SAE INTERNATIONAL®

UPDATE

NEWS & INSIGHTS FOR MOBILITY PROFESSIONALS

TECH FOCUS: AEROSPACE

SAE AeroTech conference to cover the aerospace waterfront.

OFFICIAL SAE MEMBER MAGAZINE
February 2023 | sae.org/update

LICENSURE

"Getting the P.E. license was reaching the goal line and making the touchdown as an engineer. The license meant I could be recognized and act as a professional engineer. It opens up career possibilities and solidifies your position in your applicable field."

Kevin Edwards, P.E., MBB
Chief Diversity and Inclusion Officer
Bechtel Corporation

Your Path to Licensure Starts Here

A professional engineering license allows you to help protect the health, safety, and welfare of your community while also advancing your career to reach your full potential.

Expand Your Career Options

Be the Seal of Approval

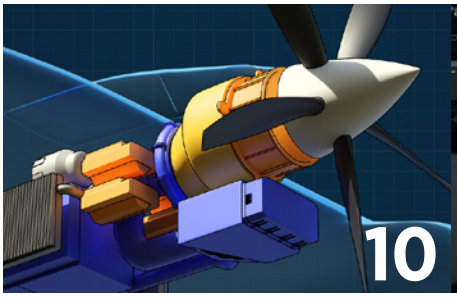
Protect the Public

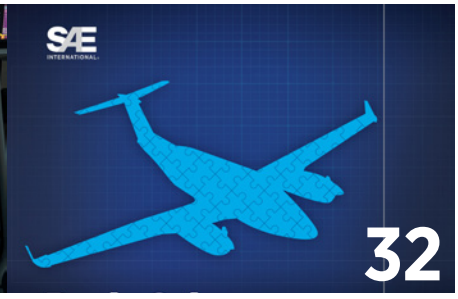
NCEES
advancing licensure for engineers and surveyors

P.E. Prove yourself without saying a word.
ncees.org/licensure

CONTENTS

VOLUME 40 ISSUE 2





On the cover

Airbus family flight consisting of the A320neo, A330-200, A350-900, and A380.

Airbus

Higher ethanol blends support the transition to a low-carbon future

By BRIAN WEST, retired from Oak Ridge National Laboratory. For more of his background, see "About the Author" at the end of this article.

Significant reduction of greenhouse gases is a worldwide goal, and it is imperative that multiple parallel efforts be pursued for success. While electric vehicles (EVs) are lauded for having zero tailpipe emissions, it is important to understand there are limitations to focusing on only one technology. Biofuels have already saved millions of tonnes (MT) of greenhouse gas (GHG) in the United States and greater use of these clean fuels should be embraced for sustained and increased contribution to this objective.

The United States is home to some 280 million light-duty vehicles and consumes around 140 billion gallons of motor gasoline per year (Bgpy). "Motor gasoline" here refers to gasoline fuel containing 0-15% ethanol. There is an impassioned (perhaps unrealistic) belief among many advocates that EV sales will overtake gasoline vehicle sales in the next few years.

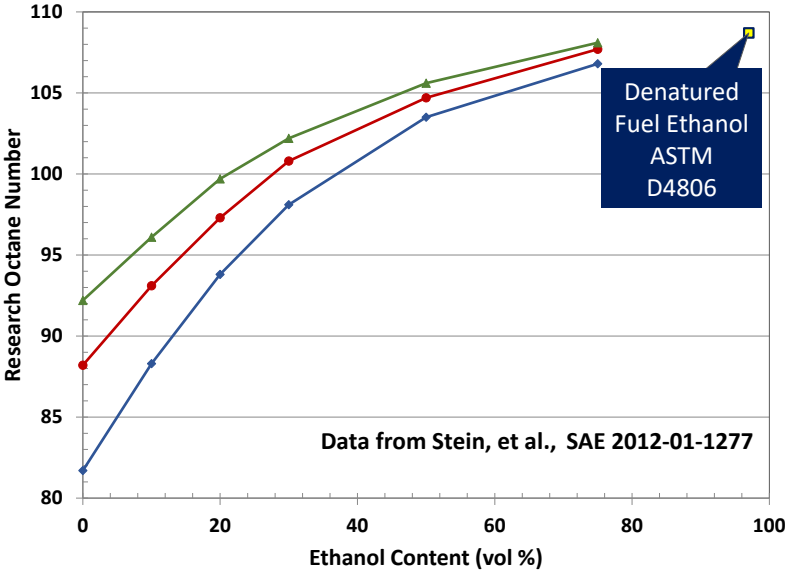


FIGURE 1: Octane number versus ethanol content for three base gasolines. Neat fuel grade ethanol also shown.[1]

While many regulators and vehicle manufacturers have made bold statements about transitioning to an all-EV future, the reality is that limitations on raw materials, charging infrastructure, consumer preferences and other factors will very likely restrain this revolution. In the meantime, millions of new vehicles with spark ignition (SI) internal combustion engines will be produced; roughly half of the vehicles sold today will still be on the road in 20 years.

I believe it is imperative that multiple complementary technologies be utilized in parallel to help curb GHG emissions and mitigate risk associated with any single solution. The U.S. agriculture and ethanol industries currently produce about 16 billion gallons of ethanol annually, with recent lifecycle modeling showing ethanol cuts GHG emissions by 44-

52% compared to baseline gasoline. Biorefineries and feedstock producers are continually reducing their carbon intensity and stand ready to ramp up to greater volumes of clean, renewable liquid fuel with pathways under development that could achieve net-zero emissions.

The Next Generation Fuels Act (NGFA) was introduced in the U.S. House of Representatives in August 2021 (H.R. 5089), and into the Senate in July 2022 (S.4621). While co-sponsorship of the bipartisan, bicameral proposal grew throughout 2022, the legislation must be reintroduced in the new Congress that convened in January.

The NGFA would establish a clean, high-octane standard for U.S. fuel (the U.S. currently has no national minimum octane standard). This legislation approaches fuel and vehicles as a system, setting a clean, high-octane standard for fuel and requiring all new SI-engine vehicles be certified using the new high-octane, low-carbon fuels. This would allow automakers to produce vehicles with more efficient engines at lower cost to consumers in the near term.

Experts agree that the U.S. will continue to consume liquid fuels for decades, regardless of aggressive growth in EV sales and recharging infrastructure. It is imperative that cleaner, lower-carbon fuels play a larger role to expedite the transition to a low-carbon future. Production of high-octane blends with 20-30% ethanol (E20-E30) would be straightforward with today's gasoline blendstocks because small amounts of ethanol provide dramatic increases in octane as shown in Figure 1. Fuels containing higher blends of lower carbon ethanol, combined with improved engine efficiency, would save millions of tons of GHG, while also curbing petroleum consumption and cutting consumers' fuel costs.

In 2011, the U.S. Environmental Protection Agency (EPA) approved the use of 15% ethanol blends (E15) for all 2001 and newer light-duty vehicles, citing the Department of Energy (DOE) Mid-Level Ethanol Blends Program as a source of critical data to help make that decision. It is important to note that when the DOE conducted its materials and vehicle emissions durability program, E20 blends performed similarly to E15, demonstrating the capability of also using E20 in the legacy fleet. The added benefits of transitioning to an E20 fuel, compared to the benefits of E10 or E15 fuel, would be immense. If only half the gasoline vehicles on the road used E20 instead of the standard E10, our nation would save 40 million tonnes of GHG in only the first year.

Transitioning to high-octane, low-carbon fuel composed of higher blends of domestic ethanol would have many benefits:

- Renewable fuel results in fewer lifecycle GHGs and offers pathways for net-zero-emissions fuel
- Domestically produced fuel reduces imports, enhancing energy security
- Ethanol boosts octane, enabling higher efficiency and further reducing GHGs

- Increasing motor gasoline ethanol content to 20% would help enable the new clean octane standard required in the Next Generation Fuels Act, improving efficiency of future vehicles designed to fully take advantage of higher-octane fuel
- Ethanol blends produce fewer particulate emissions, and added ethanol also reduces gasoline's most toxic components and further reduces sulfur levels that impair emissions control function, thereby providing immediate air quality benefits
- Biofuel blending supports the rural U.S. economy; In 2021, the U.S. ethanol industry supported over 407,000 jobs
- Higher ethanol blends provide consumer price relief at the pump. In summer 2022, E15 saved drivers nationwide an average of 16 cents per gallon compared to regular E10, according to Growth Energy.

When calculating GHG savings from various technologies, it is imperative to use a full lifecycle analysis which considers not just the vehicle's tailpipe emissions of GHG, but also the upstream sources such as oil extraction and refining, mining, farming,

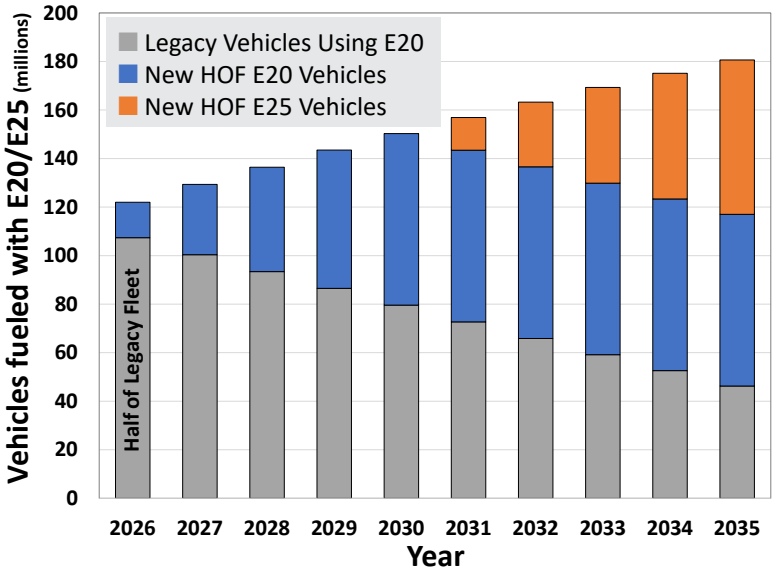


FIGURE 2: Assumed number of vehicles fueled with E20 and E25 for GHG analysis.[2]

manufacturing, and distribution. The DOE's Argonne National Laboratory developed the GREET (Greenhouse gases, Regulated Emissions, and Energy use in Technologies) model for lifecycle analysis, and it is used by many experts to assess GHG emissions.

GREET was employed to estimate the GHG benefits of the NGFA combined with an E20 waiver, and Steffen Mueller and I presented those results at the 2021 SAE Fuels and Lubricants Meeting. The analysis revealed substantial immediate GHG savings–hundreds of millions of tonnes in only a decade.

Figure 2 illustrates the notional NGFA/E20 waiver scenario, showing the shrinking legacy fleet as electric vehicles and high-octane fuel (HOF) vehicles take over. Even with several conservative assumptions, in only 10 years the U.S. fleet could deploy over 130 million HOF vehicles using clean, high-octane fuel. These more efficient vehicles will use lower-carbon fuel for decades, continuing to provide GHG reductions that would not be realized with conventional regular gasoline.

The cumulative GHG savings of this scenario would

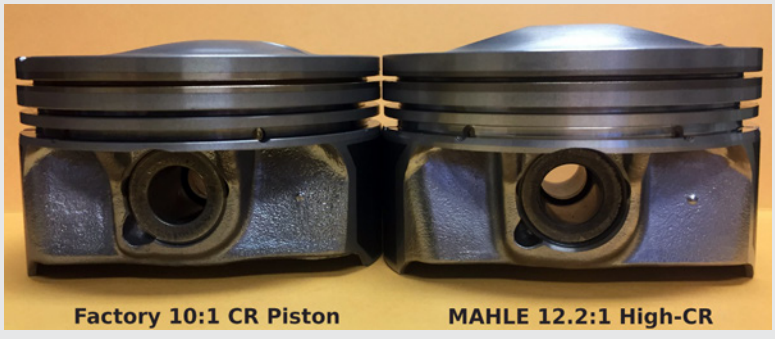
Case study

A 2016 Ford F150 was provided to Oak Ridge National Laboratory by the Missouri Corn Growers Association for a demonstration experiment. The truck was equipped from the factory with the 3.5-L turbocharged, direct-injection V6 engine. ORNL engineers tested the truck with regular E10 and a high-octane E25 such as would be required by the Next Generation Fuels Act, to demonstrate the fuel economy and acceleration performance advantages of high-octane, low-carbon fuels. The work was supported by National Corn Growers Association and Illinois Corn Marketing Board.

The F150's V6 engine was removed after baseline testing and the factory 10:1 compression ratio pistons were replaced with 12.2:1 compression ratio pistons provided by MAHLE Powertrain. With high-compression pistons and high-octane E25, the truck achieved 5-6% improvement in efficiency in all driving conditions compared to the E10 baseline tests, and 0.8 second faster acceleration in a wide-open throttle test.

Results are detailed in a report available at https://info.ornl.gov/sites/publications/Files/Pub109556.pdf. ■

PHOTOS: Oak Ridge National Laboratory



TOP: The Ford F150 3.5-liter V6 engine.

MIDDLE: Factory and high-compression pistons used in the Ford engine.

