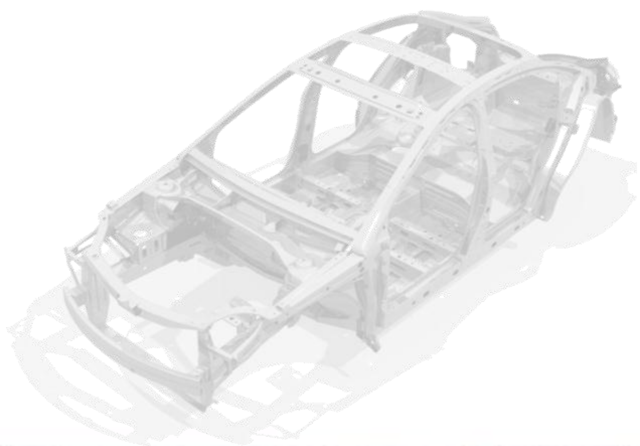


Gestamp BIW

Dynamore Forum 2012

Cross Car Beam Multi Optimization

Authors: Francesc Volart
Sergio Faria

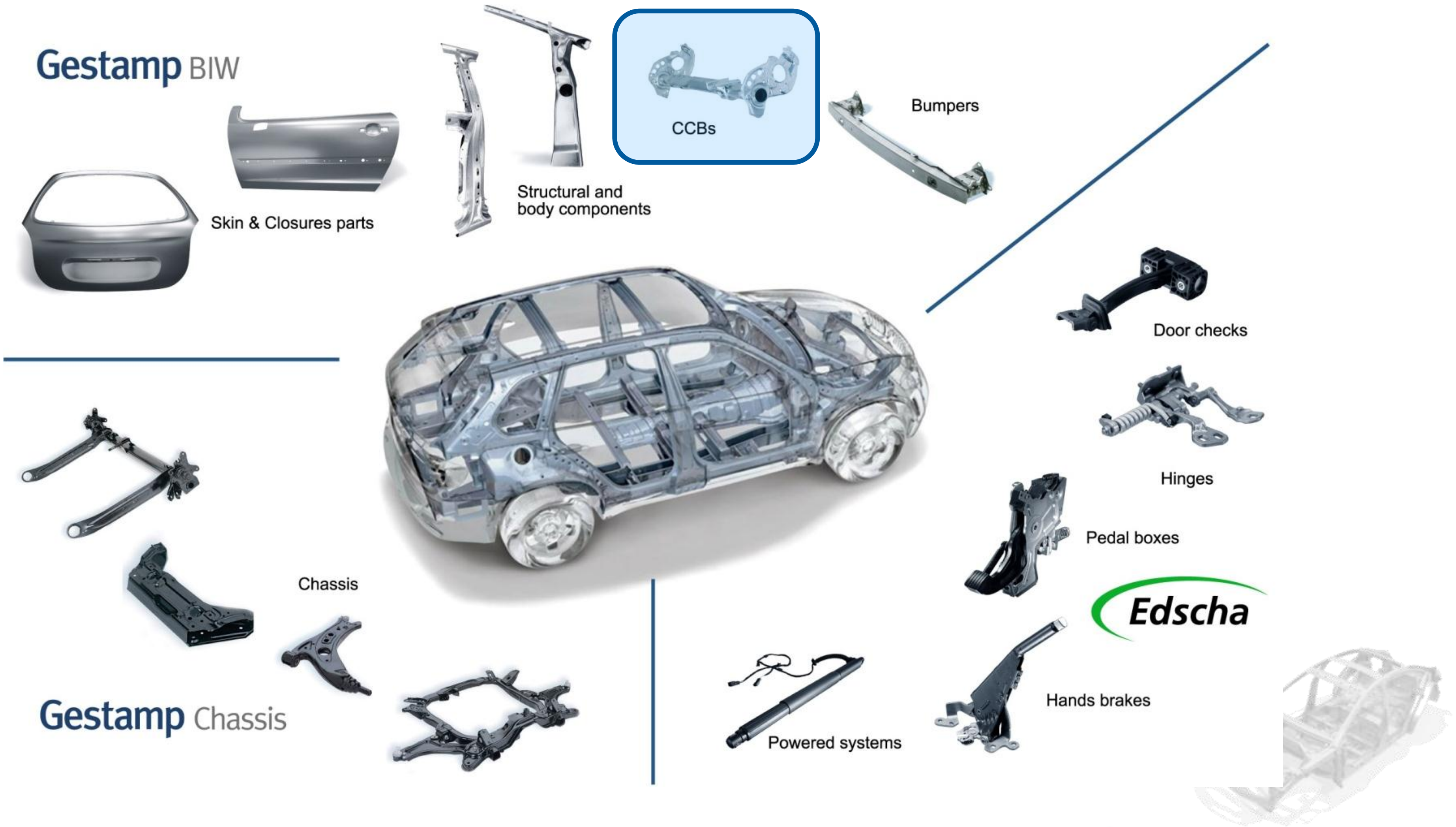
Summary

Gestamp Corporation

Gonvarri Steel Industries	GESTAMP	Gestamp Renewables
Steel Services Centers	**Automotive Metal Components**	**Renewable Energies**

Activity	• **Automotive metal components supplier** for **OEMs**
Employees	• **27.000 employees worldwide**
Sales	• Turnover 2011: **4.775 M€**
Facilities	• **89 industrial plants** worldwide + Launching 9 new plants
Leadership	• **Body-in-White, Chassis and Mechanisms** • Wide range of technologies.

