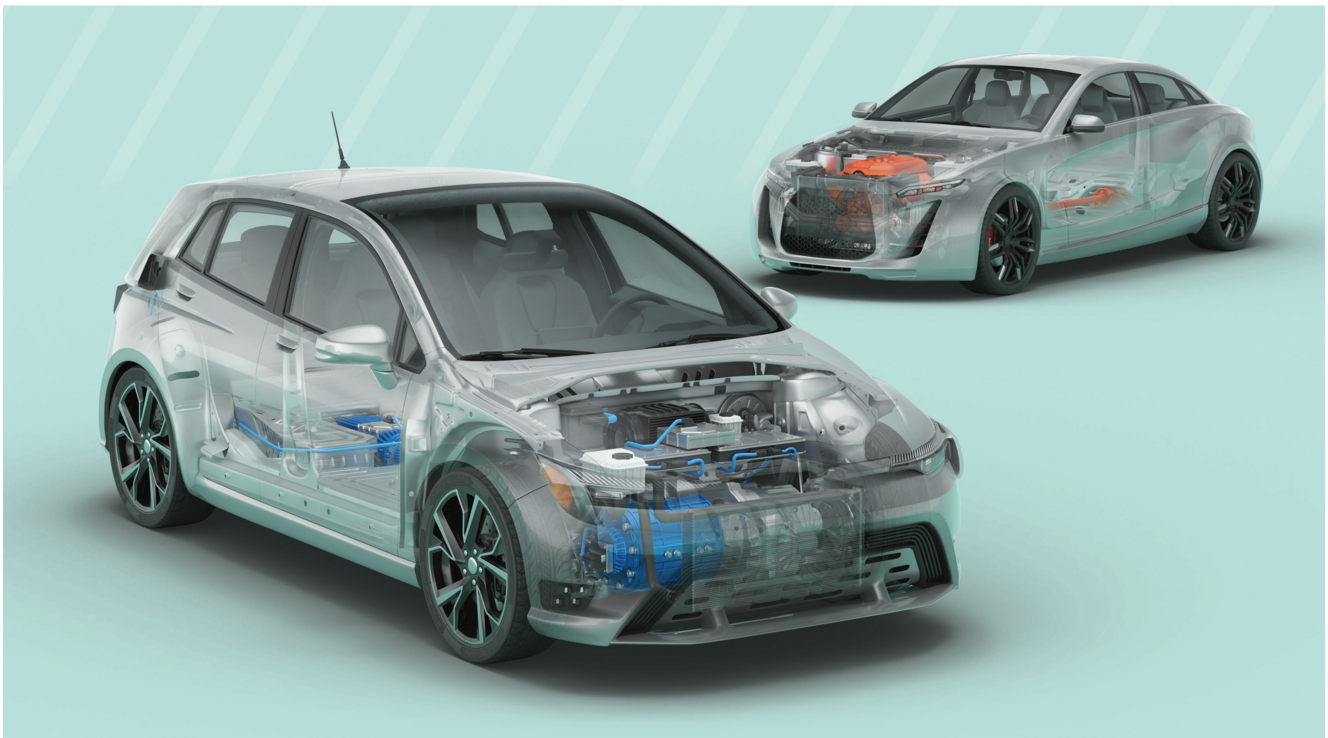
Topology Optimization as a Development Strategy for Sustainable Plastic Components

Less Is More: Reduce Is Better than Recycle

In engineering plastics, sustainability does not just start with recycling. At the component design stage it is crucial to use only as much material as needed for optimum product performance. Topology optimization plays a vital role here because, as the key to lightweight construction, it simplifies the selection of sustainable design alternatives.



Altair provides solutions for the entire automotive product development cycle: from feasibility studies, concept development and variant optimization to detailed multidisciplinary optimization. © Altair

Offering material properties that enable high performance at low weight, engineering plastics are often the materials of choice to meet the requirements of a complex lightweight part. However, the design of such components is complex, as not only the specific material properties but also a design suitable for production must be taken into account. Automotive electrification brings new challenges due to new modules, components, and their changed installation situation and higher demands for interior acoustics. This necessitates innovative approaches to structural design to attain a balance between structural and acoustic performance characteristics within weight and cost limits. A holistic simulation of engineering plastics, in particular the prediction of the noise, vibration and harshness (NVH) behavior of the components is therefore an important development aspect and should already form the basis for material and design decisions in the early concept phase.

