Technology Spotlight

CAD / CAE Integration: Opportunities in the Automotive Industry

Sponsored by: Dassault Systèmes

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EXECUTIVE SUMMARY

Vehicle manufactures are pressured by the challenge to deliver better products in a shorter period of time. They can not afford the burden of large, unproductive R&D investments or risk the failure of new product launches. Functional design validation steps may increase the frequency of issues being discovered too late – just before the start of production – which in turn could bring back high costs in the development stage.

For this reason, IDC identified the need for a continuous functional and technological feedback loop between the design engineering (using CAD) and stress analysis (using computer-aided engineering – CAE) departments. When it comes to technology, IDC advises the implementation of a multidisciplinary approach, to be able to simulate and validate parameters regarding noise, vibration, crash testing, and torsion in a synergic way with the design process.

This study includes a technology provider profile of Dassault Systèmes and a case study by the Group Research of the Volkswagen AG that highlights the opportunities of CAE/CAD integration and that could provide a relevant paradigm for vehicle manufacturers.

SITUATION OVERVIEW

The automotive industry is being influenced by new boundary conditions. A new generation of drivers – always-connected, urbanized, environmentally conscious, looking for new ownership models and technological features – determine a different customer experience. At the same time, the automotive industry is under the spotlight, with governments and regulatory authorities caring more than ever about carbon footprint across all lifecycle phases.

Customers from multiple global markets have different expectations in terms of product features, quality, costs, and compliance to a number of local rules and regulations. The successful manufacturers are those able to identify and meet those specific needs and are able to be more customer-centric than their competitors. They are aiming to create highly customized products to better fulfill customer expectations. Vehicle manufactures are pressured by the challenge to deliver better products in less time. In particular, companies need to transform their product range without losing brand identity or wasting money on unsuccessful projects. To achieve rapid new product development and introduction, they can no longer afford the burden of large, unproductive R&D investments or risk the failure of new product launches.

While time to market is always applying pressure, automotive companies can't compromise on quality, safety, and environmental standards.

Nevertheless, these drivers are not just challenges. They actually provide an opportunity for automotive companies to transform constraints into powerful levers of innovation. This can even result

in a competitive advantage for companies that are able to improve product development and quality more rapidly and more successfully than their competitors.

EVERYTHING CONVERGES IN THE DESIGN PHASE

Most of these challenges originate – and can be fixed – in the conceptual design phase. So enhancing productivity and efficiency in the conceptual design process has to become the final goal for successful vehicle manufactures. However, this can become a very difficult task for companies that are not prepared to embrace it holistically. While business process management/improvement practices are actually focused on minimizing any risk in operating processes, "pure" innovation finds its main boost from disruptive changes to the accepted standards. To find the best possible balance between these two different worlds, companies need to explore as many concepts as possible very quickly in order to validate the best ideas. However, this often reaches the limit of capacity in early stages of existing development processes and therefore companies miss the opportunity to get a holistic assessment.

Improving decision making across innovation environments is therefore essential. This will provide consistent processes, informed staff, and open lines of communication along the innovation value chain. The ability to identify a problem and isolate the root causes upfront, to understand the effect of early decisions on the customer experience, and to enable corrective actions as quickly as possible, is what will distinguish any successful innovation environment.

Overcoming complexity, breaking organizational silos, and fostering collaboration

Vehicle manufactures have long been investing in simulation and analytics-powered development, geared around the notion of Digital Twins, in which products, processes and services are conjointly designed and simulated. Moreover, the need to support embedded software creation in digital products has opened the way to the inclusion of formerly unknown practices (such as application lifecycle management) in the industry.

To face up to their challenges, automotive manufacturers should overcome complexity by breaking organizational silos and fostering collaboration, with a view toward speeding up decision-making capabilities to be able to successfully transform the unexpected in routine. What is emerging is the need to transform processes, organizations, and business models. To do so, it will be essential to modernize current CAx-systems to support in-depth design studies and fully automated mathematical optimization in complex design spaces. Simulation leaders in the CAE teams have to deal daily with increasing – and often competing – requests involving different disciplines. They strive to get highly integrated software tools to succeed in their jobs. For example, they need to be able to quickly validate the key attributes of a car body's design concept – such as crash performance (frontal and side), weight, or stiffness – for a large number of design alternatives.

