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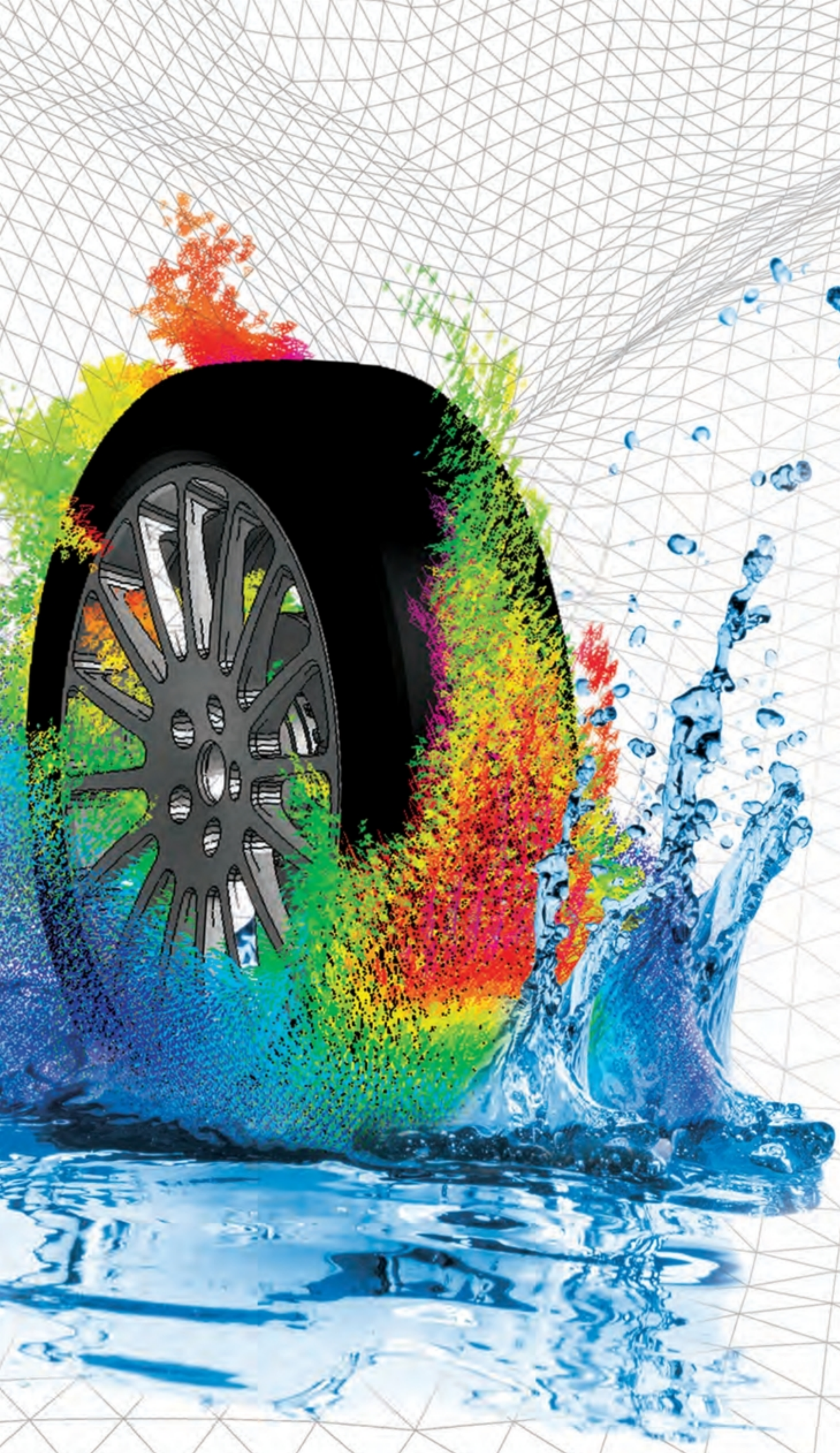
Thomas Lukaszewicz

The inside story of Ford's dual approach to the research and development of automated driving



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Light and safe

Automotive OEMs are under pressure to develop lightweight vehicles. Virtual prototyping can support engineers in the challenging task of shedding vehicle weight without compromising safety

AUTHOR CAROLINE BOROT, ESI GROUP, FRANCE
IMAGES EP TENDER, ESI GROUP

Throughout the history of car making, vehicles have largely been made with rather homogenous sheet steel structures, and the parts that are subject to particularly strong local stresses were often oversized. While materials including aluminum, high-strength steel and composites offer weight savings, production difficulties and cost prevent them being used for the entire car body. The most efficient weight reduction strategy is to use the most appropriate material for each application and component.

