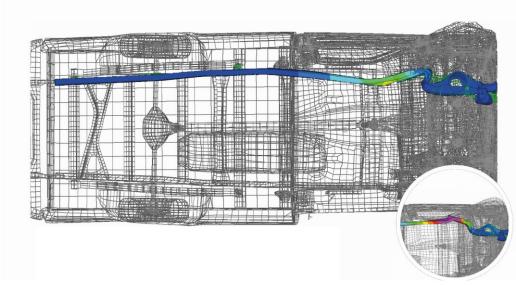
Process to improve optimization with combined robustness analysis results



Dominik Borsotto, Lennart Jansen, Clemens-August Thole

Dominik Borsotto

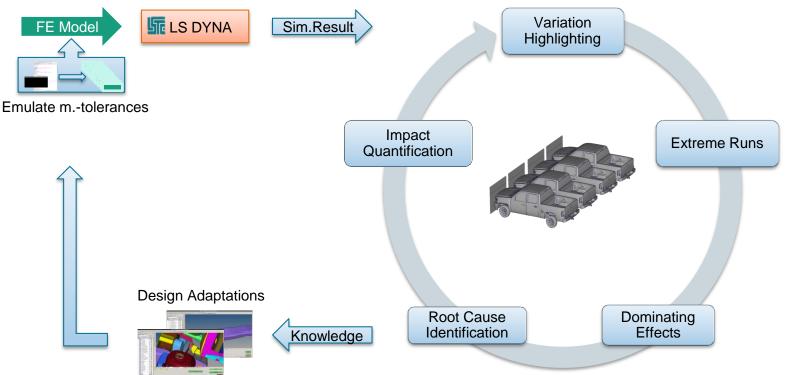
Agenda

Introduction

Combined Optimization & Robustness Analysis

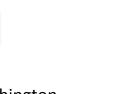


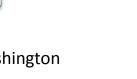
Introduction **Robustness Workflow**



"The model has been developed by The National Crash Analysis Center (NCAC) of The George Washington University under a contract with the FHWA and NHTSA of the US DOT" http://www.ncac.gwu.edu/vml/models.html

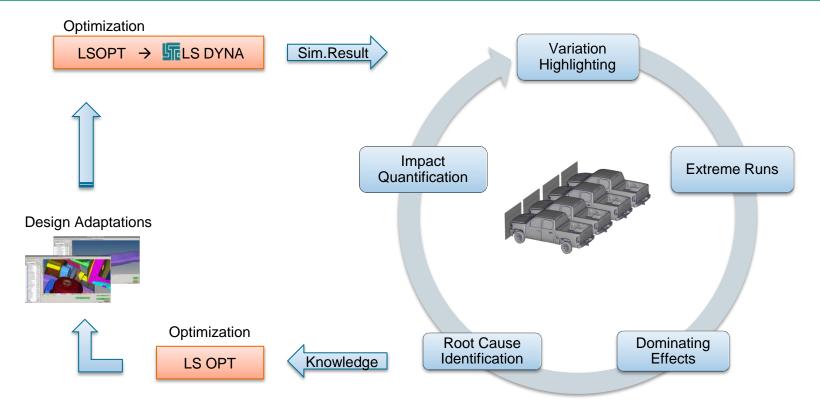








Introduction Robustness & Optimization Workflow



DIFFCRASH

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"The model has been developed by The National Crash Analysis Center (NCAC) of The George Washington University under a contract with the FHWA and NHTSA of the US DOT" <u>http://www.ncac.gwu.edu/vml/models.html</u>



Optimization: Chevrolet Silverado



Chevrolet Silverado

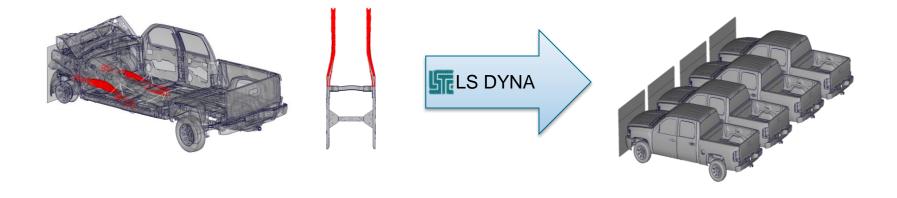
Model	Chevrolet Silverado
Year	2007
Number of Parts	679
Finite-Elements	929,131

"The model has been developed by The National Crash Analysis Center (NCAC) of The George Washington University under a contract with the FHWA and NHTSA of the US DOT" http://www.ncac.gwu.edu/vml/models.html



