REVEAL

the world we live in

Issue #3 2021

DASSAULT SYSTEMES | The 3DEXPERIENCE® Company

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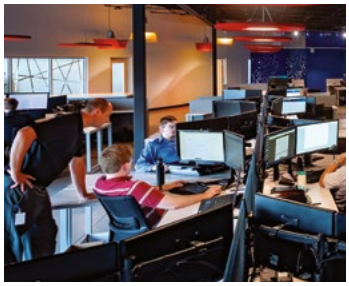
Features



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SIMULATION FOR ALL

What once seemed like a far distant dream is now coming to fruition. Where there previously existed a productivity paradox, there is now metamorphosis. Over the past 20 years, simulation has provided invaluable insights leading to tremendous advances in almost every industry. However, there is always room for progress. Although we have made great strides, product design can still take too long with many risks. There is no doubt that we are living in challenging times. We face many complex issues, including electrification, sustainability, circular economy, and resource limitations. These hurdles will not be solved by incrementally improving today's typical engineering processes. These trends are disrupting the markets and to keep a position (or gain a competitive edge) development and engineering of innovative solutions outside the known perimeter needs to be much faster.

So, what is next?

There is a new term that you may be hearing more of these days: MODSIM. What exactly is MODSIM and why is it important to you? How will it impact the future of simulation? MODSIM is more than just simulation-driven design, it is simulation for all. And while MODSIM includes putting simulation tools into the hands of designers, it is more than just providing access to these tools. MODSIM is about people working together and eliminating the silos that exist at many companies. Now is the perfect time to break down barriers, foster collaboration, share ideas, exchange best practices and capture knowledge.

You, as a simulation user, see the tides shifting in this direction. Virtual testing is a must. Designers and innovators know there is a need to do as much simulation as possible and as early as possible in the development cycle. More simulations will be conducted in the future. But why hasn't implementing this process worked better and with better outcomes? New tools alone will not spark innovation. It is not enough for simulation to just evolve, in addition, your thinking needs to transform. It is the only way forward.

For innovation to thrive and for companies to transform, the people, their knowledge, contributions, ideas, and know-how have to come together at the right time with the right tools. Transformation requires change. It is about people and platform.

Many in the simulation industry think that a platform is about tools and software. But it is really about people and allowing them to collaborate naturally. To provide them with a creative space where they can share and iterate on ideas, brainstorm, interact. A home for innovation. What if we were able to connect a product designer to a simulation engineer throughout the design process, putting valuable knowledge in the hands of designers with validated methods and workflows, all in a single, cloud-based architecture that supports real-time idea-sharing? More than just a vision for organizations leveraging fully integrated modeling and simulation on the **3D**EXPERIENCE® platform. This way of working benefits both highly complex products, such as vehicles and aircraft, all the way down to everyday products such as bottles and cans.

Simulation-driven design is necessary, and while it will help you meet the challenges of today it is not enough for the future. The future of modeling and simulation is all about bringing people together. Having a supportive community brings it all to life. I hope you will join me in the MODSIM community, go.3ds.com/modsim! There you can connect with simulation, modeling, and design experts from around the world including customers already benefiting from a MODSIM approach and Dassault Systèmes R&D experts.

Discover replays from the MODSIM **3D**EXPERIENCE Conferences, as well as presentations, demos, and tutorials. Ask a question. Start a discussion. Become an author. Establish yourself as a thought leader!

The future of simulation is here, are you ready?

FLORIAN JURECKA,
VP SIMULIA Industry Process Success & Marketing

ACCELERATE BUSINESS VALUE THROUGH UNIFIED MODELING & SIMULATION

The following article is based on the plenary presentation, Accelerating Business Value Through Unified Modeling and Simulation, presented at the 2021 Global **3D**EXPERIENCE Modeling & Simulation Conference. Gregor Judex, SIMULIA WW Industry Consultant Director, and Daniel Pyzak, CATIA Mechanical Industry Process Consult-Management Senior Director, showcased a unified environment to improve productivity and collaboration during product development with the Dassault Systèmes **3D**EXPERIENCE platform.

MODELING AND SIMULATION TOGETHER?

Many of us are familiar with the expression "two heads are better than one" as a way to say that bringing multiple people together simultaneously to solve a challenge can achieve a better outcome more quickly. But how is this idiomatic phrase pertinent to the field of engineering? One word: MODSIM. In the past, modeling and simulation have been seen as separate yet equal entities, working simultaneously without being entirely associated. But trends in the industry, such as electrification, disruption from startups, and intense global competition, are accelerating change and increasing complexity. To keep up with these changes, product development cost and speed matter more than ever before. Companies can bring new and innovative products to market more quickly if they can iterate design alternatives faster. And when simulation is done early in product development, it can improve insight into performance and later validate requirements. Therefore, a modern system needs to enable full collaboration among those defining product requirements, designing the product, and validating performance.

Let's examine the development process further using the MODSIM approach to see how everyone benefits when modeling and simulation work together. With this project, we have many stakeholders working together and they will need an environment for collaboration. The **3D**EXPERIENCE platform has a rich web interface where teams can share results, discuss any changes, perform analytics, and track tasks and progress.

EXAMPLE OF MODSIM ON THE 3DEXPERIENCE PLATFORM

For this example, we will use modeling and simulation of a floor panel (figure 1) of an electric vehicle, showcasing a unified environment that dramatically improves productivity and collaboration by using the **3D**EXPERIENCE platform. Every development process starts with requirements, so let's start there. At the beginning of developing an electric vehicle, you need a lot of flexibility in the structure. For example, the batteries may not be fixed in size. The size of the batteries influences the panel itself, which has to be stiff enough to carry all the loads. And at the same time, it has to be soft on the boundaries to absorb enough energy in case of a crash. By tweaking the different parameters, we can then modify the floor panel of the vehicle.

Figure 1: Floor panel design

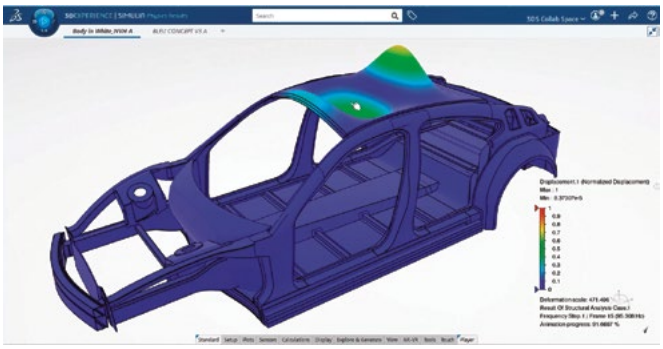


Figure 2: Initial roof design vibration mode shape

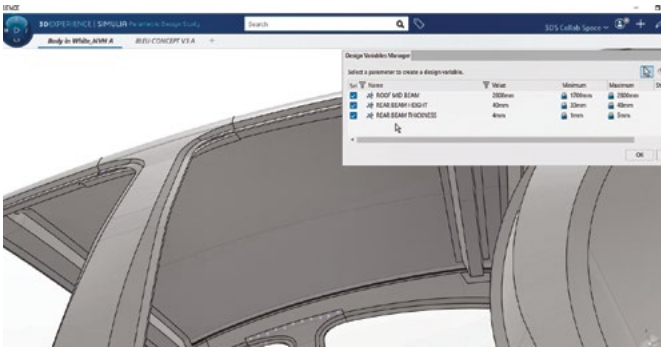


Figure 3: Performance study

Next, let's move forward to another example to show you exactly how you can play with different parameters. In this particular case, we will optimize the stiffness of the roof panel to be about 33 hertz to avoid any vibrations in the roof. The variables we have to do this is first to move

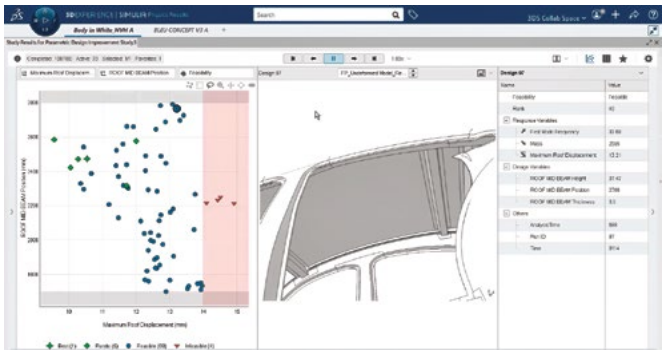


Figure 4: Launching the optimization process

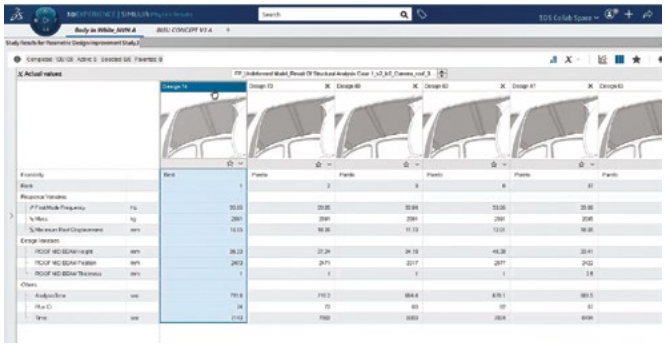


Figure 5: Compare choices

Figure 6: Results of the final run

the stiffener itself, and then modify the height and the width of the beam. Now this seems to be an easy task, so to acknowledge the challenge here, while we are moving that stiffener, it has to adapt its length to fit into the width of the roof, and at the same time, we have to update the fastener as, as well.

So now, we can see the results of our initial design (figure 2) and we can start our performance study (figure 3) by simply selecting different parameters such as the height, the width, and the position of the beam. Then we move through the different positions automatically to see if everything regenerates well, and this is one step before we even start the optimization process itself. Once everything works, we can find what kind of response variables we want to use. For this example, we used the displacement of the roof, the frequency, and the total mass of the vehicle.

Now we launch the optimization process (figure 4). We will get multiple positions for where the stiffener could be. And now we can compare those best choices (figure 5) next to each other and then we can select which of those designs we want to use. Once a design is selected, we can store it as the new variant for that position, and we are feeding back that information and that process to our design experts.

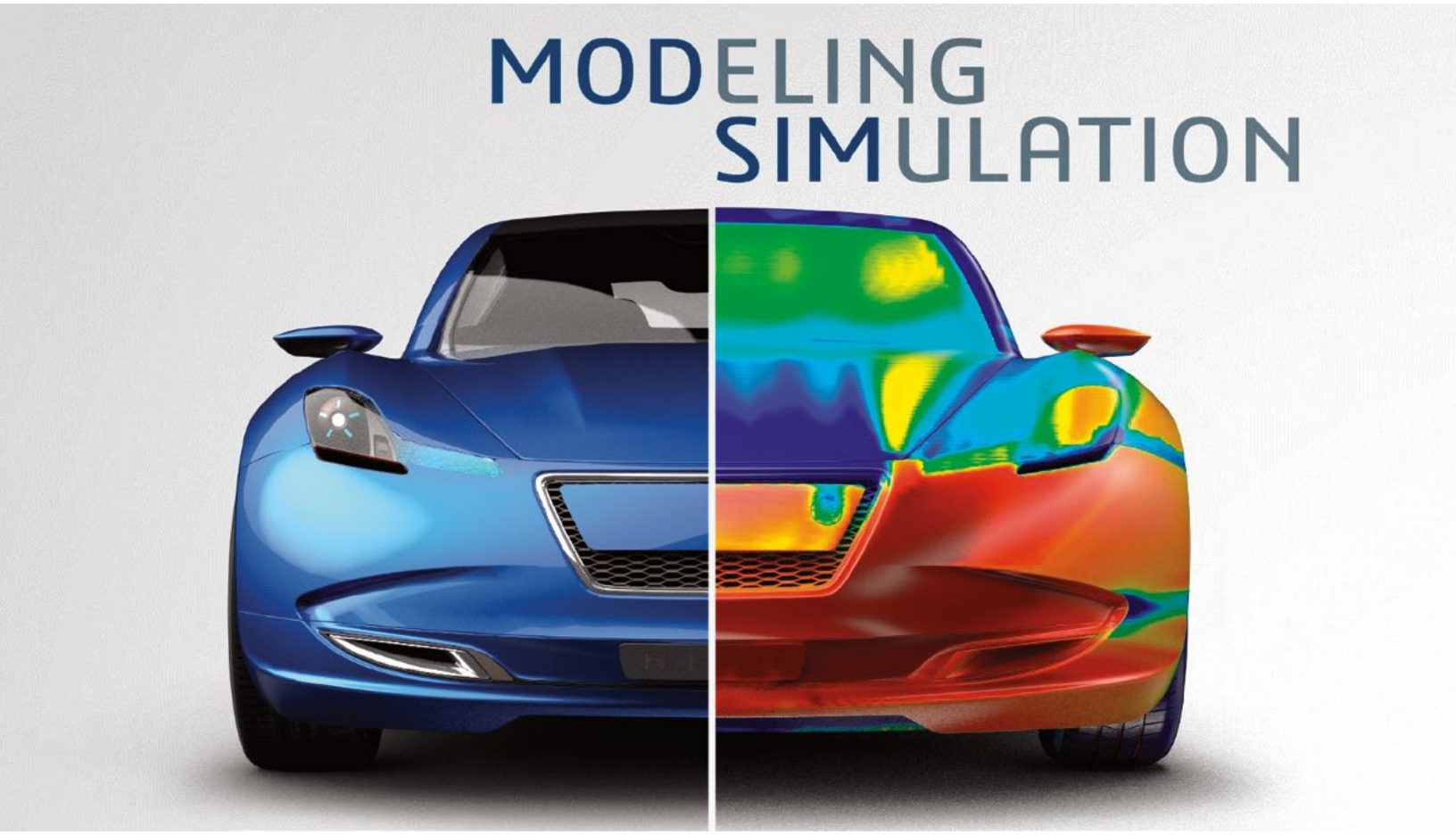
And now we can see the results of the final run (figure 6). Just a note that what we have been doing so far is within one specific domain. If we want to extend to multi-domains, we will need processes. We can create processes that can directly access all the objects within this experience and all the geometry parameters. Not only that but all the attributes of the simulation can be tweaked within the process as well. And if all those simulations are associative to that baseline geometry, you can start to do multi-disciplinary design optimization. So, we not only have the design engineer and the simulation engineer working together, there are multiple stakeholders all working collaboratively.