To implement lightweight materials while ensuring expected performances under various load conditions requires many prototype crash tests. Multimaterial strategies require a precise understanding and an early prediction of how materials behave once assembled. Any uncertainty may lead to conservative decisions and costly over-engineering. In this context, virtual prototyping should be used early in the development process to optimize the design and material selections and to test multiple ideas in very short loops.

Light bumper design

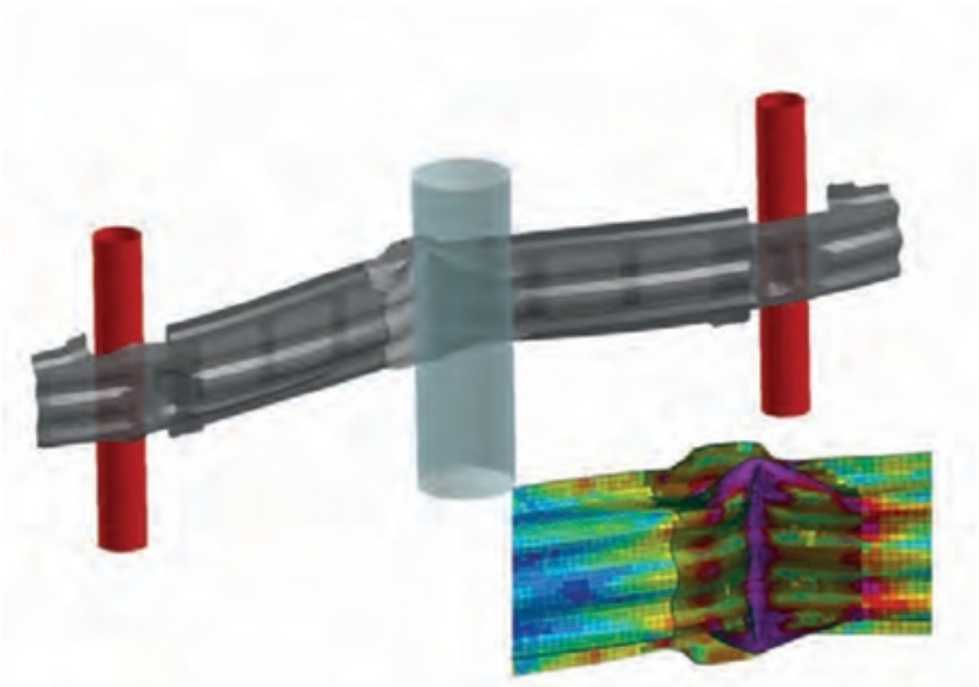
The United States Council for Automotive Research (USCAR) has initiated a research group for the United States Automotive Materials Partnership (USAMP), constituted of General Motors, Ford Motor Company and Chrysler Group. The consortium's work is supported by the US Department of Energy, and has the objective of halving the mass of vehicles, making them of higher quality and more recyclable, while keeping them affordable.

The group is currently assessing the technical readiness of composite crash simulation through the virtual design of a front-bumper crush-can (FBCC) system and the validation of its finite element-based performance prediction. The first results were presented at the Automotive Composites Conference & Exhibition in September 2016.[1]

While weight saving was an important aspect, the main objective was to deliver an accurate performance prediction for the FBCC system, meeting the crash performance objectives of a steel surrogate design.