Optimization: Dataset

77 Simulation runs with random thickness variations of the longitudinals

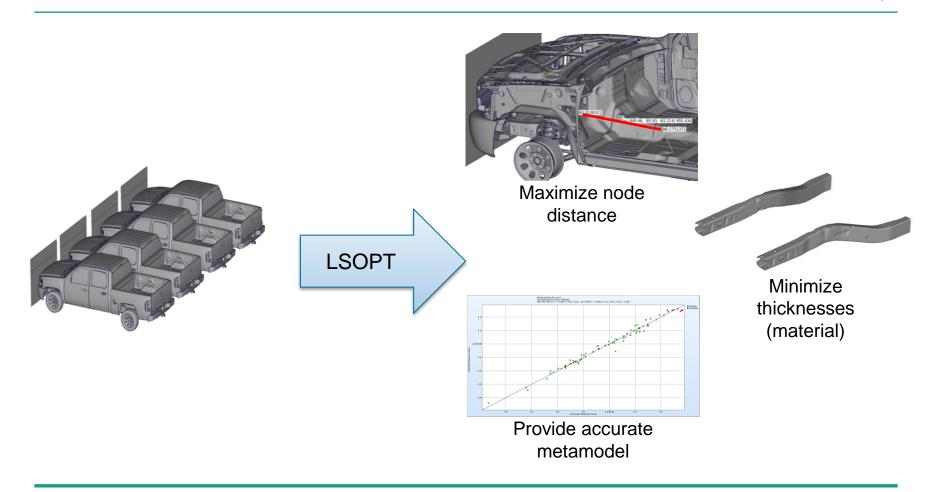


"The model has been developed by The National Crash Analysis Center (NCAC) of The George Washington University under a contract with the FHWA and NHTSA of the US DOT" http://www.ncac.gwu.edu/vml/models.html



Optimization: Goals





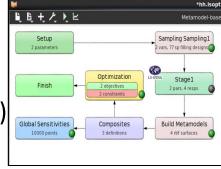
Optimization: LSOPT

- Metamodel optimization
- Input variables: longitudinal thicknesses
- Maximize node distances (between firewall and seat)
- Minimizing the sum of the thicknesses

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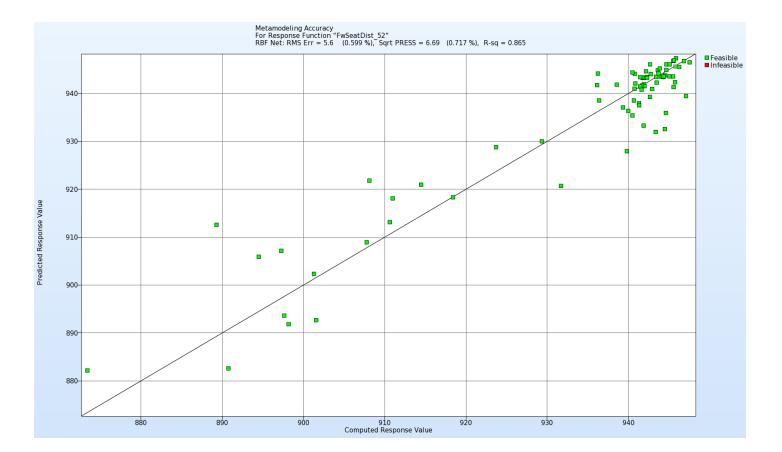






Optimization: Meta Model Quality Node Distance

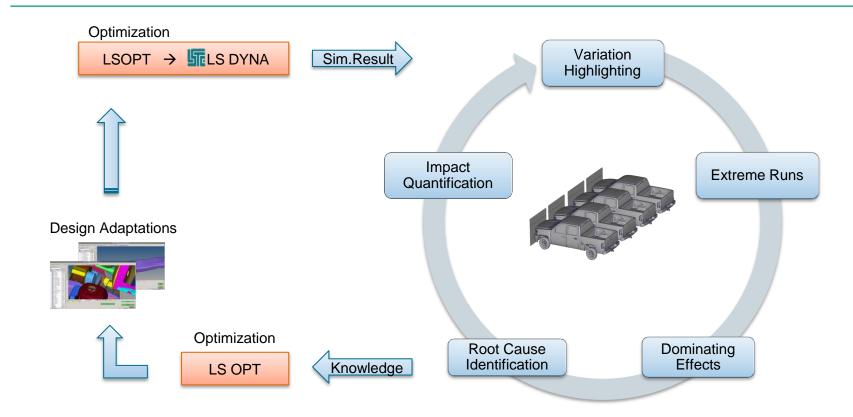




© SIDACT GmbH

Robustness Analysis:



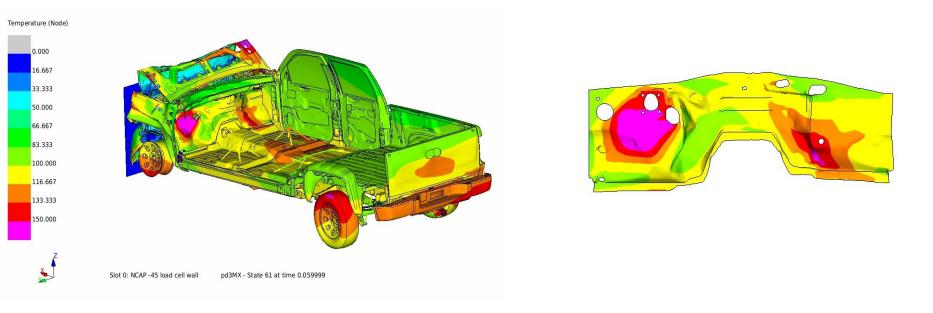


"The model has been developed by The National Crash Analysis Center (NCAC) of The George Washington University under a contract with the FHWA and NHTSA of the US DOT" <u>http://www.ncac.gwu.edu/vml/models.html</u>

Robustness Analysis: DIFFCRASH



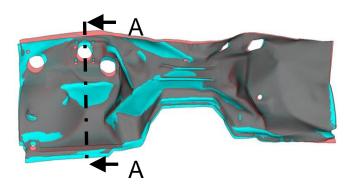
Scatter Overview

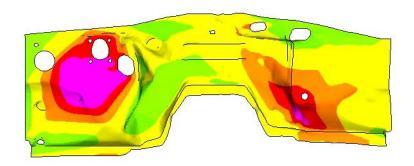


Maximum variation of node position in [mm]



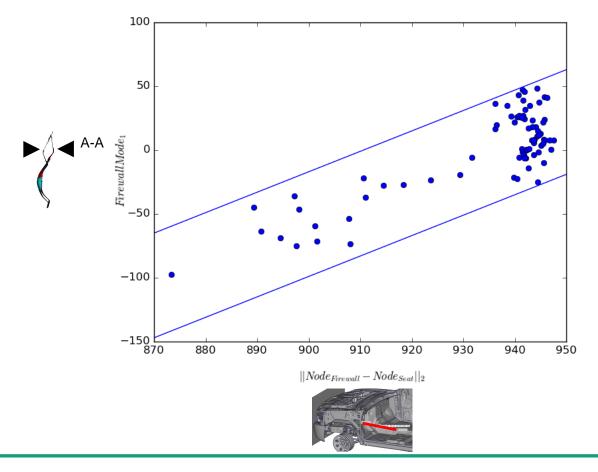
Robustness Analysis: Mode information DIFFERASH





- \rightarrow Intrusion information
- \rightarrow Replacement for node distance?

Robustness Analysis: Mode information



LS-OPT – Mode as objective and variable

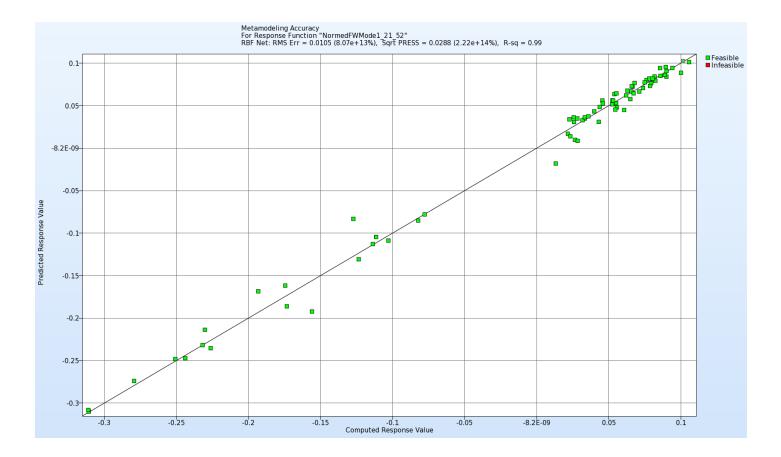
- Firewall mode (intrusion)
- Input variables: longitudinal thicknesses
- Maximize node distances (between firewall and seat)
- Minimizing the sum of the thicknesses