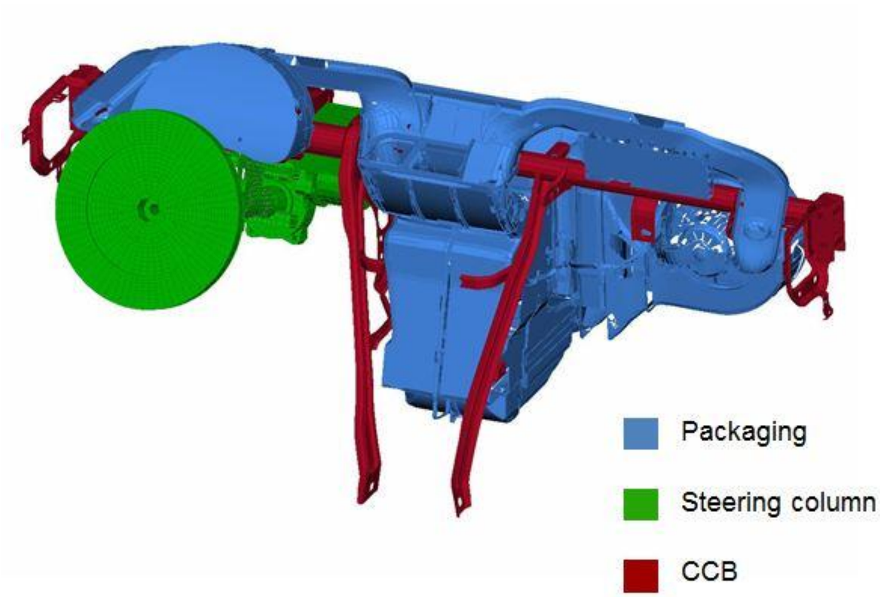
II. Gestamp Automotive Portfolio



2. The Project

I. Context

Cross Car Beam Assembly



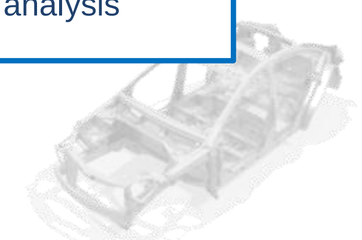
Cross Car Beam is a support that usually holds all Instrument Panel including HVAC System, Knee Airbags, **Steering Column**, Radio and many other components.

Previous Optimization Experience

- Simple morphing shapes (beads, flanges)
- Material properties
- Modal and static analysis

New challenges of this New Project

- Complex morphing shapes including remeshing
- Components position displacement
- Welding projection after shape modification
- Include both static and dynamic analysis

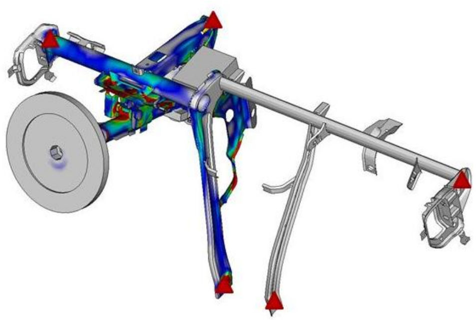


2. The Project

II. Load Cases

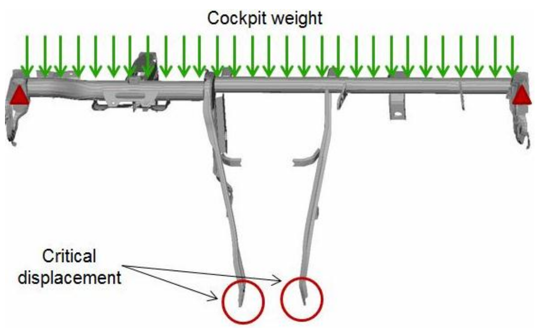
NVH

NASTRAN



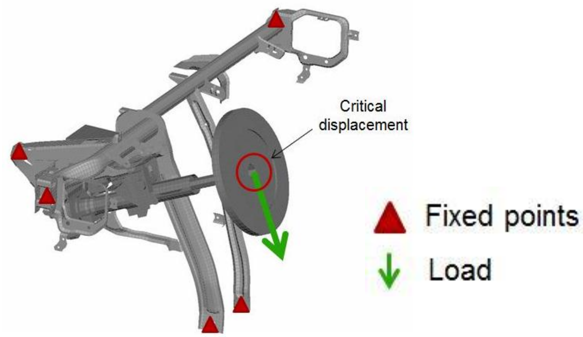
Modal Analysis

First mode **above 45Hz**.



Deflection Test

Total displacement **below 1,5 mm**.

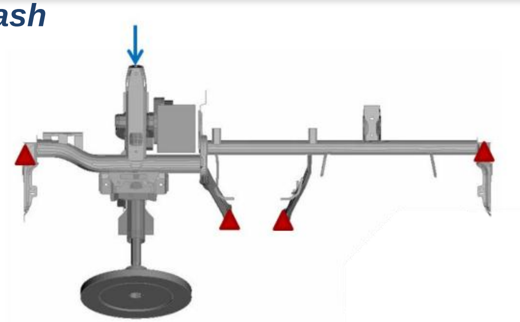


Steering Column Stiffness

Displacement in load direction **below 1,5 mm**.

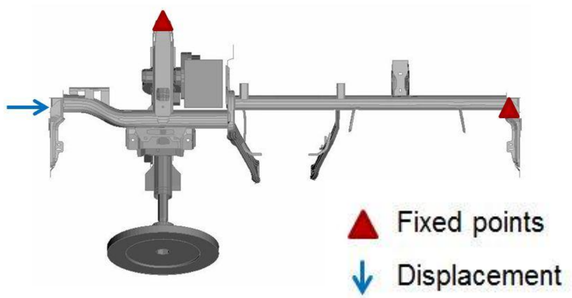
Crash

LS-DYNA



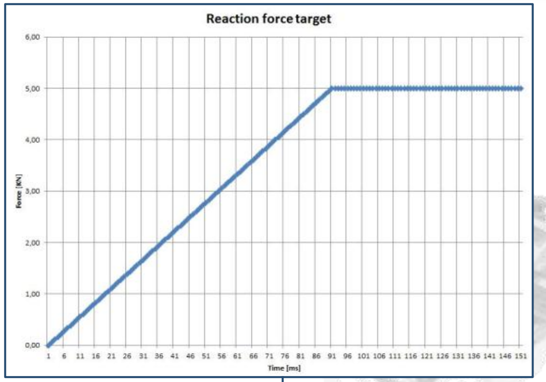
Frontal Crash

Displacement of steering wheel **below 20 mm**.