LEFT: Dynamometer testing of the Ford F150 at ORNL.

easily exceed 600 MT over 10 years, as shown in Figure 3. Note that the use of E20 in only half the legacy fleet nets CO_2 reduction of 40 MT in the first year alone. Clearly, using E20 in a larger portion of the fleet would achieve even greater GHG reductions. As a comparison, consider that the recent EPA GHG rule projects saving only 27MT in 2026, with cumulative savings not surpassing 600 MT until 2033. The combination of the EPA rule, an E20 waiver, and passage of the NGFA could be extraordinary, readily mitigating over a billion tonnes of GHG in only a decade, not to mention giving automakers and consumers lower cost vehicle and fuel options.

Please consider contacting your congressional representative and/or senators today and urge them to support the Next Generation Fuels Act. ■

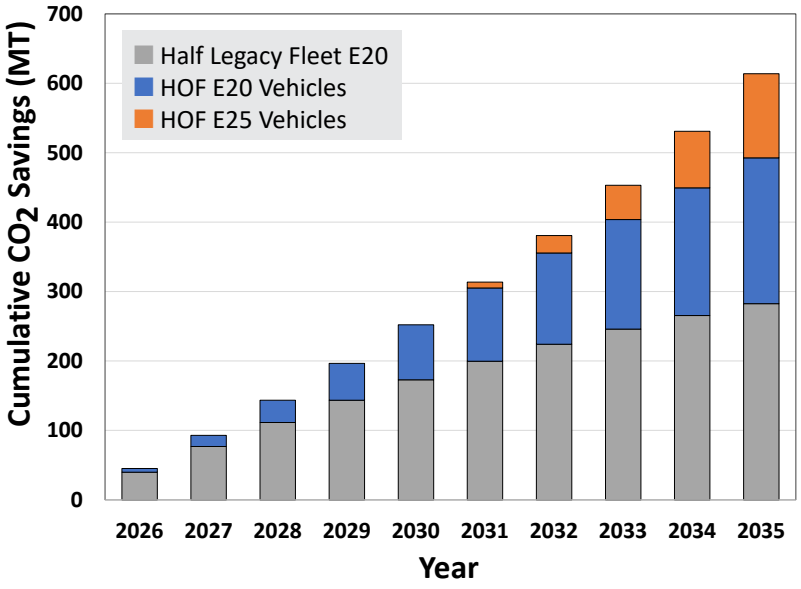


FIGURE 3: Cumulative GHG savings (CO_2 equivalent) from 2026 rollout of E20 waiver and Next Generation Fuels Act.[2]

References

1. Figure 1: Stein, et al., 2012-01-1277
2. Figure 2 & Figure 3: West and Mueller, 2021

ABOUT THE AUTHOR

SAE Fellow (2012) Brian West retired from Oak Ridge National Laboratory in 2019 after working 31 years as an automotive engineer, conducting research on vehicles, fuels, engines, and emissions control technologies. He led portions of the U.S. Department of Energy's Mid-Level Ethanol Blends Program (MLB), enabling EPA's approval of the waiver allowing E15 in 2001 and newer vehicles. Following the MLB effort, West and his team conducted several projects to demonstrate the emissions and efficiency benefits of high-octane, low-carbon fuels, such as E25 and E30. As a consultant, he has continued to advocate for high-octane, low-carbon fuels and is supportive of the Next Generation Fuels Act.

Officers and Directors of the Board

The Nominating Committee invites SAE International members to submit names for consideration for the Board of Directors, Slate of Nominees. Key qualifications of SAE Board members include: a demonstrated, strong commitment and knowledge of the SAE Vision and Ends; active membership and participation in the society; and the time and talents to serve in a leadership role. Nominations may be submitted at any time via email to secretary@sae.org or fax +1.724.776.5944.

SAE INTERNATIONAL®

P231089981

On-Board Diagnostics Symposium–Europe

March 14-16, 2023 | Prague, Czech Republic

Keep Pace with Developments in On-Board Diagnostics Worldwide

Keynote Presenter

Dr. Panagiota "Penny" Dilara
Senior Expert and Team Leader for Clean Vehicles, European Commission

Technical Topics

- Euro 7 - OBM, sensors, fault detection and electric vehicle requirements
- Updates on light-duty CARB, worldwide OBD, and zero-emission vehicles
- Toyota battery electric vehicle diagnostics
- And so much more!

sae.org/obd-eu

Register by March 1 to SAVE!

Making "connexions"

There are various ways to become involved with SAE International, one of the most important being the new Connexion+ online community for SAE members and volunteers. Consider it your gateway to engagement.

Volunteer opportunities

Opt into the volunteer pool to stay up to date on the latest volunteer alerts for you. SAE has opportunities for involvement, fromthe local section level to leadership and speaking opportunities at engineering meetings, events, and conferences. Browse opportunities that match your skills, interests, and expertise — from committee leaders and advisors, to school STEM programs and university chapters, to technical authors and assorted board and committee chairs.

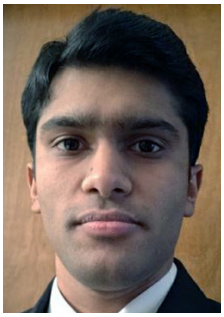
Connect with your colleagues at the local level

Are you looking to connect with other local professionals within the engineering community? SAE local sections offer a strong local network of mobility industry peers, mobility events, and technical meetings, company tours, and social events.

Connect with your local section on Connexion+ today!

Sections speaker series

SAE's Local Sections Speaker Series connects mobility experts and industry thought leaders with the local SAE member community. We are proud to introduce our two newest speakers.



Ayush Lal, senior mechanical engineer, Aptiv Corporation

Presentation: *"Vehicle Electrification"*

Dipali Ghodake, aeroacoustics engineer, Canoo

Presentation: *"Aeroacoustics Problems and Modelling Challenges in Electric Vehicles"*

A complete list of available speakers is available here.

Interested in inviting a speaker to your local event or joining the SAE Speaker Series? Contact Amanda Kibler for more information.

The merits of mentoring

Why not take time to assess where you are in your career, where you're headed, and who can help you get there by participating

in the SAE Mentor Program? Connect with other SAE mmbers from across the mobility industry who can help you:

- Enhance your industry knowledge and technical skills
- Navigate career changes and workplace challenges
- Grow your professional network

SAE Partner Program discounts

SAE also provides Members-only exclusive benefits on business services, insurance, and personal benefits. These programs can easily save you more than the cost of your annual dues, and they return royalties to help support SAE development and educational programs. Check out all Partner Program Discounts. ■

SAE member profile

SAE members, please revisit your profile on the SAE website at https://my.sae.org/ to ensure you receive the most recent information available on a variety of topics in a variety of forms. Contact customerservice@sae.org if you have any questions.

TECH FOCUS: **AEROSPACE**

This special section serves as a preview of the 2023 SAE AeroTech conference in March. But there's more to it than that.

"Industry 4.0 can seem vague and like marketing buzz at times, but it's really just about how we can use a variety of digital data to better understand our processes and make smarter decisions faster than ever before."

-Curtis Richardson

IN THIS SECTION

ZeroAvia

Keynoter Val Miftakhov is founder and CEO of ZeroAvia.

SAE International

A scene from last year's AeroTech conference.

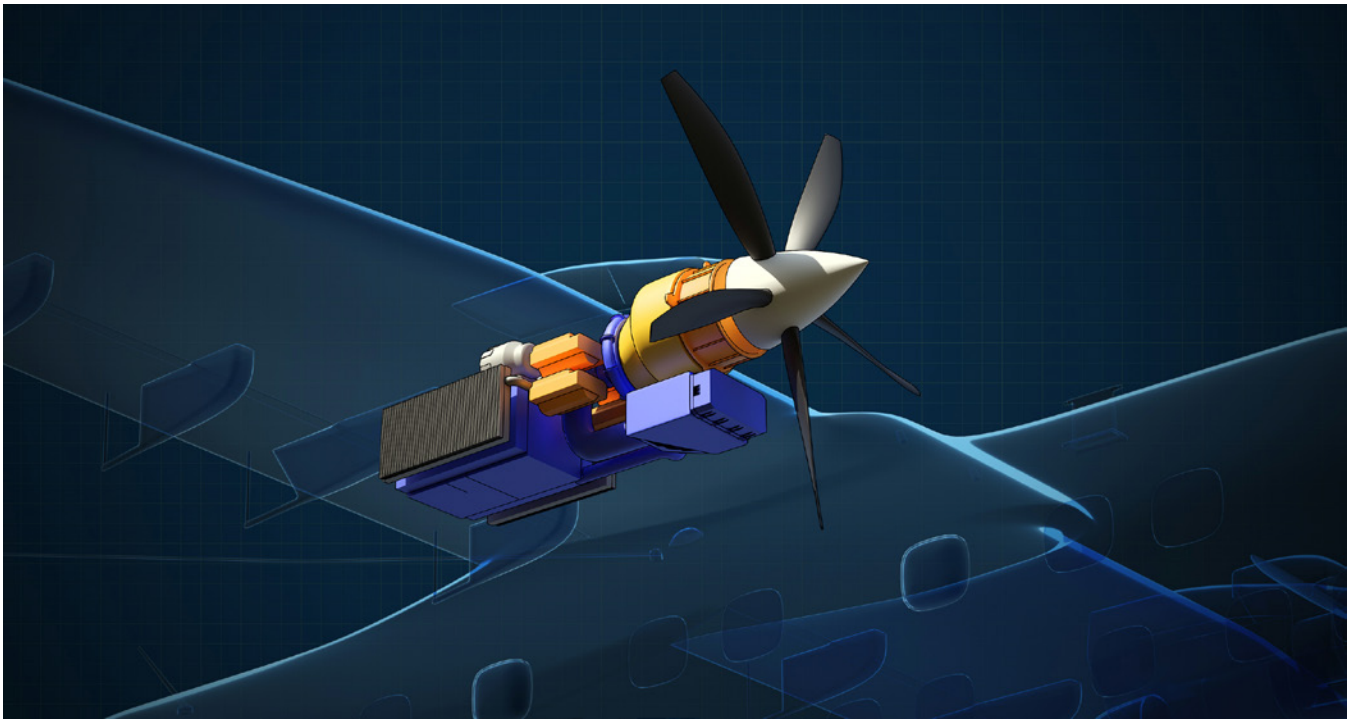
UNSTOPPABLE AEROSPACE INDUSTRY & INNOVATION

SAE's AeroTech celebrates the aerospace and defense technical community and its achievements, advances, and innovations as the strength of community shines through the pandemic.

By COURTNEY E. HOWARD, a senior content developer manager at SAE International. Contact her at Courtney.Howard@sae.org.

Aerospace and defense professionals worldwide are convening at AeroTech to share, cast a spotlight on, and celebrate the collaborative community and its myriad technology advances, achievements, and innovative solutions to pressing challenges, even as the aviation market is hit hard by and continues to emerge from the global pandemic.

SAE International is bringing its AeroTech aerospace and defense technology conference and exhibition to the Fort Worth Convention Center in Fort Worth, Texas, from March 14 through 16, 2023. AeroTech is, for the second consecutive year, co-located with ASM International's AeroMat conference and expo focused on advanced aerospace



ZeroAvia

ZeroAvia founder and CEO Val Miftakhov will talk about his company's zero-emissions initiative focused on hydrogen-electric solutions, initially including a 300-mile-range, 9–19 seat aircraft by 2025 and a 40–80 seat aircraft with up to 700 miles of range in by 2027.

materials and processes.

The AeroTech technical program, crafted by engineers for engineers, is a reflection of the global industry's technology and process advances, achievements, and priorities each year. "Sustainability emerged as the overarching theme of AeroTech 2022, during which dozens of industry innovators shared successes in aircraft electrification, including continued progress in the use of hydrogen power and sustainable aviation fuel sources," said Jeremy VanDomelen, a longtime aerospace and defense industry veteran who now serves as AeroTech's event manager. "Industry showed up ready to discuss, collaborate on, and resolve pressing challenges, many of which resulted from the pandemic."

Safety and security are always central at AeroTech, where several standards committees meet to work on, discuss, and impart updates to critical standards, but it is even more so in the wake of the pandemic. "The AeroTech technical program is a bellwether," VanDomelen added. "It is a clear indicator of current challenges and predictor of priorities." For example, the 2022 technical program shared practical information on overcoming challenges likely influenced by the pandemic — such as supply chain and parts obsolescence, as well as digital transformation and manufacturing automation — while simultaneously focusing on transformative and disruptive technologies, including advanced air mobility, artificial intelligence, connectivity, and more.

Celebrating industry and innovation

AeroTech's technical program is likewise the culmination of a year of hard work by the global aerospace and defense technical community and an acknowledgement and celebration of industry and its efforts, achievements, and advances. Engineers, engineering managers, high-tech executives, researchers, scientists, and academia from across the global aerospace and defense industry volunteer their time and contribute their expertise to AeroTech's technical program annually.

"Industry volunteers are invaluable to SAE and AeroTech," said Frank Bokulich, senior manager, engineering events at SAE International. "We are incredibly grateful for their willingness to lend their time and talents to the technical program, and we're appreciative of industry-leading companies that encourage staff to volunteer on SAE and AeroTech technical committees for the benefit of the global industry and greater good." (Anyone interested in joining the committee of peers organizing the AeroTech technical program are invited to write Courtney.Howard@sae.org or call +1 509-209-7674; visit https://www.sae.org/participate/volunteer for more on volunteering with SAE International.)