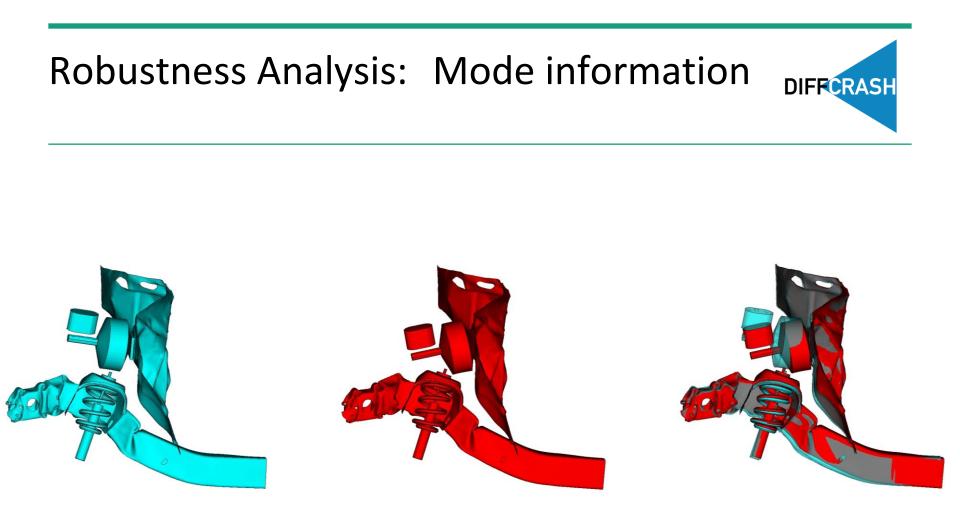
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DIFFCRASH

Optimization: Quality of the Meta Model Firewall Mode

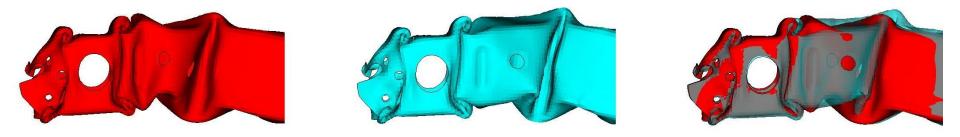




Firewall scatter mode at power-brake



Robustness Analysis: Mode information



Dominating firewall scatter mode at longitudinal rail



LS-OPT – Mode as objective and variable

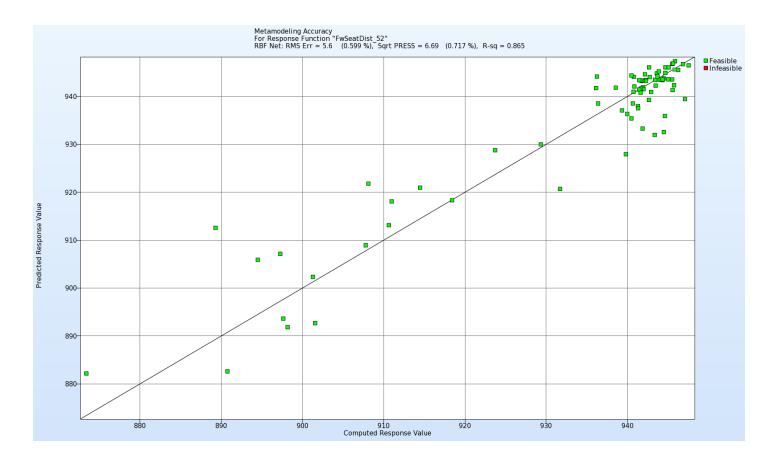
- Firewall mode (intrusion)
- Variables: Brake booster & left longitudinal buckling modes
- Possibility to choose best specification of the modes for our objectives.

