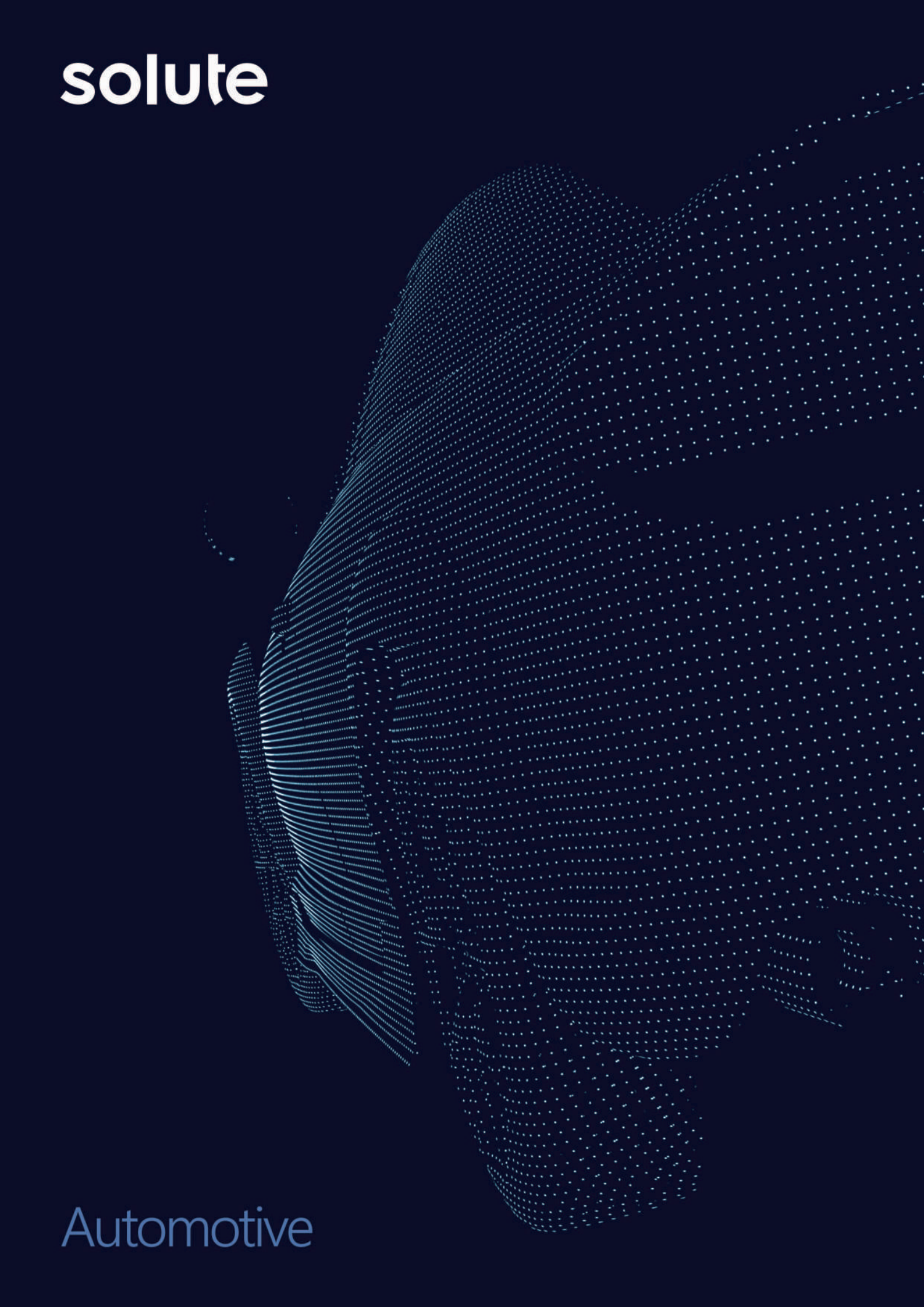
solute



Automotive

Index

"Engineering is not merely knowing and being knowledgeable, like a walking enciclopedia; engineering is not merely analysis; engineering is not merely the possesion of the capacity to get elegant solutions to non-existent engineering problems; engineering is practicing the art of the organized forcing of technological change... Engineers operate at the interface between science and society..."

Dean Gordon Brown
Massachusetts Institute of Technology (1962)

About Solute

Solute is a multi-disciplinary engineering firm based in Madrid and Barcelona, Spain. We take great pride in our expertise, clients and projects.

Our mission is to provide quality services to different companies that demand advanced, innovative and reliable technical solutions. These solutions have been made and offered for operational services and R&D projects.

Above all else, Solute strives to provide outstanding service and technical excellence. We listen, collaborate and confer with our clients to ensure successful projects. We listen, we investigate, we solve. Our engineers focus everyday hand in hand with our clients to reach the desired solution until the client is completely satisfied. The satisfaction of both parts is reached with 100% availability, constant communication and taking care of every detail.

Since its inception, Solute is a great example of success as it has been growing its team as well as the client and projects portfolio. We are an organization far away from reaching its limits as we are constantly learning new techniques, software and solutions.

Currently Solute is acknowledged as a premium quality CAE provider for many industries. The broad experience amounted to in the automotive industry constitutes one of our main pillars of knowledge and our portfolio encompasses almost all competences available in the market.

This fact has ranked us within the three first positions for each CAE provider election among the main manufacturers and OEMs.

The manufacturers and OEMs that have relied on Solute to aid their developments are located around the globe so different CAE programs, working structures, R&D concepts and structural solutions are kept inside Solute's know how.

Solute automotive

Solute has become an official automotive provider for top manufacturers in the automotive Industry. Since the beginning, Solute has been providing engineering both in our client's R&D offices as well as remote working in Solute's headquarters.

The relationship with our clients has been such a success that Solute has made the strategic move of opening offices close to our clients and thus enhancing interaction.

All these has led to other projects with many OEMs and other international companies as a reference in the CAE industry.

All this effort and experience that Solute has accumulated throughout the years translates into a lot of experience and a large portfolio on each of the automotive disciplines in which simulation takes part.

SIMULATION SOFTWARE

POSTPROCESSING

Meta
Hyperview
Animator 4

SIMULATION

Pam-Crash
Nastran
Abaqus
Epylisis
Open Foam

PREPROCESSING

Ansa
Hypermesh
Loco2
Ansys Workbench

EXPERIENCE PER DISCIPLINE

Disciplines

Solute has a wide experience in many different fields of simulation. Each of this fields is applied to the automotive industry for different disciplines.

HVAC

Simulations to ensure the proper behavior of heating, ventilation and airconditioning systems.

Aerodynamic Analysis

CFD study of air flow around the vehicle to improve consumption and speed.