Side impact

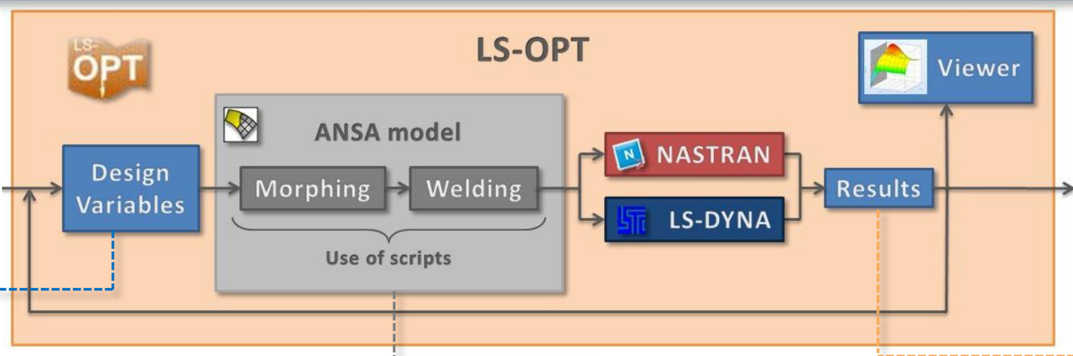
Reaction force **above <u>target curve</u>**.



Gestamp BIW

3. The Optimization

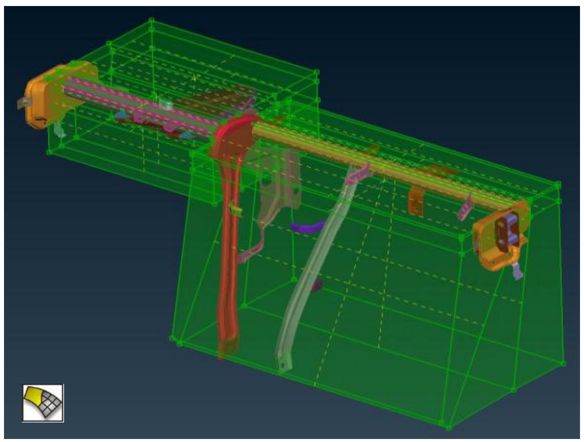
I. Optimization Flow-Chart



Design Variables

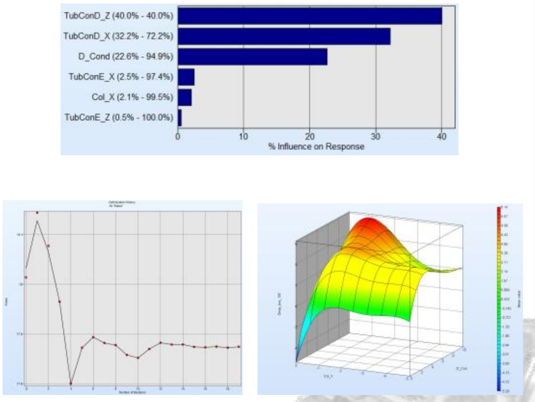
VARIABLES ADDED	
Side bracket position	Morphing Variables (shape)
Passenger's tube position Z	
Driver's tube position X	
...	
Passenger's tube thickness	Properties Variables
Driver's tube thickness	
Side bracket thickness	
...	

