embedded SW to control the electronic brake control module on BEVs &AVs using MATLAB &Simulink modeling &C programming language. Perform SW projects through three phases; Reqmt &Architecture Design, Detailed Dvlpmt, &Implementation. Document SW change projects using IBM RTC. Decompose high level physics, system &safety reqmts into low level controls reqmts. Collaborate w/ Physics, Systems &Safety teams to refine high level reqmts. Test &confirm that high level reqmts are captured in low level controls reqmts &properly implemented in SW through in vehicle testing. Create SW design diagrams using IBM Rhapsody incldg context, class, sequence &state diagrams. Implement SW in C programming language that conforms to Motor Industry SW Reliability Association C Standards, SEI CERT Coding Standards &GM C SW Standards. Bachelor, Mechanical or Automotive Engrg. 12 mos exp as Engineer or related, collaborating w/ Systems &/or Safety teams to refine high level reqmts, &testing or confirming that high level reqmts are captured in low level controls reqmts &implemented in SW through in vehicle testing, or related. Mail resume to Ref#3324, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

DAIMLER TRUCKS NORTH AMERICA LLC SEEKS IT SYSTEMS ENGINEER in Portland, Oregon. This position will provide physical architecture for project initiatives and ensure technology objectives are aligned to both business needs and future IT objectives, among other duties. Requires Bachelor's in Computer Science, Electronics or Electrical Engineering, or a related technical engineering field. Also requires 4 yrs of exp. in job offered or a related position, which must include: two years of group leader, project lead or mentoring experience. Must have experience in: Manufacturing Plant Processes and experience developing software and managing infrastructure in premises, cloud, and hybrid-cloud. 25% domestic/international travel required annually. To Apply email resume to Anthony Long at tony.long@daimlertruck.com; reference job number DAI0000PAJ.

CONNECTED VEHICLE DATA ENGINEER, Warren, MI, General Motors. Execute concepts, dvlp, &test new data collection projects using Outbound Data Collection, Vehicle Task Mgr, &Vehicle Data Hub. Shape reqmts for new data collection enablers. Create, execute data load scripts for data collection projects &ensure data integrity w/ rules in place. Use MTFS, &IBM RTC for SDLC. Run data anlys, parsing rules by comparing against diagnostic specifications available &collaborate w/ engrs. Run tests for new data collection requests as designed for outbound calls &verify required data elements are configured to collect for a given request. Verify data collected from psgr vehicles using data streaming applications incldg Kafka, HIVE, HUE. Run data integrity checks on data collected from production vehicles against reqmts &specification provided. Monitor &collect vehicle logs using VehicleSpy, Dvlpmt Programming Sys &LGE-ATT CAN tools, &analyze log text using Notepad++ text anlys tool. Master, Electrical, Computer Engrg, or related. 12 mos exp as Engineer, using Microsoft TFS, &IBM RTC for SDLC, &collecting vehicle logs using VehicleSpy &LGE-ATT CAN tools, or related. Mail resume to Ref# 2812-205, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

INDUSTRIAL ENGINEER, Warren, MI, Brose North America. Plan, engr, &improve Brose Jefferson Plant productivity, product throughput, &worker safety using tools such as Six Sigma methodology, PFMEA, 8Ds, 5S Method &Fishbone Diagram, &AutoCAD tool, to ensure timely continuous improvement. Monitor &improve KPIs to increase process performance during project life. Monitor OOE anlys; perform Value Stream Mapping; &utilize &apply Lessons Learned &best practices, during production of automotive mechatronic closure syss w/ latch module lines; &mechatronic door modules w/ door module lines supplying global automotive OEMs. Plan facilities floor space to assure high-volume manufacture of closure, door, &latching syss. Assure high qlty, volume production &delivery of proprietary psgr vehicle closures, door, &latch syss on JIT/JIS &batch production bases to major global OEMs, w/ U.S. vehicle assy plants located in MI &KY. Bachelor, Industrial, Mechatronics or Mechanical Engrg, or related. 24 mos exp as Engineer, engrg, &improving plant productivity, product throughput, &worker safety using tools such as Six Sigma methodology, PFMEA, 5S Method &Fishbone Diagram, &AutoCAD tool, to ensure continuous improvement, or related. Mail resume to Ref#643-141, Brose, Human Resources, 3933 Automation Ave, Auburn Hills, MI 48326.