Interior Modules

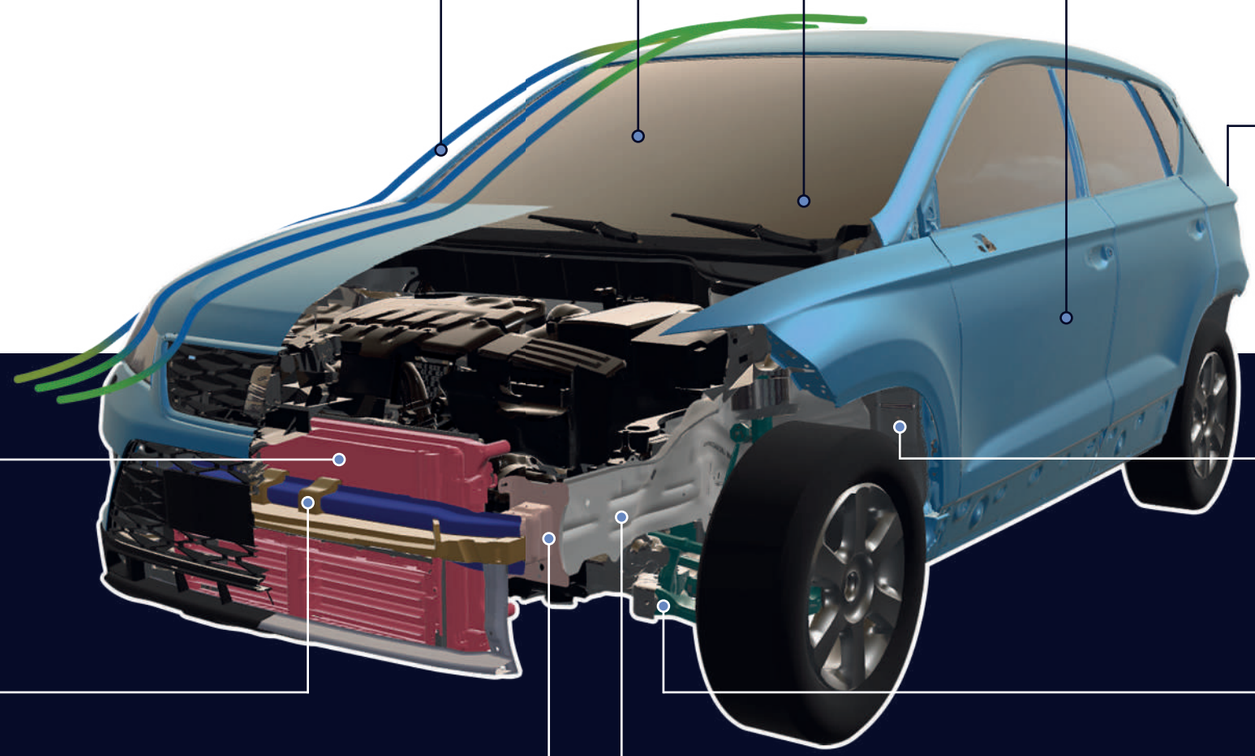
Implicit, explicit and modal simulations to improve quality feel of different interior parts.

Add-On Stiffness

Implicit analyses to test different behaviors and strength of structural parts added to the body in white.

Passive Safety Sensors

Calibration of different sensors of the car under a wide range of load case scenarios.



Motor Cooling

MRF method calculation of the mass flow rate at the cooling package.

Pedestrian Safety

Explicit simulations to ensure protection of different body parts during an undertake.

Low Speed Crash

Implicit and explicit simulations to measure costs of reparability.

Crashworthiness

High Speed explicit analysis for developing structural parts of body in white.

Optimization

Topology redesign of components to improve its behavior and reduce weight.

NVH

Implicit, modal and frequency response simulations to study unwanted vibrations of the structure.

Pedestrian protection

The homologation process of each car must be safe not only for the people inside the car but also for pedestrian. In order to qualify a car as safe, the Pedestrian Protection tests measure levels of potential risk at injuries to the human body. The body parts that could be irreversibly damaged during an undertake at 40km/h are represented by three different tests:

- Lower Leg impact
- Upper Leg impact
- Head impact

Solute has a wide experience in designing key components for Pedestrian Protection from the structural point of view.

These parts include bonnet, windshield and bumper. Our target for every project is always to reach the highest standards of protection by getting a 5-star qualification from the Euro NCAP tests.

Correlation tasks have proven our simulations as accurate and representative of what really happens during the test. Very high detail of the structure is necessary to see the influence of each part of the car to the test. Also, complex simulations with different fracture and nonlinear material behaviors are needed to reach this point of fidelity.

HEAD IMPACT

- Decreased HIC redesigning under bonnet supports
- Bonnet stiffness compromised but reached target
- Material distribution to meet production requirements

UPPER LEG

- Part collapsibility designed to decrease force levels
- Front bumper reparability compromised for low speed crash tests but reached solution for both disciplines

LOWER LEG

- Foam design optimized to decrease MCL
- Foam density modified

Low speed crash

Concepts such as damageability or reparability have started to be considered paramount features during the design phase of the vehicle. The aim is to provide solutions that minimize the extent and cost of the losses suffered in an accident and ease repairing.

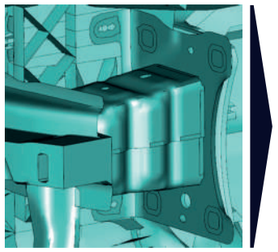
The costs of reparability after a low speed crash are key factors for insurance companies when establishing the rating of each car model with a degree of reparability and its associated insurance cost of the vehicle for the owner.

Low speed crash tests try to represent a broader range of occurring impacts situations at different speeds and with different impact testing devices (AZT, RCAR Bumper and pendulums) that requires the complete vehicle simulation in FE.

For RCAR test, the vehicle must withstand with no evidence of damage in the main structure.

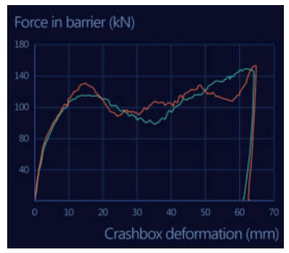
This is a complex issue due to the current compact vehicle design, where very little space is available for an effective energy absorption. The integration of the crash management systems (CMS) into the overall concept of the vehicle represents a challenge for manufactures. Furthermore, the outer design specifications of the vehicle often determine the shape of the CMS among other elements.