ANSA model



Parameterized FEM & Scripts

Results



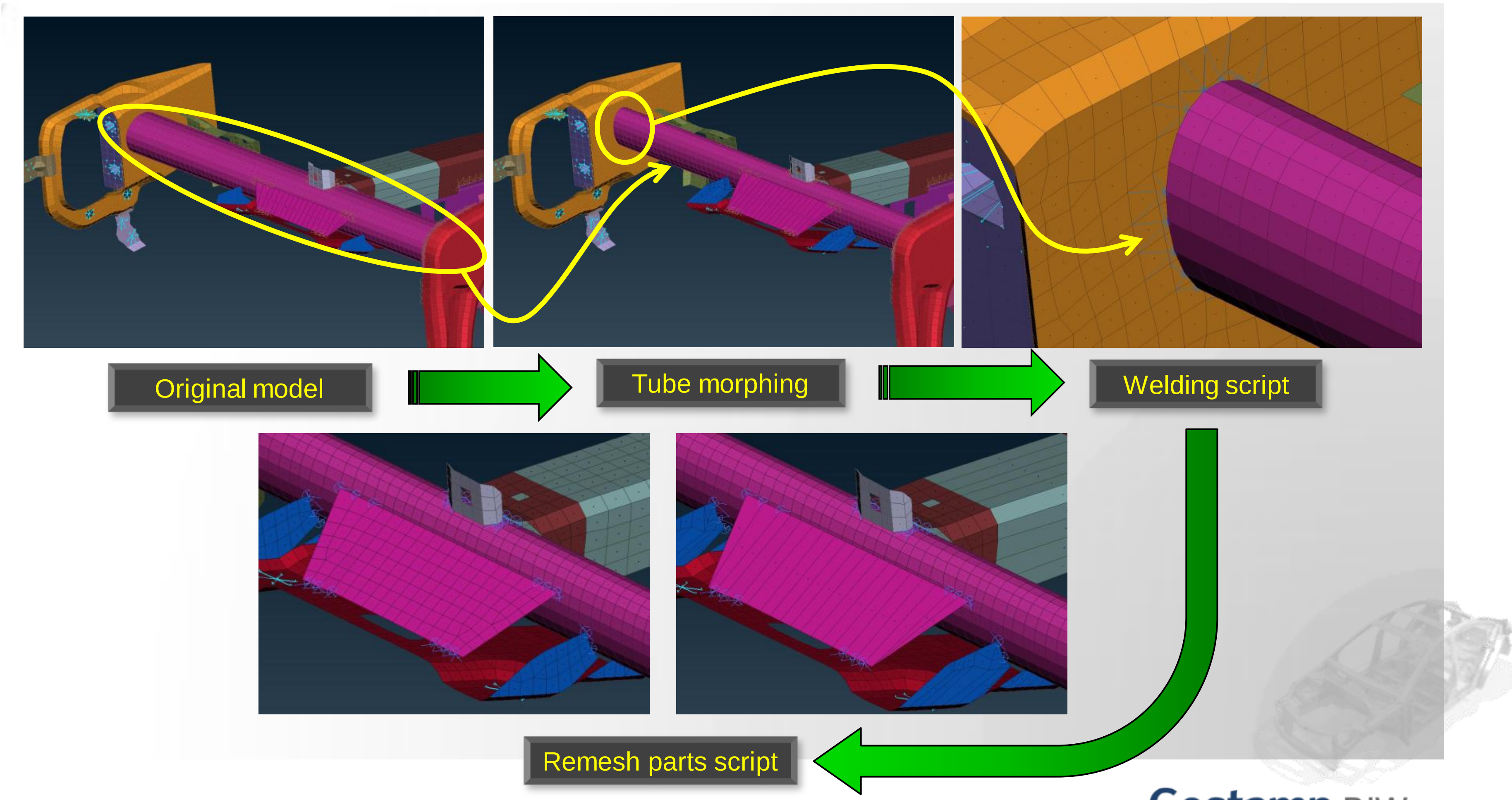
LS-OPT Viewer

Gestamp BIW

3. The Optimization

I. Optimization Flow-Chart

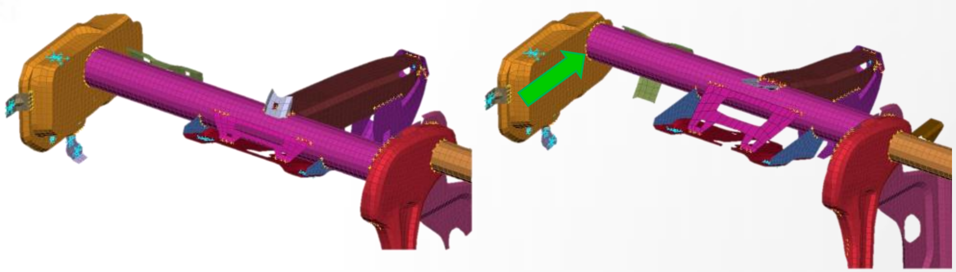
Morphing process



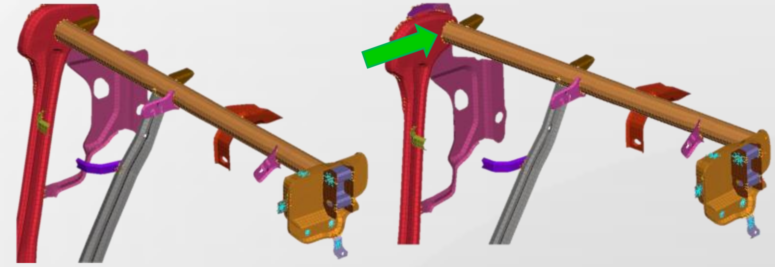
3. The Optimization

II. First Optimization Phase (NVH) – DOE studies

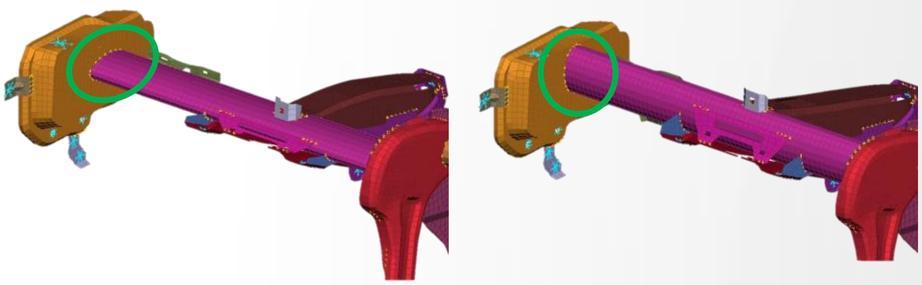
Morphing examples



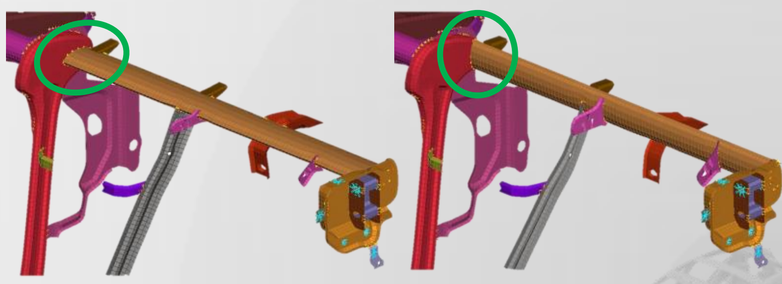
Driver's tube position



Passenger's tube position



Driver's tube elliptical shape



Passenger's tube elliptical shape

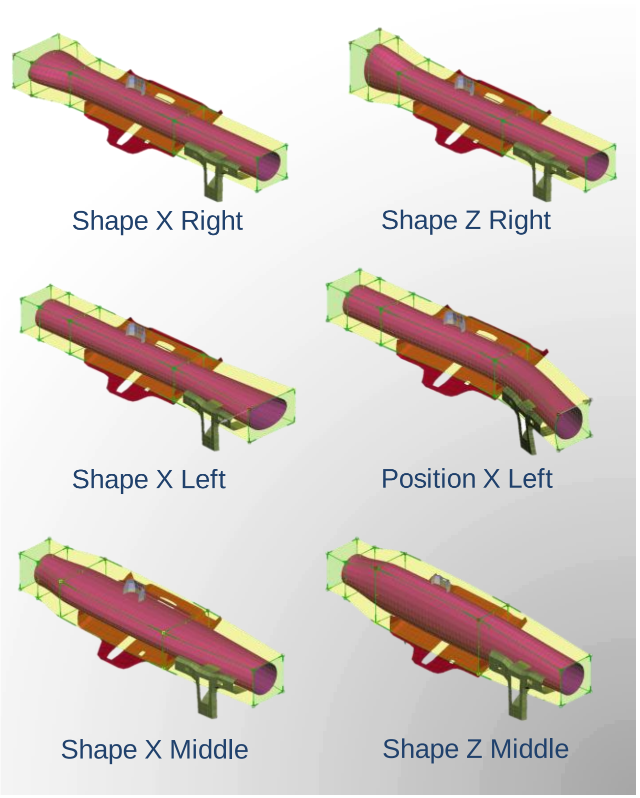
Gestamp BIW

3. The Optimization

II. First Optimization Phase (NVH) – DOE studies

Design variables studied

Example driver's tube morphing



Shape X Right

Shape Z Right

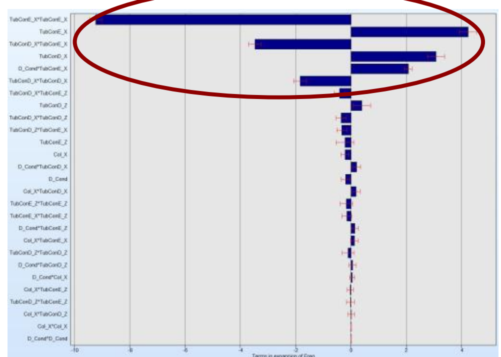
Shape X Left

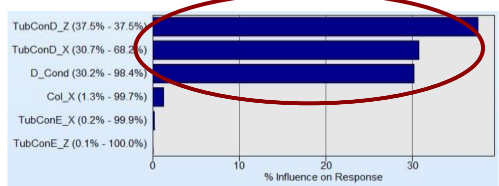
Position X Left

Shape X Middle

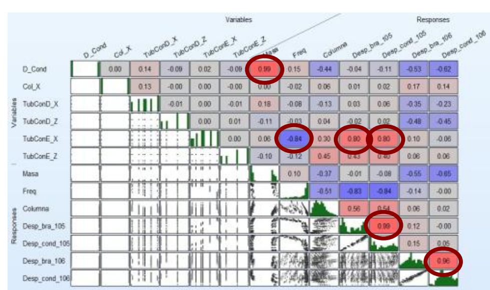
Shape Z Middle

Sensitivity





Correlation matrix



VARIABLES	
Side bracket position	Passenger's tube shape Z Right
Passenger's tube position X	Driver's tube shape X Left
Passenger's tube position Z	Driver's tube shape Z Left
Driver's tube position X	Driver's tube shape X Right
Driver's tube position Z	Driver's tube shape Z Right