FUTURE OF MODSIM

What does the future hold for MODSIM? And how will traditional roles evolve in the future? Customarily, the design came first, and then the simulation was performed. However, in the future, these roles may change. But more interestingly, there is democratization. We can use the same process we talked about earlier and put that in the hands of non-experts, maybe design engineers or other stakeholders within the company, to run sophisticated analyses. So, what simulation experts may do in the future is create simulation processes for non-experts. And a non-expert will never have to move into a different environment, using all of the features from within the **3D**EXPERIENCE platform, attaining all the results needed for decision-making.

To learn more about MODSIM, the **3D**EXPERIENCE platform, and to hear this presentation in its entirety, please visit the MODSIM community.

For More Information
go.3ds.com/2021MODSIM-Replay



GLOBAL 3DEXPERIENCE MODELING & SIMULATION 2021 CONFERENCE HIGHLIGHTS

For many years, modeling and simulation were separate but equal entities, important elements of the overall design process often working in tandem but never together. Until now. We are at the beginning of a transformational journey where the insularity that once existed between modeling and simulation has dissipated revealing MODSIM in its place. If you have not heard of MODSIM before, now's the time to learn more. "MODSIM is about people working together," says Dale Berry, SIMULIA Offer Marketing Senior Director. "It's about eliminating the silos that exist at many companies ...not only between design and simulation departments but extending to manufacturing, marketing, sales, the supply chain, and even consumers. Eliminating these silos to foster collaboration, to share ideas, to exchange best-practices, to capture knowledge and to sustain innovation."

Companies can now bring products to market more quickly by iterating design alternatives earlier in the product development cycle. Therefore, MODSIM enables full collaboration between all stakeholders, including those defining product requirements, designing the product, and validating performance. At Dassault Systèmes, we understand the game-changing significance of MODSIM and know that for it to reach its peak it needs a platform to inspire innovation. MODSIM on the **3D**EXPERIENCE platform is the next step in the engineering revolution.

This year the SIMULIA and CATIA brands of Dassault Systèmes held the virtual **3D**EXPERIENCE Modeling and Simulation Conference. The event was built on previous in-person events in Germany, India, and North America, to share important messaging and bring together different user communities. This event was a huge success, defining a clear explanation of MODSIM, bringing clear messaging about the value of MODSIM, and showcasing customer examples from those who have already started on their MODSIM journey.

If you weren't able to attend the MODSIM conference, not to worry—all of the content including panels, keynotes, and roundtable discussions are available in the Modeling & Simulation (MODSIM) Community, which you can access and join via the QR code on the next page. The MODSIM Community is the go-to place where users can start conversations, engage with their peers, ask questions of CATIA and SIMULIA subject matter experts and R&D, watch replays, download white papers, and access other content. Continue reading for a roundup of some of what was presented at the 2021 conference!

CONFERENCE KEYNOTES:

- ***The Present and Future of Modeling & Simulation in Jaguar Land Rover***, Jose Garcia-Urruchi Head of Digital Engineering Capability, Jaguar Land Rover
- ***Virtual Development: Building a Virtual Test Lab Delivering Results in 1 hour—Using Automation and Democratization***, Gilmar Pereira, Senior Manager–Modelling & Simulation, Novo Nordisk
- ***Modeling and Simulations in Airbus: a Key Pillar of Our Digital Transformation***, Marco Ferrogalini, VP Head of Modelling and Simulations (MBSE), Airbus

In addition to the keynotes, the conference also explored in-depth some key MODSIM topics with media, analysts, and 16 customers from the SIMULIA, CATIA, and SOLIDWORKS userbases, such as Boeing, Ferrari GT, Kitty Hawk, Thyssen Krupp, GE Healthcare, Renault, Volvo, General Motors, Ford, Toyota, Integral Powertrain and NIAR. Topics included:

- Drive Faster Innovation with Modeling & Simulation
- Accelerate Advanced Design Concepts for New Mobility Trends
- MBSE Integrates the System Model and Its Simulation
- Improve Your Design Concepts Through Additive Manufacturing & Lightweighting

All the previously mentioned content (and more!) helped build the 2021 Global **3D**EXPERIENCE Modeling & Simulation Conference: a series of 3.5 hours broadcasts, with the plenary sessions originally filmed live from the amphitheater in Vélizy on October 13 for the European broadcast and then played simulive in different time zones for different audiences, including broadcasts in November with subtitles in Mandarin, Japanese and Korean to ensure maximum visibility of the content.

"For MODSIM to be a key component of a company's digital transformation, it requires a mindset shift within the organization," Berry says. "It is not just about the tools. It is about how to properly set yourself up to take full advantage of them in the right context, the right architecture, and the right time."

The conference helped the SIMULIA and CATIA brands establish and strengthen connections with managers, directors, and influencers who want to hear about business transformation and the value of MODSIM on the **3D**EXPERIENCE platform. We hope this conference inspired and motivated these leaders and others to start or continue on their MODSIM journey.

DISCOVER NEW FEATURES AND UPDATES FROM THE LATEST 2022 RELEASES

The newest versions of **3D**EXPERIENCE and SIMULIA products include a range of upgrades and performance improvements for existing workflows, as well as new features to unlock new potential for simulation in design and analysis.

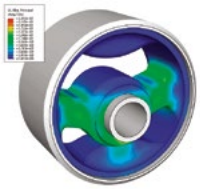
3DEXPERIENCE

The **3D**EXPERIENCE platform is a collaborative environment that empowers businesses and people to innovate in new ways and create products and services using virtual experiences. A few 2022 updates are listed below:

- Users can now create a Whiteboard to allow team members to more easily and visibly contribute to projects.
- A new Compact View has been added to community feeds.
- The advanced options of the Duplicate command are now available for **3D**EXPERIENCE drawings with CAD master other than CATIA V5.
- In Bookmark Editor, when an object attached to a bookmark is revised, the original revision of the object is retained.
- The 3DSpace app is now able to keep the 3D annotations created in PDF documents in 3DPlay embedded viewer in the comments associated with the visualized object.
- In 3DStory, updates include a new Animations Library, YouTube Integration, and a Free aspect ratio for unlimited playback freedom.
- Administrators can now activate the Primary and Secondary revision format for all Engineering Definition, Engineering Evaluation, and Engineering Resource object types.

ABAQUS

The Abaqus Unified FEA product suite offers a complete solution for realistic structural simulation covering both routine and advanced workflows across a range of industrial applications. A few Abaqus 2022 updates follow:



Structural Mechanics

- The LaRC05 damage initiation criteria for fiber-reinforced composites is now available in Abaqus/Standard.
- The Hosford-Coulomb damage initiation criteria for ductile metals is now available in both Abaqus/Standard and Abaqus/Explicit.
- The Valanis-Landel hyperelastic material model to analyze rubber-like materials is now available in Abaqus/Standard.

Analysis Techniques

- You can now use the cyclic symmetry analysis technique in Abaqus/Explicit to reduce simulation time and memory requirement.
- Abaqus/Standard now enables running multiple nonlinear load cases from within a single job. This new capability significantly reduces run time and the number of output files compared to running multiple jobs.
- The import capability has been extended to allow transfer of nodal temperatures and user-defined field variables between Abaqus/Standard and Abaqus/Explicit.

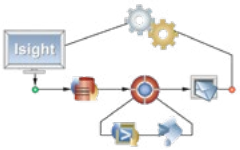
Modeling and Visualization

- Abaqus/CAE now provides a tool remove selected data from an odb which can significantly reduce file size.
- CATIA V5 geometry can now be directly imported on the Linux platform.
- SolidWorks assemblies can now be imported as multiple parts.

Performance and HPC

- You can now execute Abaqus/Explicit in hybrid mode using a combination of MPI and threads with each MPI process launching a user-specified number of threads. Hybrid execution takes advantage of the Non-Uniform Memory Access (NUMA) architecture and the trend of increasing the number of cores available on each socket.
- The iterative linear equation solver in Abaqus/Standard now supports common modeling features including hybrid elements, connector elements, distributing couplings, and hard contact.
- Parallel scaling of linear static simulations with a large number of load cases has been significantly improved.

ISIGHT



Isight and the SIMULIA Execution Engine (formerly Fiper) are used to combine multiple cross-disciplinary models and applications together in a simulation process flow, automate their execution across distributed compute resources, explore the resulting design space, and identify the optimal design parameters subject to required constraints. Below are a few of the Isight 2022 updates:

Abaqus Component Upgrade

- The Isight Abaqus component creates a direct link to Abaqus, allowing automated execution of Abaqus from Isight.

- In Isight 2022, Abaqus component is enhanced to support Abaqus 6.14 through Abaqus 2022 and maintenance releases thereof.
- No other functional changes to the component.

Middleware upgrade

- Apache TomEE
  - Isight 2021 & previous releases shipped Apache TomEE 1.7.2.
  - Isight 2022 ships Apache TomEE 8.0.5.
  - All the security fixes delivered by TomEE between these versions are now automatically available for SEE, Webtop, and Web Dashboard applications running on TomEE.
- Oracle database
  - Supported version of Oracle database has been upgraded to Oracle 19c.
- Microsoft SQL Server database
  - Supported version of Microsoft SQL Server database has been upgraded to Microsoft SQL Server 2019.

Isight/SEE 2022 Improved Stability and Reliability

5 Customer reported bugs closed in this release:

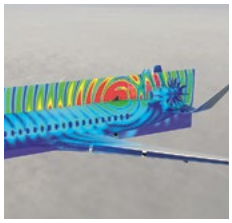
- 1 CST Component
- 1 Pointer-2 Technique
- 1 Model Validation
- 2 Documentation

TOSCA

The Tosca optimization suite provides dedicated fast and powerful structural and flow optimization solutions based on finite element analysis (FEA) and computational fluid dynamics (CFD) simulations. A few 2022 updates are listed below:

- Unified material interpolation in topology optimization (MIMP) enhances topology optimization result interpretation and extends the type of problems that Tosca can solve.
- Rib design constraints
- More robust maximum member size constraint to improve manufacturability
- Manufacturing constraints for bead optimization.
- User design responses based on SIMULIA Abaqus user subroutines
- Advanced stress metrics and plasticity approximation factors
- Resume a job that has run a maximum number of iterations and yet not converged.

CST STUDIO SUITE/OPERA



CST Studio Suite is a high-performance 3D EM analysis software package for designing, analyzing and optimizing electromagnetic (EM) components and systems. Below are a few 2022 updates:

- Low-frequency simulation is enhanced by the Opera Machines Designer.
- A Spark-3D task has been implemented in Design Studio
- Antenna Magus now includes the first reflectarray design using a square unit cell.
- The radome library has been expanded to include multilayer versions of the existing aerodynamic nose cone radomes.
- Performance has been improved when creating CST project files for large projects.
- A **3D**EXPERIENCE user interface theme with updated menu and tree icons has been added.

XFLOW

XFlow, part of SIMULIA's Fluids Simulation portfolio, allows for complex simulation of products' real-world behavior in extreme conditions. A few XFlow 2022 updates follow:

- CATpart and CATproduct importation enable the importation of visualization geometries.
- Solver Surface/Volume Integrals support immersed-boundary geometries and geometries with disabled boundary conditions.
- Solid geometries in Conjugate heat transfer can now be used as the internal domain bounding geometry.
- Moving porous media pressure drop has been improved
- Animated geometries are now supported as Post-Processing shapes, even with loaded data.
- The rotational speed law for a body can be input in RPM for enforced motions.

Interested in discovering more? View the full list of product release webinars by visiting:
https://events.3updateds.com/2022-simulia

2021 SIMULIA CHAMPIONS

The SIMULIA Champions Program pays tribute to our most active and influential simulation experts and brings them together to advance the future of simulation. Connect with our Champions in the SIMULIA Community!

go.3ds.com/SIMULIA-Champions

AMINE AMIMI
Development Engineer,
Tetra Pak
Packaging Solutions

ADVAIT BHAT
Principal Engineer
Packaging Innovation,
Design & Technology,
PEPSICO Global
Beverage R&D

GIORGI (GOGA)
BIT-BABIK
DMTS R&D,
Motorola Solutions

ANDREAS K. BITZ
Professor of Electromagnetic
Theory and Applied Mathematics,
FH Aachen—University of
Applied Sciences

JIN FENG CAO
Associate Professor,
Qingdao University
of Technology

"I love simulation because it ensures that my designs are based on facts and science, and not on gut feelings."

—Sajeesh Sulaiman, Siemens Gamesa Renewable Energy

VENKAT RAJU DASU
Principal Researcher,
TATA Steel

DMITRY GRENISHEN
Team leader of CAE group,
JSC KAMAZ

MARIA GROL
Project Leader,
LLC LMTI UC RUSAL

SUSANNE HIPP
Professor,
OTH Regensburg

ARAM KIM
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PSK

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ShanghaiTech Unviersity

KAI LONG
Associate Professor,
North China Electric Power University

ROBERT LUO
Principal CAE Engineer,
Trelleborg AVS UK

"I love simulation because it allows me to gain a greater understanding of engineering activities that we undertake, and gives us insight into the design and integrity of components that we wouldn't be able to achieve any other way."

—David Scholtz, Wood Group

SIMONE MANCINI
Acoustics and Vibration Engineer,
Airbus

SATYENDRA SAVANUR
Supervisor Underbody Systems CAE and Automation,
Ford Motor Company

DAVID SCHOLTZ
Practical Engineer,
Wood Group

SAJEESH SULAIMAN
EMC Expert,
Siemens Gamesa Renewable Energy

ELLIE VINEYARD
Modeling and Simulation Analyst,
PepsiCo

"I love simulation because it helps in visualizing a better picture of a product or a process, and it better informs the performance of the devices. Eventually it helps accelerate R&D innovations and reduces cost and time to market."