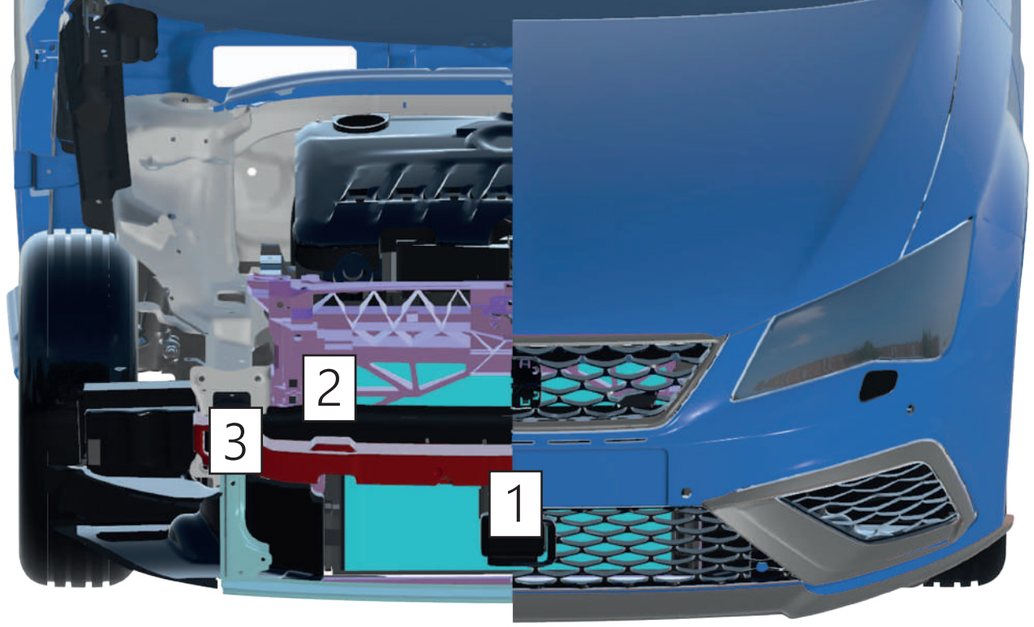
Proposal



Prototype

Correlation





FOAM 1

Target
Avoid contact between bumper and cooling systems parts.

Solution
Increase foam density and change shape.

FRONTEND 2

Target
Avoid damage in cooling package, motor and headlights.

Solution
Redesign rib distribution to avoid contact with headlights.

CROSS BEAM AND CRASHBOX 3

Target
Prevent from under or override as well as damages on bodywork.

Solution
Redesign cross beam and crashbox indents.

In pendulum and wall load cases, only little damage is acceptable like marking or punctures in bumper skin. Solute performs 3D simulations to define solutions by means of integrating a combination of energy absorbing disposable elements such as foams, dampers, reinforcing ribs, additional plastic elements to reduce the damage and also be compatible with pedestrian protection requirements.

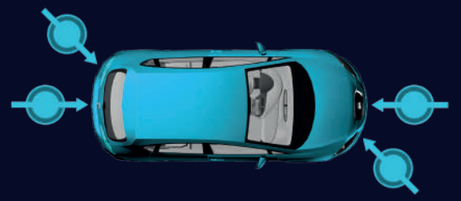
LOW SPEED CRASH TESTS

FRONT AND REAR AZT

16km/h crash with a 10-degree rotated non-deformable static wall (front) or a 10-degree moving barrier.

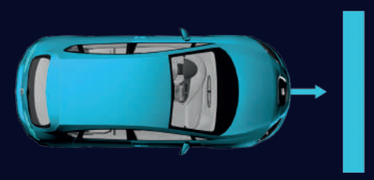
FRONT AND REAR RCAR BUMPER

10km/h crash against a deformable static barrier.



PENDULUM

3.5-4.5km/h around different positions of the front and rear bumper.



WALL

3.5-4.5km/h frontal and rear crash against a non-deformable static wall.

Crashworthiness

The crashworthiness of a vehicle's body structure plays a vital role in fulfilling the requirements of legislators, international consumer tests programs such as NCAP and insurance companies.

In this regard, multiple tests are developed to assure crashworthiness and enhance the vehicle safety. These crash tests also provide insights of the vehicle protection and in case of consumer tests like EURONCAP, provides the opportunity to receive an independent assessment of their vehicles which also serves for customers as purchase decision driver.

Crash protection must be assured through structural elements capable of absorbing kinetic energy by deformation. A collapsible front structure is necessary to assure a controlled deformation during the collision that guarantees first, a deceleration of its occupants below the maximum admissible to reduce the injuries and secondly, the passenger compartment of the car keeps its shape to protect the driver and the passengers.

The passenger compartment must be designed and built to resist the high crash forces maintaining a sufficient survival space for its occupants in crashes. Moreover, inner elements such as the dashboard, steering column and pedals or structural elements like roof pillars or floor panels should not be pushed severely inwards.

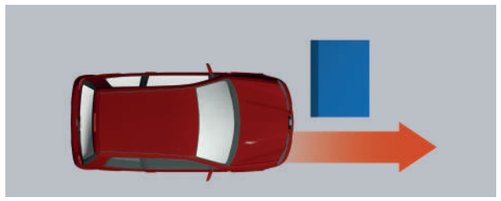
Solute performs CAE simulations to analyze the deformation and failure of components subjected to high dynamical load, providing its expertise in FE simulation to evaluate the results and suggesting modifications in its design to improve structural properties such as the crashworthiness.

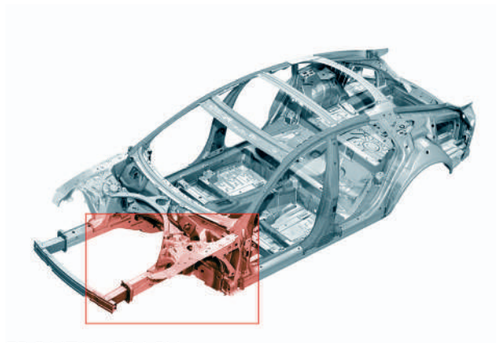
New generation of cars, such as electric, GNC or PHEV among others, add more restrictive regulations. This kind of cars have big battery modules or gas tanks that can´t be touched by deformable regions of the body in white.

The minimal touch could lead to the explosion of this components or leakage of dangerous chemicals.

In Solute we are working currently in both types of vehicles thus adding experience and updating to the future of car manufacturing.

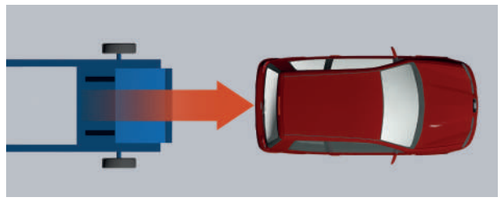
CRASH TESTS PERFORMED

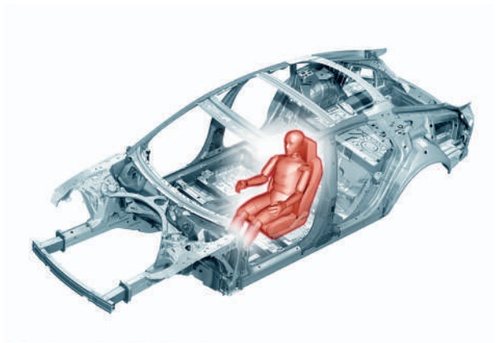




FRONTAL CRASH

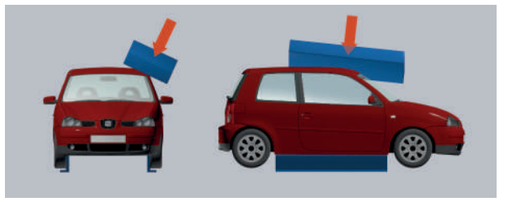
Rigid barrier (NCAP) and offset deformable IIHS and EURONCAP.