To make sure development is seamless, given the elevated levels of time pressure; designers would ideally need to carry repeated simulations at an early stage of the process, even when many characteristics of the product are still unknown. In fact, the key requirement to achieve speed, quality, sustainability, and innovation is to aggregate as much information as possible at the concept phase. But in reality, companies still manage their design phase in a sequentialand often manual connected way where style, performance, and manufacturability are considered separated domains. This in turn generates waste in the design process:

- There is a need for a functional and technological continuous feedback loop between the design engineering (using CAD) and stress analysis (using CAE) departments. Besides the problem of having elongated development time due to departmental handover, a failure to

share the same systems creates a risk of performing functional validation such as NVH (noise, vibration, and harshness) or crash simulations on outdated geometries.

- Having manually connected functional validation steps increases the frequency of issues being discovered just before the start of production, which in turn brings back high cost in the development step.
- Loss of opportunities due to a lack of alternative validation or conceptual innovation resulting from limited time and resources.
- The clash of contradicting functional targets with functional disciplines (for example NVH performance vs. body weight) hampers an efficient drive of body shape and typology.

THE BENEFITS OF CAD/CAE INTEGRATION IN ENHANCING PRODUCT KNOWLEDGE

When it comes to technology, IDC advises the implementation of a multidisciplinary approach, to be able to simulate and validate parameters regarding stiffness, noise, vibration and crash testing in a synergic way during the design process. The solution is that CAE evaluation must run concurrently with the other streams of the development process.

Vehicle manufactures can achieve major benefits from creating one single functional validation model for safety and NHV to avoid retrofitting separate models after each modification has been made. This will be essential to simplify collaboration – having an iterative interaction of different decision makers around the same model rather than a sequential process.

Anticipating "knowledge" on the earlier phases of product design could allow automakers to perform design and validation activities in a more efficient and effective way, generating the following benefits in the process:

- Increased maturity in design through the generation and validation of innovative concepts.
- Experimentation with more new design solutions, in a productive way, creating valuable support for decision making.
- Validation of expert knowledge at an early stage, and the ability to store this knowledge and reapply it when needed.

This can, in turn, help the business in multiple ways.

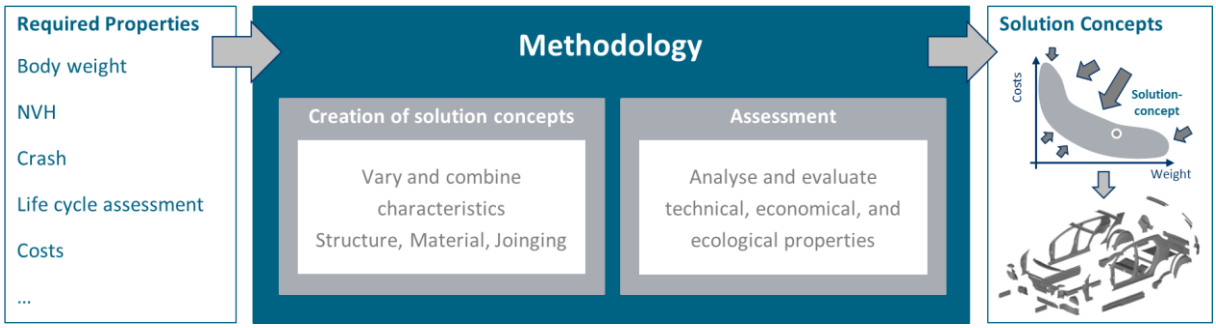
On an immediate basis, automakers can optimize many parameters (e.g. weight, stiffness, dynamic frequency) without compromising on the design aesthetics. This significantly helps to improve product quality, streamlining the product design phases, and helps to retain more solid brand identity.

A Real Example: Group Research, Volkswagen AG

The Group Research of the Volkswagen AG is making significant progress in this field. The Group Research investigated the interaction of the development of vehicle bodies influenced by the conflicting goals of safety, reduced weight, environmental compatibility, and economy. With a high proportion of the total weight of the vehicle (approximately 35%), it is then important to reduce bodyweight significantly to achieve future CO_2 limits. To counter these issues, the Group Research is implementing an approach that opens up a very variable and future-oriented solution. The objective is to implement a solution to fully automate the assembly of parametrically variable calculation models, with the objective of generating multidisciplinary FE simulations.

FIGURE 1

Volkswagen's Simulation Methodology Outline, With Requests as Inputs and Solutions as Outputs



Source: Volkswagen, 2016

Initially, theoretical solution variants are created from dimensional concepts for different body types from existing components. For a pre-selection of these variants, abstract CAD vehicle-body-models with variable components are fitted and parametrically adapt to the constraints of the variant described. The resulting geometry models are directly converted into simulation models, including materials and connections. This way, the properties of the pre-selected solution variants are evaluated in a thorough simulation process. This evaluation leads to a parametric adjustment to make an already confirmed reselection of advanced solution variants, which in turn are automatically prepared for final review. In this iterative process, all the available opportunities are systematically assessed and reviewed at both the level of the complete body and the level of individual sections, and the vehicle concept is gradually optimized. The result is a deeper understanding of the characteristics of the examined body models.