—Venkat Perumal, Stryker Global Technology Center

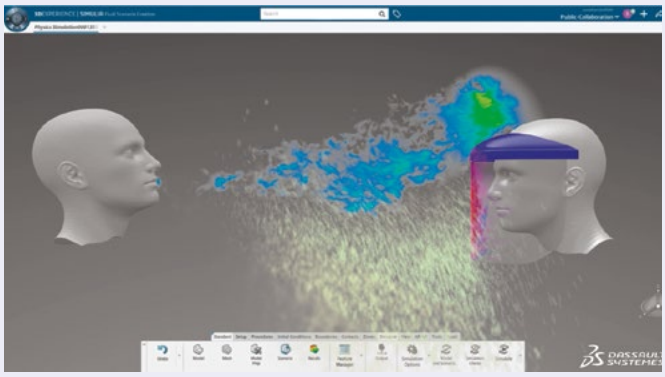
PABLO ZAVATTIERI
Professor of Civil Engineering,
Purdue University

XIAOYU ZHANG
Additive manufacturing Technical Leader,
Beijing Institute of Spacecraft System Engineering

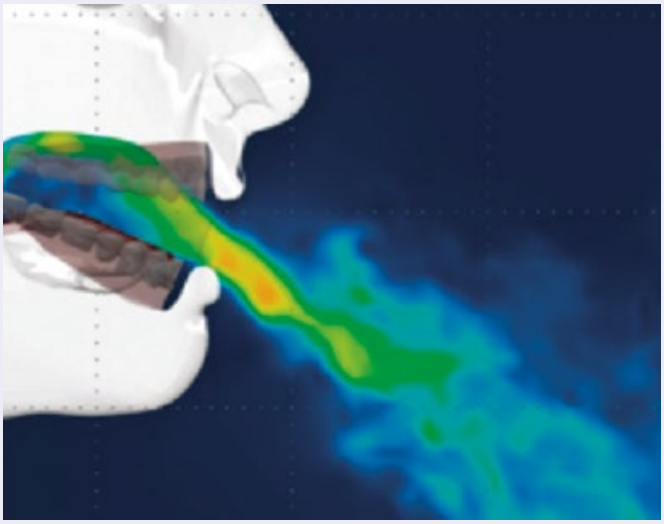
ALLAN ZHONG
Distinguished Scientist,
Halliburton

CARING FOR PEOPLE, COMMITTED TO THE WORLD

SCIENTIFIC INNOVATION
Research-based approaches to combat COVID-19



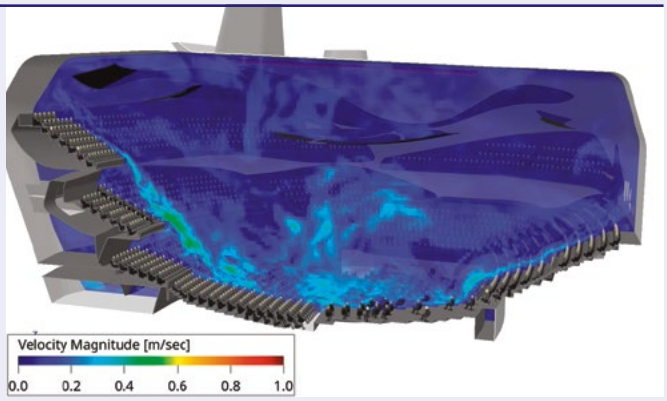
Because many designers, engineers and architects have never had to consider contagion in such depth before, our SIMULIA software is enabling analysis of the contamination risks and helping to design palliative measures.



SIMULIA's fluid solutions can simulate contaminant transport to better predict how COVID-19 will spread.

PROTECTING PEOPLE AND COMMUNITIES
Keeping people safe during the pandemic

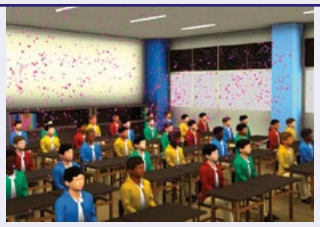
The **3D**EXPERIENCE® platform was used to optimize a flow splitter so that it could provide air to multiple patients at one time.



La Philharmonie de Paris partnered with Dassault Systèmes for its extensive experience in high profile airflow and particle dispersal simulation projects.

CONTINUITY IN BUSINESS AND EDUCATION
Ensuring people can work and learn remotely

Cloud solutions like the **3D**EXPERIENCE platform are critical in keeping companies up and running during the pandemic.



SIMULIA's solutions can help determine the best ways to keep students and teachers safe in the classroom.

GEA Group consulted Dassault Systèmes to simulate the best way to reopen a workplace cafeteria safely.

For More Information
ifwe.3ds.com/caring-for-people-committed-to-the-world

PepsiCo Pursues a Virtual Future: Simulation for Food and Beverage Packaging

Dr. Ellie Vineyard,
Associate Principal Engineer,
PepsiCo

Like most consumer packaged goods companies, innovation is important to win market share and bring new products to market. This requires overcoming challenges related to materials selection, waste reduction, manufacturing, recyclability, and product transportation. Using a combination of modeling and simulation, and advanced rapid prototyping, PepsiCo is working on several initiatives to improve the packaging development process for gains in productivity, quality, and sustainability.

Pepsi is likely one of the first beverages one thinks of when it comes to soft drinks. PepsiCo is much more than just its popular namesake beverage. The corporation has a large Food and Beverage Portfolio, in which twenty-three of the brands—including Pepsi-Cola, Quaker Oats, Tropicana, Lay's, and Gatorade—are generating more than $1 billion each in retail sales every year. All these brands' development work involves a lot of processing and packaging—and that's where simulation plays a large role.

Dr. Ellie Vineyard is an Associate Principal Engineer at PepsiCo, joining the company in 2019. She also made the time to share her expertise as a speaker at the 2021 Americas Regional User Meeting, as well as taking on the role of a SIMULIA Champion. At the time she started with PepsiCo, Dr. Vineyard did not have a great deal of experience in packaging, but she quickly became an expert on beverage packaging, which requires highly precise physics and engineering to create, despite the apparent simplicity of their shapes.

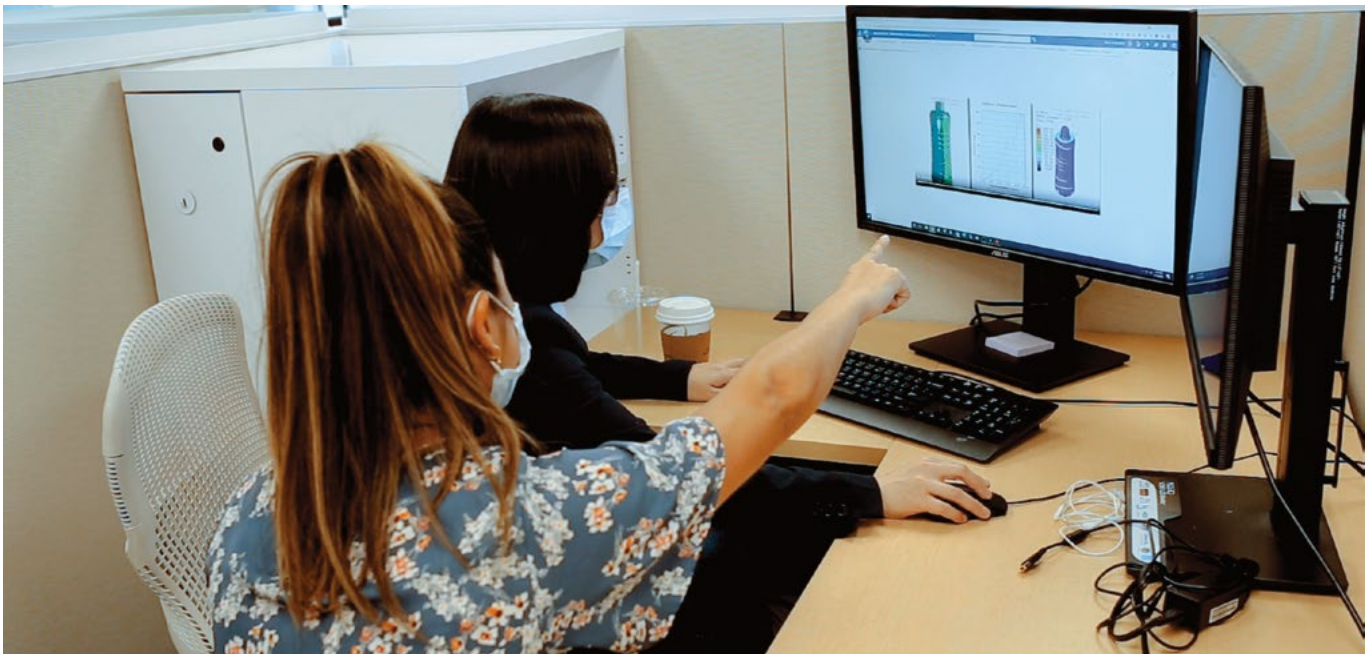
"If you don't take a systematic approach to design bottles, you're going to see failure after transportation," she says. "And when the bottles go to consumers' hands, are you going to pick a bottle with denting on it? We all pick the best bottle on the shelf."

THE VIRTUAL FIRST PRINCIPLE

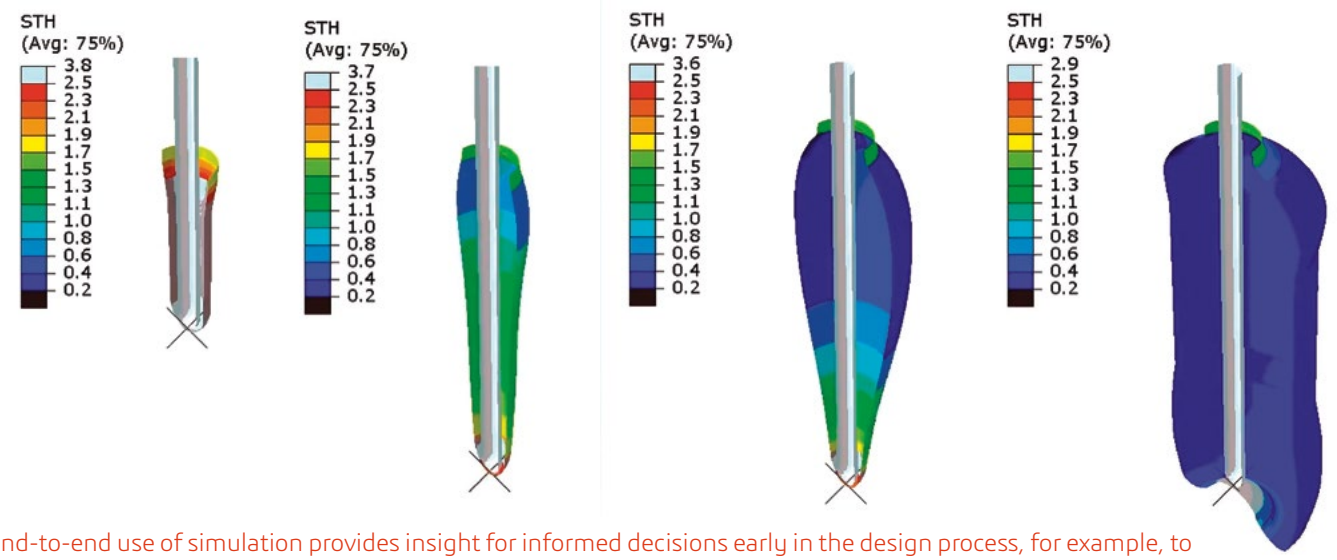
Dr. Vineyard and her team are highly involved with each phase of the packaging development cycle, relying on simulation the entire way. First is the ideation phase, in which the industrial design team comes out with a few design iterations for each new packaging design. Dr. Vineyard's team uses simulation to perform a design iteration analysis and select the best design among all the design iterations.

After the best design has been selected, it will be put into a proof of concept evaluation, in which a highly detailed evaluation is carried out using simulation to determine whether the packaging will meet PepsiCo's requirements. Then comes the transportation simulation, which actually involves line simulation (to evaluate the bottle's performance on the conveyor line) and vending machine performance. Sometimes they will also perform e-commerce simulation, to assess the package's performance when shipped from an online platform.

For example, to make design and manufacturing improvements earlier in the development process, PepsiCo used Abaqus technology from the SIMULIA brand of Dassault Systèmes to simulate stretch blow molding or extrusion blow molding, to decide which process conditions can produce the best wall thickness distribution for the bottles. In the later stages of design, the company combines process simulation and performance evaluation to optimize the bottles for the required performance. The



Dr. Vineyard and her colleague use simulation to perform a design iteration analysis and select the best design among the design iterations.



End-to-end use of simulation provides insight for informed decisions early in the design process, for example, to evaluate which combination of design elements and manufacturing conditions will result in the best bottle.

end-to-end use of simulation has helped PepsiCo greatly reduce trial-and-error—and cost. By bringing simulation and performance evaluation in-house, the company can produce direct and indirect annual savings of over one million dollars, according to Vineyard.

These methods are part of what PepsiCo calls the Virtual First Principle, a philosophy that involves testing products virtually before performing any physical tests.

"When we go to physical trials, we can make sure the packaging is going to pass all the requirements from a performance standpoint or from transporting standpoints," says Dr. Vineyard. "So we are going to do the Virtual First Principle to reduce the cost and time like we did in the unit trial."

WOMEN IN ENGINEERING: CHALLENGE AND INSPIRATION

Dr. Vineyard's interest in engineering started at a young age. She grew up on a farm and her father always spent his time troubleshooting and fixing problems with farming machinery, which influenced her decision to pursue an engineering degree after high school. Choosing a specialization took some time and exploration; her first college major was in Process Equipment, which then led to a strong interest in mechanical engineering as she moved into graduate studies.

"At that time, I had a great passion," she says. "I want to apply computer simulation in mechanical engineering, like in product development work. So that drove me to go to the USA to further my education in which my doctoral degrees focused on topology optimization in mechanical metamaterials."

There are fewer women in mechanical engineering, Dr. Vineyard admits, but that did not dissuade her from pursuing her passion for the field. Instead, she pushed herself harder in order to excel over her male peers and to inspire other women and girls.

"Even though it's rare, I do believe women engineers are a good inspiration to future girls and women," she says. "If they have passion, they can always pursue engineering careers…I think all girls should be encouraged to pursue engineering. Do not let the stereotype stop you from doing what you want to do. If you have some passion in engineering, in mathematics, physics, I think any kind of engineering is a good path for you."

