A summary of the Breakout Discussions that took place at the 2021 virtual event.

Simulation in the Automotive Industry:

Creating the Next Generation Vehicle

Simulating Reality – How do you know the simulation is correct?

Tim Hunter, Wolf Star Technologies

The discussion centered around the main frustration of not understanding the loading correctly on components. System simulations can be too coarse to get the fidelity of loading at the components. There was frustration that durability courses/standards are set too conservatively, which drives overdesign. However, companies were not willing to challenge old standards that have been working. Also, there was frustration that perhaps the testing regimes were not correctly mimicking real-world applications – which added insult to injury when trying to have a simulation that matched a test condition.

What is the role of the digital thread in creating the next generation vehicle?

Rod Dreisbach, NAFEMS Technical Fellow

The primary concern was how to become prepared for the next generation product development environment based on model-based engineering techniques, with the realization that a digital thread architecture is a mandatory requirement for implementing digital twin scenarios. The definitions for these two terms used during the discussion are noted below. Neophytes who are addressing this topic are especially concerned about implementing digital continuity of information flow in contrast to what exists today where the 1D through 3D CAx data artifacts are disconnected. Underlying the overall requirements is the concern of having sufficient executive management support of an appropriate "Simulation Governance and Management Infrastructure" that ensures the required integration and collaboration between the various disparate technical disciplines.

Digital Thread (Ref: JAMA Software on Internet)
A data-driven architecture that links together information generated from across the product lifecycle and is envisioned to be the primary or authoritative data and communication platform for a company's products at any instance of time.

Digital Twin (Ref: Joint NAFEMS/INCOSE SMSWG)
A digital surrogate is a description of a physical asset such as one or more products, processes, systems, people, and devices that can be used for various purposes. It makes use of data to/from its real-world asset and may change in tandem throughout the lifecycle of the physical asset.

How can universities work with industry partners to promote the creation of the next generation vehicle?

Emily Nutwell, OSU SIMCenter

As the COVID-19 pandemic has illustrated this past year, the college experience is much more than just what we teach in the classroom. Although it is important that universities incorporate simulation and modeling into the curriculum, they also need to provide student experiences with simulation and modeling in the co-curricular space. Summer internships as well as other work experiences are invaluable to students even at the undergraduate level. Universities can work with industry to understand the onboarding of new employees to see what universities can address ahead of time to make the onboarding process more efficient. In addition, universities can partner with industry to provide continuing professional education to the workforce. The only thing that is constant these days is the constant change. Providing structured but manageable programs for working engineers looking to adapt to new tools and methods can prove to be very valuable as we grapple with the challenges of developing the next generation vehicle.

What is the role of simulation in vehicle electrification for the next 10 years?

Kristian Flores, Ford Motor Company

Topics Discussed:

- The system modeling needs to handle different infrastructures and configurations using 1D, 2D, and 3D simulations, capable to manage ICE, BEV, and HEV vehicle configurations.
- Batteries and cells are the greatest challenges in the design of electric vehicles and they open a great opportunity to tackle them with simulation.
- Lithium plating phenomenon caused by the Fast Charging strategies can be predicted with simulation since this phenomenon cannot be measured physically.
- Challenges in the battery cell design are the thermo-chemical-mechanical interaction, which leads to a multi-physics problem that needs to be account for optimization of the cells.

How automation, AI, and machine learning will disrupt the CAE industry and the relevant job security in the future, and what skills should we prepare now to face the challenge?

John Liu, Ford Motor Company

Participants agree that it is no use to try to resist the technology transformation as history has shown that no one can stop the progress of technology that can make work more efficient and effective. Automation, AI, and machine learning-enabled CAE tools and methods present huge potential to improve design, testing, and manufacturing efficiency and effectiveness. We, as CAE analysts, should embrace the opportunity and learn and adopt the new technology to make us more efferent and effective, and there are many different ways we can get involved, learn, lead and adopt, such as proactively learning the relevant new tools and methods, etc.

For vehicle automation projects, what is the right balance between simulation and testing for training and validation?

Emily Horn, Deere & Co.