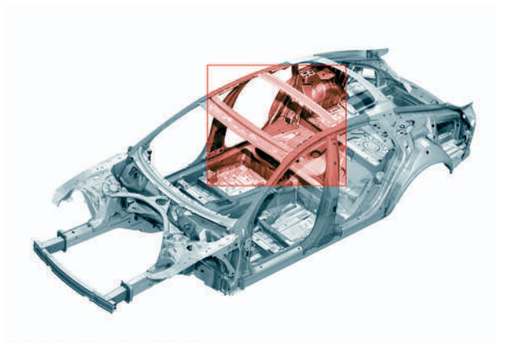




REAR-IMPACT CRASH

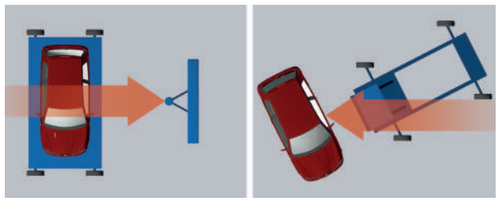
Rear-crash protection to avoid injures such as whiplash trauma by designing head-restraint elements.

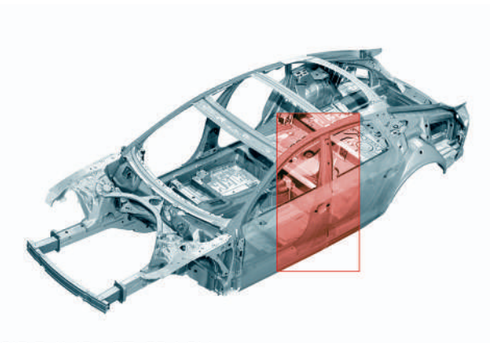




ROOF CRUSH TEST

Reduce the risk of death and serious injury in case of rollover.





SIDE-IMPACT CRASH

Pole and moving deformable barrier (MDB).

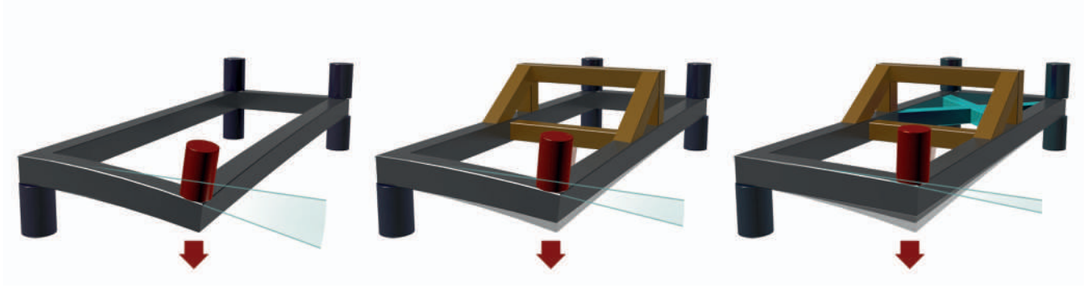
NVH

Comfort and lightweight requirements in vehicles are constantly increasing being these opposing specifications. Weight reduction on the latest car concept designs often makes it more susceptible to undesired vibrations.

Therefore, components such as the body structure, powertrain or chassis must be designed considering the local and global, static and dynamic stiffness requirements.

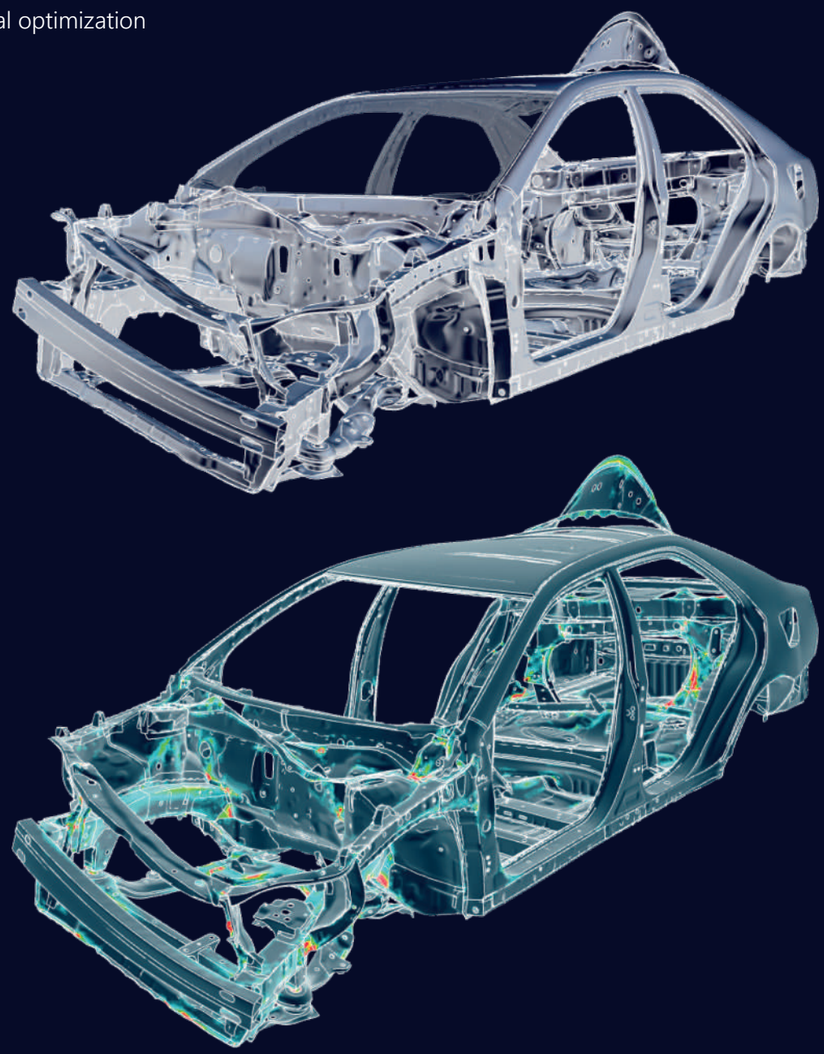
The most straightforward way to improve the structural behavior of a vehicle is by adding weight to the vehicle. However, this is not usually an option and that is why it becomes an engineering challenge. Nowadays, fuel efficiency standards force OEMs to seek alternatives to the addition of weight to a vehicle. Therefore, design optimization is the key to reach a compromise between structural stiffness and lightweight requirements.

NVH STRATEGY



All these concepts are measured by different types of analysis:

- Local/global static and dynamic stiffness values.
- Modal analyses
- Frequency response analyses
- Operational modal analyses
- Sensitivities
- Numerical optimization



STRAIN ENERGY

Interior modules

Interior modules must meet various functional demands. These include requirements relating to vehicle safety, stiffness, strength, durability and comfort.