The design process of load-bearing plastic inserts to improve the NVH performance of a body-in-white usually starts with performing sensitivity analyses. These determine the parameters that exert a significant influence on the component properties. Once the important component parameters are identified, an iterative optimization process is used to determine the best concept by a compromise between maximum performance at a comparatively low weight. Topology »

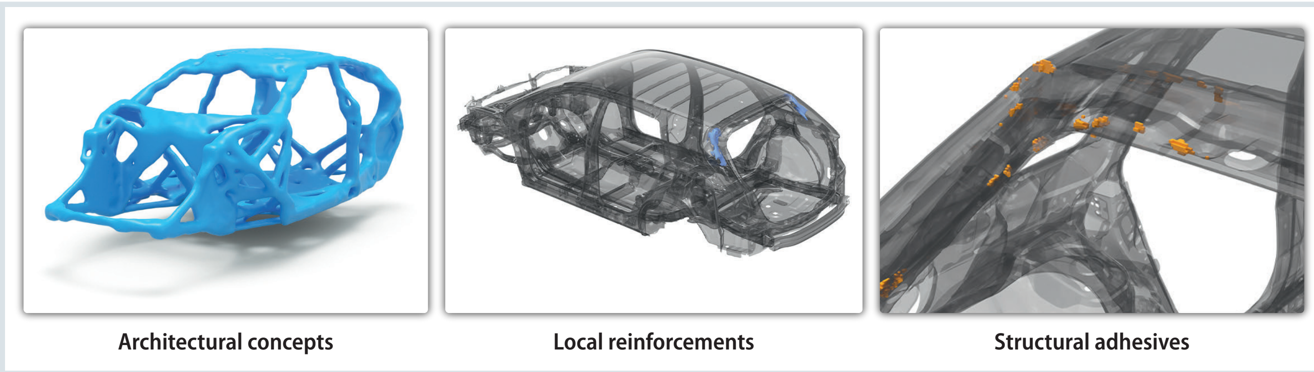


Fig. 1. Altair's processes simplify the strategic application of topology optimization for global architectural concepts, local reinforcements, and the efficient use of structural adhesives. In practice, this means up to 80 % time savings for model setup and analysis. © Altair

optimization is an important design tool that is most effective when used as early as possible in the development phase. The topology of a component ensures design concepts are appropriate regarding loading and manufacturing from the start.

Organizational Hurdles and Transformation

Strategic application of topology optimization relies on efficient design space generation. However, this is difficult because, on the one hand, there is often a lack of suitable tools and, on the other hand, the involvement of several departments leads to considerable time delays. To exploit the potential of topology optimization and enable faster and better decisions, the necessary input variables must be available as early as possible. To achieve this, the barriers between the CAD design and CAE departments must be removed.

The lessons learned from many projects that have helped streamline the processes around topology optimization, Altair has developed a set of new process building blocks. These facilitate and simplify the application of topology optimization as a strategic key to mass reduction and the development of sustainable components and systems. It results in time savings of up to 80 % in model generation, leaving more time for evaluating different design alternatives and improving the engineering solution (**Fig. 1**).