The conversation quickly moved off of using simulation to train AI and instead centered more on using simulations for design optimization and design robustness. The group discussed the benefits of using Design of Experiments vs. numeric optimization, using those techniques together, and using the iterations completed during optimization to learn more about model sensitivities. The group also discussed the benefits of including input distributions and/or tolerances for robust design techniques. While the group agreed on the benefits of looking at variation within the design, the group had different experiences regarding the ease and cost of obtaining adequate data (or valid assumptions) for realistic input variation. For software and controls design, simulation, and robust design techniques have helped companies improve their virtual calibration to reduce the amount of parameter or gain tuning needed via physical testing. Again, the companies had different experiences regarding how much reduction in physical calibration they have experienced and everyone agreed that physical calibration will be necessary for the foreseeable future. The social aspect of job displacement and re-training was also discussed at this point due to the replacement of calibration engineers with simulation. The re-skilling of our workforces is seen across the board from displacing calibration engineers with simulation to displacing traditional simulation engineers with automation; our simulation engineers are now required to have more skills in programming and software development to automate our simulation processes. Finally, the value of simulation is seen via robust design, design optimization, and improving the efficiency of calibration; a few companies felt that proving the worth of simulation to other communities is most clearly demonstrated when simulation is connected with our systems engineering tools to expose the simulation process and results to a larger community.

This time it's different: The role of simulation in the design, development, and manufacture of all-electric vehicles.

Keith Meintjes, CIMdata & NAFEMS Technical Fellow

Keith Meintjes introduced the discussion with a comment that automakers are already reducing resources devoted to the development of vehicles with petroleum fuel-based powertrains. He expects demand for (new) electric vehicles to increase dramatically in 2023 and beyond.
He suggested that simulation for electric vehicles would be different because of:

1. Changes in physics, such as battery vs. combustion chemistry;
2. Changes in loads, such as those imposed by the powertrain on the vehicle structure, and;
3. Changes in vehicle design.

He noted that these changes are largely separate from simulation requirements for autonomous vehicles and intelligent highways.

Noise and vibration: Powertrain excitation concerns are much reduced. Higher frequencies will be more relevant, pushing us towards SEA (statistical energy analysis) techniques. There was disagreement on whether N&V simulation would become less important; noise may not be as loud, but it may be more annoying or unpleasant.

Vehicle structure; Body-in-White and chassis: Powertrain loads are different. Vehicle design will change, perhaps to a great extent, with the different constraints for powertrain (and cooling and induction and exhaust) system packaging.

Crash: The requirements remain, subject to changes in vehicle structural architecture. Battery damage during impact is a new consideration.

Aero: Requirements remain. The underbody may be enclosed. Front-end shape may change appreciably due to changed powertrain (engine) packaging requirements.

Fluids and thermal: Thermal optimization for issues like passenger comfort and batteries will be especially important. High temperatures (combustion and exhaust catalysis) and waste heat dissipation are of much less concern.

Vehicle simulation: Tools like MatLab, AMESim, and GT-Power will remain essential for system simulation and simulation. Obviously, they need to comprehend changes in vehicle architecture and systems.

Controls: While control systems remain a critical issue, it was felt that the overall problem is much simpler for all-electric powertrains than for petroleum powertrains. Keith noted that powertrain calibration is a significant contributor to critical path timing for conventional (petroleum) vehicle development.

Chemistry: It was felt that the chemistry issues are much simpler (batteries vs. combustion), but also much different.

Vehicle Development: One of the keynote speakers had said that with shortened development time, vehicle styling (Class A CAD surfacing) and die development (manufacturing simulation, metal stamping) would be on the critical path and receive increased attention.

With the shift towards more vehicle automation (incl. ADAS/AD), what are the challenges facing the virtual validation of these new technologies?

Karim Zouani, Ford Motor Company

1. Management of the requirements needs to be improved. Some requirements are not well defined/written and can be misinterpreted or hard to validate. Lack of a standard to cascade the requirements (SysML, Word documents, PowerPoint,..).
2. Linkage of simulation models to requirements is not automatic. The process is often manual with no traceability of the simulation models to the requirements.
3. Some suppliers do not have the capabilities to build simulation models required for ADAS validation. Others don't incorporate MBSE as part of the product development process.
4. Modeling of some sub-systems/components is still a challenge. In particular, sensors modeling capabilities are very limited.
5. Models created with different tools cannot be exchanged due to a lack of common standards (or adoption of existing standards).
6. Tool vendors are pushing for their ecosystem. This is often not feasible since the eco-systems used are varied and there is a lot of legacies.
7. Selecting the right tool and building confidence in simulation takes years.
8. Identifying scenarios that are important to feature validation is still a challenge. How do we know when it is enough?

What is the role of classical CAE methods for Big Data?

Nagesh Gummadi, Ford Motor Company

Discussion started with Nagesh's brief introduction about the topic: CAE is preferred when limited inputs (data) are available and physical interpretation of the data is essential. Big data, ML and AI are used interchangeably. Big data relies on a large amount of data for the answers. In most cases, interpretability is not necessary. A hybrid approach that keeps the physics of the problem for interpretation and at the same time, makes use of available big data may be a preferred way at this time.