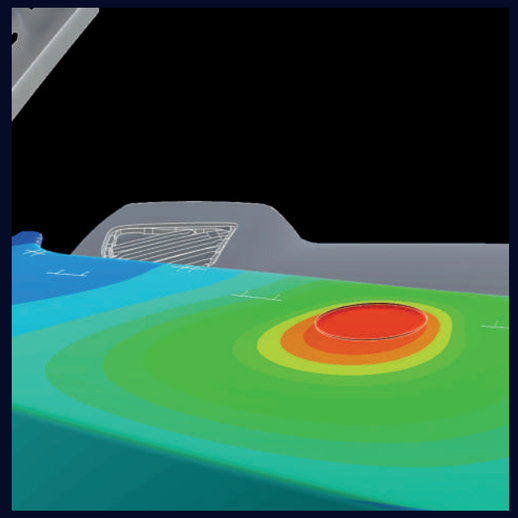
After the exterior of the car, features and aspect of the interior of the car is commonly the second aspect customers bear in mind. Each manufacturer wants to stand out from the rest adding new innovative finishings to the car interior. The concept of quality that many consumers have is based on the materials used for the seats, driving wheel, dashboard, etc.

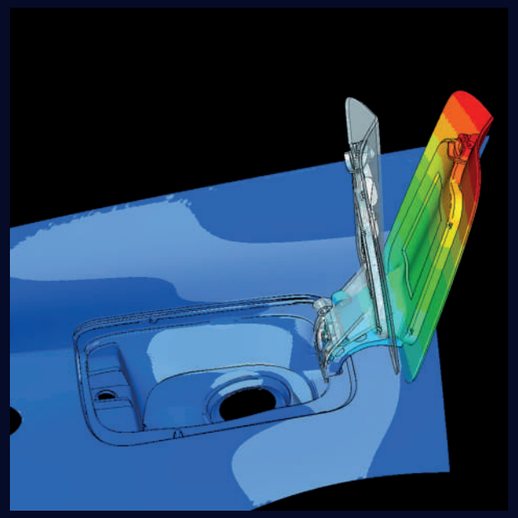
Riskier designs are being introduced for the interiors that lead to a more complex construction and modeling of this part of the car. Each manufacturer wants to introduce its own signature in the appearance of its vehicles and yet competitive in costs.

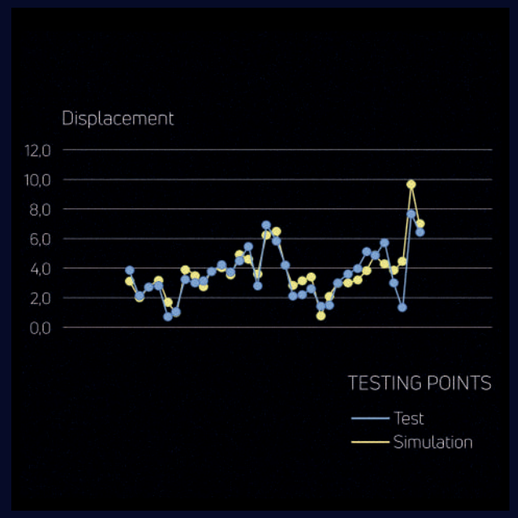
In Solute we are asked to calculate each component from the gear stick to the cooling system, each one with a more complex group of pieces and connections. High quality standards for these components make them very sensitive to changes and manufacturing processes.

The difference in feel between a good quality component and a bad quality component for a customer varies in millimeters of displacement when a certain force is applied. That´s why many proposals are needed as well as very refined mesh and details in the models that Solute offers its clients.

Stiffness, misuse and frequency response calculations are the models used to measure the quality and comfortability of the interiors. Regarding the interior modules safety simulations like the airbag inflation and deployment as well as interior head impacts for the American regulation have been performed in Solute.