Column position X	Driver's tube shape X Middle
Passenger's tube size	Driver's tube shape Z Middle
Passenger's tube size Left	Passenger's tube shape X
Passenger's tube size Right	Passenger's tube shape Z
Driver's tube size	Driver's tube shape X
Driver's tube size Left	Driver's tube shape Z
Driver's tube size Right	Thickness properties
Passenger's tube shape X Left	Materials properties
Passenger's tube shape Z Left	...
Passenger's tube shape X Right	...

Main variables (Sensitivity > aprox. 10%)

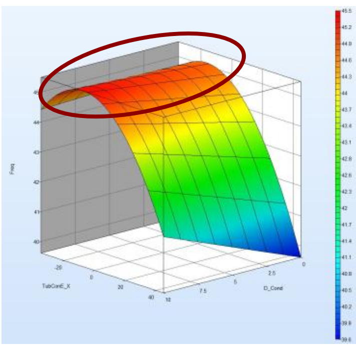
Less important variables (Sensitivity < aprox. 10%)

Gestamp BIW

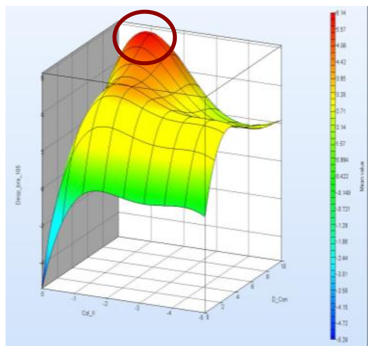
3. The Optimization

II. First Optimization Phase (NVH) – DOE studies

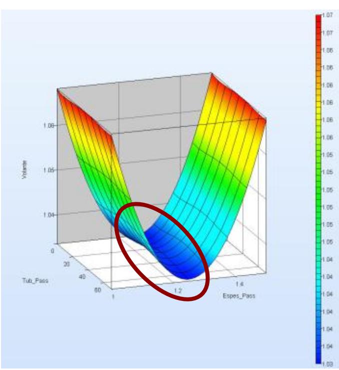
Analysis Results - Metamodels



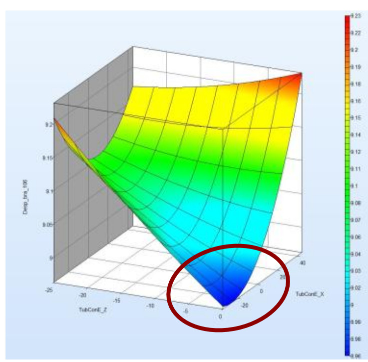
Modal analysis



Deflection test



Deflection test



Steering wheel stiffness

Metamodels were used to redefine the range of the design variables.

For example the driver's tube diameter range changed from [40-70]mm to [55-70]mm

First Phase Results

1. After this first optimization phase the amount of design variables was reduced from 35 to 10
2. The design space was also reduced changing the design variables range to the place of the best response results.

