# ANALYZING SCATTER OF CRASH SIMULATION RESULTS USING THE DIFFCRASH PLUG-IN WITHIN METAPOST

**[1]Dominik Borsotto*, [2]Antonis Perifanis, [2]Dimitrios Siskos**
[1]SIDACT GmbH, Germany, [2]BETA CAE Systems SA, Greece

KEYWORDS - Robust Design, Chevy Silverado, Scatter, Metapost

ABSTRACT –

The investigations described here are related to the unstable behaviour of crash-simulations due to minor changes in the model. As a consequence the received simulation results become in some way unpredictable, whereby the causes can be various: e.g. modelling failure, contact issues, numerical instabilities, physical instabilities, etc..

To identify and separate these scatter sources with our approach the results are analysed by means of visualizing the standard deviation of scatter itself and computing scatter-modes for selected parts of interest. Latter computations are based on the principle component analysis (PCA), and deliver new virtual crash results representing the most extreme geometrical shapes of the scatter-modes. This improves and speeds up the process of identifying scatter causes.

For illustration a realistic application case based on the freely available Chevrolet Silverado from the National Crash Analysis Center (NCAC) of The George Washington University is analysed by means of robust design of the crash model. Therefore 25 simulation runs were performed based on small random part thickness changes (representing production tolerances). The part of interest for the investigations is the variance at the fire-wall. As an outcome major scatter sources in the interaction of power-brake and suspension as well as at the longitudinal rail are found which are strongly correlated to the firewall scatter.

Approving the software based prediction exemplary design adaptations lead to a significant reduction of scatter on the firewall. The described mathematical methods are part of the software DIFFCRASH.

Based up on a newly integrated plugin of DIFFCRASH the interactive analysis was driven from within Metapost.

EXTENDED ABSTRACT -

## 1. BACKGROUND

Since the past few years the overall awareness of variability and scatter for CAE predictions is steadily increasing. Giving the fact that variability is inherent in nature it is also a major task to master it during product- and in this case especially vehicle-development. As a matter of fact in car industry for many load cases there is only provision for a single performance confirmation test to verify the CAE model. As such a test is influenced by a series of potential variability sources like e.g. production tolerances and crash test parameter settings, the chance to run into unpredictable crash results rises. In case of unforeseen results this usually leads to expensive and inefficient design changes, at a late vehicle development phase.

To counteract the above mentioned the CAE model should already have a robust design which is not sensitive to small variations and still delivers predictable results. Thus before applying design optimizations, the overall robustness of the model needs to be ensured.

Taking a deeper look into the complex event of a car crash many reasons can be discovered why small variations actually lead to a big spread among the results. Just to mention a view, consider parts kinking in one direction or the other or parts passing each other instead of hooking up. As a consequence one approach to generate a robust design is to find these events (often referenced to as bifurcations) and derive design suggestions that can handle the variations and still deliver a deterministic crash behaviour.

To identify and separate these scatter sources with our approach the results are analysed by means of visualizing the standard deviation of scatter itself and computing scatter-modes for selected parts of interest. Latter computations are based on the principle component analysis (PCA), and deliver new virtual crash results representing the most extreme geometrical shapes of the scatter-modes. This improves and speeds up the process of identifying scatter causes.

## 2. FIREWALL EXAMPLE

For illustration a realistic application case based on the freely available Chevrolet Silverado from the National Crash Analysis Center (NCAC) of The George Washington University is analysed by means of robust design of the crash model. Therefore 25 simulation runs were performed based on small random part thickness changes (representing production tolerances). The part of interest for the investigations is the variance at the fire-wall, where a variation of around 90 mm can be discovered (see Figure 1).

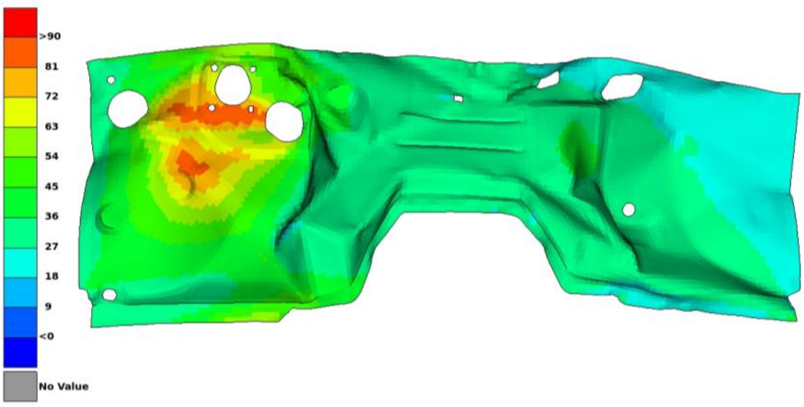


Figure 1 – Scatter of 30 simulation runs on the firewall for initial design in mm