PEPSICO VIRTUAL TEST LAB: AUTOMATED SIMULATION FOR ALL

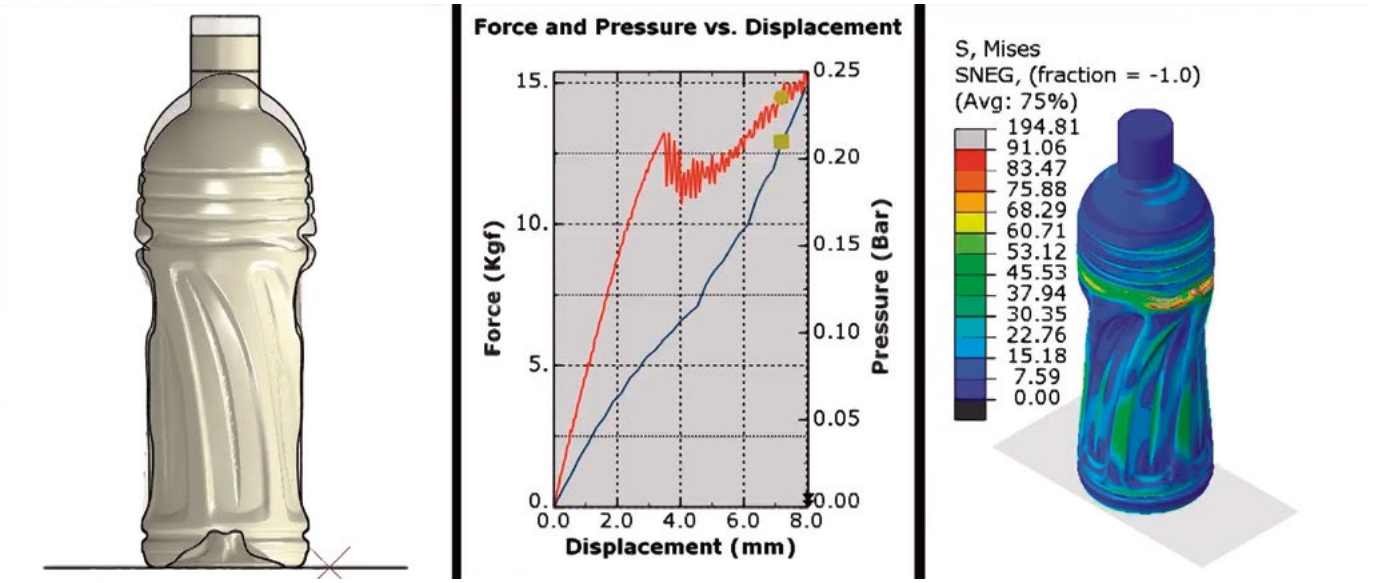
PepsiCo began collaborating with Dassault Systèmes in 2020 to expand their simulation capabilities and develop a web-based Virtual Test lab. Since then PepsiCo has been gradually transitioning manual offline simulations to fully automated, streamlined, simulation processes. The end goal is to bring roughly 70% of physical tests into the Virtual Test Lab, particularly for beverage packaging.

The Virtual Test Lab, according to Dr. Vineyard, plays a big part in the democratization of simulation. Because the lab is fully automated and streamlined, it does not require expert knowledge of a user and can be operated by industrial designers, packaging engineers, and other non-CAE experts. This then frees up experts for innovative tasks, such as developing more simulation applications.

In 2016, Dr. Vineyard says, her team conducted a comparison among different software on the market and chose SIMULIA's Abaqus technology for its powerful nonlinear explicit functionality.

The company is also going to begin utilizing more rapid prototyping technology. PepsiCo developed and patented a modular blow mold, and has been able to blow thousands of functional bottles using this innovative technology. Currently PepsiCo is in the process of bringing its own blow mold in-house so that it can use the 3D printed modular mold to blow over 10,000 bottles in a 48-hour time period. This will allow them to quickly evaluate all of their packaging designs in, potentially, under a week.

"After we use the Virtual Test Lab to do some feasibility studies, we can then utilize our advanced rapid prototyping capabilities to produce functional blown bottles under one



By leveraging a Virtual First Principal to test products virtually before performing any physical tests, PepsiCo ensures that new packaging will pass all requirements.

week," says Dr. Vineyard. "We can then use those bottles to do some consumer testing as well as some line trials without going to the cost-extensive production trials."

PepsiCo is also using simulation to reach its sustainability goals, such as reducing plastic usage.

"We want to use recycled plastic as much as possible," says Dr. Vineyard. "We also try to use alternative materials other than plastics, such as developing paper beverage packaging. We can use simulation to address these alternative material based packaging performances."

MOVING TO THE CLOUD WITH 3DEXPERIENCE

PepsiCo also uses Dassault Systèmes' **3D**EXPERIENCE platform to help with collaboration and productivity. Currently, says Dr. Vineyard, the information is not housed in one central location, so they are trying to take a cloud-based approach so that they can store their project information in a single platform and all stakeholders from different regions can access the information freely.

"I think the Dassault Systèmes **3D**EXPERIENCE platform is a great cloud-based environment for collaboration, but also we can put our simulation data in a single platform, and we can track the information after," she says. "If you ask me how I could access the simulation results from three years ago, it's going to take me a long time to dig through my own hardware to find it, but if we can store all the simulation data in a single place, that can reduce the time. It increases traceability."

Dr. Vineyard describes how by using the **3D**EXPERIENCE platform apps they can develop and deliver the "turnkey solutions" they are building up in their Virtual Test Lab, with applications like Process Composer serving as a sort of back end for building processes.

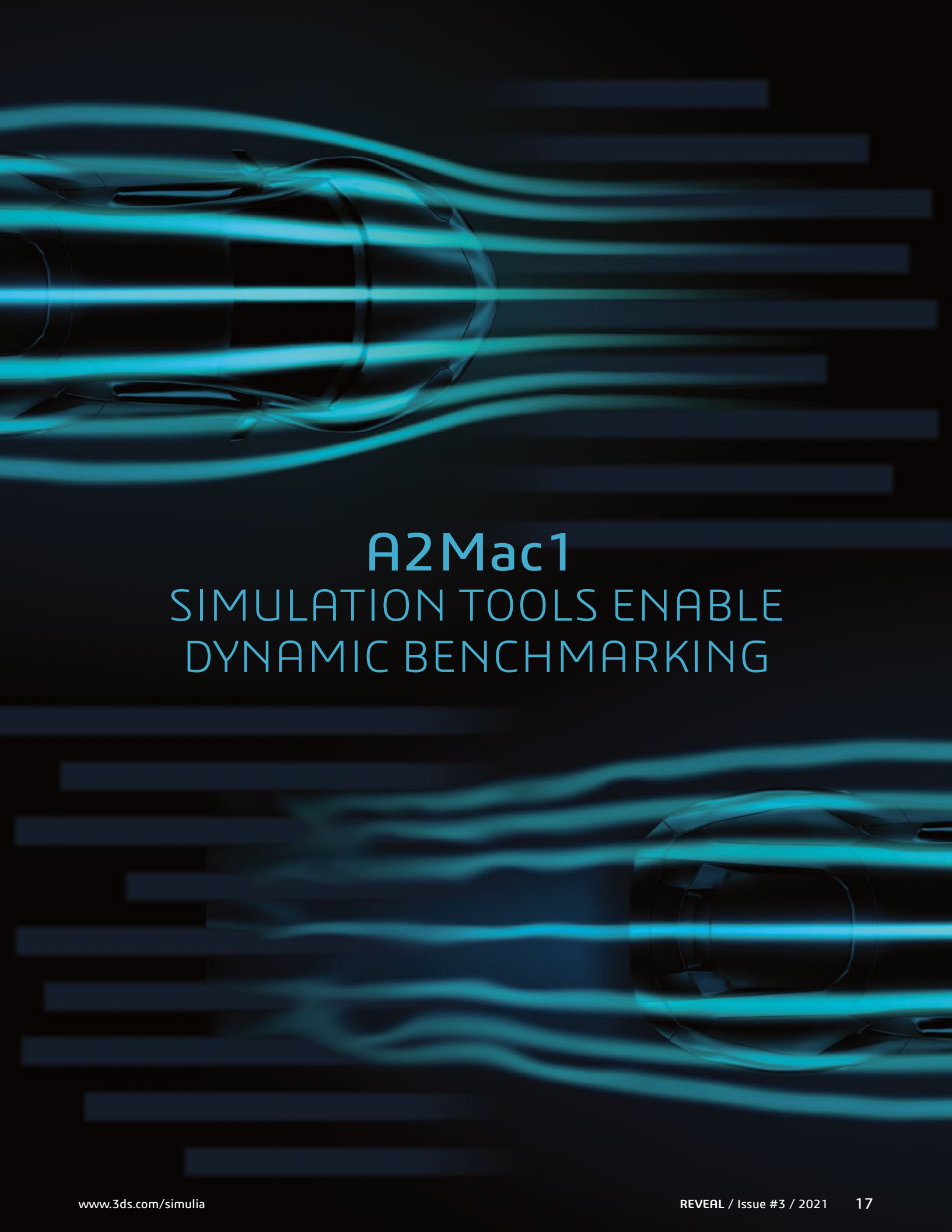
"Because Dassault Systèmes products is a Multiphysics simulation platform, it can help us conduct end-to-end solutions for our beverage packaging process," she says.

Dr. Vineyard is excited about the future of PepsiCo. She attributes much of this to simulation. PepsiCo is currently pursuing digital twin solutions as a Virtual First Principle to combine the physical and digital worlds, further improving product development, reducing cost, and improving productivity and efficiency.

Dr. Vineyard is a SIMULIA Champion, which enables her to learn more about the products, new advancements, and further improve PepsiCo's simulation capabilities.

Principal Engineer at PepsiCo, collaborates with a colleague at PepsiCo R&D Headquarters.

For More Information
www.pepsico.com



A2Mac1
SIMULATION TOOLS ENABLE DYNAMIC BENCHMARKING

For more than 20 years, A2Mac1 has been a global leader in benchmarking, with clients in industries ranging from automotive to agriculture, appliances, construction and aeronautics. Its slogan, "Your global partner for benchmarking," rings true for both large and small companies. So what exactly is benchmarking?

"Benchmarking is a way to extend the knowledge you have of your own production to the worldwide view…and based on that knowledge you can innovate," says Jacques Leveillé Nizerolle, CEO of A2Mac1. "Benchmarking is basically helping you [expand] on your knowledge about car engineering in general, to innovate not only from what you do, but innovate from what everybody is doing. So it's a way to help you innovate and optimize the work that you do in engineering."

Although its reach extends to the multiple industries named above, A2Mac1 is primarily an automotive benchmarking company that studies about 100 cars per year, disassembling them and then reassembling them in a virtual space through use of 3D scanners. This is known as static benchmarking, but A2Mac1 goes a step further into what is known as dynamic benchmarking, which involves simulating the performance of the vehicle as well as testing the physical product.

"We're driving the car, measuring thermal, measuring energy management, measuring aerodynamics," continues Leveillé Nizerolle. "We can do it physically with the car, or we can do it virtually using the data that has been created in 3D to basically simulate, using simulation tools, the behavior of the car."

Simulation is changing the way companies do benchmarking, and benchmarking is changing the way manufacturers design cars. This, in turn, changes the way consumers buy cars – giving them more options for customization, comfort, and cost-effectiveness, just to name a few of the aspects that customers look for in a vehicle.

SIMULATING VEHICLE PERFORMANCE

A2Mac1 is enabling customers to see and discover things they wouldn't be able to see and discover otherwise—like noise, vibration and handling, which are critical to customer comfort but impossible to judge without actually riding in a car —or seeing a high-quality simulation, which is what A2Mac1 provides using SIMULIA software.

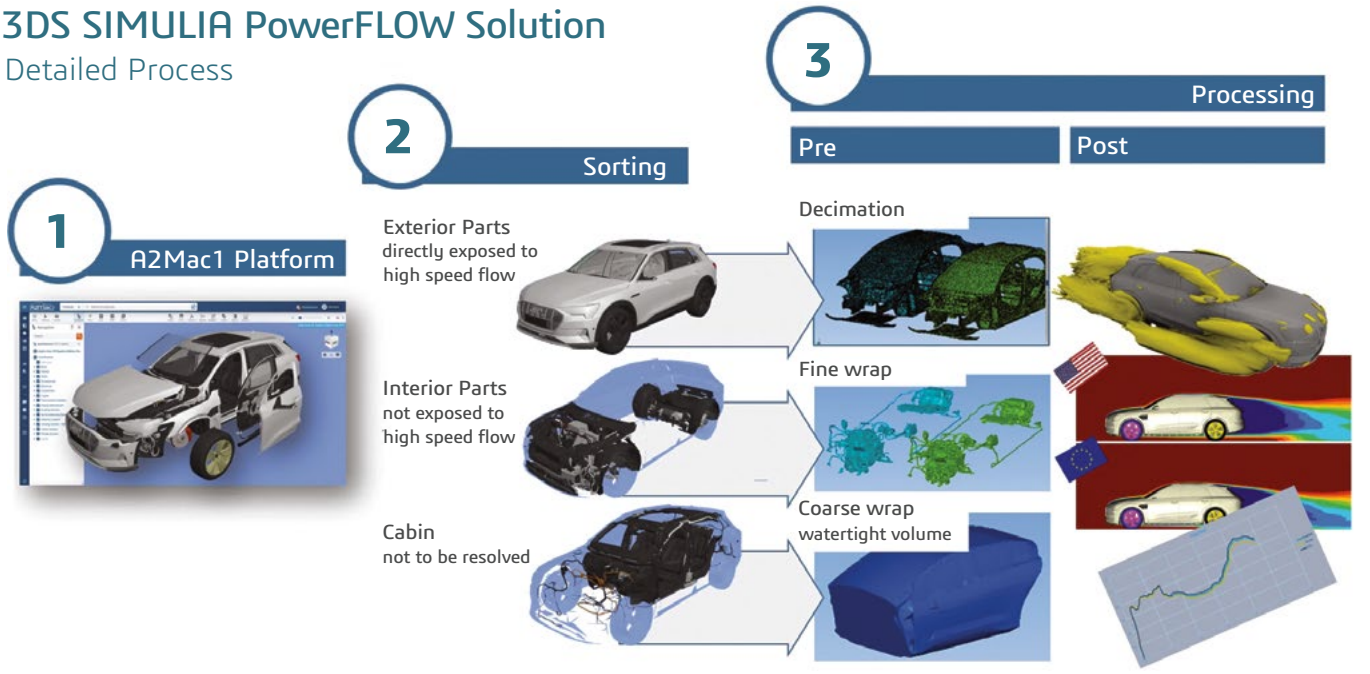
> **"I love simulation because it helps to push the frontier of innovation."**
>
> **—Vincent Keromnes, Dynamic Benchmarking Domain Leader, A2Mac1**

"We count most automotive manufacturers and major suppliers as our customers," says Vincent Keromnes, Dynamic Benchmarking Domain Leader at A2Mac1. "Dynamic benchmarking…makes visions of simulation and tests affordable to everybody. To make sure that all the automotive industry contributors have access to something that traditionally is very expensive, but that can be a lot of value because it's all about the market as it is right now."

