

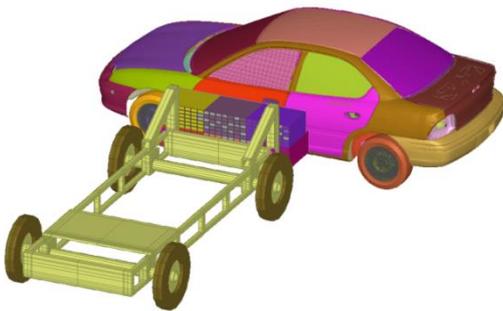
## Optimization of Spotwelds distribution using ANSA and μETA

### Introduction

The way that some parts of an assembly are connected with each other can be a great factor of influence of the models' behavior. For this reason an optimization of the connection type or pattern offers an important improvement to specific model characteristics. In this paper the distribution of spotwelds on a b-pillar is optimized using the ANSA parameterization and automation capabilities, in order to reduce the maximum intrusion during a side impact.

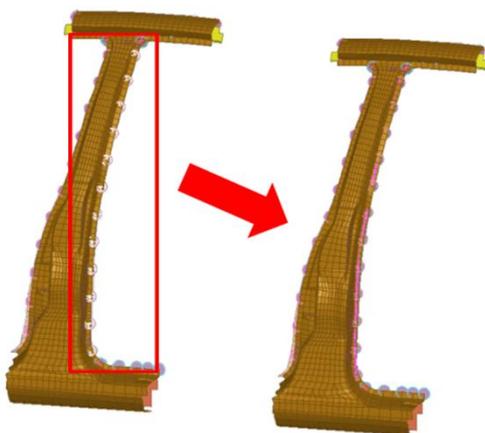
### Problem description and goal

The body of a car is subjected to a side crash analysis in PAM-CRASH with a speed of 56 km/hour. The objective is to find the optimum distribution of the spotwelds along the two b-pillar flanges, in order to minimize the intrusion of the b-pillar into the cabin.



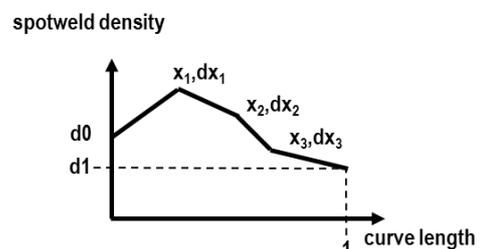
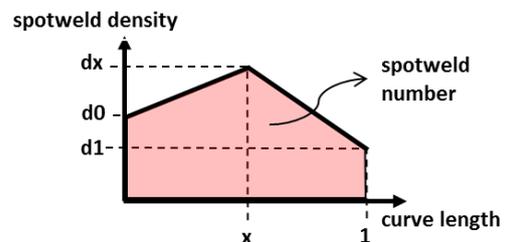
### Connection Lines

This optimization technique is based on connection lines which can be easily created from 3d curves or pre-existing connection points. In the latter case all the information of the points regarding the connection type, is passed to the connection lines.



### Density Curves

A user defined function represents the spotweld density along the length of a connection line. The X-axis of the function corresponds to the connection line length normalized form 0 to 1. The Y-axis represents the spotweld density [number of points per unit length]. A whole variety of curves can be defined in this way, using the ANSA scripting language. As soon as the density curve is attached to a connection line the function is mapped to the connection line length. The area of the density function represents the total number of spotwelds that will be applied on the line. This information can be extracted in order to be used for the optimization.



### Density Curves Parameterization

The density curves are being parameterized in order to be controlled by the optimizer. In this case 8 parameters are being used.  $d_0$ ,  $d_1$  and  $x_1$ ,  $dx_1$ ,  $x_2$ ,  $dx_2$ ,  $x_3$ ,  $dx_3$ . The first 2 represent the initial and final density

respectively, while the other 6 represent 3 pairs of values that describe the density of the points in three different positions along the connection line length. These parameters are the design variables of the optimization problem. The creation of the density curve is performed by a script while the whole procedure is controlled by the optimization task of ANSA.