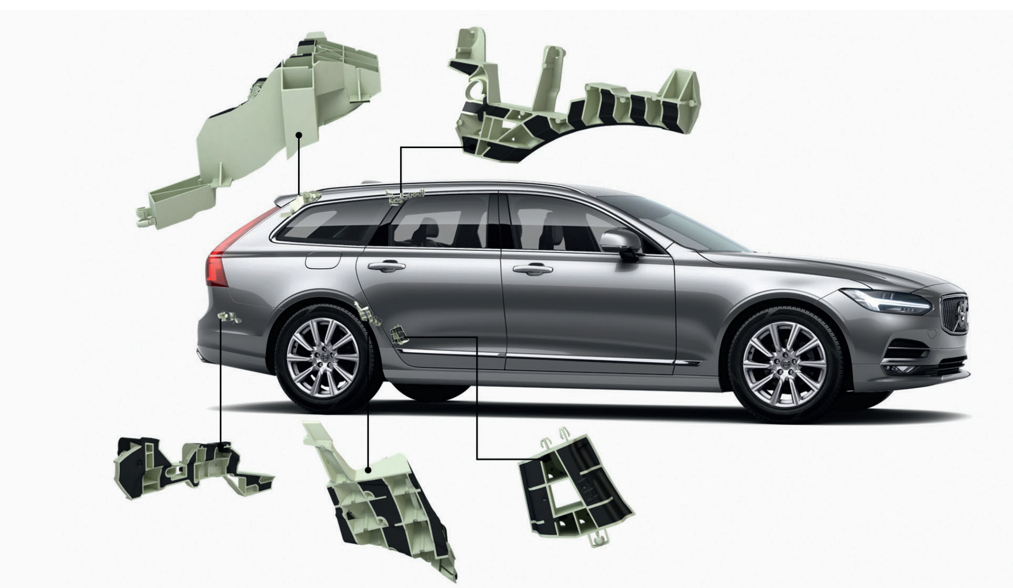


Fig. 2. When developing structural inserts, Sika engineers were able to eliminate time-consuming steps using the Altair Design Space workflow, achieving the results in minutes instead of hours. © Sika

Application Example Sika: Structural Inserts for Lighter, Quieter Vehicles

Sika Automotive AG, Romanshorn, Switzerland, offer a range of adhesives systems for sealing, damping, reinforcement and protection. Also, their solutions for noise reduction and vibration damping in car body construction make them an important development partner for automotive manufacturers and suppliers. When developing structural inserts, Sika typically creates an initial design and then optimizes the design until the best compromise between performance and weight is achieved.

To gain a deeper understanding of where best to place the material in the body-in-white (BIW), the team uses Altair OptiStruct software for structural and NVH analysis in their workflow. To further optimize the process, Altair reviewed Sika's previous approach to NVH studies and identified several areas for improvement. To accelerate the development process, the simulation experts recommended the Altair Design Space workflow, which Sika used to study a D-pillar.

With the previously established workflow, it took Sika up to three hours of design space to generate an initial concept idea for the D-pillar insert. With the new workflow, however, engineers defined the build space, created a voxel mesh, modified the intersections, and took less than 40 minutes to prepare the simulation. In addition to accelerate decision-making, Sika benefited from the solution's ease of use, which allows the team to produce results faster and easier than before.

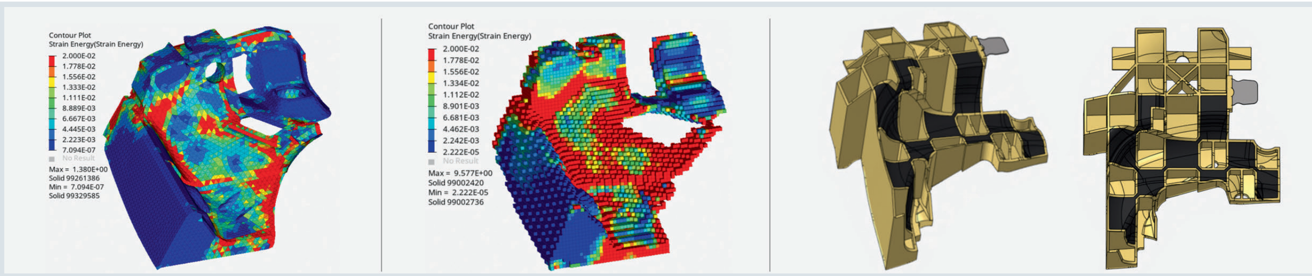


Fig. 3. Since modeling time was reduced by 70 %, the Sika team could further improve the component through iterations. Left: design space model (traditional workflow); center: model created using the "Altair Design Space" workflow; right: example of a D-pillar NVH reinforcer. © Sika

Using the Altair Design Space workflow, Sika engineers eliminated time-consuming steps so they could get the results they needed in minutes instead of hours. It enabled them to make faster go/no-go decisions regarding potential positions for their reinforcer solutions in BIW (**Fig. 2**). With modeling time reduced by 70 %, the team was able to invest more time to gain deeper knowledge of the part and further improve it through iterations (**Fig. 3**).