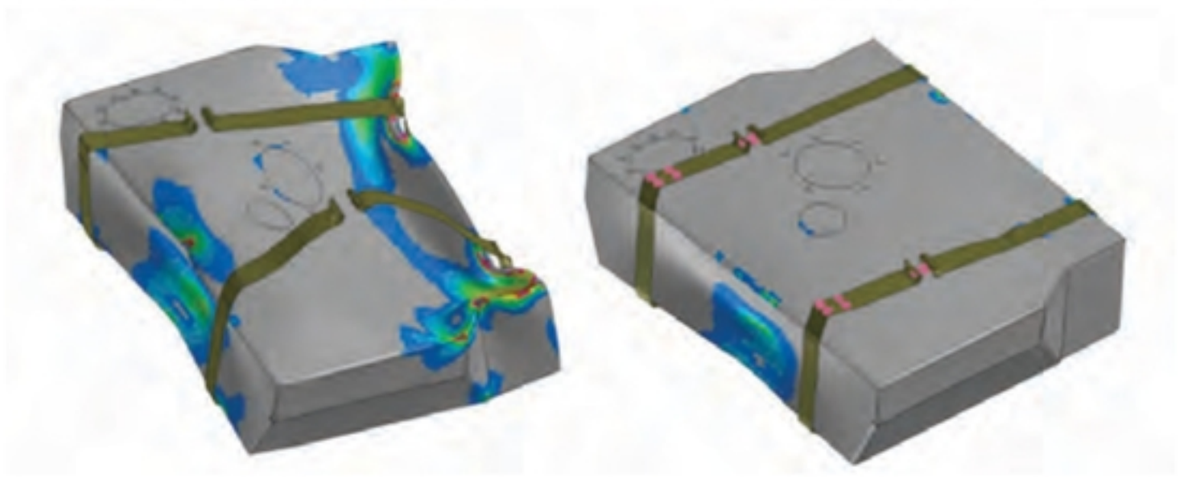
The consortium contacted ESI for this work. ESI is a virtual prototyping software editor, well known for its all-around performance testing solution Virtual Performance Solution. ESI teams in North America, Germany and France were tasked with investigating the design of the compression-molded composite front bumper beam, with the objective to employ unidirectional or carbon-fiber woven fabrics for the primary structure. The number of fiber layers, their orientation, and the geometry of the beam, were determined through virtual engineering.

Once the design targets were set for the composite FBCC, iterative simulations were used to optimize the design to fit within the set space, and also to select the material, lay-up sequence and attachment methods (bonding rather than the welding or riveting methods used for steel parts). Two composite plys were tested (woven



Multimaterial joining research

Several research projects are currently using virtual prototyping to develop innovative approaches for joining composite and metallic parts while ensuring good crash and fatigue performance in the area of the join. For example, the EU Horizon 2020 project ComMUnion is investigating the use of laser texturing, which could increase shear strength by several 100%. The texture definition optimization work will be done through multiscale end-to-end virtual prototyping.



(Far left) EP Tender's range-extending device for EVs, Tender'Lib

(Left) Simulations of fuel tank deformation, with and without the VPS water flow module

(Above) A bumper design simulated in VPS

and unidirectional), but only woven composites made the final design.

The FBCC predictions correlated well with experiments at the coupon and component levels, suggesting that this method can assess crash behavior efficiently under different load conditions. The new advanced composite crash and strength models introduced in ESI's Virtual Performance Solution (VPS) predict the rupture behavior of composite parts and their capability to absorb energy during a crash. The accuracy of composite structural performance prediction is also increased by taking into account manufacturing effects such as fiber orientation, inherited from the composite forming process.

Modeling tank sloshing

Recently, ESI introduced a water flow simulation module to its VPS, to predict fluid structure interaction (FSI) accurately with minimal effort. This is especially critical in a crash situation where the mass coupling and incompressible behavior of the fuel can change the accuracy of the simulation result. Start-up company EP Tender has used the module to ensure the safety of its trail-mounted fuel-powered generators for EVs – an innovative product, for which risks in the case of a crash must be evaluated carefully however.

"Using VPS has enabled us to validate our crash scenario for the generator's fuel tank virtually and to demonstrate that our trailer brings more energy-absorption capacity," says Jean-Baptiste Segard, founder and CEO of EP Tender. "Integrating ESI's latest water flow module for tank sloshing in our model has been particularly efficient in modeling the content of the tank accurately."

EP Tender's engineering team demonstrated the trailer's ability to resist even the most severe rear crash configuration listed in the FMVSS 301 US regulation. As this regulation requires fuel tanks to remain sealed after a crash, the design includes a patented structure that would preserve the generator's fuel tank during an impact by shifting it downward. Simulation results enabled EP Tender to validate the crash scenario quickly.

To test the tank's watertightness, the team first modeled it as an empty structure, adding the mass equivalent of the fuel it would contain – a quite common simplification for tank modeling. However, simulation results demonstrated an abnormally high plastic deformation, reaching rupture limits in some location. ESI therefore proposed an investigation using its new water flow module for tank sloshing based on the incompressible finite pointset method (FPM).

Simulation showed that using the water flow module provided a more realistic model of the fuel. Thanks to the precision level the team gained using VPS's new module, the tank no longer reached its rupture limit and the design was validated. This demonstrates that the accurate modeling of fluids is essential for this kind of simulation. ‹

References

1) Pasupuleti P R, Doroudian M, Dwarampudi R, Coppola A M, Berger L, Faruque O, Truskin J and Mehta M, Validation of material models: design and analysis of composite front bumper crush-can system, Automotive Composites Conference & Exhibition, September 7-9, 2016, Novi, Michigan

• *Caroline Borot is ESI Group's industry solutions product manager*