### The Optimization Task

The optimization task is a sequence of actions that is executed in a step wise sequence during the optimization. It contains 8 design variable items, each one of which represents a density curve parameter. The next item is a script that reads the design variables values, creates the corresponding density curve and applies the computed density to the appropriate connection line. The result is an unequal distribution of connection points on the b-pillar. Additionally, there is another script file that extracts the total number of connections points in a txt file while the last action is the creation of a solver input file in PAM-CRASH format.

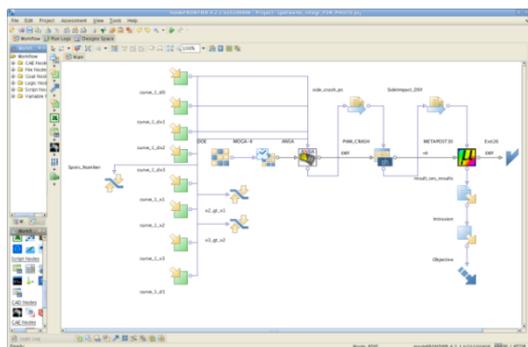
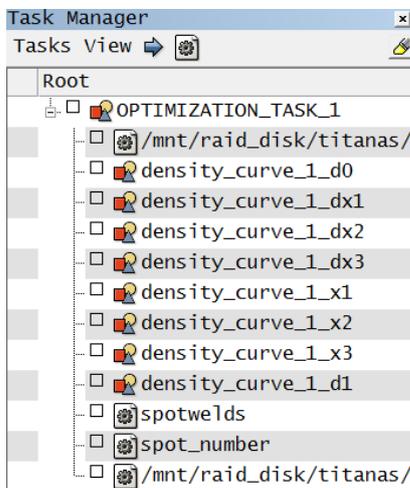
### The Optimization Problem

The design objective is to minimize the intrusion of the b-pillar and the total number of connection points is the design constraint. The design variables are the parameters that control the density function but in order to define a proper curve some design variable constraints must be defined in the optimizer.

<b>Objective:</b>	Minimize Intrusion
<b>Constraints:</b>	Number of spotwelds per curve $\leq 20$
<b>Design Variable Constraints:</b>	$x_1 > 0$
	$x_1 < x_2 < x_3$
	$x_3 < 1$
<b>Design Variable Bounds:</b>	$0.008 < d_i < 0.05$ [num. of spotwelds/mm] where $d_i$ : $d_0, dx_1, dx_2, dx_3$

### Design Responses Extraction from IHS toolbar

An initial run of the model is being performed in order to assess the model and extract the design responses, in this case the maximum intrusion.  $\mu$ ETA offers a special toolbar, the IHS, that automates the post processing of side impact analysis. It automatically creates the necessary 2d-plots that are used for comparing the model with the regulation limits, and extracts, among others, the maximum intrusion value that can be defined as a design constraint through the Optimizer Set Up Toolbar. It creates also automatically a report with all the respective information. The maximum intrusion in this case was about 58.8[mm] from the drivers' centerline and can be categorized as an acceptable value. Despite this the maximum intrusion can be further decreased.