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2:3:15 Component Name Lower Value Upper Active 2:3:15 StandardComposite1 2.5 < 0.5 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0.4 < 0	2:11:5 negativ material 2:11:5 StandardComposite2 2:11:5 StandardComposite2 2:11:5 2:11:5 2:11:5 2:11:5 OBJECTIVE VALUES 2:11:5 OBJECTIVE VALUES 2:11:5 Objective Name 2:11:5 InfoOde 2:11:5 InfoOde 2:11:5 InfoOde 2:11:5 InfoOde	-5,824 2.5 3.324 Objective is MAXIMIZED Component Name Value WT.
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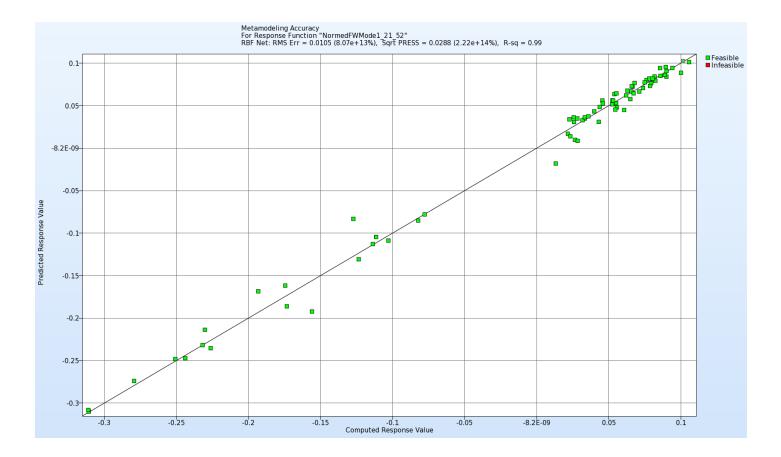


DIFFCRASH

Optimization: Quality of the Meta Model Node Distance

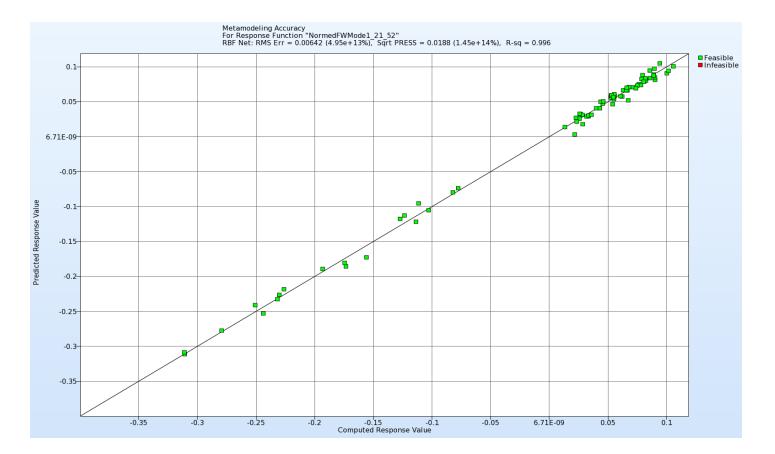


Optimization: Quality of the Meta Model Firewall Mode



Optimization: Meta-Model Accuracy Firewall/BreakBooster





Robustness Analysis: Mode information

 $LSDYNA(D_1, D_2)$ intrusion($LSDYNA(D_1, D_2)$)

 $\alpha_{FW} (D_1, D_2) \cdot M_{\alpha_{FW}}$ $\beta_{FW} (D_1, D_2) \cdot M_{\beta_{FW}}$

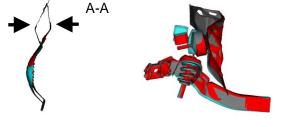
 $intrusion(\bar{f} + \alpha_{FW} (D_1, D_2) \cdot M_{\alpha_{FW}} + \beta_{FW} (D_1, D_2) \cdot M_{\beta_{FW}} \dots)$ $intrusion(\bar{f} + \alpha_{FW} (D_1, D_2, I_{BB}) \cdot M_{\alpha_{FW}} + \beta_{FW} (D_1, D_2, I_{BB}) \cdot M_{\beta_{FW}} \dots)$

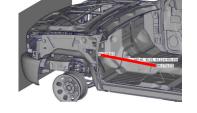
$\alpha_{FW}(D_1, D_2)$	Metamodel of 1st FW Mode	intrusion
$\beta_{FW} (D_1, D_2)$	Metamodel of 2nd FW Mode	\overline{f}
$M_{lpha_{FW}}$	1st FW Mode	
$M_{\beta_{FW}}$	2nd FW Mode	
D _i	Thicknesses	
•		•



Function to determine intrusion

Average simulation result

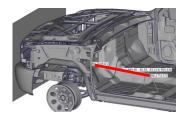






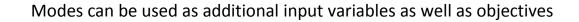
Robustness Analysis: Mode information

DIFFCRASH



Modes describe geometrical deformation of an area compared to single points

Less prone to locale effects (e.g creasing)



Describing effects, modes allow a classification (preferred behavior vs bad behavior)

This enables us to use a combined optimization with robustness knowledge





Thank you for your attention!

Dominik Borsotto