AUTOMATED DRIVING ADVANCED DEVELOPMENT-RADAR SYSTEMS ENGINEER, Warren, MI, General Motors. Design &dvlp strategies to better integrate radars in Autonomous Vehicles (AV) &Active Safety (AS) features. Research, study &simulate antenna arrays &beamforming algorithms in radars from suppliers to better predict efficiency, radar sensing, &packaging impact on radars in psgr vehicles. Formulate calibration algorithms to mitigate packaging impact on radar performance. Devise verification methods to ensure high-fidelity 3-D electromagnetic simulation of radars. Minimize &eliminate packaging impact on radars. Apply knowledge of radar sensing &material properties as they affect radio frequency performance. Perform electromagnetic simulation to support anlys-based radar cmpnt packaging evaluation. Measure &simulate radar packaging details such as S-parameters to quantify signal attenuation &phase distortions allowing packaged radar performance prediction. Execute radar test &measurement anlys to support advanced radar research work involving fully polarimetric &high frequency radars. Perform advanced AV sensor laboratory measurements to dvlp &support optimized radar sensing sys dvlpmt for psgr vehicles. Participate in AS cmpnt workgroups for side blind zone alert, short-, mid-, &long-range radars. Master, Electrical Engrg or related. 12 mos exp as Engineer, dvlpg algorithms for radar signal processing in autonomous driving applications, &researching antenna arrays to arrive at better beamforming solutions in radar sensing, or related. Mail resume to Ref#2384-206, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

VEHICLE DIMENSIONAL QUALITY MANAGER, Warren, MI, General Motors. Dvlp, engr, &improve full vehicle Dimensional &Static Qlty from prgrm initiation Document of Strategic Intent, Vehicle Program Initiation through launch on assigned prgrm &projects for current &future psgr vehicles. Perform, improve &lead dimensional engrg integrity, &deliverables of BIW &underbody syss; closure syss, incldg doors, hoods, fenders decklids &liftgates; head/taillamps, IPs, consoles, door trim, front/rear fascia, interior/exterior vehicle trim, seats, &carpets, reducing dimensional variation in high volume vehicle assy plants. Validate &lead execution of psgr vehicle dimensional &static qlty using Tc Vismockup, Siemens NX, Romer arm &Leica Laser Tracker scanning, &CMMs tools, &GD&T method. Engr &assure successful production of psgr vehicle assy through cmpt mfg processes, tooling &eqpt, incldg dimensional gauging, welding, stamping, surface qlty, &General Assembly (GA) processes, robot guidance, &manual (low automated) &high automated assy line syss (incldg robotics). Bachelor, Mechanical, Mechatronics, or Electrical Engrg. 24 mos exp as Engineer, Quality Lead, or related, engrg or assuring full vehicle Dimensional &Static Qlty during high volume vehicle assy, &improving dimensional engrg integrity of psgr vehicle BIW syss &closure syss, reducing dimensional variation in Body Shop &GA areas in high volume vehicle assy plant, or related. Mail resume to Ref#37515, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

RADAR SYSTEM ENGINEER, Brose North America, Auburn Hills, MI. Dvlp short range &ultra-short range radar technologies for automotive customer projects in W &V band. Ensure products meet country regulatory reqmts applicable to operating regions incldg FCC-US, CE-EUR, TELEC/MIC-JPN, ISED-CAN, &KCC/MSIP-KOR. Track changes in government documents affecting dvlpmt of radar products. Acquire &maintain applicable homologation reqmts for all countries in NA/SA, EUR &Asia. Assure products adhere to automotive regulatory standards for radar syss, incldg FMVSS rules governing safety standards. Support Radar Radio Frequency (RF) front end design &dvlpmt, ECU assy, verification &publish Decs of Conformity. Evaluate radiated spurious emissions, emission bandwidth, Fundamental Equivalent Isotropically Radiated Power (EIRP) &conduct peak output power, peak power spectral density, transmit duty cycle, frequency stability &RF exposure limits of developed systems according to FCC DA 21-407, 15.207, ETSI EN 302 264-1; FCC Part 95/ISED RSS-251 &EN 62311. Measure antenna patterns according to ITU-R F.1336, ETSI EN 303 396, ETSI EN 302 264 recommendations &optimize RF front end designs to reduce power losses &achieve max antenna gains in desired direction. Master, Electrical, Mechatronics, Automotive Systems Engrg, or related. 24 mos exp as Engineer, evaluating radiated spurious emissions &Fundamental EIRP &conducting peak output power, peak power spectral density, transmit duty cycle, &RF exposure limits of developed sys, or related. Mail resume to Ref#950, Brose, Human Resources, 3933 Automation Ave, Auburn Hills, MI 48326.

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