3. The Optimization

III. Second Optimization Phase (NVH and Crash)

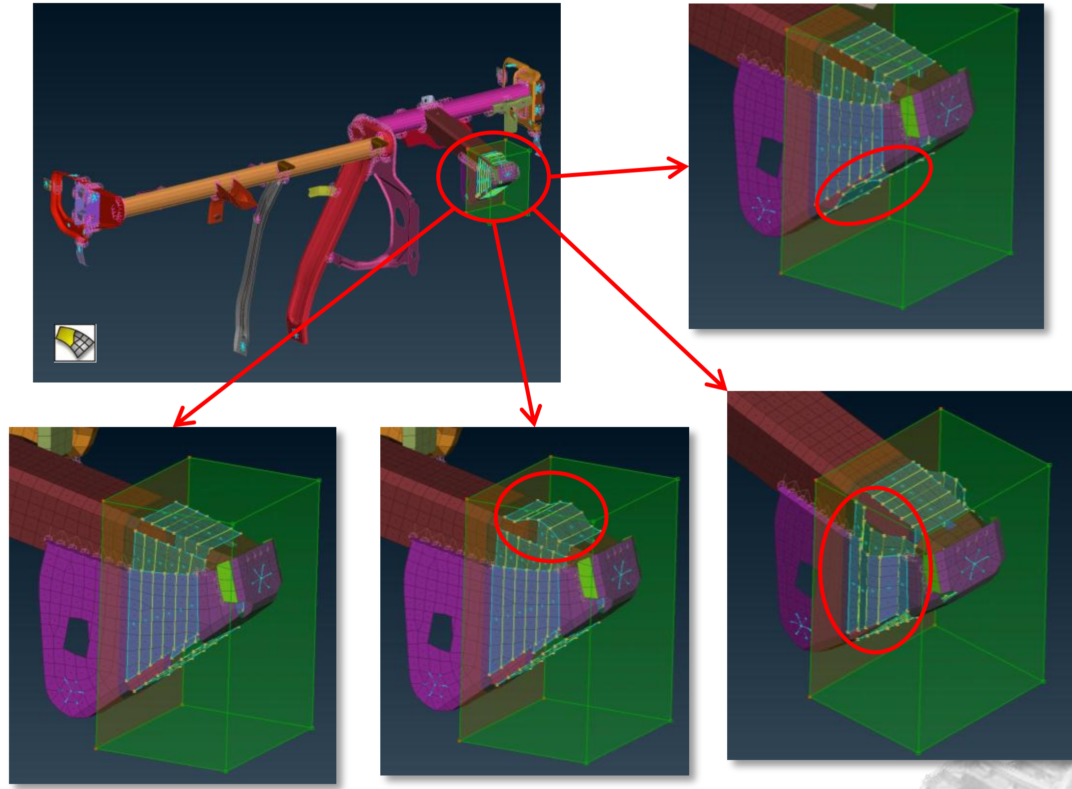
Design Variables

VARIABLES ADDED
Firewall shape top
Firewall shape bottom
Firewall shape side
Firewall shape width
Passenger's tube material
Driver's tube material
Tunnel's leg material

Some design variables were added for frontal crash optimization.

In crash analysis materials stress strain curves were used as design variables as well.

Morphing



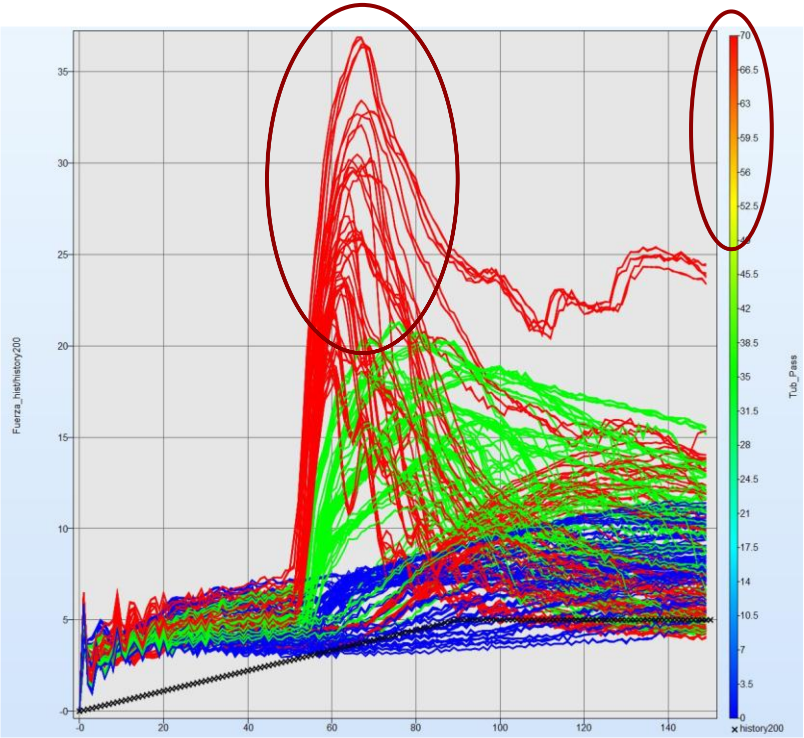
Parameterized firewall attachment point

3. The Optimization

III. Second Optimization Phase (NVH and Crash)

DOE Study

DOE study was used to analyse and have more information about the new variables.