Multitasking in March at AeroTech

AeroTech provides several opportunities for professionals to grow their knowledge base, skill set, and connect, celebrate, and collaborate with peers worldwide.

Boeing

Keynoter Julie Brightwell

Bell

Keynoter Matt Holvey

Standout sessions in the 2023 AeroTech program

KEYNOTE ADDRESSES

- Matt Holvey, Director, Intelligent Systems – Innovation, Bell, Textron Inc.
- Val Miftakhov, Founder and CEO, ZeroAvia
- Julie Brightwell, Flight Deck Chief Engineer, Boeing

SPECIAL TRACKS & SESSIONS

- Advanced Air Mobility Ecosystem, organized by NASA
- Aviation Cybersecurity
- Model-Based Systems Engineering (MBSE) and Digital Engineering
- AeroFast fastening, tooling, and assembly track, award, and AAFC meetings

Presentations and technical papers will cover myriad topics, including aircraft systems; advanced manufacturing; business, economics, and forecasting; materials; power, thermal, and propulsion; safety and security; supply chain, obsolescence, and sustainment; sustainability and circularity; and more.

Attendees are encouraged to make the most of their time at AeroTech by participating in special events held alongside the conference. In addition to the technical program, AeroTech boasts an exhibition showcasing the latest technologies and solutions, as well as networking and special events.

Community is key to the AeroTech experience, which delivers several networking opportunities, including a welcome reception and daily networking breaks. March 2023 also marks the much-anticipated return of the AeroTech Gala dinner, sponsored and made possible this year by Boeing, and the debut of the first annual AeroTech pub crawl.

AeroTech attendees have the opportunity to participate in myriad other special events at the conference and exhibition, including:

- The SAE AeroConnect Challenge, a student engineering design competition (https://www.saeaeroconnectchallenge.com/)
- SAE Aerospace Standards meetings (https://www.sae.org/standards)

Boeing – Thomas Hanser

Flight decks will be the subject of a keynote address by Julie Brightwell, Boeing Flight Deck Chief Engineer.

- SAE Awards
- Tour of Collins Aerospace facility in Fort Worth

Plan to participate in SAE's AeroTech conference and exhibition and join industry innovators, thought leaders, and high-tech professionals worldwide to celebrate aerospace achievements, share successes and practical information to advance technology and processes; keep pace with and gain guidance on aerospace standards and regulatory activities: and network and collaborate to move the industry forward and reach new heights. For more information, visit https://www.sae.org/attend/aerotech/. The entire technical program can be viewed at https://bit.ly/3HZdCrT. Visit https://www.sae.org/attend to view the full calendar of SAE engineering events. ■

SAE INTERNATIONAL®

AeroTech®

March 14-16, 2023 | Fort Worth, Texas

SAE International's Premier Global Aerospace Technology Event Is Coming to Texas!

The aerospace technical community will come together as an industry March 14-16 in Fort Worth, TX to share information on the latest technical achievements, learn about the practical application of technologies, discuss challenges and opportunities, and develop personal and business relationships to move the industry forward.

Gain the latest technical knowledge in commercial, military, general aviation, rotary wing and unmanned aviation through technical sessions, lively panel discussions and engaging keynotes.

AeroTech is once again co-located with ASM International's AeroMat, so you'll have even more opportunities to meet the industry's leading professionals powering aerospace, defense and materials science.

Secure your spot today – prices increase February 28. SAE Members save over 35% off registration!

REGISTER TODAY
sae.org/aerotech

P221055955

SAE INTERNATIONAL AeroTech

Where the physical and digital meet

By **CURTIS RICHARDSON,** Technical Fellow at Spirit AeroSystems.

Walk into any aircraft factory today and you are likely to see at least one industrial robot in use. In fact, it's very likely you would see several. It's also more and more common to see mobile robots in these facilities, whether it's autonomous mobile robot (AMR) platforms delivering parts or the actual industrial arms themselves being moved from station to station.

Twenty years ago this would have been science fiction for the aerospace industry, but it's become the norm. This is the culmination of Industry 3.0: utilizing computerized automation to take on the dull, dirty, and dangerous jobs and allowing

people to focus on higher-level things like problem solving.

While the performance of modern industrial robots is

Automated non-destructive inspection cells like this one are an example of melding of a physical inspection process with analysis of the complex datasets produced, characteristic of Industry 4.0.

Spirit AeroSystems

Spirit AeroSystems

A320 spoiler production at Spirit AeroSystems.

impressive, and the flexibility afforded by mobile automation can add to productivity, these capabilities shed light on the importance of data and connectivity. After all, wouldn't it be useful to not just know that the robot is currently drilling, but to understand how many parts it's drilled since the shift started, how well it's drilling them, and whether it will need to run on third shift or over the weekend to keep up with demand? And it would be equally helpful to have this information automatically generated and available at your fingertips wherever you may be, without needing to walk out into the factory, extract it from individual machines, and then manually aggregate it to create a status snapshot. Ideally, the automated system itself would be capable of interpreting the data and deriving options that either you could choose from or allow the system to select based on criteria you define.

This is the essence of Industry 4.0, where the physical and digital worlds meet, and it's resulting in the convergence of the OT and IT communities. This is

illustrated by the very basic example above. Traditionally, the IT organization might only be responsible for ensuring the machine's controller is connected to the network to facilitate transferring NC programs or update status lights on a dashboard.

In an Industry 4.0 world, they need to consider bandwidth requirements based on type, volume, and time-sensitivity of data transmissions. And that depends entirely on how the data will be used – as determined by the OT organization responsible for the manufacturing process. Those use cases can span the gamut from accumulating data on a cloud server over time for trend analyses to edge analytics that adjust manufacturing parameters in real-time. The type of analytic techniques needed and the software that enable them require a tighter collaboration between IT and OT than ever before.

Spirit AeroSystems

The author of this article, Curtis Richardson, is scheduled to make a presentation on March 14 at SAE's AeroTech conference slated for March 14-16 in Fort Worth.

Sometimes the most valuable data come from sources outside your manufacturing cell. Industry 4.0 connectivity and data management capabilities can help leverage information from suppliers, both internal and external.

For instance, consider this scenario: A supplier's IoT system signals your supply chain management system indicating that a critical bracket for the current line unit (let's call it "N") won't arrive onsite until the morning instead of tonight as originally planned. But luckily, your internal logistics IoT system reports that all detail parts for the next assembly line unit (say "N+1") are available in inventory and automatically updates the workflow to trigger delivery of those parts to the shop for pre-assembly overnight. The revised workflow also includes schedule re-sequencing for your mobile robot drilling platform, so when the operator comes in tomorrow

the robot will be located at "N+1" and ready to drill, and the operator will be none the wiser that there was ever an issue.

Perhaps the most important Industry 4.0 advancement for automation relates to more efficient safety. Data generated from sensing devices throughout a workspace can be fused together by sophisticated AI-like systems to track within tens of milliseconds where humans and robots are inside a specific area as well as how fast and in what direction each is moving. Done correctly, this type of situational awareness can be so comprehensive and robust that it satisfies industry safety standards for collaborative robot applications. This means that humans and robots are allowed to work and even interact within a shared space based on carefully defined limits and conditions.

To dive into more detail about how this is possible, check out the ANSI/RIA R15.06 robot safety standard and the associated technical reports like RIA TR R15.306 and R15.606.

Industry 4.0 can seem vague and like marketing buzz at times, but it's really just about

Spirit AeroSystems

People still play a vital role in interpreting process data and conducting work done by automation, even in an Industry 4.0 world.

how we can use a variety of digital data to better understand our processes and make smarter decisions faster than ever before. These capabilities have enormous potential to offer insights into leaning out our manufacturing systems, improving productivity, and making our factories even safer. As with all technological advances, the sooner you get started testing it in your operations, the sooner you will find the right applications and begin reaping the rewards. ■

ABOUT THE AUTHOR

Curtis Richardson has been a Technical Fellow at Spirit AeroSystems since 2018. In this role, he works in the company's research & technology organization leading strategic portfolio development and execution activity related to "Accelerating the Manufacturing Learning Curve." In this regard, technology capabilities spanning areas including Knowledge Based Manufacturing, Adaptive Automation, and Dynamic Inventory Controls support elimination of waste associated with open loop manufacturing and the resulting conventional learning cycles. Richardson is scheduled to make a presentation on March 14 at SAE's AeroTech conference slated for March 14-16 in Fort Worth.

WHAT WILL YOU CREATE?

MARCH 1, 2023

CreateTheFutureContest.com

PRINCIPAL SPONSORS

COMSOL

MOUSER ELECTRONICS

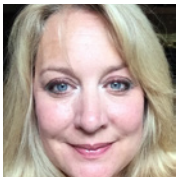
ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

intel

CATEGORY SPONSOR

ZEUS

Standards roulette: which one to use for safety-critical software and hardware development?



By TAMMY REEVE, Founder & CEO of Patmos Engineering Services, Inc and Airworthiness Certification Services LLCs. For more details about her, read "About the author" on the last page of this article.

For this year's Aerotech 2023 in March, I will be presenting on a commercial aerospace FAA and EASA harmonized published guidance for airborne electronic hardware, "What's new with Airborne Hardware Design Assurance for Aviation? Newly released FAA AC20-152A harmonized with EASA."

This presentation focuses on accepted means of compliance to the FAA and EASA certification regulations for commercial aircraft of all sizes, including propulsion. As the title suggests, it will address hardware aspects of these systems performing as intended with a safety-critical level of reliability.

So, what is reliability in a complex custom hardware or software design? How does one measure the error-free nature of a custom design in a field programable gate array (FPGA) or complex software program used in critical functions of aircraft operations? In answer to these questions, many papers have been written.

Government (military and civil) have the responsibility for keeping the public safe and securing our safety. To do so, it relies on

Airbus

Standards cover aircraft from stem to stern, including electronics. Shown is the Airbus A350 XWB cockpit touchscreen.

industry standards to carry out the laws put in place via legislation. Industry standards are written by many organizations, SAE being just one...albeit an important one. ISO, ASTM, IEE, RTCA, and many others use industry experts under working groups to write best practices standards — many times in cooperation with government agencies — to ensure public safety in critical aircraft, automotive, naval, nuclear, medical, and other public services or potential public-impacted areas of life.

Which standard is the one to use? What do you do when there are competing standards for demonstrating reliability of hardware or software aspects of certification of safety-critical systems? Choosing the correct standard for the industry you will be developing for is

important. Most of the regulating industries align themselves with a standard they believe is sufficient for demonstrating the level of rigor (reliability) for the safety-critical systems. So, find out what the industry regulator you will be working with accepts.

For airborne software and hardware, the civil authority is the FAA in the U.S. and EASA in the E.U. Other countries have their own regulating body for airborne civil aircraft. In the U.S., civil avionics related to safety-critical systems are certified under the regulatory laws published in the Code of Federal regulations (CFRs). EASA in the E.U. has similar regulations called certification standards (CS).

Both EASA and the FAA acknowledge industry standards that they consider acceptable means of compliance (MOC) via an Advisory Circular document. AC20-152A/AMC20-152A is currently the document that acknowledges the RTCA standard DO-254 as a MOC for airborne hardware aspects of certification. AC/AMC20-115D acknowledges RTCA standard DO-178C as a MOC for airborne software aspects of certification. Similar ACs/AMCs acknowledge ARP4754A/ARP4761, DO-160G, for environmental testing and systems and safety development.

There are alternative MOC accepted as well, but they require closer interactions and support from the regulating body. This can increase risk, schedule, and costs. It is very important in the civil aviation certification program to read the AC/AMC first before jumping in reading the industry standard. The AC/AMC provides tailoring and is the regulator's opinion on how to use the industry standard for regulatory approval.

To Learn more about the industry standards and use for safety-critical systems for airborne hardware and software, attend AeroTech 2023 and see my presentation. Or, reach out to Tammy@patmos-eng.com for support. ■

S-18 Committee members on the move

The "Move with SAE Mobilus" program recently featured three members of the SAE S-18 Aircraft and System Development and Safety Assessment Committee to talk about, among other things, planned revisions of ARP4754A/ARP4761. The January 18 interview featured with Bob Voros, System Safety Manager at Merlin Labs; Andrew Wallington, Boeing Enterprise Safety & Mission Assurance; and Cory Laflin, Engineering Process Improvement Specialist at Textron Aviation.

About the Author

Tammy Reeve, Founder & CEO of Patmos Engineering Services, Inc. and Airworthiness Certification Services LLCs, is an independent FAA DER and a software and digital hardware engineer who works with companies in safety-critical development, both commercial and military, in meeting design and compliance requirements for the government regulators. She is an active member of SAE and serves on several committees, including AeroTech, WG34 Machine Learning and AI, S-18UAS, RTCA Forum for Aeronautical Software RTCA WG-117 SG-1 Low Risk Software. She is a recipient of the SAE Cordell Breed Award.

SAE INTERNATIONAL AeroTech

How to write a digital-ready standard

By LESLIE MCKAY, senior product manager specialist, SAE International.

As the world moves from analog to digital, engineering resources need to be accessed in a digital format. This drive for digitization promotes interoperability between different systems to help drive efficiencies and development of complex products. While the industry hopes to get to a point where a single tool can be used to author both a digital standard and a PDF natively, we are not there yet. In the interim, SAE is using AI models to read and convert PDF standards into a true digital format.