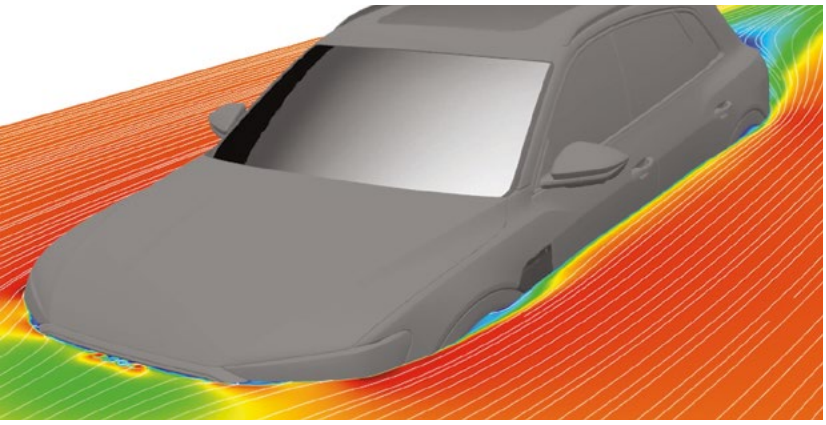
Simulation has taken benchmarking to a whole new level. Take aerodynamics as an example—previously, testing a vehicle's aerodynamic performance would involve multiple wind tunnel tests, which are time-consuming and expensive. In a virtual setting, however, tests can be run and run again as many times as needed without additional cost, and with minimal additional time. This allows OEMs

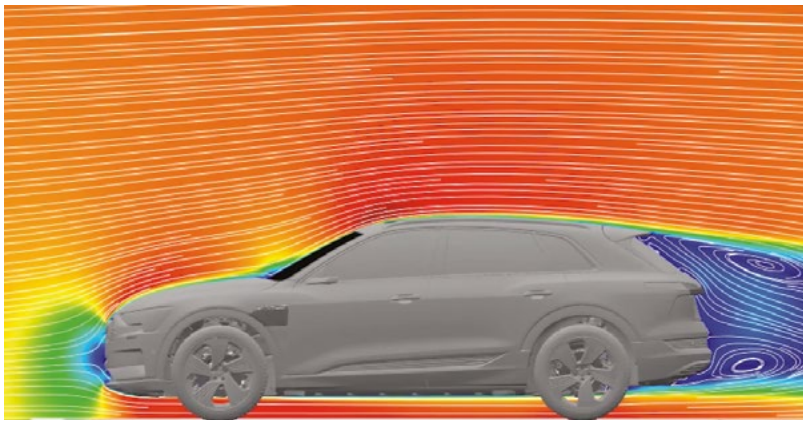
3DS SIMULIA PowerFLOW Solution

Detailed Process



Realistic rendering in SIMULIA PowerVIZ – Jaguar I-Pace aerodynamics





Velocity cut plot post processing in SIMULIA PowerVIZ—Audi Etron aerodynamics

to go in-depth and zero in on small details and specifics situations. A2Mac1 is versatile in handling simulations according to the customer's needs, either running a full simulation for them or providing raw data so that they can run the simulations themselves.

Keromnes gives an example of a manufacturer that had designed an electric SUV with a hood shape that is more commonly seen on a two-door car. Since A2Mac1 already had the digital mock-up of that hood shape, the manufacturer was able to easily try it on as a virtual prototype to see how it affected drag, acoustics, and vibration.

BENCHMARKING WITH SIMULIA

A2Mac1 delivers results quickly, which is largely thanks to their choice of SIMULIA simulation tools. SIMULIA's tools allow the company to significantly compress the preparation time —of which, according to Keromnes, 70 percent was spent on cleaning up geometry. With that extra time cut down, A2Mac1 is able to produce results from a digital mock-up in just three days.

"We decided to work with SIMULIA because they have some of the best tools in the market today for automotive simulation," says Leveillé Nizerolle. "I really trust the tools, and the customers trust the tools, and this is very important."

"With simulation, we are able not only to get the performance of the car with this device or that device, but we are also able to better understand the configuration of each element," adds Keromnes. "And this is something you could do in physical testing, but it's very complicated and you cannot push it to the limit. But with the simulation, once we have the digital mock-up of the car, it's very easy to replace one device with another one."

Replacing a mirror with a camera could be one such example, as OEMs begin to shift more towards the design and manufacture of electric and autonomous vehicles. This is, overall, a huge shift, but simulation and benchmarking are making it so that engineers are not working blindly to redesign these vehicles from the ground up.

"It's a complete process of reinventing the way to do cars," Leveillé Nizerolle says of the shift. "And in that context, customers need to understand the way others are trying to solve problems, are trying to enhance design to make it more effective. And so benchmarking is critical and it's getting more and more critical."

BOOSTING INNOVATION THROUGH DEMOCRATIZATION

A2Mac1 believes that leveling the playing field by making world-class benchmarking available to all manufacturers will accelerate automotive innovation as a whole.

> **"So we are generating simulation data and we want everybody to be able to access it and to get the value of it and then to do engineering jobs, which is from the simulation data to take the right decision to improve the product and to innovate."**
>
> **—Vincent Keromnes, Dynamic Benchmarking Domain Leader, A2Mac1**

"We want to democratize the access to the simulation data," says Keromnes. "So we are generating simulation data and we want everybody to be able to access it and to get the value of it and then to do engineering jobs, which is from the simulation data to take the right decision to improve the product and to innovate."

New challenges are arising not only in the form of autonomous and electric vehicles, but in new regulations such as the Worldwide Harmonized Light Vehicle Test Procedure (WLTP), the newest standard for measuring fuel consumption and emissions in vehicles, as well as simply more discerning customers. Automobiles must be designed more carefully and consciously than ever before, and to avoid falling behind, OEMs need to be able to see what others are doing to meet these challenges. For this, simulation is vital.

"Simulation is getting more important because we are moving from product to experience again," says Leveillé Nizerolle. "Now, what's important is the driving experience. And the driving experience means comfort and the different aspects of comfort. The handling of the car and all those things have to be simulated. So if you want to benchmark the driving experience, you need to simulate the behavior of the car. I love simulation because it helps us bring the benchmarking to a new era, bring the benchmarking from product benchmarking to experience benchmarking."

Keromnes agrees. "I love simulation because it helps to push the frontier of innovation," he says.

A2Mac1 offers a subscription model in which they disassemble and reassemble a certain number of cars each year, with customers voting on which cars they would like them to study and benchmark. In this way the company brings true democratization to automotive design, allowing manufacturers to learn from each other as they navigate the challenges of today's automobiles.

For More Information
www.A2Mac1.com

ATA ENGINEERING LEVERAGES ABAQUS FOR MODELING ADVANCED COMPOSITES IN EXTREME ENVIRONMENTS

In recent years, the US Department of Defense (DoD) has accelerated efforts to modernize existing reentry systems and develop new high-speed flight systems to counter significant advancements in hypersonic technology made by other nations. The term hypersonics generally refers to flight systems that travel at speeds greater than Mach 5—five times the speed of sound, or about a mile per second. The extreme environment of hypersonic flight requires that systems survive a much wider range of temperatures (70–5000+ °F) and pressures compared to traditional flight systems. Due to these challenging aerothermal conditions and the interdependent physical phenomena, time- and labor-intensive analysis and testing efforts are required to validate flight-critical components and the advanced aerospace materials from which they are made.

Currently, the US Navy is developing the next generation of strategic seaborne systems and hypersonic platforms, a process demanding innovative solutions to complex problems that include the design, characterization, qualification, and ground and flight testing of hypersonic system components. The Navy Strategic Systems Programs (SSP) and the Office of Naval Research (ONR) sought a numerical simulation approach using nonlinear finite element analysis (FEA) to perform modeling and simulation of candidate materials to be used in flight-critical components such as a thermal protection system (TPS).

Under a multi-year research effort culminating in a Small Business Innovation Research (SBIR) Phase III Rapid Innovation Fund contract, ATA Engineering, Inc., (ATA) developed COMPAS, a composite material modeling and simulation add-on for the Abaqus Unified FEA environment. COMPAS predicts the thermomechanical response (and associated statistical variability) of composites and improves modeling accuracy while reducing the reliance on today's costly build/test paradigm for qualifying these advanced materials. In developing the COMPAS add-on, ATA leveraged many of the native modeling capabilities of Abaqus and integrated machine learning techniques to accurately and efficiently extract material properties from limited test data and to predict the nonlinear response of heat-resistant candidate materials when subject to thermomechanical loads.

ATA is an employee-owned small business headquartered in San Diego, California, providing analysis- and test-driven design solutions to support the engineering needs of customers and government agencies. ATA actively participates in the US SBIR/STTR Program to develop new engineering methods and tools, including this multi-year research effort to develop and validate COMPAS for use in computational characterization of the Navy's candidate TPS materials as well as similar Air Force, Army, and NASA programs that have advanced COMPAS and Abaqus-based solutions over the past decade.

TPS materials protect sensitive internal structures and components from the extreme conditions of hypersonic flight and the effects of aerodynamic heating, in particular. Engineers must ensure that a TPS design is capable of controlling erosion while minimizing heat transfer to the underlying structure, factors that, if not adequately addressed, could result in mission failure. Thus, TPS structures are fabricated from advanced heat-resistant materials, most often 2D and 3D woven carbon-carbon (C/C) composites, which are among the few suitable materials that can survive the demands of hypersonic flight. These advanced composites are orthotropic in nature and macroscopically heterogeneous, possessing irregular phase geometries and nontrivial degrees of porosity. C/C composites also exhibit extremely nonlinear progressive damage behavior with several damage and failure modes contributing to their aggregate performance across the very wide temperature range experienced from launch through flight.

Changes in raw material availability, along with the tremendous time and labor required to test and analyze new candidate composites, have complicated the design and manufacturing of TPSs for current and future high-speed flight systems. The need to replicate the severe thermal loads and other conditions of hypersonic flight make ground testing of these materials challenging and costly. As a result, material characterization test data is

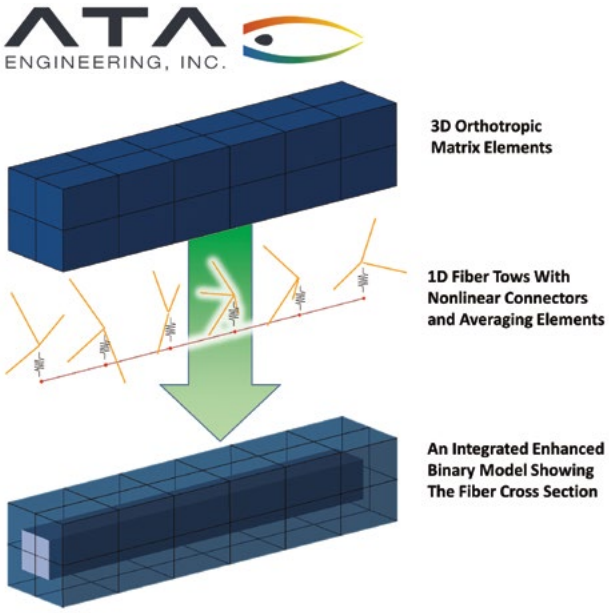


Figure 1. The EBM formulation for composite material architectures.

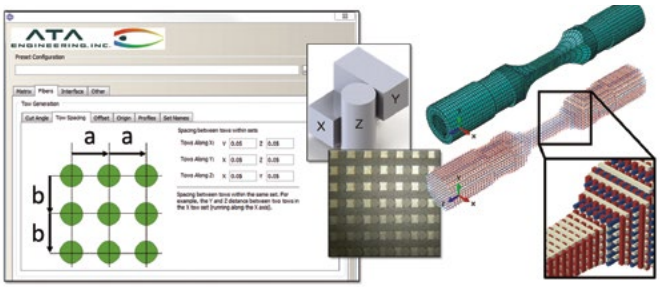


Figure 2. COMPAS automated model generators rapidly create EBMs of arbitrary part geometries.

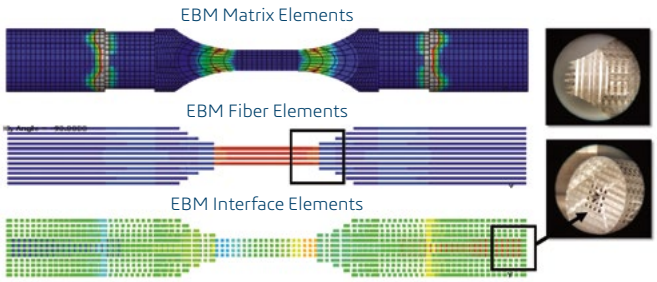


Figure 3. COMPAS virtual tensile tests predict observed fiber rupture and fiber pullout failure modes.

often very limited and not wholly representative of the damage encountered in the complex flight environment. To reduce risk of failure during flight testing and to provide a more affordable means of virtual qualification of new TPS materials, the Navy sought an Abaqus-based solution in their call for innovative methods under SBIR topic N141-082: Non-Linear Behavior Models for Design of Carbon-Carbon Composite Components.

ATA answered this call by developing COMPAS, which uses the nonlinear simulation capabilities of Abaqus and custom tools to extract material model coefficients (and associated scatter) from limited constituent material and mechanical test data to predict the response of novel TPS materials and component designs under thermostructural loading. Developed in the Python programming language, COMPAS is a modular package containing different modeling and analytical process flows, each with corresponding modules that guide the user through the process flow. The modules have graphical user interfaces (GUIs) associated with them that are accessed as Abaqus plug-ins for ease of use.