The detailed strategy was developed by the research engineers Mr. Hasenpusch and Dr. Hillebrand at the Group Research at the Volkswagen AG and was presented in June 2015 on the 19th international Dresden Lightweight Engineering Symposium.

The implementation of the process was carried out together with Dassault Systèmes experts to create a parametric geometry and to implement advanced FE-simulation methods. The CATIA | SFE CONCEPT solution from Dassault Systèmes has been used to solve the demands on the automatic generation of a whole parametric body model from device components based on existing information, created in first stage of the methodology. The selection of material and joining technologies is located there. CATIA | SFE CONCEPT uses this data to assign the material attributes. CATIA | SFE CONCEPT is the one important module of the software solution that provides the capability of the model structure and parametric adaptability and also the downstream process flow with CATIA backbone.

This solution has the potential for significant savings in time and costs in the early phases of the development process, while increasing overall product quality at the same time. The in-depth analysis of the design variants in the early phases of development facilitates optimization and qualitative adjustment at an early stage without the high cost of the detailed development process. Validation of the functional quality before investing in the detailed development also reduces the risk of failing to recognize quality conflicts in time.

CONSIDERING DASSAULT SYSTÈMES CATIA|SFE CONCEPT

Dassault Systèmes is a product development and manufacturing execution application provider, delivered on the proprietary 3DEXPERIENCE platform, enabling 3D design, engineering, 3D CAD, modeling, simulation, data management, and process management. After the acquisition of automotive body conceptual engineering and performance evaluation and optimization company SFE GmbH in 2013, the company moved forward in the integration of that product portfolio with its flagship CAD and simulation tools CATIA and SIMULIA. This resulted in a fully parametric simulation geometry concept dedicated to the automotive world.

According to Dassault Systèmes, the parametric definition of topologies and shape in CATIA|SFE CONCEPT – when deployed alongside SIMULIA optimization tools Isight and Abaqus – allows engineers to freely modify their models, covering either single components or the entire vehicle body. As a result, when a design department propagates new changes to a model, the engineers can quickly evaluate the impact of those changes on the functional performance of the complete structure by means of CATIA|SFE CONCEPT, supporting most industry-standard FE simulation solvers, including SIMULIA Abaqus, NASTRAN, Ansys, LS-Dyna, RADIOSS, Pam-Crash, and PERMAS. CATIA|SFE CONCEPT can be coupled to the typical software products for automatic optimization such as SIMULIA Isight, LS-Opt, Optimus, ModeFrontier, OptiSlang, and Heeds. In this way, an optimization process can potentially be fully automated and calculations run "overnight."

Challenges

Vehicle manufactures looking to improve their CAD/CAE integration should be aware that they must not to forget that their innovation strategy should not be limited to a purely "product-centric" vision. They should carefully consider the broader ecosystem in which their products will operate in order to establish long-run competitive advantage. To do so, firms will need to put in place an end-to-end product lifecycle process that is not exclusively tied to the phases of design, engineering, and industrialization, but also – and above all – includes fundamental activities related to marketing, sales, supply chain, and manufacturing operations.

CONCLUSIONS

Today modern PLM technologies are surely essential to provide a single collaborative and decision-oriented environment. At the same time, in the modern and fast-paced business environment, traditional PLM approaches may be not enough, especially if they are only focused on managing product design and engineering phases in an isolated way. Vehicle manufactures can exploit significant benefits of optimizing vehicle performance and decision-making in products during the early conceptual design and innovation stages, including capturing and validating decisions against the appropriate rationale to ensure a more complete impact assessment and make decisions earlier in the conceptual phase with a higher level of confidence.

REFERENCES

This document is the result of IDC's primary and secondary research. In particular, IDC carried on interviews with:

- Dr. Andreas Hillebrand and Jan Hasenpusch, Volkswagen Group Research, Wolfsburg, Germany.

As an additional reference, please consider:

- Jan Hasenpusch, Dr. Andreas Hillebrand und Prof. Dr. Thomas Vietor: *Parametrische Methodik zur Entwicklung anforderungsoptimierter Karosseriestrukturen in Multi-Material-Bauweise.* Paper 19. Internationales Dresdner Leichtbausymposium / 18. – 19. Juni 2015).

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