Over the past year or two, SAE has digitized over 1500 parts and materials standards into a database format. Throughout this process, SAE has learned a lot of lessons and helpful hints about how to structure tables, content, etc. to make it easier for AI models to be used to digitize a standard.

Do you know:

- The best way to reference tables and figures in your requirements?
- How to best organize data tables for digital conversion?
- How to set up your data so that customers can search across multiple digital standards on properties, elemental composition, etc.?
- The importance of consistency to minimize the complexity of your AI models?

Table 2 - Hardness and minimum tensile properties

Condition	Tensile Strength ksi (MPa)	Yield Strength at 0.2% Offset ksi (MPa)	Elongation in 4D %	Reduction of Area %	Hardness (1) HB	Hardness (1) HRC	Temperature/ Time °F (°C)/Hours
H900	190 (1310)	170 (1172)	10	40 (2)	388-444	40-47	900 (482)/1 (3)
H925	170 (1172)	155 (1069)	10	44 (2)	375-429	38-45	925 (496)/4 (4)
H1025	155 (1069)	145 (1000)	12	45	331-401	34-42	1025 (552)/4 (4)
H1075	145 (1000)	125 (862)	13	45	311-375	31-38	1075 (579)/4 (4)
H1100	140 (965)	115 (793)	14	45	302-363	30-37	1100 (593)/4 (4)
H1150	135 (931)	105 (724)	16	50	277-352	28-37	1150 (621)/4 (4)
Solution Heat Treated					363 (5)	39 (5)	1900 (1038) (6)

NOTES:
1. Hardness shall not be the basis for rejection if tensile properties are acceptable, determined on specimens taken from the same sample as that with nonconforming hardness or from another sample with similar nonconforming hardness.
2. For sizes over 3 inches (76 mm), 35% for H900 condition and 38% for H925 condition.
3. Temperature tolerance ±10 °F (±6 °C); time tolerance ±0.1 hour (±5 minutes); cool in air.
4. Temperature tolerance ±10 °F (±6 °C); time tolerance ±0.3 hour (±15 minutes); cool in air.
5. Maximum; alternate for wire: 175 ksi (1207 MPa) or equivalent hardness (see 8.3).
6. Temperature tolerance ±25 °F (±14 °C); time commensurate with thickness, heating equipment, and procedure used, and cooling as required to below 90 °F (32 °C).

SAE International

Example of a poorly thought-out table.

SAE has gathered information together to create awareness and educate others on how to write a digital-ready standard. The information is organized to consider:

Document structure: Standards authors need to understand how to best organize titles, subtitles, and content and how to reference figures and tables.

Table structure: Humans and machines "think" differently. A table that can be read and interpreted by a human may not be so easily understood by a machine. As a result, this section looks in detail at table structure, the organization of rows versus

headings, and how notes are referenced in tables.

Content: Most of the recommendations in this section can be summed up in one word: consistency. It is important for standards authors to be consistent in how they reference properties, elements, data ranges, and units of measure. Inconsistency results in more complex AI models, more manual extraction, more manual verification, and the need to maintain mapping tables outside of the system.

Drawings and variables: This section covers how to handle variables shown in drawings and the importance of using consistent variable names across standards within a Part Type and Subtype.

The table on the preceding page is a good example of how machines and humans think differently. Note the following in the table:

- Multiple values in one column: Several of the columns have multiple values. some are a different unit of measure; some represent a range; and the last column has a mixture of different values, different units of measure, as well as other symbols and notes. This can be confusing for a machine to interpret. It is best to store one value per column so that each value can be referenced.
- Inconsistent use of punctuation: This table has columns where numbers in parentheses denote a different unit of measure. However, parentheses are also used in some columns to identify a note. How is a machine supposed to identify when numbers in parentheses are a different unit of measure versus a note? Standards authors should be consistent in how they use punctuation and other written formats to avoid incorrect interpretations by a machine.

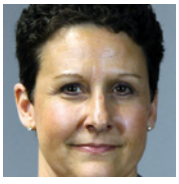
Given the issues with this table, it would likely require manual intervention by a human so that it is digitized correctly—and this intervention will add cost and time to your digitization efforts. However, if the table was structured differently, it could be interpreted by a machine without this added time and cost.

Ultimately, the goal of this session is to get standards authors to think differently about standards. Standards should no longer be viewed as individual stand-alone documents. Standards need to be treated as data inputs into a database so that users of digital standards systems can search across standards.

Standards authors also need to understand how consistency will lead to simpler AI models required to digitize standards. And simpler AI models will lead to faster digitization, with less manual review and fewer external mapping tools required to support the digitization process.

Interested in learning more? Below are in-person or virtual options to learn more about how to write a digital-ready standard: AeroTech, March 14-16 in Fort Worth. Or contact Leslie McKay to arrange a session for your team. ■

AI, ML, DLA are subjects of new special issue of SAE's aero journal



By KIM MARTIN, Editorial Director, Journals, Technical Papers, and MobilityRxiv, SAE International.

The SAE International Journal of Aerospace publishes peer-reviewed, cutting-edge engineering research within the aerospace industry. The journal is an essential resource for anyone in academia, industry, or government seeking the latest studies and technology in aerospace engineering. In addition to being identified as some of the best published technical articles on current technology, the journal archives historic findings and illuminates the future of aerospace engineering and how we plan to get there, covering propulsion, safety and reliability, software, systems, rotorcraft, maintenance, and general aviation.

The most recent issue is a special issue on Artificial Intelligence, Machine Learning, and Deep Learning in Aerospace, with Guest Editors Dr. Dnyanesh Rajpathak, General Motors, Chief Data and Analytics Office, (CDAO); Mr. Mark Roboff, SkyThread, Co-Founder and Chief Executive Officer; Dr. Huafeng Yu, Boeing Research and Technology; and Prof. Gautam Biswas, Vanderbilt University, in consultation with Editor-in-Chief Dr. Ravi Rajamani, Independent Consultant; Research Professor, UConn; and Visiting Professor of Aerospace, Transport and Manufacturing, Cranfield University, UK.

Following is an excerpt from the Open Access Letter from the Guest Editors (Rajpathak, D., Roboff, M., Yu, H., and Biswas, G., "Letter from the Guest Editors,"

SAE International

SAE Int. J. Aerosp. 15(2):123-125, 2022, https://doi.org/10.4271/01-15-02-0008):

"The global aerospace and defense industry is undergoing a massive transformation driven by the emergence and maturation of Artificial Intelligence (AI) technologies, particularly Machine Learning (ML) and Deep Learning (DL).

The availability of large amounts of data and computational resources, coupled with new architectural innovations, are the principal drivers behind the success and recent rise of

ML and DL. We have witnessed how ML and DL are rapidly reshaping adjacent industries, such as automotive and heavy manufacturing, enabling new applications such as autonomous vehicles, robotic manipulators, image analysis, computer vision, natural language processing, diagnosis and prognosis, and time-series analysis. DL architectures have also been widely used to replace the first principal models in complex problem areas for engineering design and optimization. In aerospace, we can expect breakthroughs in AI to enable the automation of complex decision making, and we can imagine AI driving exciting advances in design and engineering through to manufacturing and aftermarket. Furthermore, AI is central to powering autonomous flight, which itself is critical to the establishment of entirely new forms of aviation such as urban air mobility.

To address the trends in AI research reported earlier, the Guest Editors have invited authors from different sectors to publish selective, novel ongoing research contributions toward new algorithms, techniques, developments, and/or applications of AI methods in aerospace. This special issue includes results of studies on ML development lifecycle for product certification in aviation, air traffic speech recognition, aircraft dynamics, optimization of flying formation for Unmanned Aerial Vehicles (UAVs), a localization method of loose particles based on chaos theory inside the additional pipe of a rocket engine, maritime-related accidents and their causes, safety of aircraft and risk assessment, anomalous behavior in aircraft, and prognostics to assess embedded delamination tolerance in composites."

This special issue is available on SAE Mobilus. ■

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* TECH FOCUS section; please refer to the editorial calendar below.

Future FOCUS Index

MARCH 2023
ADAS & automated vehicles

APRIL 2023
Materials

MAY 2023
Vehicle dynamics & NVH

Shutterstock

The rubber will meet the road at the combined SAE-INCE conference in Grand Rapids May 15-18.

SAE and INCE-USA cooperate to provide a unique conference experience

By JIM THOMPSON, JKT Enterprises, with assistance by SAE's Melissa Jena. Turn to the last page of this article for more background on the author.

After the 2015 SAE N&V conference, Jim Thompson talked with Melissa Jena as the new manager of the SAE N&V conference to discuss the possible co-location of the SAE Noise & Vibration and the INCE NOISE-CON conferences. This was his last try to make a combined conference happen. Her reaction was a completely different experience. To his surprise, she got the idea. While he was starting to argue for the concept, she said that it was a great idea. After Jim got up off the floor, they started talking about how to

make it work. 2017 was the first time the co-located conferences were attempted. It was an outstanding success.

This year's Noise and Vibration conference and exhibition is slated for May 15-18 in Grand Rapids, Mich.

The benefits of bringing two conferences together

So, why does bringing these conferences together make sense? There are several

conferences related to noise and vibration around the world each year. There are at least six devoted to noise and vibration. In addition, there are several like the Brake Colloquium with numerous noise and vibration paper presentations. There are too many conferences in a year. It is a difficult decision for people working in noise and vibration to decide which ones to attend.

The SAE and INCE conferences are complementary. The SAE conference is focused on noise and vibration related to the mobility industry. Many of the papers and sessions are focused on mobility products and customers. The INCE conference covers the broad spectrum of noise and vibration issues. Many of the principles related to noise issues in mobility products are discussed, but not in the application specific sense as at the SAE conference. Also, there is work in building acoustics, industrial noise, and other areas that may be helpful to those in the mobility industry.

Having the two conferences together allows attendees to see issues from multiple perspectives. As one attendee said, she heard about a new way of modeling

Jim Thompson

Jim Thompson speaking at the last NOISE-CON conference to promote this year's event.

vehicle aerodynamic noise in an SAE session. Then, in an INCE session, she learned about the details of this technique. Seeing multiple applications on different products, the strengths and weaknesses for her mobility applications were evident.

With two conferences in the same place at the same time, there are significant savings in travel expenses and time out of the office compared to attending two conferences separately. This can be thousands of dollars in savings per person. Just as importantly, the time out of the office is cut in half compared to traveling to two conferences.

Why don't other conferences do this?

One of the challenges for the two organizations is to provide the same experience for our members and conference attendees as the regular separate conferences while working with each other to coordinate events, sessions, and other activities. To achieve the best experience for all attendees, we have

chosen an unusual arrangement for these co-located conferences. The exhibit is organized and managed by SAE. Many of our exhibitors attend both conferences. They love the opportunity to work with both groups in one location at one time.

Each conference operates as a separate entity with a few overlaps to provide the best experience for all attendees. Special events such as receptions, technical tours, social events, and keynote talks are coordinated to be available for the attendees of both conferences. In addition, there are enhancements like joint sessions with contributors from both organizations to provide content and speakers that would not be available at separate conferences.

Trying to schedule two conferences at the same time with joint keynotes, sessions, and other events could be a disaster. This would not work without tremendous cooperation. Each organization must be completely open. There is no room for competition or one-upmanship. We have forged a tremendously cooperative relationship and are planning to co-locate the conferences regularly going forward. Without complete trust this would not be possible.

Is the result worth all this extra effort?

The important question to ask is does all this hard work at cooperation pay off? The best metric I had was from a friend who had worked a long time in automotive NVH. At the end of the 2017 conferences, I bumped into this friend, and he stopped to express

SAE International

At the 2021 conference, Dr. Gavin Song of Ford was recognized for winning the SAE Forest R. McFarland Award. The award recognizes individuals for their outstanding contributions in the planning, development, and dissemination of technical information through technical meetings, conferences, and professional development programs held at SAE events, or in otherwise facilitating or enhancing the enterchange of technical information.

his thanks for the co-located conferences. This friend said it was the best conference he had ever attended. The ability to hear about similar topics from different perspectives was a major learning experience for him. Jim walked away with a big smile — those years of frustration were worth it. ■

About the Author

Jim Thompson is an SAE Fellow (2006) and a member of the SAE N&V Conference General and Executive committees. He'd previously served as chair of the SAE N&V Conference. With INCE-USA, he is a Fellow, editor of the Noise Control Engineering Journal, and chair of NOISE-CON 2023. He was also a past president of INCE-USA and chair of NOISE-CON 2017. Thompson is also president of JKT Enterprises where he does noise & vibration consulting.

SAE INTERNATIONAL®

Move Mobility Forward at WCX™ 2023

The largest technical mobility event in North America returns to Detroit. Join thousands of engineers, executives, suppliers, academics and R&D professionals for WCX™ World Congress Experience to exchange ideas, discuss today's challenges, and build powerful relationships to move your career and the mobility industry forward.