Applying the prescribed methods as an outcome major scatter sources in the interaction of power-brake and suspension (see Figure 2) as well as at the longitudinal rail are found which are strongly correlated to the firewall scatter. The scatter modes reveal the different crash behaviour and allowed us to derive design adaptations.

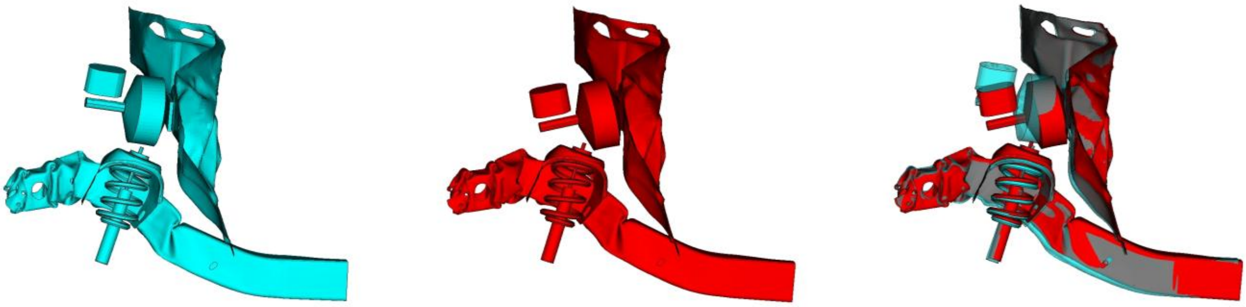

Figure 2 – Scatter mode deformation shapes for shock absorber – brake unit interaction

Approving the software based prediction exemplary design adaptations then lead to a significant reduction of scatter on the firewall (see Figure 3), where only around 20 mm scatter is remaining. Thus the design could be improved by meanings of robustness and the scatter occurrence at the firewall could be decreased significantly from 90 mm to only 20 mm in peak areas.

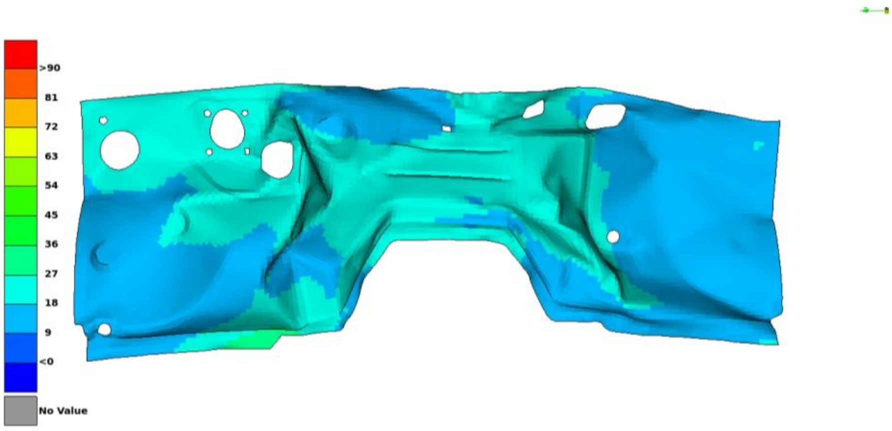


Figure 3 – Scatter of 30 simulation runs on the firewall for revised design in mm

The described mathematical methods are part of the software DIFFCRASH, which was used in this study. Based up on a newly integrated plugin of DIFFCRASH the interactive analysis was driven from within Metapost.

## 3. CONCLUSIONS

Improving the robustness of a crash model is still a challenging topic but especially important before applying optimization technics. One approach based up on PCA based scatter modes was illustrated which allows finding instabilities within models and deriving design suggestions to improve the robustness of the crash model. The mixture out of standard statistics to highlight critical areas in combination with the derived scatter modes allows improving model robustness and also speeds up the process of analysing a set of simulation runs.