A key feature of COMPAS is a tool that automatically creates finite element models of arbitrary TPS architectures and part geometries using an innovative modeling formulation, the Enhanced Binary Model (EBM). The EBM is based on the Binary Model, which explicitly models individual fiber tows using 1D elements and the matrix-dominated material using 3D elements. These elements are rigidly connected in Binary Models to represent the composite material, and in the EBM, a nonlinear connector element between fibers and matrix additionally models the behavior of the fiber–matrix interface, as shown in Figure 1. Using built-in Abaqus material models, nonlinear constitutive behavior is defined for the fiber tow elements, matrix elements, and interface spring elements. Figure 2 shows the rapid setup of tensile coupon EBMs using COMPAS tools to support virtual testing of a 3D woven architecture.

COMPAS leverages Abaqus to provide the user with two primary process flows: the Material Model Correlation Process (MMCP), which is used to quantify mean values and corresponding statistical distributions of unknown material model parameters (e.g., directional moduli and strengths) by comparing predicted responses to measured responses that exhibit scatter, and the Multiscale Simulation Process (MSP), which enables the user to simulate responses across multiple length scales and capture the effects of local damage on the overall response of the structure. ATA has applied these tools to rapidly set up virtual test models, calibrate material model parameter statistics with limited data, and predict a variety of material responses and failure modes, including fiber rupture, matrix cracking, and fiber pullout, as shown in Figure 3.

ATA and other organizations have used COMPAS to accurately predict the thermomechanical response of a variety of C/C composites and ceramic matrix composite (CMC) materials, including orthogonally woven 3D materials. The availability of reliable material model parameters will accelerate adoption of new material systems and foster more lightweight, capable, and affordable solutions for high-temperature composite structures, extending beyond TPS components to turbomachinery, propulsion, and nuclear power applications.

By making COMPAS available at no cost to US Government Abaqus users, ATA anticipates that the software will play a key role in supporting a key national security priority: leading the world in the fielding and sustainment of high-speed flight systems. ATA looks forward to continuing to support these organizations, their system integrators, and material vendors in applying COMPAS and other Abaqus-based capabilities, such as the Co-Simulation Engine (CSE), in the development of next-generation hypersonic systems.

For More Information
www.ata-e.com

KINETIC VISION
CROSS-INDUSTRY INNOVATION THROUGH SIMULATION

When Kinetic Vision first opened its doors 30 years ago, the company stood out with a unique service: helping clients to virtually test products using modeling and simulation in an era when the technology was rarely seen outside the aeronautical and aerospace industries.

Founded by Rick Schweet as an analysis company, Kinetic Vision has since grown into an integrated technology company, expanding its focus beyond modeling and simulation to other technologies like computed tomography scanning, visualization, machine learning and non-destructive testing. The company now consists of eight different groups focusing on these various technological services.

"We are a services company. We help other people make their things better," explains Shane Mooney, Group Manager of Kinetic Vision's Modeling and Simulation Group. "We're just a group of talented people with diverse backgrounds and diverse skillsets who are really interested in the creative problem-solving method."

"I love simulation because it lets me test absolutely anything without having to build it. I can answer the what-ifs of any scenario and trust that my answer will be accurate," says Mooney. "I love that SIMULIA is part of that wonderful technology suite that I get to use on a daily basis."

—Shane Mooney, Group Manager of Kinetic Vision's Modeling and Simulation Group

TWINS IN THE VIRTUAL WORLD

Kinetic Vision works with many industries, though most of its clients come from the biomedical devices and consumer-packaged goods sectors. The Modeling and Simulation Group leverages virtual twins, which Mooney defines as "a digital copy of anything that exists in real life." Virtual twins can be created of anything from a small part to an entire assembly line. They allow for virtual testing that yields the exact same results as a physical test on the real object or system—without actually having to perform those costly and time-consuming physical tests.

"A virtual twin is when you have a synthetic version of reality that you can leverage to better understand, optimize, and develop your product," says Kinetic Vision Senior Vice President Jim Topich. "A virtual twin can exist

in different levels of fidelity and it can have different levels of accuracy. Some of the tools that we're using today enable us to develop extremely accurate virtual twins that can provide value back to our customers."

Without virtual twins and virtual testing, Topich believes that all of Kinetic Vision's projects would take twice as long at minimum. The technology allows Kinetic Vision's clients to not only save time but money and materials, fully testing and evaluating their products in the digital world.

Kinetic Vision uses SIMULIA software to create these virtual twins in a partnership that has served the company well.

"SIMULIA, much like Kinetic Vision, is always being innovative," says Topich. "They're always thinking outside the box. They've enabled us to do things that we've never been able to do before, including scaling up, using cloud resources and cloud technology to run our projects faster and more efficiently."

"The big engineering dream that's been around for a while is an all-in-one inclusive package," says Mooney. "All that really means is that your CAD model is tied directly to your mesh and directly to your simulation inputs. The benefit is that when you make a small tweak upstream, you set the refresh button, and everything downstream in the model updates."

He adds that while a few companies are working on delivering that all-in-one package, the **3D**EXPERIENCE platform has a large head start, and is also innovating new features such as revision tracking and cloud computing.

A CLOUD COMPUTING EXPERIENCE

Kinetic Vision was introduced to the cloud by Adaptive, its value-added reseller. Adaptive exposed Kinetic Vision to the benefits of the cloud and allowed the company to run some small pilots—with fantastic results, according to Topich.

"Adaptive is a continued resource that we lean on regularly to bounce ideas off to figure out new ways to solve problems," he says. "We have a great relationship with them, truly something we value."

Adopting cloud services through the **3D**EXPERIENCE platform was a "no-brainer" according to Mooney. The cloud allows Kinetic Vision to scale "infinitely and instantly" for any project needs. If a client asks for a project that requires hundreds of simulations, that request can be rapidly fulfilled with the **3D**EXPERIENCE platform on the cloud solution.

In Kinetic Vision's early days, its capabilities were limited by model size; the team could only work with models that could be installed on a CPU in a reasonable amount of time. Now, the size of the model is much less important, and the team can focus on how many models they can run in parallel—and how fast they can get the answers back.

The cloud has achieved a level of security that offers confidence in scaling up solutions.

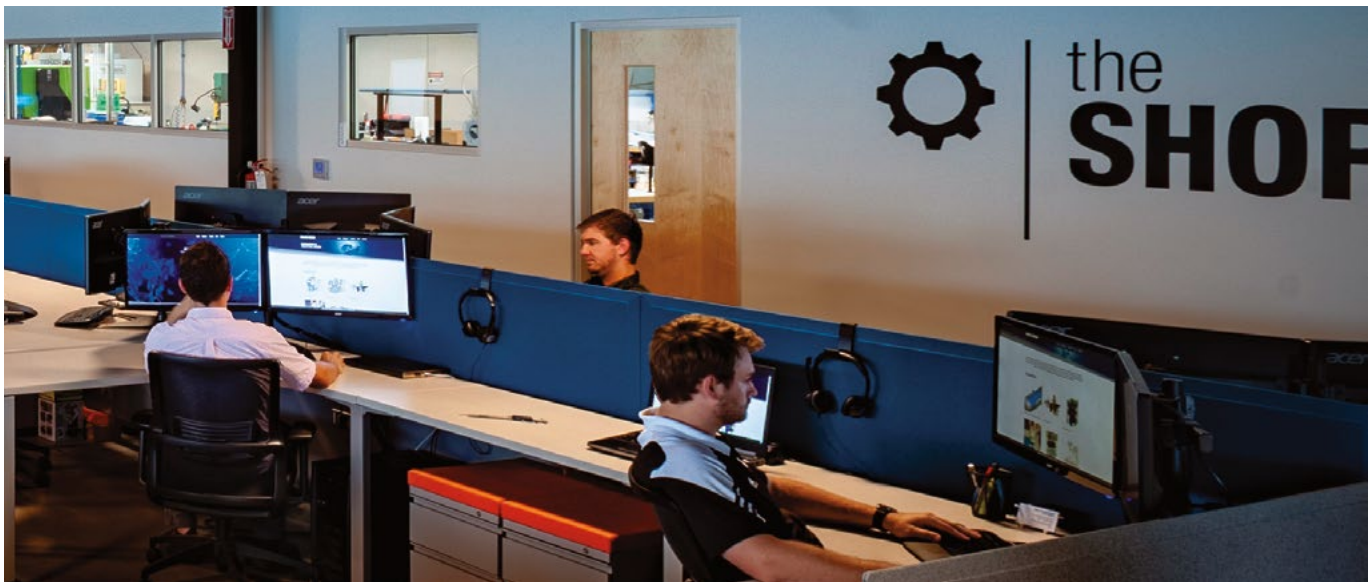
"With the advances in security and protection, I absolutely trust the cloud. And having a high level of security is imperative for our clients," says Mooney.

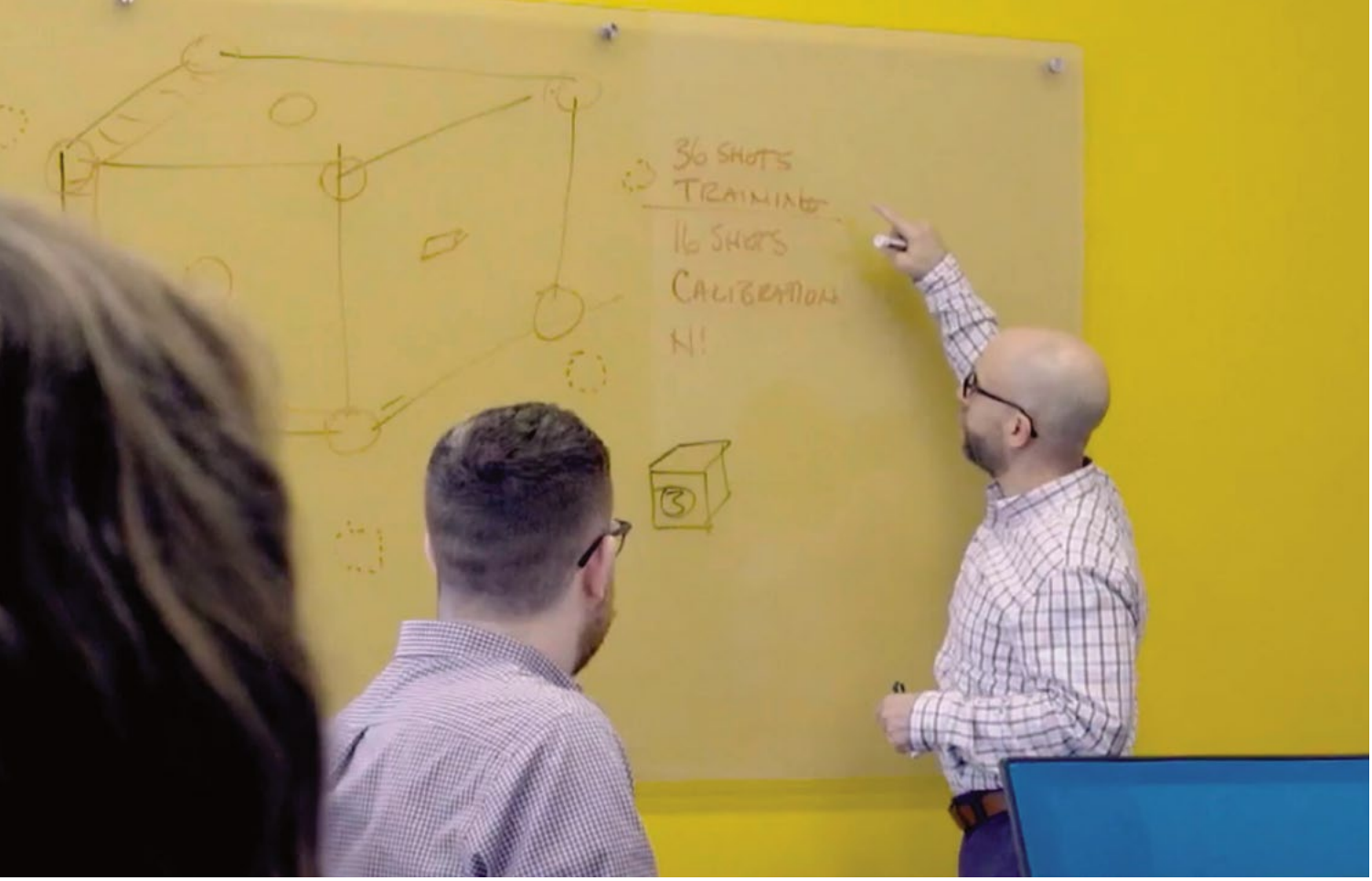
In the not-so-recent past, many people may have felt the opposite, but COVID-19 and the resulting increase in remote workers has changed that. As more people have begun working with and becoming familiar with the cloud, they have begun trusting it to a fuller extent, and Kinetic Vision is seeing many of its clients move toward adoption of the technology.

BRIGHT FUTURE WITH SIMULIA

Topich believes that in the future, Kinetic Vision will be nearly 100% cloud-based in terms of running tools and software, and that SIMULIA will continue to play a large role with the company.

"Having a continued relationship with SIMULIA, I think we're going to continue to be exposed to advancements in the tools that we're already using today—advancements in





the workflows, and how we can more efficiently leverage those tools to be successful for our customers," he says.

Mooney expects that the company will continue to grow as it explores and leverages the latest technology. As Kinetic Vision evolves, however, one thing will stay the same—its focus on innovation.

"Innovation to me is all about creating something new," says Mooney. "It's taking the building blocks that exist in the world, the things you walk by every day, the things you use every day, and just combining them in a way that they've never been combined before, using them for a purpose that's never been used before, and the result of that is an innovative new process or product."

He, like Topich, expects that SIMULIA will remain a large part of Kinetic Vision in the future.

"I have a vision for the work experience that I want as an engineer," he continues. "I have a vision for what I think the software should do and what I think my job should be, and I think SIMULIA, especially the latest **3D**EXPERIENCE products, go very much along with that vision. I think SIMULIA is embracing all the latest trends and delivering the products that I want to use."

Both Mooney and Topich are big fans of simulation, acknowledging that without the technology, they would not be able to offer their clients the solutions that have made Kinetic Vision such a trusted and respected provider.

"I love simulation because it lets me test absolutely anything without having to build it. I can answer the what-ifs of any scenario and trust that my answer will be accurate," says Mooney. "I love that SIMULIA is part of that wonderful technology suite that I get to use on a daily basis."