Register today at sae.org/wcx

P231059176

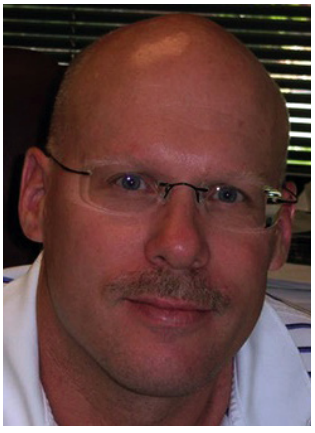
A deep dive into aircraft accident reconstruction

By SHERRY NIGAM, publisher, SAE Books

While the flight data recorder (FDR) is considered one of the most important witnesses to an aircraft accident, what happens if it has corrupted data, is not recovered, or is not installed in the aircraft? Donald Knutson shares his experience with performing hundreds of crash investigations in his book, Basic Science and Art of Aircraft Wreckage Reconstruction, to help answer this question.

In fact, according to Knutson, the vast majority of crashes and failures don't conveniently come with "black boxes" because aircraft required to be equipped with them (e.g., commercial airliners and some corporate airplanes) make up less than 10% of the total aircraft involved in crashes. This fact furthers the need to understand how to (a) piece together evidence concerning the person, machine, and environment; (b) "visualize" the situations and "read" the wreckage; (c) be innovative and creative to analyze or test for potential causes and contributing factors; and (d) comprehensively document and clearly articulate what happened to the decision-makers.

The book provides basic investigative methodologies and techniques that apply to all kinds of aircraft, whether they are



Donald Knutson

Don Knutson has performed hundreds of crash investigations domestically and internationally involving various models of civilian and military aircraft since 1991. He is president of Knutson Aviation Services, a consulting firm specializing in aircraft (airplane and helicopter) accident and wreckage reconstruction, airframe and powerplant (piston and turbine) system failure analysis, and air safety education and research.

"heavy iron" or light sport. Knutson carefully presents the content in a way it is not sensationalized, and encourages investigators to work towards "connecting all the dots" from the beginning to the end of an event, without "cherry-picking" findings that conveniently fit or hastily jump to a conclusion.

Alan Simmons, Fellow of the Royal Aeronautical Society, recently reviewed the book and observed, "Some of the subjects covered — witness statements, crashworthiness, impact forces, human factors, and the 'see and avoid' concept, for example — may seem surprising, but they are all areas where the investigator who is 'kicking tin' must have a degree of expertise. The author introduces these matters with clarity and accuracy. His description of an initial visual appraisal

without touching anything, and his comments about the theft of wreckage, are the practical considerations of an experienced investigator in the immediate aftermath of an accident."

Simmons also shares his take on the book's title, *Basic Science and Art of Aircraft Wreckage Reconstruction*: "The title reflects the fact that sometimes the work resembles an art as much as a science."

"I found this to be an excellent and useful book," Simmons continued, "ideally suited as a reference for accident investigation training courses and a useful aid to practitioners. It is not another 'air crash detective' book, but will appeal instead to government and industry investigators, technical staff who may become involved with aircraft accidents, and those with a general interest."

The book has become an important part of aircraft accident investigation (AAI) courses offered at Embry-Riddle Aeronautical University, Lewis University, and Capitol Technology University. In addition, it has also been utilized for AAI training programs developed for DVI Forensic Laboratories and the National Institute of Aviation Research (NIAR). In essence, this book serves as a useful investigative resource, whether you are an apprentice or veteran with a government aviation agency (NTSB, AAIB, FAA, etc.), an aircraft/engine/component manufacturer, military branch, insurance company, law enforcement agency, or law firm. ■

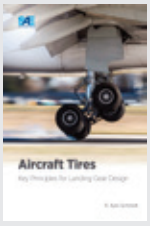
Featured book list for February

Here are a few works that, Sherry Nigam, Publisher, SAE Books, believes are worth a read.

Aviation Engineering: Navigating Through the Golden Years
by Marijan Jozic

Aircraft Wheels, Brakes, and Brake Controls: Key Principles for Landing Gear Design
by R. Kyle Schmidt

Airfield Compatibility: Key Principles for Landing Gear Design
by R. Kyle Schmidt



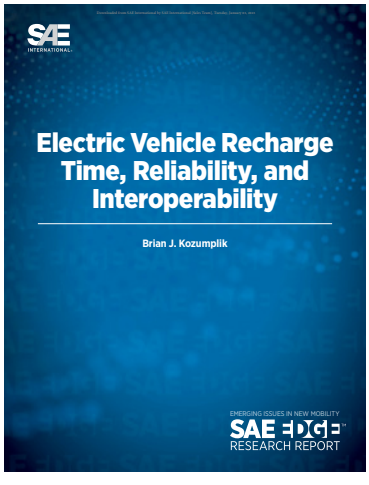
Aircraft Tires: Key Principles for Landing Gear Design
by R. Kyle Schmidt

Flight Paths to Success: Career Insights from Women Leaders in Aerospace
by Rhonda Walthall and Brenda Mitchell

SAE International

The team that brings you SAE EDGE Research Reports. Left to right: Will Kucinsky, Monica Nogueira, Sarah Yack, and Michael Thompson.

The SAE EDGE Research Reports: The team behind many stories



SAE International

One of SAE's more recent SAE Edge Research Reports. Edited by Brian J. Kozumplik, it navigates issues such as charging equipment reliability; the complexity of interoperability concerning charging networks, EVs, and payment systems; various public and private charging network issues; and lagging regulations and standards.

By MONICA NOGUEIRA, Director of Content Acquisition and Development, SAE International

Three years ago, we got the assignment: build a new collection of special reports that would focus on the unsettled topics impacting the mobility industry.

They would have to be short, direct, and tackle the real challenges of how we move today and, in the future.

The format? Bring together a group of subject matter experts to be interviewed by an author who is also an SME in the field.

The result? An EDGE Research Report that would quickly provide an insightful take on the issues at

hand, with recommendations on how to solve these problems using advanced engineering and standardization.

Three years ago, we published 12 EDGE RRs. In 2022, there were 32 of them.

Covering the BIG technologies out there, we have also kept our minds open to new topics and ideas. Multiple authors came back with additional suggestions, and our "focused series" were born.

We are always looking for what is unsettled, for what still needs debate and deeper conversations so we can contribute to the solution that will make a difference and move the needle.

The EDGE Research Reports rely on a process that works from content contracting and development to deep editing and product management.

Here are the stories of those who bring the EDGE Research Reports to you:

- **Michael Thompson,** Director of Standards, Information and Research Publications: Michael has been with SAE International for 15 years and comes from the publishing world. He holds an MBA.
- **Monica Nogueira,** Director of Content Acquisition and Development: Originally from Brazil, she has been with SAE International 13 years. She is a journalist with masters' degrees in international business management and environmental sciences.
- **William Kucinski,** Managing Technical Editor: Will is responsible for making all the EDGE Research Reports easy to read and understand. He holds a degree in English and a master's in science writing.
- **Sarah Yack** is our Product Manager and responsible for interfacing with our marketing and sales teams. She is a mechanical engineer who also holds a master's degree in in ME.

We focus on making developing an EDGE Research Report a special experience for authors and contributors alike. ■

Pathways for auditing professionals

SAE, International's Professional Development team will be launching a new series of courses to support quality management and quality auditors in the aerospace industry.

Beginning this month, for the first time ever, SAE will launch C2211 AS9100D Third-Party Auditor, a course credentialed by Probitas Authentication to train in-service professionals who wish to audit to AS9100D and AS13100. Aerospace auditors can use this course for initial or recertification. This course was developed by and will be taught by two certified auditors Dario Yamamoto and Buddy Cressionnie who combined have decades of experience in the work.

Alongside this course, SAE PD team will rerelease two related courses:

- C1634, AS9100D Internal Auditor Training, developed and taught by Paul Kunder
- C1633 AS9100D Understanding the Requirements, developed and taught by Buddy Cressionnie

These courses have been freshly revised, and like all SAE courses related to AS9100, ISO9001 will continue to be reviewed and updated as those standards undergo revision.

Additionally, SAE PD will also be highlighting four on-demand courses that support auditing to AS9100D and ISO9001 in February. These courses offer a basic to advanced pathway for aerospace professionals who need to know more about the standards and how they apply to their organization's work.

These courses are, as all SAEI courses are, in close concert with the revision of standards.

Here is a volunteer opportunity for SAE members: Help us make short videos about the value of the auditing profession in aerospace, and how SAE Standards help support their work. For more information, contact sherri.pobjecky@sae.org.

SAE International's professional development team is the industry's go-to resource for training on SAE standards. In 2022, over 12K professionals enrolled in SAE's professional development courses, which delivered over 141K of completed hours of training. ■

Featured New Aerospace Quality Pathway in 2023, SAE Professional Development

C2211 AS9100D	Third-Party Lead Auditor Authenticated by Probitas™
C1634 AS9100D	Internal Auditor Training
C1633 AS9100D	Understanding the Requirements
C1862 AS13100	Problem Solving Requirements for Suppliers (8D)
C2212	Human Factors for Aviation
C1889 AS13100	Process Failure Mode and Effects Analysis and Control Plans
C2213 AS13100	Requirements for Advanced Product Quality Planning and Production Part Approval Process
C1878 AS13100	Measurement system Analysis Requirements for Aerospace Engine Suppliers

Thank you for impacting the lives of young learners

SAE members and volunteers had a huge impact on young learners in 2022, contributing more than $60,000 in donations through membership dues renewals alone to the SAE Foundation. Your generosity supports SAE's award-winning A World In Motion (AWIM) PreK – 12th grade STEM education programs. Your generous contributions will help fund new STEM curriculum, scholarships, and crucial educator training.

Throughout the year, dozens of SAE members also have volunteered to support classroom learning and provide invaluable mentorship for students that need it most. By sharing real-world examples and opening the door to potential career paths, they helped bring STEM education to life for hundreds of students.

Whether you make a donation, serve as a volunteer in the classroom, or encourage your employer to get involved, there are countless ways for SAE members and volunteers to make a lasting impact in 2023. ■

SAE International

SAE International

CLASSIFIED ADVERTISING

John Murray
Sales Manager
Phone: +1.973.409.4685
john.murray@saemediagroup.com

Post your resume and search job openings at sae.org/careers/.

SAE assumes no responsibility for the statements set forth in any listing or the availability or existence of such listed positions. SAE does not review or warrant the qualifications or statements of those responding to a listing.

JOB OPPORTUNITIES

SOFTWARE IN THE LOOP (SIL) SIMULATION INTEGRATION ENGINEER, Milford, MI, General Motors. Perform &validate embedded ECU testing &integrate ECU in SIL environment, using MATLAB, Simulink, SimDriveline, Embedded Coder, ETAS INCA/MDA, CANalyzer/CANoe, &GMSIM, tools. Integrate high-fidelity plant models using GT Suite &GT Power, CarSim, &Amesim tools, low-fidelity models using SimDriveline, &ECU models in Embedded C &C++, w/ controller SW source code &perform virtual system simulation. Gather technical requirements, &design battery electric vehicle BEV embedded SW focusing on serial data communication &diagnostics for ECUs in External Object Calculation Module, Electronic Brake/Engine/Integrated Chassis/Processor/Transmission Control Modules, & others. Set technical objectives &tasks to implement production intent SW for infrastructure &platform SW components supporting communication for ECUs in Embedded C &C++, Eclipse IDE, using Git, Gerrit, Jenkins, gcc compiler, gdb debugger, IBM RTC. Master, Automotive or Mechanical Engineering, or related. 12 mos exp as Engineer, integrating high-fidelity plant models, using Simscape, GT-Suite &AmeSim, &low-fidelity models using SimDriveline, to improve simulation capability; &generating embedded C &C++ source code, using Simulink &Embedded Coder for SIL testing, or related. Mail resume to Ref#2772-922, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

DIGITAL SCULPTOR, Warren, MI, General Motors. Plan &perform advanced surfacing concepts &timely &careful dev of Class A surface of full vehicle interior &exterior systems. Interpret &define design intent of designer while collaborating w/ engineering, packaging, human factors, &tooling teams. Design &develop 3D Class A surfaces of ICE, diesel, BEV &AV full vehicle passenger car, truck &SUV interior cmpnts incl. IPs, door trims, consoles, seats, headliners, A/B/C/D pillars, garnish &trim, trunk covers &detailed interior cmpnts incl. air vents, defrosters, latches, handles &switches, &ext cmpnts incl. full exterior body sides, hood &deck lids, roof, front, rear &side glass, front &rear fascia, &detailed exterior components including grilles, badges, headlamps, tail lamps &wheels, &exterior cmpnts incl. front &rear fascias, grills, headlamps, taillamps, doors, fenders, A/B/C/D pillars, skid plates, liftgates, truck beds, using Autodesk Alias AutoStudio, Autodesk Maya, Siemens NX, VRED &Teamcenter tools, for U.S., global &emerging markets. Bachelor, Transportation Design or Industrial Design. 60 mos exp as Digital Sculptor, Digital Modeler, or related, designing or developing 3D Class A surfaces of full vehicle passenger car, truck &SUV interior cmpnts incl. instrument panels, consoles, seats, &A/B/C/D pillars, &exterior cmpnts incl. full exterior body sides, hood &deck lids, glass, &fascia, using Autodesk Alias AutoStudio, Autodesk Maya, &Teamcenter tools, for U.S., global &emerging markets, or related. Mail resume to Ref#4032, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