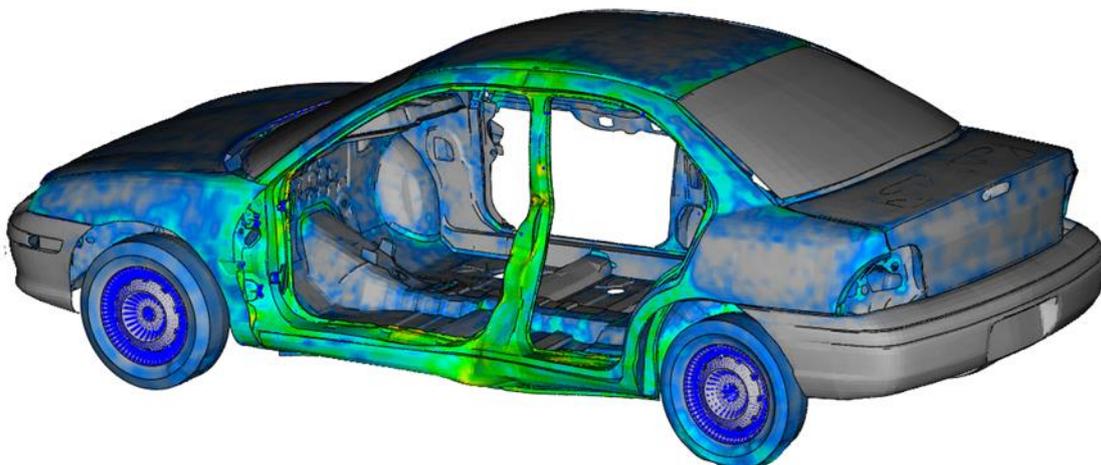
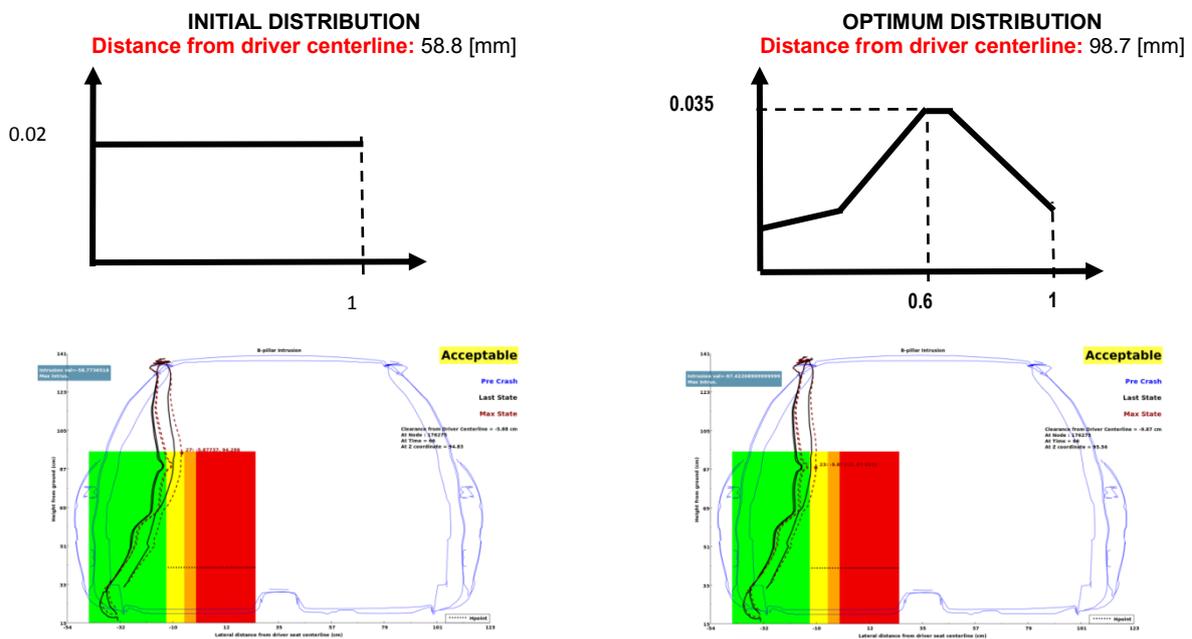


## Optimization

ANSA and  $\mu$ ETA can be directly coupled with many parametric optimizers including modeFRONTIER that has been used in this case. ModeFRONTIER offers two special ANSA and  $\mu$ ETA nodes that make the coupling between the software a quite easy task. The optimizer reads the design variables from ANSA and automatically creates them in the workflow, while at the same time reads and assign to them the proper bounds.

## Optimization Results

The optimum solution represents a density curve that applies the maximum connection point density at 0.6 of the normalized connection line length. With this new distribution the maximum intrusion as extracted from the IHS toolbar is being reduced by 4.7% at absolute values. The new maximum clearance from drivers centerline has moved from 58.8[mm] to 98.7[mm] an acceptable value by the standards.



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