"I love simulation because when you're developing and testing a product physically, you usually know, did the product or system work? Yes or no?" adds Topich. "When you're using simulation, you're able to understand why it worked, or did not work, not just the yes or no."

This kind of detailed knowledge about products lets Kinetic Vision stand out as a provider of invaluable solutions to its clients, and SIMULIA plays a large role in delivering that detailed knowledge. Together, Kinetic Vision, Adaptive, and SIMULIA are helping a wide variety of companies to create better products in less time with less resources spent, and will continue to do so as simulation technology advances in the future.

For More Information
www.kinetic-vision.com
www.adaptivecorp.com

COMPLEX & CONFORMAL FREQUENCY SELECTIVE SURFACES BASED RADOME DESIGN

By Reza Hosseini

The efficient simulation of periodic structures and their application in radome design are the focal points of today's blog. I will discuss the workflow that brings us from an individual element to the finite array as well as suitable approaches to simulate them.

PERIODIC STRUCTURES—UNIT CELLS

Periodic structures often exhibit interesting electromagnetic behaviors. Metamaterials, artificial magnetic conductors, and Frequency selective surfaces (FSS) are few examples of applications based on periodic structures. The latter can be used as a potential approach to obtain customized frequency filtering radomes for antenna applications [1-2].

CST Studio Suite can tackle the periodic structures using two general approaches. One is eigenvalue problems for which Eigenmode Solver should be used to obtain standard results such as dispersion diagrams including bandgaps and light line curves [3]. The second approach is based on the Floquet theorem in which different so-called "Floquet modes" for the desired periodic structures are considered and excited. CST Studio Suite finds transmission and reflection between the Floquet modes and other ports (excitations) existing in the model.

UNIT CELL SIMULATION SET-UP

To start the FSS design, I consider a hexagonal lattice based unit cell of a dielectric filled by a metallic disk at center as depicted in Figure 1. It is simulated in CST Studio Suite using the Frequency Domain Solver (F-solver) and Unit cell boundary condition (Floquet mode analysis).

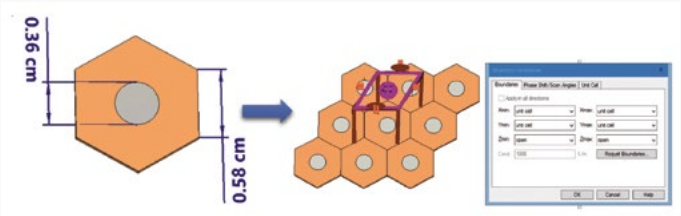


Figure 1. Unit cell structure; Floquet mode analysis of infinite array with the help of Unit Cell Boundary condition provided inside Frequency domain Solver.

As the reflection coefficient of the unit cell suggests (Figure 2a), there is a frequency, namely at 19.12GHz, in which the fields can mainly penetrate through the periodic structure while there is a relatively huge reflection at other frequencies. Thus, it is safe to say that we have a kind of band pass filter.

The default setting of the unit cell boundary condition delivers the simulation results for normal incidence only. However, it is important to evaluate the electromagnetic behavior of the infinite structure at different incident angles. This can be easily achieved by performing a parameter sweep over the scan angle parameter provided in the unit cell boundary condition window. Figure 2a shows the reflection coefficient of the proposed unit cell under three different incidence angle of incoming plane wave. Figure 2b shows the electric field behavior at the pass band and notch band frequencies, accordingly.

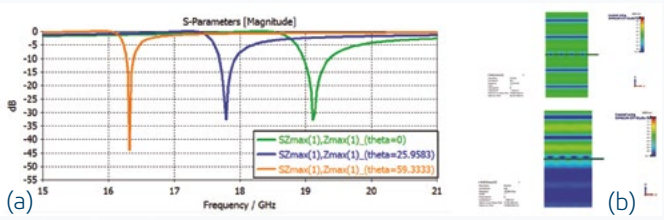


Figure 2. a) Reflection coefficient of the infinite array based on different angle of incidence, b) Electric field animation at transparent and opaque frequencies of the unit cell.

FINITE SIZE FSS BASED RADOME

Although simulating based on infinite periodic topology is always a good starting point to figure out how the FSS works, its performance should be checked under finite size FSS radome assumptions. Figure 3 shows the complete flow from an infinite array to a realistic radome structure.

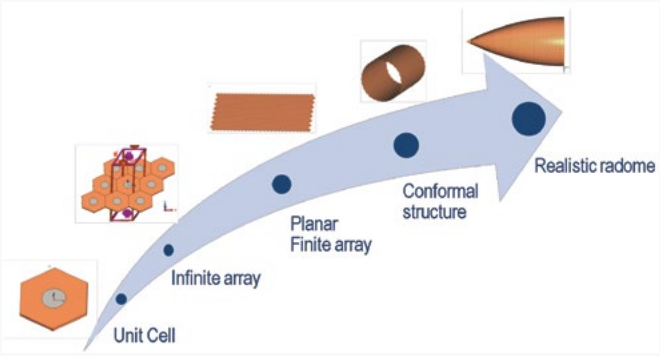


Figure 3. Design and analysis flow for a periodic structure for Radome applications.

THREE APPROACHES TO SIMULATE FSS BASED RADOMES

The question that arises here is: which solver(s) or material model should one use? To address this question, I introduce three approaches in the following:

The first approach is to use full wave solvers and include all geometrical details of radome and antennas. Although this approach would be the most complete approach, it would also be the most computationally expensive one. However,

CST Studio Suite offers several ways to accelerate the simulation time such GPU hardware acceleration, distributed computing, MPI, etc. for more information; please see the SIMULIA website [4].

The second approach is to use full wave solvers while representing the radome with the help of compact material modeling known as thin panel material in CST Studio Suite. Thin panel materials would be defined either based on stack-up layers of materials or scattering matrix data. The complex geometry of the FSS is replaced by continuous and compact represented materials, which is computationally favorable. It should be noted that thin panel is an approximated model based on plane wave and one incidence angle (normal incidence for the type of stack up and customized by user for the type of S-matrix).

The third approach is to separate the antenna from the radome simulations, perform each in the best suited solver, and establish the link between these simulations through field sources. This Hybrid Solver approach enables us to use, for example, the Asymptotic Solver (A-solver) in which a ray-tracing physical optics (PO) based algorithm is being employed for simulating the radome whereas transient solver is used to simulate antenna. It makes the overall simulation computationally less expensive. Furthermore, the A-solver supports thin panel materials for which Fresnel reflection and transmission table for different incident angle could be defined. This feature improves the result accuracy of A-solver simulations.

CONFORMAL FSS-TYPE RADOME SIMULATION RESULTS

To show a proof of concept, I have simulated a half-cylindrically bended FSS based radome. An F-inverter antenna with omnidirectional pattern was used as the source antenna.

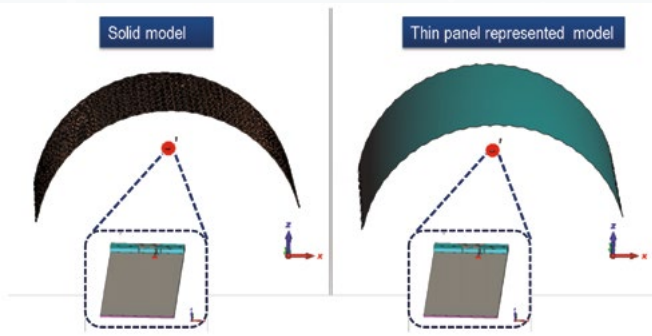


Figure 4. Curved FSS type radome and F-inverter antenna in full model (left) and thin panel represented (right) simulations.

The full wave simulations, including the conformal finite size FSS and antenna, were conducted using the time domain Transmission Line Matrix (TLM) solver. The animated visualizations in Figure 5-7 show the electric field for f=15, 25, 19.2 GHz, respectively.

NOTCH-BAND FREQUENCIES

For the notch-band frequencies (f=15 GHz, f=25 GHz), full model and thin panel approaches have been only investigated and plotted. The field animation of figures 5 and 6 show the almost perfect agreement between these two approaches for the structure under study.

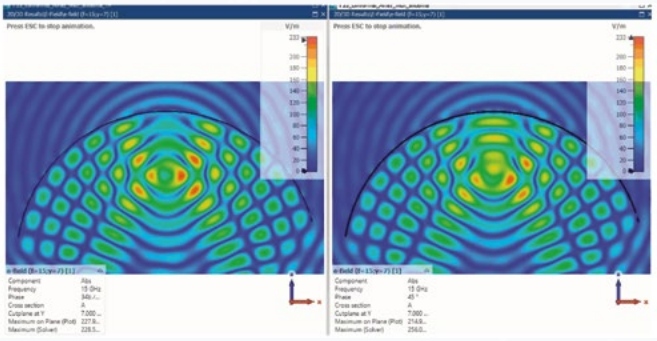


Figure 5: Electric field visualization for solid model (left) and Thin Panel (right) at f=15 GHz.

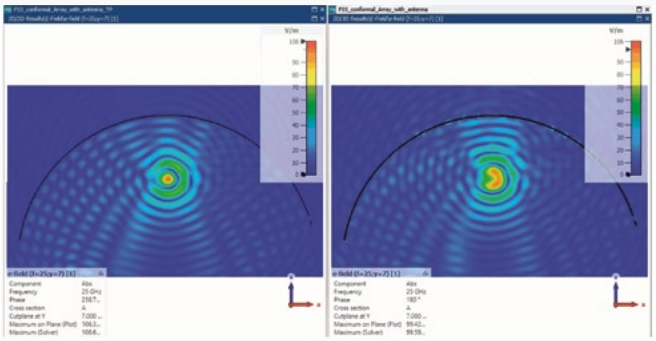


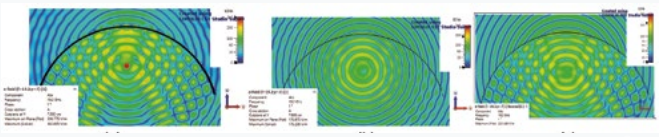
Figure 6: Electric field visualization for solid model (left) and Thin Panel (right) at f=25 GHz.

PASS-BAND FREQUENCIES

It is interesting to compare the simulation results for the pass band frequency–namely 19.2 GHz–as well. Since not all the radiated waves from the antenna hit the radome surface with a perpendicular angle, multiple reflections are generated simply because the reflection and transmission properties of the FSS unit cell changes with the incident angle (see figure 2a). This leads to standing wave behavior or cavity-like resonances. This effect can be seen very well in Figure. 7a. In addition, some surface resonances are generated that can be only captured using full wave approach as shown in the same Figure. The thin panel (S-matrix type) model, shown in Fig. 7b, is unable to deliver the same result compared to full model simulations. The reason lies on this fact that the thin panel material can only be defined based scattering matrix of one incident angle (we used normal incidence in this case) and therefore it does not include the reflection and transmission for non-normal incident angles.

Last, we used the Hybrid Solver approach to simulate the proposed model. A bi-directional coupled TLM and

asymptotic solver is used to simulate antenna and radome models accordingly. Two solvers communicate through near field source and the relative residual error decreases below an acceptable threshold over a few iterations. It can be noted that the hybrid solver approach is also able to capture the standing-wave field behavior similar to the full model approach as shown in Fig. 7c.



(a) (b) (c)

Figure 7: Electric field visualization at f= 19.2 GHz for a) complete model simulated in transient solver b) thin Panel S-matrix simulated in transient solver c) thin panel-Fresnel table simulated using hybrid solver of transient -asymptotic solvers.

CONCLUSION

Conformal and frequency selective surfaces being used as radomes create a complicated electromagnetic environment that demand accurate and reliable simulations. In this study, three approaches were investigated starting from full-wave complete model simulation, full-wave and compact model simulation and hybrid solver simulations. Table. 1 summarizes the above-discussed approaches and their applications in FSS radome design. The author hopes that this short article could give CST Studio Suite users deeper insights to select the most suitable solver/approach for their antenna/radome simulations.

All the geometry creation, handling, simulations have been performed with CST Studio suite. Transmission line matrix (TLM) solver, asymptotic solver, frequency domain solver, and hybrid solver workflow were the solvers that have been used in this study [4].

I will be presenting a Tech Talk on this topic, where I will demonstrate the workflows in detail. For more information and to register, see the 3ds.com website. CST Studio Suite offers different approaches to strike a good balance between accuracy and simulation times for different types of radomes.

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Reza Hosseini is a SIMULIA Industry Process consultant, where he currently works on providing solutions for the electromagnetic challenges of SIMULIA customers interested in high frequency, microwave/antenna, optical, radio frequency (RF) and electromagnetic compatibility (EMC) applications through a variety of industries such as Transportation & Mobility Suppliers, Aerospace & Defense, etc.

Reza Joined CST in 2018 as an application engineer and later Dassault Systèmes via CST's acquisition. Reza holds a Ph.D. in Electrical Engineering, Silicon Photonics, from Dresden University of technology (TU Dresden) in Germany. He had been involved in different simulation and experimental high frequency and photonics projects covering the broad range from component level up to system level.

Table 1: The summary of the user guideline for radome simulations in CST Studio Suite.

Simulation Approach		Applicability
Solver	***Model***	
Full wave	Full structure	Highest accuracy.
Full wave	Thin panel (stack up or S-matrix)	High accuracy but be aware of the incident angle limitation. Computational expense and simulation time are reduced.
Hybrid solver	Thin panel defined in A-solver	High accuracy but not a purely full wave technique. Good approach to deal with complex antenna structures.