Alan indicated that he is using the available big data to determine the inputs for the problems he is involved with. He suggested that one might be able to capture the inherent non-linearities in the physical system by making use of the Big data very effectively. He also cautioned about the quality of the data available as the data collected is not systematically collected. Malcolm concurred with that opinion saying that using wrong or unsuitable data will lead to a totally erroneous conclusion. Suman views some problems (from a flow perspective) where linearized interpretations are sufficient for an answer may make use of AI-based algorithms very effectively at this time. Problems that need 3D representation may not be able to use Big data alone for interpretation and some sort of Hybrid approach may be required. He referred to some ongoing research work where reduced-order models are effectively used to generate multiple data sets. This data is effectively used to generate solutions (response surfaces, reinforced learning, etc.). Malcolm commented that theoretically if enough parametrization is done, it is possible to use ML for 3D simulations also. Suman referred to some recent work from NVIDIA and the University of Illinois. Sunil indicated that his team is working with a company to generate AL algorithms for simple CFD problems. At this stage, they have generated a significant amount of training sets using conventional CFD models and are trying to develop an AI method for physically interpretable parameters for a simple 3D problem. This is an investigation to see if deep learning can replace Navier Stokes for simple fluid problems. Malcolm indicated for any successful implementation of Big Data-based algorithms, data management (appropriate data required and how they are stored and how they are used) is essential, or else the results can be disastrous. All the panelists indicated that strong CAE is necessary for the appropriate use of Big Data for solving a physical problem.

The ongoing transformation of the Automotive Industry and the ascending role of simulation as a principal catalyst for success in a very disruptive environment.

Mario Felice, virsolTech Engineering Consulting, LLC

Great discussion was held around the extraordinary opportunities for Numerical Simulation in the industry as the main driver to deliver all demanding technologies for a fast-changing automotive world. Innovation and speed to market are key to stay competitive and simulation plays a key role! The transforming propulsion system to electrification energy and battery technology development was a key part of the discussion, along with ADAS and Autonomous Vehicle simulation requirements. Other topics discussed included the need for faster simulation tools. Most methods are 3D and numerical intensive, requiring hours of CPU for solution convergence, this limits execution of large DOE's required to fully explore the design & manufacturing variational space. Need to have software companies develop faster and more efficient 1D physics-based solutions to drive and validated design with minimum physical DV testing! Additionally, discussed the need for more efficient System Level simulation methods for full system design evaluation, since it is still difficult to integrate models, data, and requirements across functions and attributes.

Digital Twin, Connectivity and Autonomous Driving: how are they linked and what are the challenges?

Frank Popielas, SMS_ThinkTank

The discussion was very fast brought down to the basic foundation needed to get to the digital twin. Some of the topics that were discussed are:

- It is part of the overall Digital Transformation of the organization.
- The need for the Digital Thread was highlighted.
- Democratization of simulation throughout the organization is essential.
- Collaboration across the domains, organization, and supply chain is needed.

In connection with the above-mentioned elements the following challenges were pointed out:

- Trust in simulation results is not always a given, yet.
- Simulation processes are not always well defined to the point that they are repeatable and consistent.
- Proper interfaces between the domains do not exist. Too often domains operate still in silos.
- Software vendors always want to push their tools and sell the overall package.
- The software tool landscape for the end-user is diversified and needs to be easily linked with each other. Standards are a must for that. Software vendors are more than happy to incorporate these standards, but they need directions on what those standards are. Then standards are not moving fast enough.
- Capturing tribal knowledge is still an issue for quite a few organizations. With all the restructuring going on, way too often the knowledge is walking out of the door.

How to effectively execute cross-functional and complete product simulations in a typical highly siloed organizational structure?

Allen Sheldon, Honda Development & Manufacturing of America

Is it better to have an organization with a centralized CAE group that could help facilitate cross-functional modeling and simulations, or can silo's of CAE applications be kept and some other approach be taken such as cross-functional CAE teams assigned to product development? We all came from automotive companies which have to some degree a similar silo-type organizational structure for CAE. We thought it would be very helpful to hear from other industries (aerospace, heavy equipment, consumer products, etc.) where perhaps a different organizational structure has allowed better success in this area.

What is the future of hybrid, plug-in hybrids compared to battery electric vehicles, fuel cell electric vehicles, and battery recycling?

Pallavi Gattu, Ford Motor Company

5 members participated in this discussion room throughout. This an open discussion that went around the Hydrogen Fuel Cell vehicle, Mounts design, and Battery recycling.

Following topics/areas were discussed:

- Challenges and problems faced with hydrogen storage systems in Hydrogen fuel cell vehicles. Challenges like dispensing hydrogen to customers, safety risks, hydrogen compression into tanks, etc.
- Interaction and discussions about individual works, challenges/ problems faced, and transition towards electrification.
- Discussion on mounts, CAE projects.
- Battery recycling technology, green cars.