History of section force on driver's tube – Side impact

Variables and responses after DOE

VARIABLES	RANGE
Passenger's tube position X	[0 – 50] mm
Passenger's tube size	[25 – 40] mm
Driver's tube position X	[0 – 60] mm
Driver's tube size	[40 – 50] mm
Firewall bracket shape top	[0 – 7] mm
Firewall bracket shape bottom	[0 – 7] mm
Firewall bracket shape side	[0 – 7] mm
Firewall bracket shape width	[-10 – 15] mm
Passenger's tube thickness	[1, 1.5] mm
Driver's tube thickness	[1.5, 2.0, 2.4] mm
Tunnel leg thickness	[1.0, 1.5] mm
Passenger's tube material	[1, 2]
Driver's tube material	[1, 2]
Tunnel leg material	[1, 2]

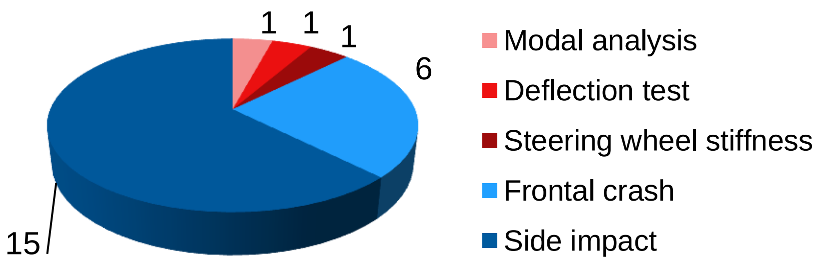
RESPONSES	TYPE	SIMULATION
1st frequency	Constraint	Modal analysis
2nd frequency	Constraint	Modal analysis
Weight	Objective	-
Deflection	Constraint	Deflection test
Steering wheel displ.1	Constraint	Steering stiffness
Steering wheel intrusion	Constraint	Frontal crash
Reaction force	Constraint	Side impact

Design variables and its ranges after DOE studies

3. The Optimization

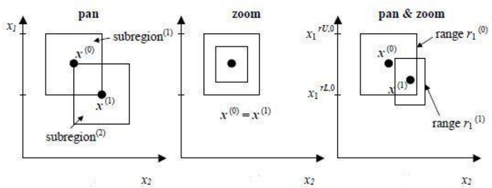
III. Second Optimization Phase (NVH and Crash)

Calculation time distribution (minutes)



Optimization used

In order to achieve the best variables configuration and reduce the number of experiments it's used Sequential Response Surface Method (SRSM).



LS-OPT configuration:

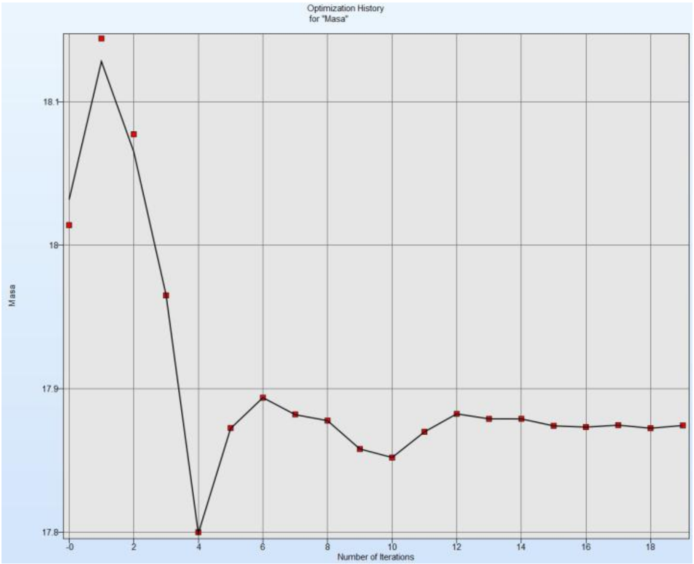
- Metamodel:

  Polynomial – Quadratic

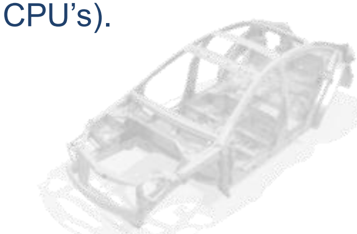
- Point selection:

  Space Filling – default 181 points

Optimization history (weight)



The optimization calculated about 20 iterations and more than 220 different configurations.
Total optimization time took 3 days (4 CPU's).