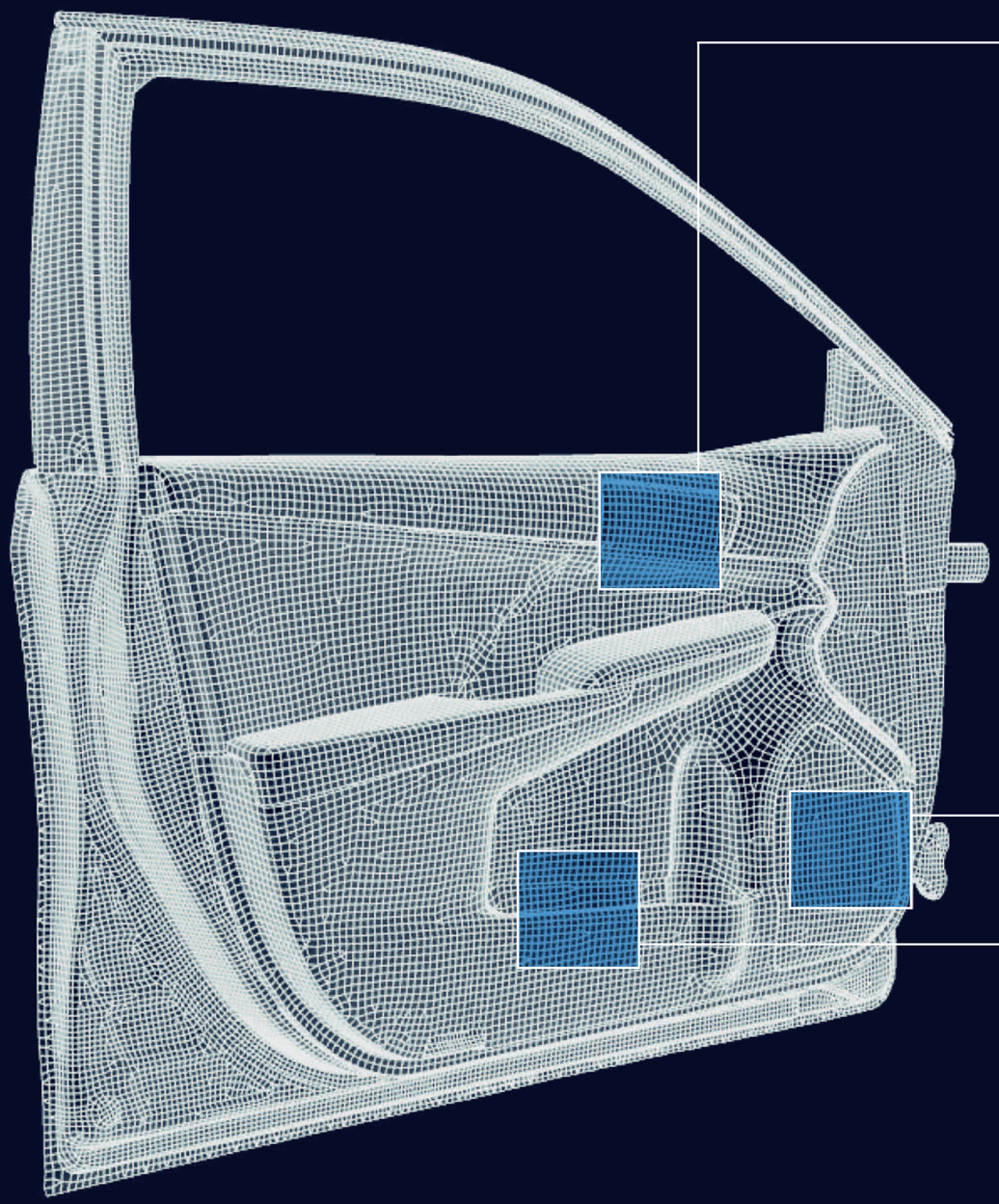


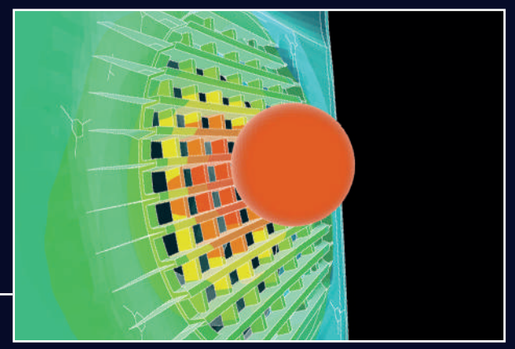
Add-on stiffness

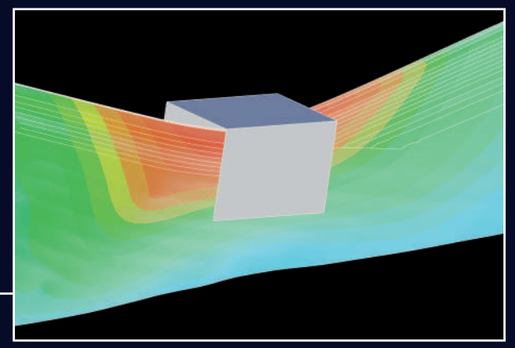
Structural add-on parts fixed to the car body that can move, such as the bonnet, side doors and the boot lid.

The structural performance aims to guarantee the constructor's targets while minimizing weight and costs. Here CAE simulations are key to achieve a balanced solution.

As well as in interior modules discipline the inner surface of the add-on parts is a visible characteristic of the quality of each car. High-end versions of a car model have more accessories and need a better quality feel to the customer. This leads to more stiffness studies with each version of the car and higher requirements for each component.

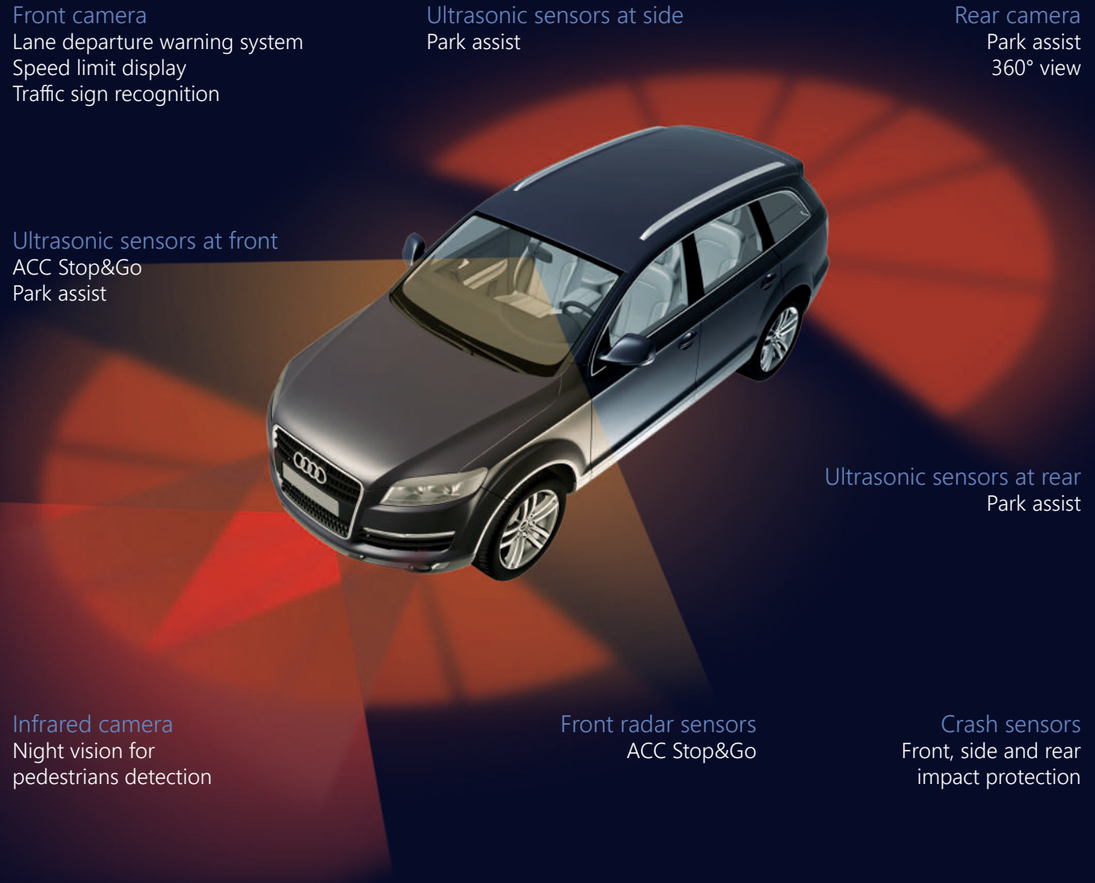






Passive safety sensors

Every car model release brings a new generation of sensors, included as standard or optional packages. From parking sensors or cameras to airbag actioners, they offer a wide range of possibilities regarding driving and park assistance and, what is most important, safety.



BARRIER FRONT CRASH

Front barriers: walls, crash barriers, etc.
Airbags should be activated.

BARRIER SIDE CRASH

Side barriers: poles, crash barriers, etc.
Airbags should be activated.

MISUSE

Misuse cases: bikes, balls, shopping trolleys...
Airbags shouldn't be activated.

Sensors in vehicles, used in real crash tests, allow the acquisition of crash pulses (acceleration-time histories), which are subsequently used for crash simulation on an acceleration sled system. These acceleration sled systems play a crucial role in the expert design and adaptation of advanced safety components such as airbags, seats or seatbelts.

Sensors signals obtained in FEM virtual simulations are very important as well. The positioning of sensors in Low Speed crash models configured in Solute assures that the signals obtained in High Speed model are accurate enough to perform a correct sensor calibration and allow the certification of the vehicle.

Solute carries out the setup of new models for passive safety sensor calibration.

The whole vehicle model, sensors included, is simulated under different load cases and the registered signals are used for the calibration of the passive safety systems. This discipline is the most challenging for a CAE engineer, as it covers almost all crash cases with the purpose ofevaluating when to display the safety systems (high speed crash) or not (bike crashing against the side of the car).

These sensors are very sensitive to any possible initial vibration or little model errors that will not affect other disciplines but here could lead to false data acquisition for a sensors analyst. In Solute, our knowledge in other disciplines allows us to calibrate and fix models prepared for sensor analysis even in the most complex situations, like car to car load cases.