CONTROLS DESIGN ENGINEER, Milford, MI, General Motors. Engineer, define, develop, implement &validate math-/physics-based algorithms for Hybrid &Battery Electric Vehicles embedded Electronic Brake Control Module (EBCM) &embedded Hybrid Control Processor ECUs for U.S. &global psngr vehicles, using MATLAB, Simulink &Stateflow models, Embedded C language, &Git, Gerrit, Jenkins, &Artifactory tools, in SAFe methodology, for future vehicle prgrms, &global markets (NA, China, SA, &RoW). Define rqrmts, &design &develop SW for brake control strategies to select most efficient &optimal vehicle operation to achieve optimal/robust/stochastic control, AI, steady state optimization &state estimation techniques incl. numerical methods &optimization techniques, in Embedded C, using Eclipse, PacMan, MATLAB, Simulink, Stateflow, Jenkins, ETAS INCA, &Vector CANape tools. Generate C code using Simulink autocode generation tool for SW developed in Simulink. Validate SW builds by flashing on the EBCM. Bachelor, Electrical, Mechanical, Electronics &Telecommunication, or Computer Engrg, or related. 60 mos exp as Engineer or related, designing or developing SW for brake control strategies to select most efficient &optimal vehicle operation to achieve optimal control, in Embedded C, using Eclipse, MATLAB, Simulink, Stateflow, &CANape tools, or related. Mail resume to Ref#47318, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

INDUSTRIAL EXECUTION ENGINEER-ET1B/EG1B FACTORY ZERO, Warren, MI, General Motors. Plan, execute &implement benchmark calculator to calculate &optimize labor at Rechargeable Energy Storage Systems (RESS) assy areas for Factory Zero &other vehicle assy plants to produce RESS for battery electric truck & passenger car. Plan RESS prgrm material handling syss &submit shopping cart requests for issuance of POs &procurement of material handling eqpmt, lift assists end effectors (incldg setting of precise mechanical specs), lift tables, dollies, kitting, repack, internal dunnage, push carts &point of use racks, based on worker &plant safety, ergonomics, qlty, cost, environment &delivery reqmts. Create &maintain Plan for Every Part doc &define inventory levels according to company standards &storage reqmts. Extract data from PFEP &enter data into Global Supply Chain material optimization system to calculate labor. Update Mfg Technical Specs doc based on verified thruput for mechanical syss incldg cell processing units, Supertrak conveyor syss, stacking dials, 7-axis robots, compression presses, &handoff fixtures, &labor estimate. Master, Industrial, Mechanical, or Production Engrg, or related. 12 mos exp as Engineer, planning RESS, transmission or other propulsion system prgrm material handling syss &submitting shopping cart requests for issuance of POs &procurement of material handling eqpmt, lift assists end effectors, lift tables, dollies, &point of use racks, based on worker safety, ergonomics, qlty, &cost reqmts, or related. Mail resume to Ref#35799, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

RESEARCHER, CHIEF DATA & ANALYTICS OFFICE, Warren, MI or Remote (Anywhere USA), General Motors. Research &develop a statistical discrete choice model that can predict demand for Advanced Air Mobility (AAM) service in different U.S. cities. Estimate parameters of statistical demand model using multimodal conjoint stated preference survey data. Implement demand model in Python &run model using trip inputs representative of actual trips conducted in city of interest. Analyze outputs from demand model using a number of different price points &AAM fleet size to understand market profile &service adoption probabilities. Recommend optimal locations of vertiports to best capture predicted customer demand. Research &build map-matching algorithm in Python that maps existing probe vehicle data to real-world transportation networks. Use map-matched probe vehicle data to detect congested links in an urban network. Propose real-time traffic signal control strategies that can be used by US DOT to mitigate congestion on detected links. Research &develop network decomposition technique to make map-matching algorithm run in parallel on different executers &thereby allowing it to process real-time probe vehicle data in reasonable compute time. PhD, Civil &Environmental Engrg, Industrial Engrg &Operations Research, or Physics. 12 mos exp as Researcher, Engineer, Graduate Research Asst, or related, researching or developing real-time network-wide traffic signal control strategy for congested urban networks, &implementing traffic signal control strategy in Python, or related. Remote: This option does not require employee to be on-site full-time to perform most effectively. The employee's role enables them to work off-site on a permanent basis. Mail resume to Ref#3015-405, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

JOB OPPORTUNITIES

CONTROLLER TEST ENGINEER, Milford, MI, General Motors. Develop controls test plans &procedures, using automated test procedures that can be run on Hardware (HIL)/Software (SIL) in the Loop &in vehicles. Perform embedded ECU testing on Powertrain, Engine, Transmission &Battery Control Modules &~10 related vehicle modules using dSPACE HIL, GM Sim SIL, ETAS INCA, VSpy, CANape/CANoe tools, &neoVI FIRE &Lauterbach HW, to verify functionality at Function, Controller &System levels prior to production intent release. Execute verification &validation testing on time &w/ qlty to meet prgrm milestones. Provide validation status to leadership & prgrm teams. Support Technical Review Board by developing test procedures to accurately test controls SW. Develop, document &review reqmts to design an automotive controls system. Review &debug Embedded C, using MATLAB, Simulink, Git, Gerrit, Jenkins, Eclipse, IBM RTC, following MISRA CERT C standards. Bachelor, Mechanical, Automotive or Aerospace Engrg, or related. 24 mos exp as Engineer, debugging Embedded C or updating calibration values based on changing algorithms in Embedded C, using Simulink, Eclipse, &RTC, following MISRA CERT C standards, or related. Mail resume to Ref#3152-101, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

CAE ENGINEER- VDDV UPPER INTERIOR, Warren, MI, General Motors. Perform &execute FEA of conventional passenger vehicle &Battery Electric Vehicle to meet occupant protection performance of automotive interiors in compliance w/ U.S. &Row regs defined by U.S. FMVSS 201U, &NCAP standards, &IIHS vehicle ratings. Analyze &model metrics for roof rail airbag deployment in side-impact load cases at virtual assessment gates. Use LS-DYNA, HyperWorks, ANSA &META to perform FE simulations of full vehicle, &psgr vehicle syss, subsyss, &cmpnts. Evaluate physical tests &tear downs &correlate CAE &FE simulation results to physical test. Analyze &execute FEAs for deployment of roof rail airbag in delivery &psgr vehicles to meet interior occupant interior safety. Design, fine tune &improve, A/B/C/D pillar trims &headliners improve occupant protection in low-speed interior impact. Master, Mechanical, Automotive, Aerospace, Aeronautical, or Electrical Engrg, or related. 12 mos exp as Engineer or Analyst, using ANSA, META, and HyperWorks for FE simulations of psgr vehicle subsystems or cmpnts, &attending physical test &correlating CAE &FE simulation results to physical test, or related. Mail resume to Ref#29601, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

SOFTWARE DEFINED VEHICLE-INFOTAINMENT SUBSYSTEM FEATURE INTEGRATION TEST ENGINEER, Warren, MI, General Motors. Develop customized HW &SW tools to improve work efficiency &automate test procedures. Integrate, test, &verify SW apps for ICE passenger vehicle &BEV embedded telematics &infotainment ECUs, incl. IP Cluster, Telematics Control Unit (TCU), Virtual Cockpit Unit, In Vehicle Infotainment (IVI), Central Gateway Module (CGM), Body, Center Stack &Engine Control Modules, OnStar Core Module, using Python &QNX, for future vehicle prgrms in NA, to meet specified electrical architecture, system, security, safety &encoding requirements. Perform Integration testing for Audio Video Bridging over Ethernet (eAVB). Test audio arbitration over CAN, Automotive Ethernet connectivity, eAVB timing, eAVB data &formatting, gPTP synchronization, &OnStar test plan audio. Simulate modules &test procedures using Functional Blocks in VSpy &verify CAN communication according to GM specs &IEEE standards incl. 802.1AS-2011. Master, Electrical or Computer Engineering. 12 mos exp as Engineer or Developer, testing passenger vehicle embedded ECU features in TCU, IVI, CGM modules, to meet electrical architecture, security, safety &encoding requirements, or related. Mail resume to Ref#24831, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

SOFTWARE ENGINEER, Milford, MI, General Motors. Review &analyze MATLAB, Simulink &Stateflow models &autocode generated SW for chassis features incl. torque control &diagnostics. Design, develop, validate, debug &integrate conventional ICE, HEV, &BEV psgr vehicles chassis &electrification torque monitoring &vehicle &sys remedial action safety SW, in Embedded C &C++, using Git, Gerrit, Jenkins, Eclipse IDE, IBM RTC, DOORS, &Rhapsody tools, following MISRA CERT C stndrds. Design, review, integrate &verify SW to meet vehicle specific architecture, syst, security, &safety reqmts of current/future global ICE &BEV psgr vehicles. Improve customer &driver safety by supporting new controls strategies, diagnostics, &controller communications. Perform embedded ECU testing on test bench &in vehicle, using ETAS INCA, Vector CANalyzer/CANoe tools, &Lauterbach HW, to verify functionality at Function, Controller &System levels prior to production release. Bachelor, Electrical, Computer, or Electronics &Communication Engrg, or related. 12 mos exp as Engineer, developing &debugging embedded ECU SW in Embedded C &C++ for ICE psgr vehicle &HEV or BEV psgr vehicle Chassis ECU, Electrification ECU, or Powertrain Control Unit feature, or related. Mail resume to Ref#24910-305, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

DIAGNOSTICS SYSTEM DESIGN SPECIALIST, Warren, MI, General Motors. Capture &analyze diagnostics reqmts from IBM DOORS &perform rationality assessments of diagnostics reqmts. Review diagnostics reqmts documented in SSTS &provide feedback to reqmts authors to improve clarity &consistency w/ established diagnostic strategies. Coordinate rationality assessments w/ reqmts authors, Subsystem Lead &Service Engrs as needed to ensure high qlty, executable subsys reqmts. Design &model Vehicle Diagnostic reqmts into Open Diagnostic Data Exchange / ISO 22901-1, to model Routine/Data/Control Parameter/&Parameter Identifiers & Diagnostic Trouble Codes (DTCs) Identifiers (PIDs) using IBM Rhapsody. Oversee &model diagnostic artifacts creation &updating in Rhapsody using model-based dvlpmt when reqmts are updated in DOORS &Change Requests are raised in IBM RTC. Bachelor, Electrical, Computer, Automotive, Production, or Industrial Engrg, or related. 60 mos exp as Engineer, Technical Lead, or related, capturing &analyzing diagnostics reqmts in IBM DOORS, or related. Mail resume to Ref#675, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

HARDWARE IN THE LOOP (HIL) SIMULATION INTEGRATION ENGINEER, Milford, MI, General Motors. Create &integrate HIL environments to enable verification &validation of ICE passenger vehicle &BEV intelligent embedded Electronic Brake Control Module for Chassis HIL lab, in C language, &using MATLAB, Simulink, Vector CANalyzer/CANape, &IBM RTC tools. Create complete vehicle plant, vehicle dynamics &physics in CarSim software &integrate CarSim exported S-Function in Simulink environment. Comprehend new features &rqrmnts rolled out to controller prgrms. Integrate dynamic plant models for HIL real-time closed loop simulation, based on those reqrmnts &features. Work w/ HIL bench users, including various Engineers to ensure HIL simulation meets their testing rqrmnts. Develop &integrate subsys models, such as sensor &actuator models, serial data communication - CAN, LIN &ECU behavioral models. Work closely w/ plant modeling &SIL teams to ensure common models &other simulation assets are shared between HIL &SIL simulations. Master, Electrical, Mechanical, Automotive, or Mechatronic Engineering. 12 mos exp as Engineer or related, performing, or involved in, algorithm development utilizing SIL &HIL &vehicle environments, &working in C programming, MATLAB/Simulink, Vector CANalyzer/ CANape, or related. Mail resume to Ref#403, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

DESIGN RELEASE ENGINEER-AUTOMATED DRIVING & ACTIVE SAFETY CAMERAS, Warren, MI, General Motors. Engineer, develop &release U.S. &global conventional passenger vehicle &Battery Electric Vehicle viewing cameras system w/ viewing viewports (front/rear standard view, junction view, bowl view, &side view) for active safety features using Siemens NX, Tc Vismockup &ECM tools. Approve product qlty, GD&T, gauge/fixture design &build. Perform &assure Vehicle Program Initiation to Start of Regular Production. Develop automotive syss that provide near &far object detection, enabling implementation of safety features in vehicle, such as lane departure warning, &Super Cruise. Develop &define camera performance according to CTS, SSTS, FTS, &certification compliance w/ U.S. &intl standards defined by FMVSS. Use Design for Mfg/Assy (DFM/A), DFSS tools &perform Root Cause Analysis, to identify systems design root cause, track Incidents per Thousand Vehicle (IPTV), &provide technical solutions for warranty claims. Coordinate development of HW cmpnts w/ Tier 2/3 suppliers. Master, Mechanical, Industrial or Automotive Engrg, or related. 12 mos exp as Engineer, using Design for DFM/A, DFSS tools, to identify psgr vehicle systems design root cause, track IPTV, &providing technical solutions for warranty claims, or related. Mail resume to Ref#14064, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