Conclusion: Digitalization and Improved Processes for Enhanced Sustainability

In contrast to the traditional approach, the processes described reduce manual efforts, unify disparate tasks from different departments into a single workflow, and shorten modeling time by up to 70 to 80 %. This saves development time, allowing engineering teams to focus on more creative work (**Fig. 4**). In the above examples, modeling time savings were determined for a single application. However, five or more areas are typically required to use structural nodes (70 % savings x 5).

The more intensive applicability of topology optimization increases design confidence and leads to cost savings as well as significant material savings. Further development of established designs, like material substitution or changed load or boundary conditions, the Altair approach of strategic use of topology optimization at various levels of vehicle development means sustainable use of plastic solutions. True to the motto "material that was not used in the first place does not have to be recycled", this methodology is a key stone for the development of sustainable plastics solutions. ■

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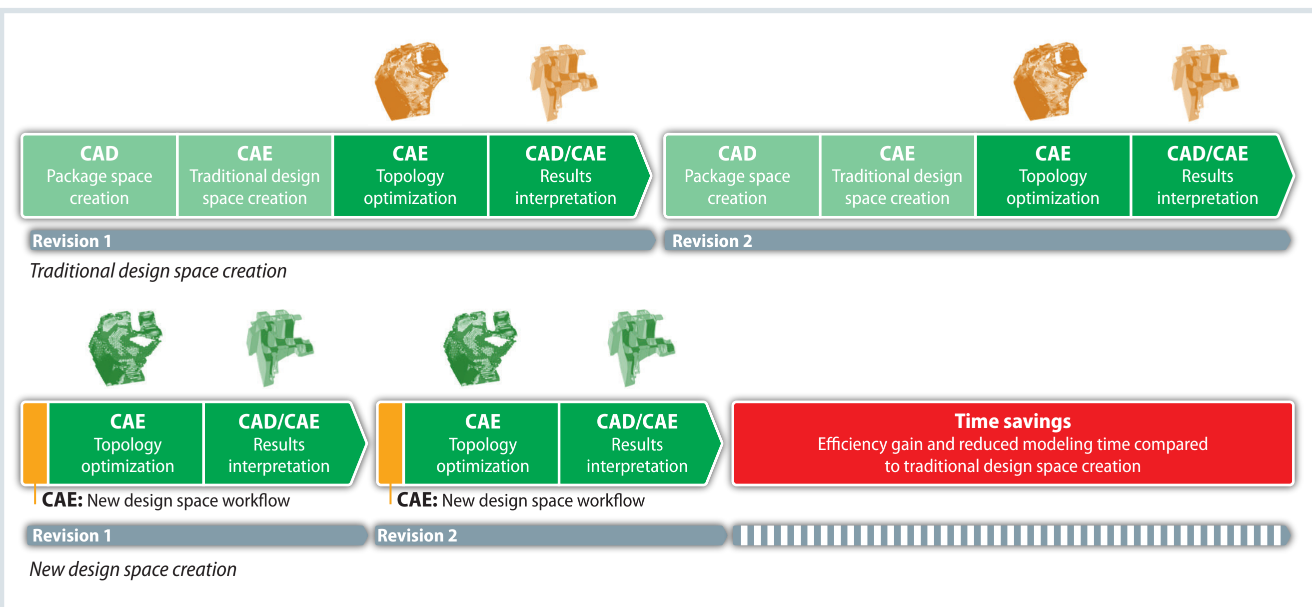

Fig. 4. Comparison between time and organizational efficiency gain. Top: process with conventional build space creation. Bottom: new approach to CAE-focused build space creation. Source: Altair; graphic: © Hanser