Optimization

To be competitive and also cleaner, vehicles need to lower their own weight, and for that Solute offers an optimization studies of the geometry, by judging functionality and imposing appropriate boundary conditions and restrictions. At the end of the process, the result maintains or even improves function parameters, optimizing weight reduction.

NEW VEHICLE	SOLUTE'S DESIGN
· +20% Extra weight · Higher loads	· -30% Weight · Stiffer · Lower cost

In the specific case of the suspension lower arm, Solute took the initial design of the manufacturer and the desired weight reduction goal. After an initial analysis of the existing part and the definition of the load cases, our team proposed the boundary conditions, limits and targets to define the topological optimization process.

The manufacturing conditionings where also considered, and together with the former parameters where introduced in DASAULT's TOSCA. Then, an iterative process of run and analysis started, and these actions ended in a accurate enough geometry. A final manufacturing design based on this functional solution was adopted with a previous analysis check. The lower arm was now 30% lighter, slightly stiffer, and with a lower cost than before.

Aerodynamic analysis

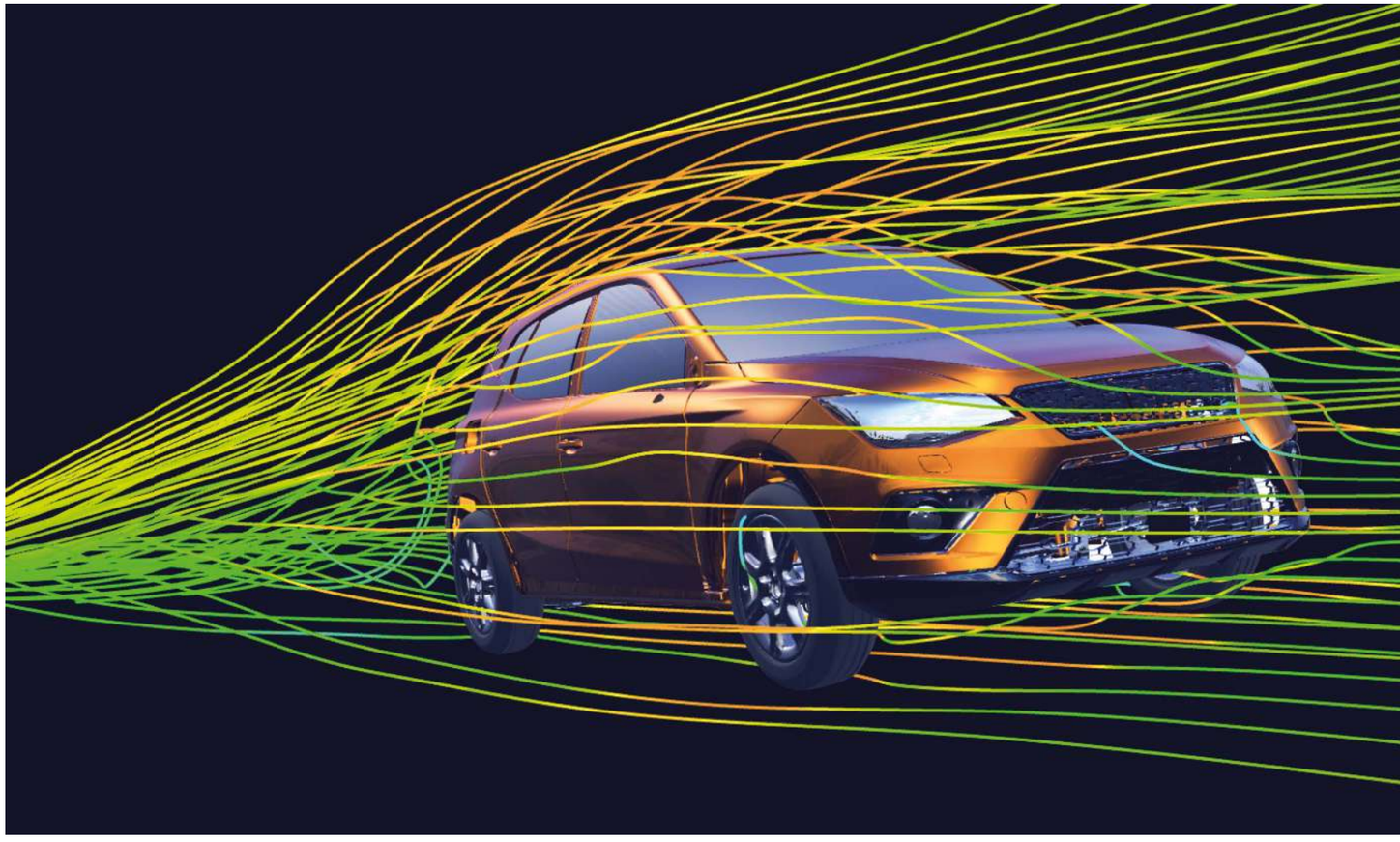
The aerodynamics simulation consists on a full car model placed in a computational wind tunnel analyzing different flow incidences (crosswind).

Industrial activities usually require working closely with the design team. This consists in a feedback loop in which new improvements are proposed according to the results of each aerodynamical test. This process requires speed and efficiency in order to follow the workflow that leads to the generation of clean geometries, mesh, simulation and postprocess.

Steady-state RANS is the cheapest option in terms of computational cost and thus time. Therefore it is the preferred option when comparing (in terms of drag) cases that arise from important design modifications. However, fluid flow around ground vehicles has an important unsteady behavior that cannot be ignored for accurate aerodynamic loads and aeroacoustics studies.

Solute team has a vast experience in this area of knowledge. Preparing high fidelity geometries in ANSA, meshing with SnappyHexMesh, cfmesh, ICEM CFD, ANSA or Ansys, to simulate it with OpenFOAM (RANS, URANS, DES, LES), Ansys

Fluent or XFLOW and to extract valuable data by means of several tools developed by Solute's CFD Group for exhaustive analysis in ParaView, EnSight or META. Among the great variety of results derived from the simulation, drag coefficient, vorticity and streamlines are magnitudes and procedures worth mentioning.