VEHICLE DATA ENGINEER, Warren, MI, General Motors. Design, engineer, &develop conventional, semi-autonomous &autonomous psgr vehicle functional technical specs level reqmts &interfaces using IBM DOORS &RTC for Vehicle Data Hub (VDH) app in OTA embedded electronic controller. Define E2E architecture &specs for nextgen Battery Electric Vehicle (BEV) connectivity feature. Identify, review, &create Feature document (FD) &Functional Specification document (FS). Analyze VDH system &improve &develop high level test matrix incl deployment SW, Back Office server, &data sourcing vehicle modules so that vehicle &cmpnt combinations are tested, validated &adhere to reliability &safety standards. Design enablers for secure in-vehicle pre-processing of data &big data collection, processing &off-loading from embedded ECUs in vehicle Autonomous Driving Compute Platform &Virtual Cockpit Unit. Master, Electrical Engrg or related. 12 mos exp as Engineer, defining E2E architecture &specification for BEV connectivity feature, &identifying &creating FD &FS, or related. Mail resume to Ref#24972-8301, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

JOB OPPORTUNITIES

ELECTRIFICATION CALIBRATION ENGINEER-BEV3/AV, Milford, MI, General Motors. Calibrate, test, verify vehicle performance, &validate Battery Electric (BEV) & Autonomous Vehicles propulsion syss in-vehicle &on test bench (SIL), using Co-Simulation, MATLAB, Simulink, ETAS INCA &Measure Data Analyzer (MDA), AVL CRETA, Vector CANalyzer/CANoe/CANape, &VSpy tools, &neoVI FIRE HW. Collaborate w/ algorithm/SW &HW engrs. Decode complex control algorithms using embedded C/C++ &Simulink models. Release &manage BEV &AV production level propulsion syss calibration for VESCOM SW releases for multi market &multi battery module vehicle variants using Creta calibration data lifecycle mgmt sys. Deliver HOS &Driver Command Interpreter calibrations to ensure feature &diagnostic functionality &robustness according to internal standards. Apply understanding of BEV torque architecture to dvlp &optimize vehicle propulsion syss features incldg max vehicle speed, regeneration energy, propulsion syss braking, vehicle traction, cruise control, axle torque, thermal stall protection, &OBD calibrations to meet performance &timing reqmts utilizing calibration standard work. Required travel to validate drivability matrices &support testing &validation field trips for high altitude, hot &cold weather propulsions systems testing in MI, AZ, CO, TN, FL, &CA, ~7 wks P/A. Master, Automotive Systems or Mechanical Engrg, or related. 12 mos exp as Engineer, calibrating &testing or verifying vehicle performance or emissions of Hybrid or Battery Electric Vehicle powertrain or propulsion sys, &using Simulink, INCA, MDA, &CRETA tools, or related. Mail resume to Ref#25556, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

SENIOR PROCESS ENGINEER-CONVEYOR CONTROLS, Warren, MI, General Motors. Plan, execute &launch high volume ICE psgr vehicle &Battery Electric Vehicle paint syss &conveyors projects for GM de Mexico vehicle assy plants Paint Shops incldg conveyors (skids, chains, Electrified Monorail Systems (EMS), skillets, automated guided carts (AGCs), &automatic guided vehicles (AGVs)), Pretreatment, eCoat, Ovens, &Color Booths. Perform &lead engrg &design of conveyors controls for new vehicle prgrms, assuring compliance w/ SORs, &verify supplier conveyor controls designs &equipment builds, approve equipment build run-offs &buyoffs according vehicle assy plant Paint Shop layouts. Engr, design, evaluate, implement, &optimize current &new automation controls incldg sealer process robotics, material handling, parts sorting, conveyors (skids, chains, EMS, skillets, AGCs, &AGVs), mfg process eqpmnt, &automation controls technologies incldg PLCs, HMIs, error proofing syss, &plant floor networks, using AutoCAD &ePlan tools for HW &TIA Portal &Studio5000 tools for SW. Required travel to 3 GM vehicle assy plants in MEX to evaluate &improve Paint Shop mfg processes &facilities layouts, integrate, &monitor plant installation of conveyors for ovens &robotic cells, &support Paint Shop launches, 8 wks P/A. Bachelor, Electrical, Electronics, or Mechatronics Engrg. 24 mos exp as Engineer, executing or launching high volume psgr vehicle paint syss &conveyors projects for vehicle assy plant Paint Shop incldg conveyors (skids &chains), Pretreatment, eCoat, Ovens, &Color Booth, or related. Mail resume to Ref#45175-2113, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

VEHICLE MOTION EMBEDDED CONTROLS (VMEC) ENGINEER, Milford, MI, General Motors. Gather architecture &SW technical reqmts from the architecture &calibrations team to analyze &formulate SW reqmts. Ensure that psgr vehicle stability &braking syss behave on normal &slippery surfaces in accordance w/ SW design intent to regulate &control wheel slip, trailer sway, yaw moment, corner exit control, brake torque process, regenerative control, power hop control &engine drag control. Dvlp embedded SW for BEV &AV syss to test &validate vehicle control regulating vehicle stability &braking syss, using MATLAB, Simulink &C, on different vehicle architecture-based Electronic Control Modules. Perform peer reviews &unit level testing using RiBeTT &CppUTest for Multiple Condition Coverage to reduce rework requests &achieve zero SW defects. Set technical objectives &tasks to implement production intent SW for infrastructure &platform SW cmpts supporting communication for embedded ECUs in Embedded C, using Git, Gerrit, Jenkins, Eclipse IDE, IBM RTC tools, &following MIRSA CERT C standards, &GM SW development process. Required travel to support testing &validation at Milford Proving Ground &field trips in test vehicle for cold weather propulsions syss testing in Upper Peninsula (MI), ~15 days per year. Bachelor, Electrical, Computer, or Mechanical Engrg. 24 mos exp as Engineer, setting technical objectives &tasks to implement production intent SW for infrastructure &platform SW cmpts supporting communication for embedded ECUs in Embedded C, &following MISRA CERT C standards, or related. Mail resume to Ref#5370, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

CONTROLS INTEGRATION ENGINEER, Milford, MI, General Motors. Collect 20-28 Tier I/II supplier embedded ECU SW packages for Body Control Module (BCM), Electronic Brake Control Module, OnStar module, Instrument Panel Cluster, Transmission Control Module &20 other embedded ECU modules, for future truck programs. Review, validate &release In-Vehicle SW Configuration Management (VeSCoM) to internal Electrical Engrg, Chassis Controls &Powertrain Engrg groups for review &debugging of current &new VeSCoM system SW packages of suppliers. Create test plans, using VSpy &DPS tools, in Controls Development Plan (CDP), based on VeSCoM &release CDP to Flint &Oshawa Assembly Plants. Create VeSCoM documentation incl. Master 3PD, release notes, ID files, HW dependencies, new features, known issues/anomalies for each VeSCoM SW release &upload to SharePoint. Perform KBTs &milestone tests of 20-28 supplier embedded ECU packages based on HD truck program monthly milestones. Perform In-Vehicle CDP testing to identify bugs in supplier before vehicles are assembled in plants &submit timely reports to Controls Mgr. Bachelor, Electrical, Mechanical or Electronics &Communication Engrg, or related. 6 mos exp as Engineer, capturing &analyzing CAN bus &LIN bus data from vehicles or test bench using neoVI FIRE2 HW &performing root cause of issues using collected data using VSpy tool, or related. Mail resume to Ref#31380-4111, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

CONSULTANT, RICARDO, INC., Van Buren Twp, MI. Analyze hybridization, electrification &autonomy issues &challenges faced by OEM &Tier I suppliers, contributing to new cmpnt development, safety syss, benchmarking &assessment of new gasoline/diesel engines, semi-autonomous, &autonomous Hybrid (HEV), Electric &Autonomous Vehicles technologies incl. electric motors, TPIM, high voltage (HV) traction batteries, DC/DC converters, on-board chargers, &deliver market &product knowledge to clients. Perform full electric &HEV cmpnt &technology assessments &technology road mapping/adopting scenario modeling/forecasting, &assessment of advanced technologies in vehicle electrification &HV electric motor, inverter &battery storage, assessing market drivers &customer needs as part of product strategy dev; product cost estimation, performance benchmarking; lifecycle analysis, overall model reviews; costing &sourcing strategies; &mfg process assessment. Use MATLAB, Simulink, C/C++ languages, &CANape, CANalyzer, CANoe, dSPACE, Motohawk, &INCA tools, to develop, simulate, calibrate, test &release control algorithms &SW. Master, Electrical, Electronics, or Automotive Syss Engrg. 12 mos exp as Engineer, Consultant, Specialist, Associate, or related, integrating, testing &releasing SW, electronic control units, tools, sensors, actuators, &harnesses into electronic system to control products in a variety of user apps, or related. Mail resume to Ref#39340-101, Human Resources, Ricardo, Inc., 40000 Ricardo Dr., Van Buren Twp, MI 48111.

MATERIAL EXECUTION ENGINEERING LEAD, Warren, MI, General Motors. Plan, coordinate, lead, &support execution of Lean Material Strategies (LMS), using AutoCAD tool, incl. material flow, material routings, storage space reqmts, kitting, small lot strategy, sequence planning utilizing Plan for Every Part, mobile eqpmt reqmts, &material layout dev for Wentzville Assy Plant. Execute material launches according to vehicle syss material execution standardized work. Develop &apply lean material strategies using standardized material matrix to ensure efficient material flow &presentation to mfg operators. Engineer &maintain SORs to procure high bay racks for material storage &automated sequence &material storage system to meet material storage reqmts. Communicate with &engage suppliers to design &procure kit totes, kit bags, kit carts, sequence racks, material display risers, material display lift tables &dollies according to mfg reqmts for efficient material presentation &delivery to lineside mfg operators. Forecast, track &manage program funding for material &LMS launch of assigned vehicle programs. Required travel to Wentzville Assy in MO to evaluate &validate kitting &lineside material strategies, installation of eqpmt, &new technology for material storage; mentor &guide contract engineers to execute LMS; &deliver supply chain leadership presentations &LMS technical training, up to 24 wks P/A. Master, Mechanical or Automotive Engrg, or related. 12 mos exp as Engineer, engaging suppliers to design &procure kit totes, kit bags, &kit carts, &evaluating kitting cell presentation reqmt &supporting team to procure material display risers &material display lift tables for delivery to lineside mfg operators, or related. Mail resume to Ref#2232, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

JOB OPPORTUNITIES

INFOTAINMENT SYSTEM FEATURE INTEGRATION ENGINEER, Warren, MI, General Motors. Create, execute, evaluate, integrate, debug, &release manual test plans &test cases for Vehicle Software Management Systems OTA reflash SW apps, for future installation in psgr vehicles of Electronic ECU modules &features. Integrate, test, &verify software apps for conventional psgr vehicle &BEV embedded telematics &infotainment ECUs, incl IP Cluster, Body Control / Center Stack / Central Gateway / Engine Control Modules, Virtual Cockpit Unit, In Vehicle Infotainment, OnStar Core Module &other vehicle modules, in Android, C, Embedded C, &QNX prgmg languages, for future vehicle pgrms &global mkts (China, NA, SA, &RoW), to meet vehicle specific electrical architecture, sys, security, safety &encoding reqmts. Simulate &test infotainment features incl Power Moding, Memory Seat Module, Performance Data Recorder, Ambient lighting &choreography, In market enhancement themes, HVAC, &Multi-Function Controller in embedded ECUs. Bachelor, Electrical Engrg, Computer Science, Electronics &Communication Engrg, or related. 12 mos exp as Engineer, integrating, testing, &verifying Subsystem Technical Specification &Vehicle Technical Specifications of psgr vehicle infotainment ECU features, or related. Mail resume to Ref#3185, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

CAE BODY STRUCTURE ENGINEER, Warren, MI, General Motors. Perform virtual validation of psgr vehicle body structure syss. Ensure body structure syss performance &design reqmts are in accordance w/ load specs. Use ANSA, MetaPost, HyperWorks, OptiStruct, NASTRAN, LS-DYNA, Primer, &MeshWorks to perform FE simulations of full vehicle body structures. Use advanced CAE modeling &anlys procedures to model, analyze &optimize battery structures, electric drive unit structures, battery control unit structures of EVs in compliance w/ internal EV performance &safety reqmts. Design, fine tune &improve BIW front rails &reinforcements, A/B/C/D Pillars, underbody cross members, &chassis (frame) structures, based on vehicle N&V, durability, &fatigue performance reqmts. Use topology/size/gauge&shape optimization techniques to identify efficient load paths to meet mass, N&V, durability, fatigue, &safety performance reqmts. Bachelor, Mechanical, Automotive, or Aerospace Engrg. 24 mos exp as Engineer, using CAE software incl ANSA, MetaPost, OptiStruct, NASTRAN, &LS-DYNA to perform FE simulations of full vehicle body structures, or related. Mail resume to Ref#3886, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

CONTROLS DESIGN ENGINEER, Milford, MI, General Motors. Design, develop, review, &verify algorithms to meet psgr vehicle specific architecture, system, security, safety &encoding reqmts of US &global Battery Electric Vehicle embedded ECU Vehicle Integration Control Module Battery Energy Transfer features incl programmable charging &charging termination, in MATLAB &Embedded C programming languages, using MATLAB, Simulink, Stateflow, Model Development Kit, Git, Gerrit, Jenkins, Eclipse IDE, IBM RTC, Artifactory, ETAS INCA, &internal tools, dSPACE HIL test bench, in Windows OS, in Agile &SAFe methodologies. Define &execute embedded ECU SW unit level testing using CppUTest &vehicle tests from customer expectations &system reqmts. Collaborate w/ teams to define &integrate cmpnts, check functionality on dSPACE HIL test bench &in vehicle. Research &develop novel solutions to various controls problems that cover multiple domains incl chemical, electrical, mechanical, &thermal. Master, Mechanical, Electrical or Automotive Engrg. 12 mos exp as Engineer, designing or developing calibration data anlys tool to detect potential defects of control SW of embedded ECU in MATLAB, in Windows Operating System, or related. Mail resume to Ref#45956, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

QUALITY COORDINATOR, New Boston, MI, Brose North America. Design, coordinate, roll out, &improve plant wide culture of systematic problem solving in qlty, productivity, product throughput, &worker safety &mentor &train Qlty Engineers/Inspectors on using problem solving tools incl. 5 whys, measles charts, &Is-Is not (root cause) tool, &use PFMEA, Six Sigma, &Fishbone Diagram tools, to ensure continuous qlty, qlty improvement processes; OEE; Value Stream designs; &best practices, during production of proprietary mechatronic door modules, seat adjuster systems, hands free access, &power liftgate syss. Coordinate, engineer &improve mfg processes, applying QA techniques to increase OEE &reduce failure rates during production at mfg plant. Apply DMAIC data control driven methodology, based on statistical tools such as Pareto, Process Capability (Cpk), Process Performance (Ppk) &Design of Experiments (DOE) analysis, &regression analysis, to identify &solve root causes of problems. Master, Industrial, Mechanical, or Automotive Engrg. 6 mos exp as Engineer, engineering &improving mfg processes, applying QA techniques to reduce failure rates during production at mfg plant, &applying DMAIC methodology, based on Cpk, Ppk &DOE analysis, to solve root causes of problems, or related. Mail resume to Ref#1602, Brose, Human Resources, 3933 Automation Ave, Auburn Hills, MI 48326.