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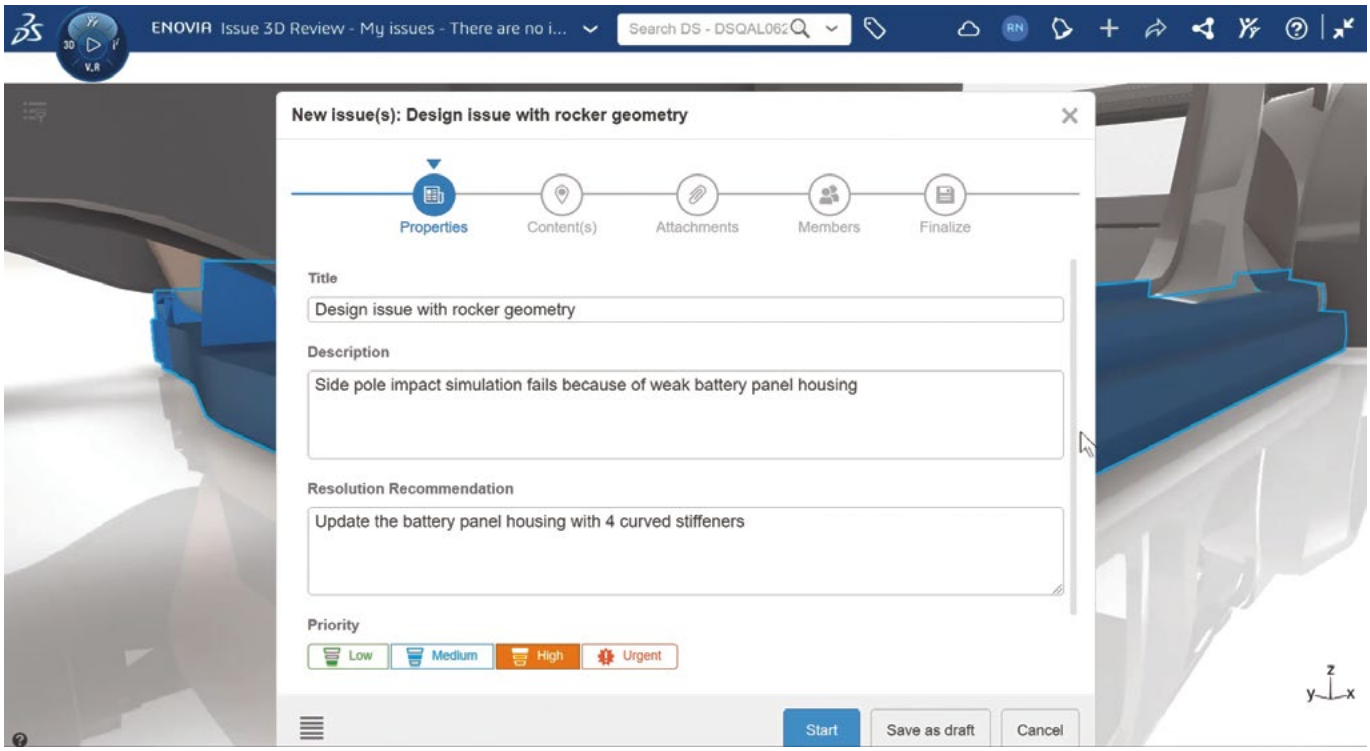
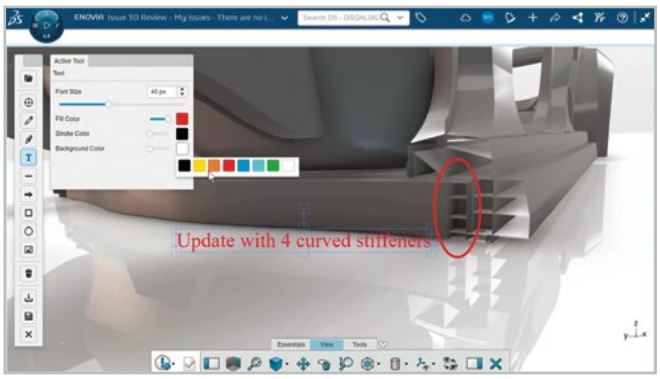
ISSUE MANAGEMENT WITH FULLY INTEGRATED MODELING AND SIMULATION

Are you a simulation engineer who wants to suggest a change or identify a problem in the geometry? Here is an easy way to give feedback by creating an issue within the **3DEXPERIENCE** platform. The issue will appear on top of the baseline geometry as a place mark so that everyone is aware.

1. In the baseline geometry, right click to create a new issue. An interface pops up where you can give a title and description for the problem. For example, "Side pole impact simulation fails because of weak battery panel housing."
2. You can add attachments to an issue, including documents and screenshots of the work area. Upon capturing a screenshot, you can create annotations, for example, to the highlight area where you want to see the improvement with another note for the designer letting them know what kind of change you are looking for.
3. Add team members involved in resolving and reviewing the issue to ensure all stakeholders are informed. Once the issue definition is finalized, you will see the 3D structure as a place marker, which everyone can open and review.



Create a new issue to report, assign and track a problem that needs to be fixed.



On a screenshot, use the annotation toolbar to add highlights, shapes, and/or comments.

The issue is pinned to the associated 3D structure for stakeholders to access and review.

TEACHING WELDING SIMULATION TO THE NEXT GENERATION

At the University of British Columbia, a 4th-year course on welding simulation is taught using Abaqus and QustomWeld

Every fall in a classroom on the campus of the University of British Columbia, a group of 30-40 students consisting of undergraduate, graduate, and post-doc students join together to attend the graduate level course "Welding and Joining of Materials". Year 2020 was virtual due to the pandemic. This course has been steadily growing in size over the last four years that it has been offered and has become one of the most popular courses at the university. The adjunct professor, Dr. Mahyar Asadi, who has 15 years of industrial experience in the field of weld modeling, has been developing this course to prepare students to apply sound engineering principals to the wide range of welding applications they will experience in their future endeavors.

ENGINEERING CHALLENGES OF WELDING

Welding plays a major role in the manufacturing and fabrication of structures all around us. There are tremendous challenges behind the welding science and engineering required to construct safe, reliable structures. Too often, the welds of a structure are taken for granted and, as a result, become the critical part of the structure that observe failures.

Minimizing the welds' adverse effects on complex structures is a difficult task that has historically relied on the experience of the welding team (welders, supervisors & engineers). When presented with a difference of opinion on how to proceed, it is difficult for a project manager to know what to do. Each scenario may have its pros and cons, with decisions based on whom the manager trusts more. In the modern age, computational modeling offers a scientific method to compare different welding scenarios. Using the high-performance-computing platform for simulation and weld modeling, combined with practical experience, welding engineers become capable of solving welding problems much more efficiently and reliably.

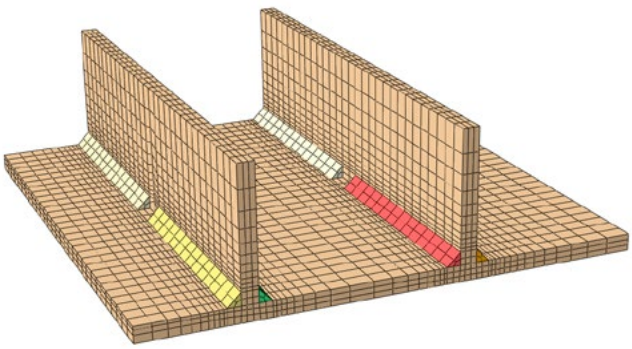
POWER OF SIMULATION

Many international welding organizations highlight the need for the welding industry to use computer models for smart welding to keep up with modern technology. Computational weld modeling uses simulation products such as Abaqus and QustomWeld to efficiently and reliably assess the behavior of welded structures. These tools allow users to address current welding engineering challenges such as distortion, residual stress, hot cracking, sequence patterns, metallurgical evolution, and so on. Additionally, faster and cheaper computers are rapidly making computer simulation and optimization of welding programs feasible during the early design and planning stages. Such capability is precious in the early stages of product design, where design decisions have the highest cost/benefit ratio.

Welding simulations are proven tools to help engineers apply their creativity, expertise and skill to be more productive and innovative. Simulation expertise and knowledge of computational modeling are now essential skills of engineering expected from engineering graduates.

TEACHING THE NEXT GENERATION

In most universities, a solid engineering curriculum may include a general-purpose course on Finite Element Analysis (FEA) that is usually accompanied by the use of a commercial software package such as Abaqus. Few universities, however, provide any programs which specialize in welding simulation. The University of British Columbia has addressed this shortcoming by offering the 4th-year course "Welding and Joining of Materials". The course provides thorough coverage of the theory, fundamentals, and weld modeling techniques including thermal, microstructure and stress-strain analysis of welds and welded structures.

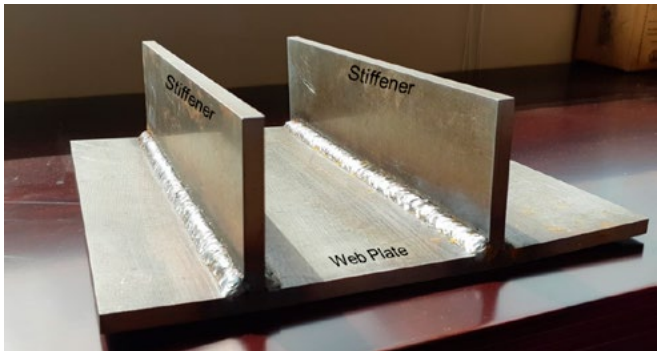


Beyond the theory of weld modeling, students learn about the specialized tool QustomWeld. QustomWeld is an independent Abaqus product co-developed by QustomApps LLC and Dr. Asadi. The product is a popular weld modeling package that offers complex weld modeling solutions on the Abaqus platform. Students learn how to use the software to address the common challenge of minimizing structural distortions due to welding.

WELDING CHALLENGE

A welding engineer prepares, reviews, and assures high-caliber instructions to produce welded joints following applicable codes, specifications, standards, or other fabrication and assembly aspects. Panel fabrication is part of many engineering structures, and welding is often the sole fabrication method to erect such structures. Distortion is a common problem in panel welding, and techniques to mitigate this problem are now primarily empirical in nature. Finding the best distortion control plan is not feasible through shop trials; however, through the use of computation tools like QustomWeld and Abaqus, simulation provides the necessary tool to achieve an optimal weld distortion plan.

The course at UBC comes with a term project where students are grouped to deliver an innovative distortion control plan for a short panel structure as shown below which includes one web-plate, two stiffeners, and four welds. The goal of the distortion control plan is to minimize the deformation on the web-plate after the stiffeners are welded in place.



They challenge themselves under major five scenarios for controlling the distortion.

The first scenario requires students to mitigate the distortion by the mean of tack welding on the web-plate. They develop different scenarios for tack welding (location, number, pattern, size, etc.), run the scenario simulations and compare to pick the best one.

The second scenario requires students to mitigate the distortion by the mean of fixturing/clamping on the web-plate. They develop different scenarios for fixtures and clamps to pick the best one using the QustomWeld model.

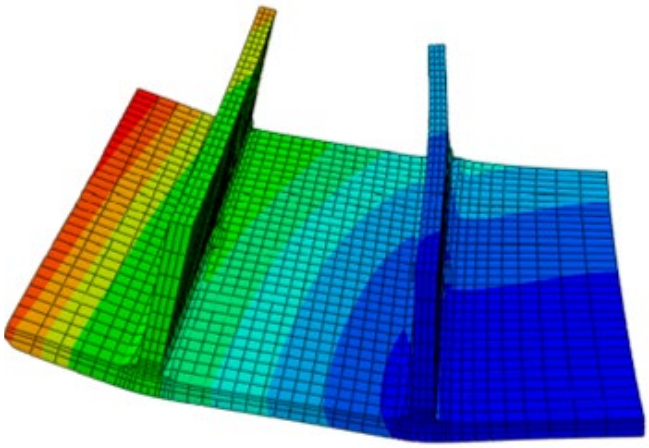
The third scenario requires students to mitigate the distortion by the mean of weld sequence design. They develop a different sequence of depositing welds (permutation, direction, segmentation, etc.). They need to find the right sequence out of thousands of possibilities.

The fourth and fifth scenarios are an innovative mix of work-plans 1, 2, and 3 to explore the best-combined scenario for the lowest distortion. In the end, they come up with a single best plan for writing a distortion control plan that delivers the lowest distortion.

The deliverable comprises the best welding plan for fabricating the panel with the lowest distortion. Each group presents the plan and approach during the last session of the class with a Q&A session. Students start by preparing a QustomWeld model of the panel welding in order to evaluate the deformation on the web-plate using various functions that quantify a 3D distortion after welding the panel.

CHALLENGE CONQUERED

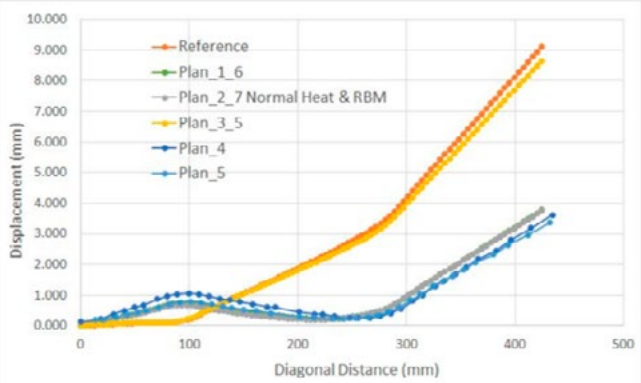
There is no one best solution to fit all welding plans. In fact, there are infinite plans that one can develop to mitigate a distortion in a welded structure. Additional to such a complexity, computational modeling adds more factors to the problem. Each group provided plans that significantly reduced distortion compared to a plan with no distortion controls at all.



Contour of displacement, magnification 30.

The groups of students all came up with different plans, but very similar results: significant reductions in distortion. What the groups found in general was that although fixturing and tack-welding outperformed weld sequencing for this particular geometry, the optimal plans that each group arrived at each involved a combination of the three controls. An example plot of the dramatic reduction in distortion is shown in the plot below. The plot shows distortion along a line at the bottom of the work piece and diagonally from corner to corner. The plots were obtained through simulation using QustomWeld and Abaqus.

A group of students decided then to put their plans to the test by heading into the shop and welding up their



An example plot of the dramatic reduction in distortion.

samples. The shop results show nice qualitative and quantitative agreement with the simulations. The overall conclusion of the groups was that, although it was difficult to predict the effects of each scenario of weld sequencing, tack-welding, and fixturing, using simulation proved an efficient method of predicting how each scenario would play out. Additionally, it was concluded that running an even larger number of scenarios would continue to find even more optimal solutions.

UNLEASHING INNOVATION

Becoming innovative beyond the standard will be an essential skill for weld engineers to benefit our manufacturing industry's future. Weld modeling and simulation are now reliable and capable of predicting the behavior of weld and welded structures. Having the skill of using welding models and creating digital twins reduces the gap between welding science and welding engineering, where our engineers become innovative beyond the standard. Incorporating a weld modeling and simulation course provides an opportunity to enrich skills and the knowledge required for the future of weld engineering.

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