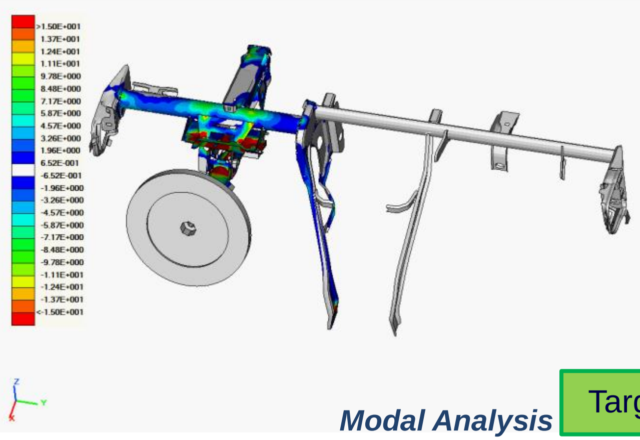


Gestamp BIW

4. Results and conclusions

I. Optimization results (NVH and Crash)

NVH results



1st frequency

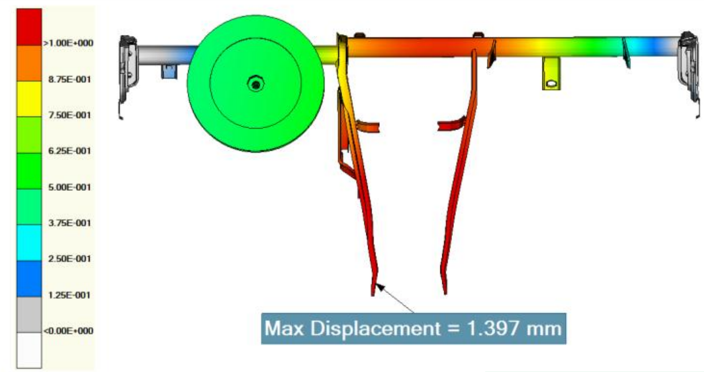
45,02 Hz

2nd frequency

45,17 Hz

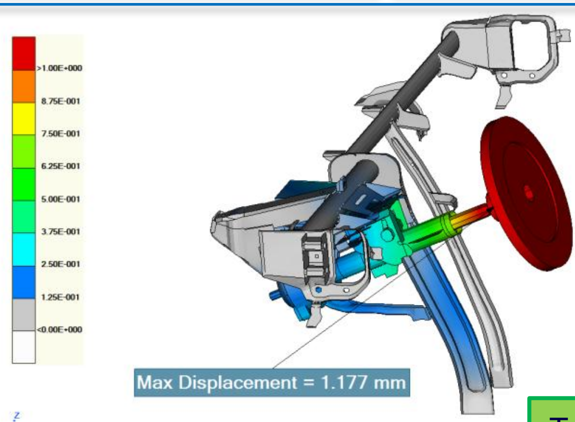
Modal Analysis

Target > 45Hz OK



Deflection Test

Target < 1,5mm OK



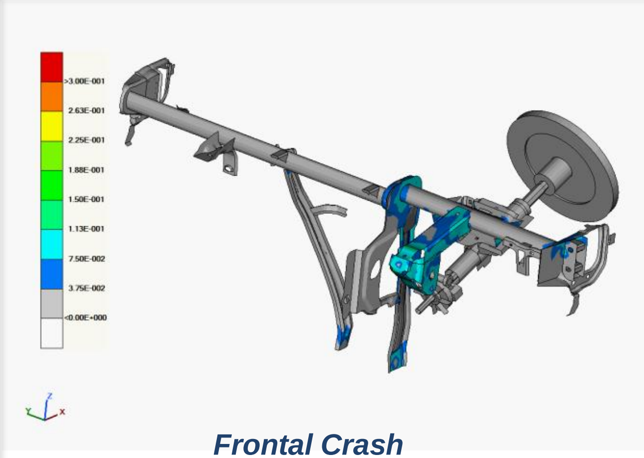
Steering Column Stiffness

Target < 1,5mm OK

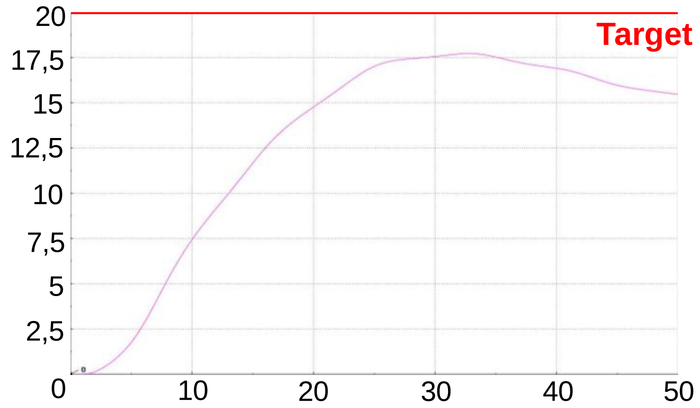
4. Results and conclusions

I. Optimization results (NVH and Crash)

Crash results

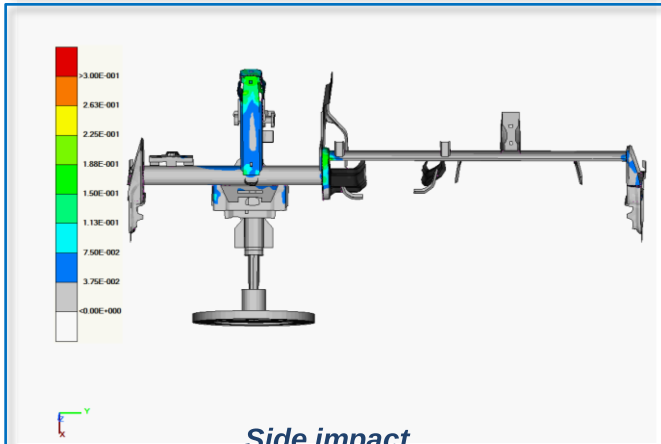


Frontal Crash

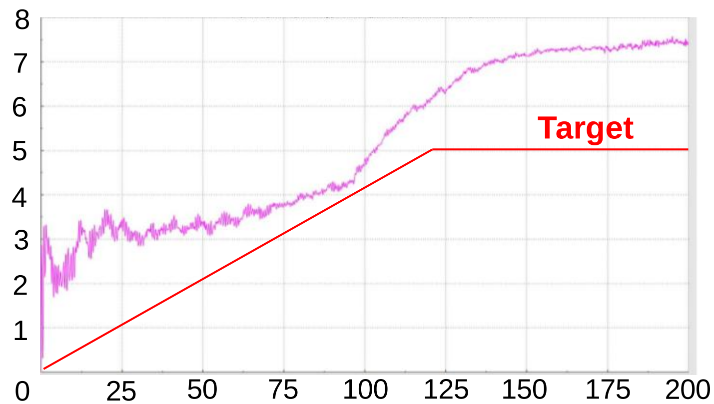


Steering wheel displacement [mm] – time [ms]

OK



Side impact



Section force [KN] – time [ms]

OK

Gestamp BIW

4. Results and conclusions

II. Conclusions

In the beginning of this project the packaging was very restrictive, the position of the components could not move too much as in a **RFQ phase** and the final optimization **did not achieved very good results**.

Therefore we decided to ignore some parts of the packaging as it were a **concept phase**. Increasing the movement of the components we could check for possible positions which we had been never tried before and see they could be a good solution design.

The final weight reduction is about 18%. (5,70 kg to 4,67 kg) achieving all targets:

- **Modal analysis,**
- **Deflection test**
- **Steering column stiffness**
- **Frontal crash**
- **Side impact**

Optimized model

LS-OPT is a useful and great tool to coordinate different kind of simulations and analyse the results.

However, working with large number of variables could carry some difficulties to manage all together.

In this project a great part of the time was dedicated in the FE-Model parameterization, welding scripting and learning LS-Opt features which we hope to reduce this time for next projects.


GESTAMP
AUTOMOCIÓN