HVAC

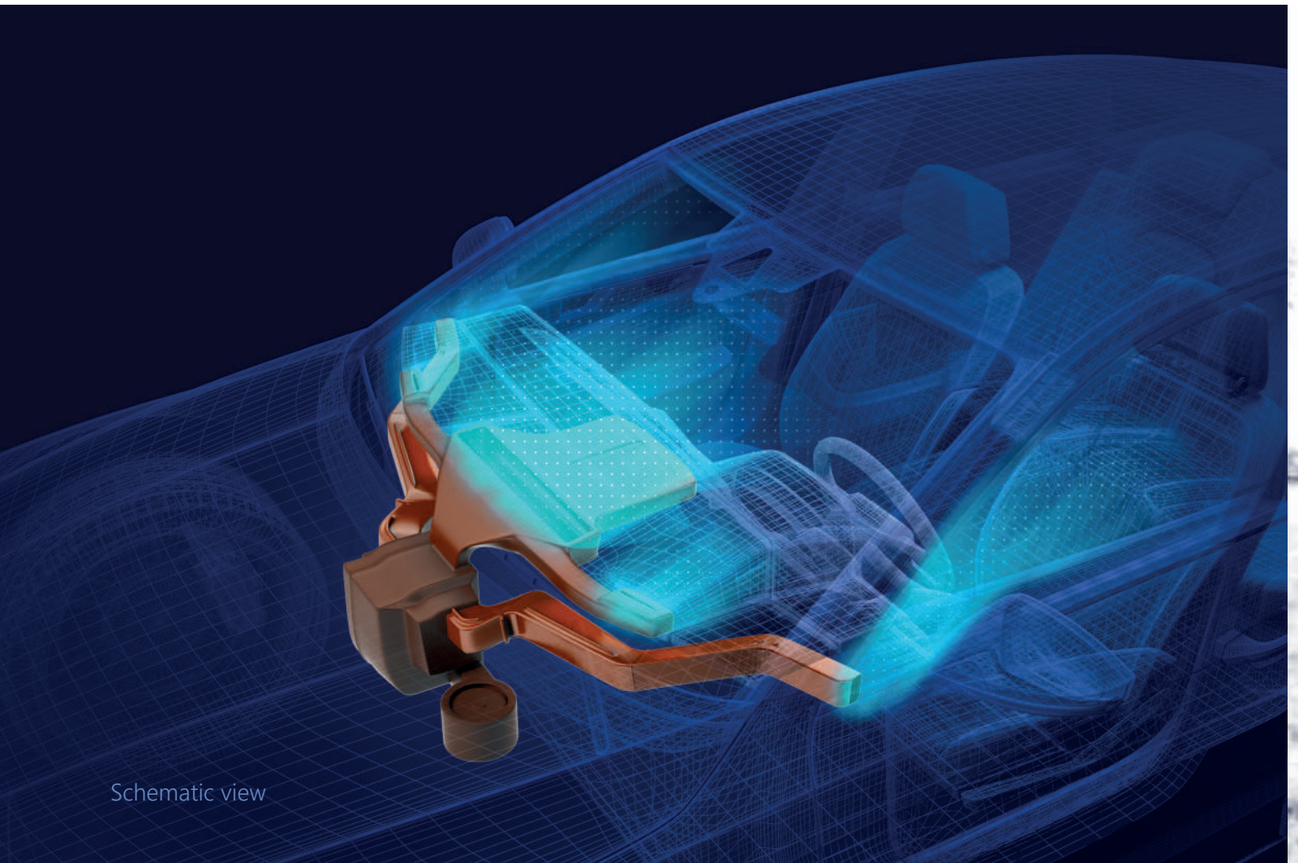
The aim of these simulations is to ensure a proper operation of the HVAC system of the vehicle. Typical CFD applications in HVAC applied to cars in which Solute has experience are:

• Duct design and optimization. Determination of the optimal duct shape according to a target pressure drop or distribution of the velocity through different sections. This optimization plays a great role due to the high number of constraints to which the duct is subjected in terms of space requirements.

• Validation of defrost and defog cases. Sectional velocity magnitude map near the windscreen and front windows to ensure that frost/fog dissipates correctly.

• Study of flow distribution inside the cockpit. Analysis of directionality for the different positions of the vents and evaluation of comfort.

Solute has years of experience performing HVAC studies for the automotive sector. The company has participated in the design and assessment of the HVAC system of several passenger cars and is currently working in the VW Group's new car model.



Schematic view

Motor cooling

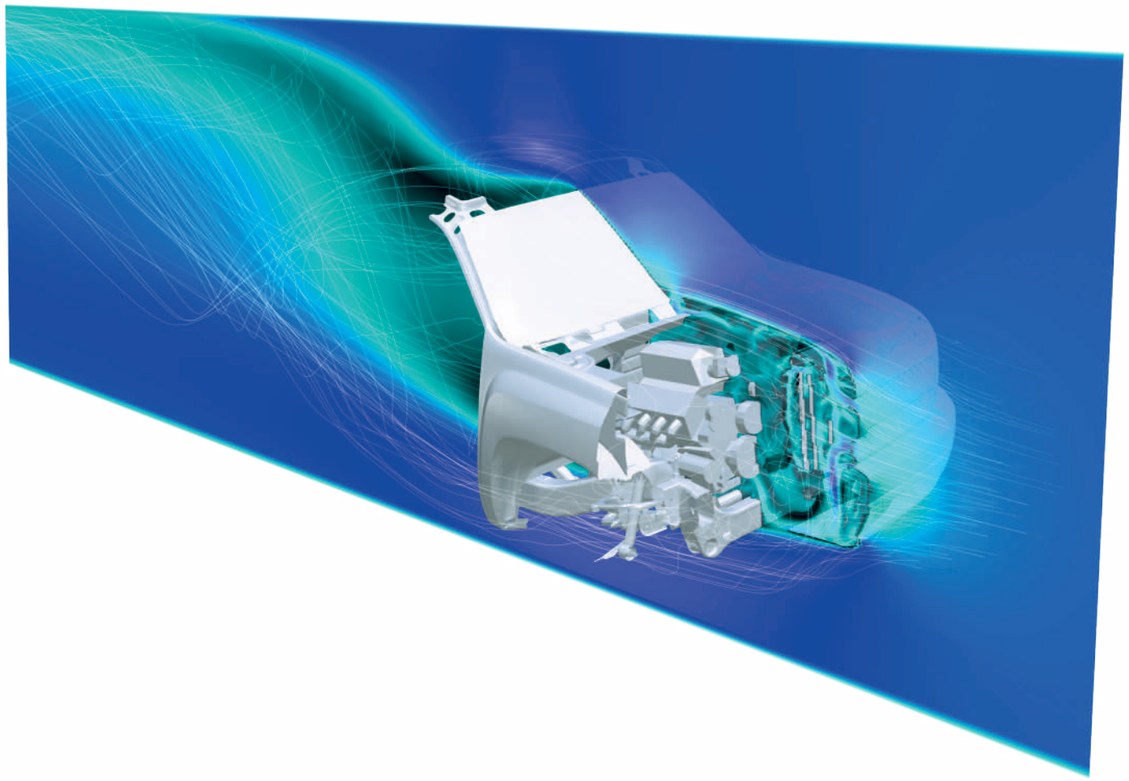
Concerning the geometry complexity in these simulations, the preparation of the CAD model demands great workload. An automatic mesh generation is fundamental to work efficiently, in this aspect, an octree mesher as SnappyHexMesh can be a key tool, among others.

Steady-state RANS is the cheapest option in terms of computational cost and it is sufficient to cover the needs of these calculations. For detailed studies LES can fit into the frame when more accuracy is necessary.

Usually two operating cases are studied:

• Maximum velocity
• 30 km/h and idle fans that are usually modelled in CFD through MRF (Multiple Reference Frame method).

We are not limited to these, but we can accomplish any case of study under client's demand.



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