CAE BODY STRUCTURE ENGINEER, Warren, MI, General Motors. Design &analyze early stage psgr vehicle body structure architecture concepts through concept modeling &optimization. Engineer, perform &execute FEA of full vehicle conventional ICE psgr vehicle &Battery Electric Vehicle in adherence with U.S. &global N&V, durability &fatigue performance of BIW Body Frame Integral &Body on Frame light weight/high strength steel structures &provide design recommendations to satisfy load case metrics at virtual assessment gates. Use ANSA, MetaPost, HyperWorks, OptiStruct, NASTRAN, LS-DYNA, Primer, &MeshWorks for Finite Element (FE) simulations of full vehicle body structures. Use advanced CAE modeling &anlys procedures to model, analyze &optimize battery structures, electric drive unit structures, battery control unit structures of electric vehicles in compliance w/ EV performance &safety reqmts & FMVSS standards. Master, Mechanical, Automotive, or Aerospace Engrg. 12 mos exp as Engineer, using CAE SW such as ANSA, HyperWorks, OptiStruct, LS-DYNA, &Primer for FE simulations of full vehicle body structures, or related. Mail resume to Ref#1084, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

CONTROLS DESIGN ENGINEER, Milford, MI, General Motors. Engineer, define, develop, implement &validate math-based &physics-based algorithms for current &next gen Battery Electric Vehicle charge estimation in embedded Vehicle Integration Control Module optimization techniques in embedded On Board Control Module (OBCM) for global BEVs, using Simulink models, C language, &Git, Gerrit, Jenkins, PacMan, &Artifactory tools, in SAFe methodology, for global markets (NA &China). Define reqmts, &design/develop SW for OBCM to select most efficient &optimal vehicle operation to meet driver demand using advanced control algorithms incl linear/nonlinear System, Adaptive, Optimal, Robust, & Stochastic Control; AI; steady state optimization &state estimation techniques, in C, using Eclipse IDE, MATLAB, Simulink, Stateflow, ETAS INCA/MDA tools. Verify &test algorithms in Model in the Loop (MIL), Software in the Loop (SIL), &Hardware in the Loop (HIL) environments using MATLAB, GMSim, &dSPACE tools &in vehicle using ETAS INCA. Master, Electrical, Mechanical, Automotive or Computer Engrg. 12 mos exp as Engineer, verifying &testing algorithms in MIL, SIL, &HIL environments using MATLAB &dSPACE tools, or related. Mail resume to Ref#1431-302, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

VEHICLE MASS PERFORMANCE ENGINEER, Warren, MI, General Motors. Gather part, total vehicle weight, &capability attributes (gross vehicle weight rating, gross axle weight rating, towing/trailering capabilities, &payload) to calculate, forecast, &ensure conventional ICE &BEV sport utility vehicle comply with U.S. EPA/NHTSA/FMVSS &CARB regs. Perform &forecast vehicle mass management &create vehicle mass management reports of current &future full size SUV. Ensure, validate, &perform linear optimization of vehicle positioning within U.S. EPA test weight classes & greenhouse gases (GHG) &Corporate Average Fuel Economy (CAFE) regs by developing vehicle weight estimates, label data, &publishing vehicle weight reports, using vehicle mass certification reporting database, global product description system, CAD modeling, &Mass track tools. Perform production &IVER audits at PPO plant to vehicle mass on production lines, incl. measuring of parts, assemblies, &total vehicle mass to achieve status to target. Master, Mechanical, Industrial or Automotive Engrg, or related. 12 mos exp as Engineer, validating or performing linear optimization of vehicle positioning within U.S. EPA test weight classes &GHG &CAFE regs by developing vehicle weight estimates, label data, &publishing vehicle weight reports, or related. Mail resume to Ref#22657, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

JOB OPPORTUNITIES

SOFTWARE ENGINEER, Milford, MI, General Motors. Gather system requirements for GM conventional ICE passenger vehicle Engine Control Module (ECM) features including Cold Start Emission Reduction, Fuel Delivery System, High Pressure Fuel Pump, &Gas Particulate Filter &functions including Cold Start Control, Cold Start Diagnostics, Fuel injector Control, Fuel Injection mode. Create designs &updates Algorithm Design &Software Description Documents. Implement designs according to embedded SW &modeling standards, using MATLAB, Simulink, Stateflow, C language, PolySpace, Gerrit, Jira, Jenkin, Artifactory, Eclipse IDE, &IBM RTC. Ensure implementation complies with MISRA, CERT &GM embedded C Coding Standards &ISO26262 safety standards. Integrate implementation into production SW &verify it w/ cmpnt &controller build. Review build logs &update SW to address build issues. Validate design &implementation performing unit testing using Simulink Test, CPPU, RiBeTT tools. Validate system behavior using vehicle virtual simulation with GMSIM &AutoVAL, HIL bench with dSPACE, Control Desk, ETAS INCA &MDA tools. Bachelor, Computer Science, Computer or Electrical Engrg, or related. 60 mos exp as Developer, Engineer, Technical Lead, Asst. Consultant, or related, designing, validating, or releasing ECM or Body Control Module (BCM), or ECM or BCM features, or related. Mail resume to Ref#23382, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

SOFTWARE ENGINEER-VMEC, Milford, MI, General Motors. Review &analyze MATLAB, Simulink &Stateflow models &autocode generated base software for torque monitoring. Design, develop, validate, debug &integrate ICE passenger vehicle, Hybrid (HEV) &Battery (BEV) Electric Vehicle engine, chassis, transmission, &electrification torque monitoring &vehicle &system remedial action safety SW, in Embedded C, using Git, Gerrit, Jenkins, Eclipse IDE, IBM RTC/DOORS/Rhapsody tools, following MISRA CERT C standards. Design, review, integrate &verify SW to meet vehicle specific architecture, system, security, &safety requirements of global passenger vehicles. Improve customer &driver safety by supporting new controls strategies, diagnostics, &controller communications. Perform embedded ECU testing on test bench &in vehicle, using dSPACE ControlDesk, ETAS INCA, VSpy, Vector CANoe tools, &Lauterbach HW, to verify functionality at Function, Controller &System levels prior to production release. Master, Electrical, Mechanical, or Mechatronics Engrg. 12 mos exp as Engineer, developing &validating conventional ICE passenger vehicle &HEV or BEV torque monitoring &vehicle remedial action safety SW, in Embedded C, using Gerrit &IBM RTC tools, following MISRA CERT C standards, or related. Mail resume to Ref#31115-20204, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

CONTROLS TOOLS DIAGNOSTIC SOFTWARE ENGINEER, Milford, MI, General Motors. Member of Test Automation Platform Team, develop test automation solutions, identify, program, tune, optimize &integrate off the shelf tools &design new SW tools to validate system & SW reqmts for conventional ICE passenger vehicle, Battery Electric Vehicle (BEV), &Autonomous Vehicle platforms' embedded ECUs, in C#.Net, Iron Python &Python, using MATLAB, Simulink, ETAS INCA, Stahle RC, CarSim, dSPACE Control Desk, NI LabView, Lauterbach Debugger &VSpy tools, &CAN devices according to J2534, &Automotive Ethernet protocols based on DoIP standards. Ensure accurate validation for low &high-risk scenarios. Mentor &work w/ offshore supplier team to develop new test methods for test automation &post data processing in C#.NET &Python programming languages, using MS Visual Studio tool for embedded ECU testing. Bachelor, Computer Science; Computer, Software, or Electrical Engineering, or related. 60 mos exp as Engineer, Developer, Lead, Consultant, or related, mentoring or working w/ team to develop new test methods for test automation &post data processing in C#.NET &Python programming languages, using Microsoft Visual Studio tool for embedded ECU testing, or related. Mail resume to Ref#35091-104, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

VIRTUAL DESIGN, DEVELOPMENT &VALIDATION ENGINEER-CRANKTRAIN STRUCTURAL FEA, Warren, MI, General Motors. Perform conventional ICE passenger vehicle engine cranktrain (incl. pistons, crankshafts, balance shafts, connecting rods, dampers, &flexplates) structural linear &nonlinear FEA, fatigue, multi-body simulation, design optimization, thermal steady state, &thermal transient analysis, using HyperMesh, SimLab, Abaqus (implicit &explicit), Abaqus CAE, Fe-Safe, AVL Excite, TOSCA, iSight &OptiStruct tools, &Python scripts. Perform modeling &simulation of crankshaft, piston &electric motor dynamics to generate loads for downstream users &make structural assessment of cranktrain &electric motor components. Develop models to simulate electric motors dynamics, &perform FEA of Battery Electric Vehicle electric drive unit cmpnts. Develop new engrg FEA capabilities. Participate in product dev teams on new, major, minor designs, providing FEA results to assess performance of new cranktrain designs. Build FEA models from CAD solid models from Siemens NX. Master, Mechanical, Automotive or Aerospace Engrg, or Machine Design, or related. 12 mos exp as Engineer, Design Engineer, or related, performing psgr or commercial vehicle engine cranktrain (incl. piston, crankshaft &connecting rod) structural nonlinear FEA, fatigue, multi-body simulation, &thermal analysis, or related. Mail resume to Ref#498-104, GM Global Mobility, 300 Renaissance Center, MC:482-C32-C66, Detroit, MI 48265.

SAE International Sections

SAE International Sections are local units comprised of 100 or more SAE International Members in a defined technical or geographic area. The purpose of local Sections is to meet the technical, developmental, and personal needs of the SAE Members in a given area. For more information, please visit sae.org/participate/membership/sections.

Collegiate Chapters at SAE International

Collegiate Chapters are a way for SAE International Student Members to get together on their campus and develop skills in a student-run and -elected environment. Student Members are vital to the continued success and future of SAE. While your course work teaches you the engineering knowledge you need, participation in your SAE Collegiate Chapter can develop or enhance other important skills, including leadership, time management, project management, communications, organization, planning, delegation, budgeting, and finance. For more information, or how to find your local Chapter, please visit students.sae.org/chapters/collegiate/.

SAE MEMBERSHIP AND VOLUNTEER ENGAGEMENT STAFF

Corey Dillon
Community Programs Specialist

Nicole Iorfido
Volunteer Engagement Manager

Amanda Kibler
Community Engagement Associate

Rachel Wetzel
Member Relations Associate

EDITORIAL/DESIGN/PRODUCTION

Patrick Ponticel
Editor, Member Magazines

Chris Whissen
Graphic Designer

Adam Santiago
Production Manager

Howard Ng
Digital Production Director

ADVERTISING

For advertising and sponsorship opportunities, please contact Joe Pramberger, Publisher, joe.pramberger@saemediagroup.com

SAE INTERNATIONAL

400 Commonwealth Drive
Warrendale, PA 15096
sae.org/update/
+1.724.772.8577
Fax: +1.724.776.3393
update@sae.org

SUBSCRIPTIONS

+1.877.606.7323
+1.724.776.4970 (Outside U.S. & Canada)
Fax: +1.724.776.0790
customerservice@sae.org

Update, February 2023, Volume 40, Number 2. *Update* is published monthly by SAE Media Group, 261 Fifth Avenue, New York, NY 10016.

ISSN 2165-123X

All this and so much more is available with your SAE Membership at an annual dues of $125.

SAE INTERNATIONAL®

YOUR MEMBERSHIP. **YOUR BENEFITS.**

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

BECOME A MEMBER TODAY AND BENEFIT FROM OPPORTUNITIES SUCH AS:

Connexion+ connexionplus.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 Program	Accelerate your career growth by tapping into industry insights from experienced SAE Members or make a lasting impact on the future of mobility by serving as a mentor
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.
Volunteer Opportunities	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!

P221116100