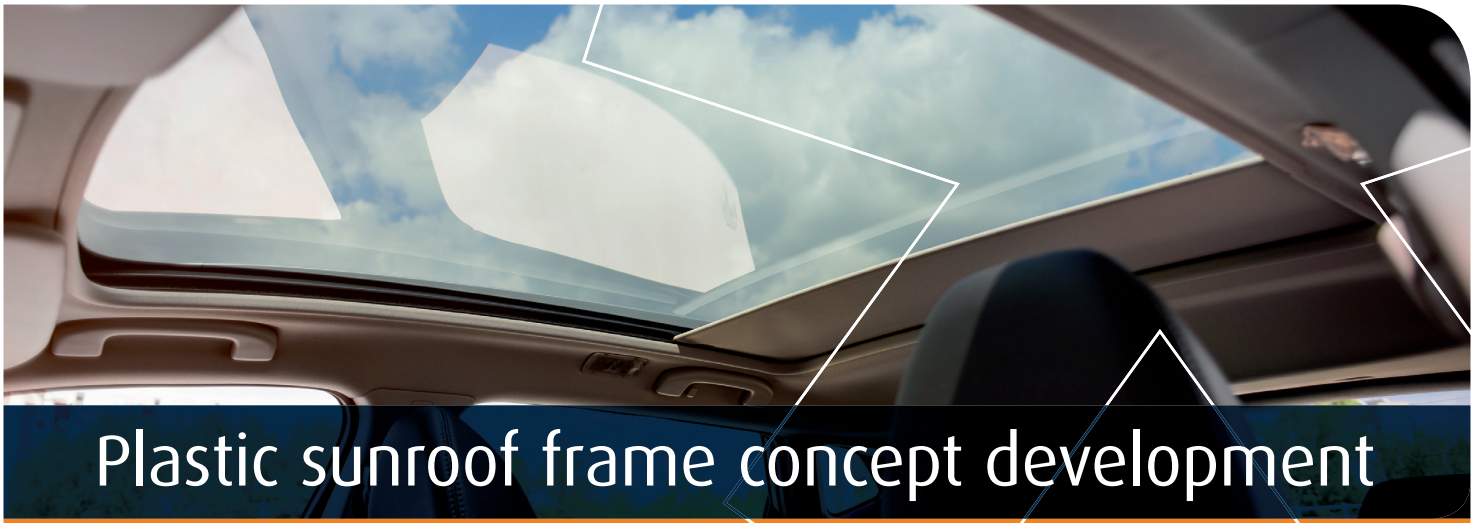


Plastic sunroof frame concept development

The project

Panoramic sunroofs in cars have become increasingly popular, enlightening the cabin and offering fresh air inside your car if desired. The sunroof frame is the load-bearing part in automobile panoramic sunroof systems. This structural part forms the connection between the car body and the moving glass, and typically integrated additional functionality such as the mountings of a motor, a sliding glass mechanism, and a sunblind system. Assigned by CIE Automotive, Code Product Solutions in close collaboration with the material supplier Polyscope assessed the potential of multiple materials and technologies in order to improve current sunroof frame designs in terms of weight and integral costs.

The challenge

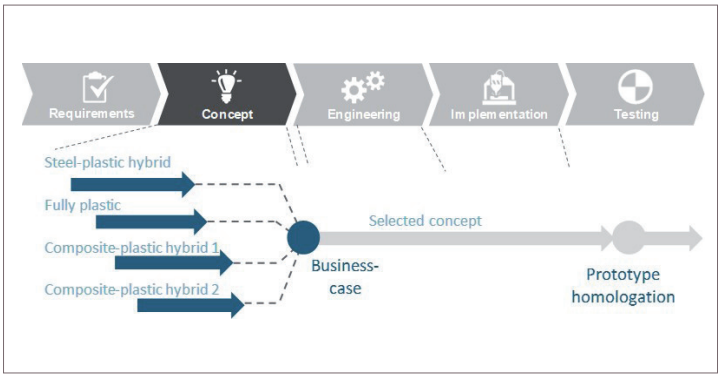
Customers demand for larger sunroofs challenges engineers since larger sunroofs generally mean more weight and further weakening of the structural stiffness of the car body. This leads into the requirement of stiff and on the same time light sunroofs.

Established sunroof frames are either made fully from metal or a combination of metal and injection moulded plastics.

CIE Automotive's benchmarking commercial sunroof frame design was composed of an injection moulded plastic frame, on which two large complex-shaped steel reinforcements were mounted for structural purposes. The main goal of this project was to create a design avoiding the need of the both heavy and expensive metal reinforcements still fulfilling all OEM requirements. All at equal or even lower costs.

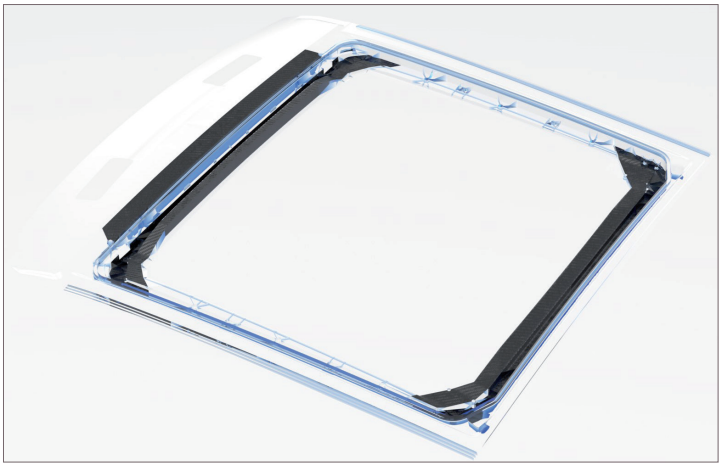
Our solution

Weight reduction of reference parts can be a challenging task especially in case of several degrees of freedom are allowed. In this project, the optimal solution should be found by applying multiple material combinations and production technologies. To handle this level of complexity, our engineers built up multiple virtual prototypes, each considering a certain lightweight concept. More specifically, a fully plastic and two plastic-composite hybrid designs (UD-tape based and organosheet based) have been assessed in terms of feasibility and costs.



Our CAE-driven development approach allowed CIE Automotive to make crucial decisions based on feasible designs within the concept phase and therefore before designs entered the detailed engineering phase and long before any physical prototype has been built.

The final fully plastic design concept design, made of XIRAN®, was selected since it offers outstanding design freedoms to integrate functions and the best ratio between costs reduction and weight considering the targeted car segment.



Concept design

Based on the reference steel-plastic hybrid design and by considering both the known OEM-specific load cases and the available packaging space, an ideal design has been derived by applying topology optimisations on the available design space. Based on the insights of this optimization studies, multiple manufacturable design concepts have been drawn up for several material combinations and technologies such as hybrid thermoplastic composites including multiple joining technologies.

Feasibility & optimization study

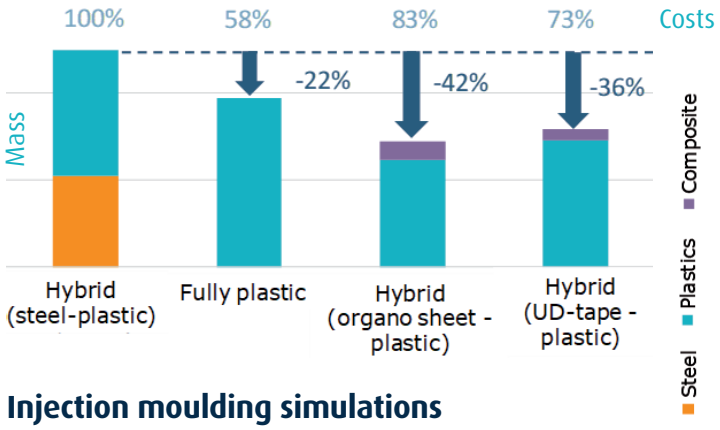
To envisage which material (combination) and/or technologies (production and joining technology) fit best, the conceptual designs of the sunroof frame have been worked out into surface-based virtual demonstrators. Feasibility of all concept variants have been assessed by applying finite element analyses on these models accounting for stiffness and strength occurring at the required load cases. Further, the locations, heights, and thicknesses of all surfaces have been optimized using computational optimization techniques. Manufacturability constraints have been used that belong to the envisaged production technology.

Matching materials and technologies

Every design concept comes with its specific challenges requiring smart solutions. All concepts commonly require materials offering a high degree of dimensional stability. This to make several parts fit to the frame, e.g. a wind deflector and moving glass mechanism. For that purpose, our engineers assessed several plastic grades in terms of mechanical performance and dimensional stability. Further, the integration of composite inserts and the bonding between the sunroof frame and the sunroof glazing required special consideration.

Evaluation of business cases

By comparing the final weight, and by assessing the risks and costs of various concepts, business cases were identified for each concept. For the cost assessment, our design experts evaluated the costs based in the bill of materials and costs associated to joining processes or processing steps, such as cutting of composites.



Injection moulding simulations

Injection moulding simulation were used to select the optimal gate locations to result in the lowest possible warpage and to manage the location of weld lines. The outcome of the injection moulding simulations is directly used for our stiffness and strength analyses. By coupling both analyses more detailed insights of the roof frame performance are gathered, enabling further improvements on design, mechanical performance, and cycle time.

Our achievements

- Virtual benchmarking of multiple feasible designs incorporating multiple materials and technologies
- Showing up business cases in an early development phase
- Min. 20% up to 42% weight savings
- Up to 42% lower costs of the fully plastic design