Robustness analysis –
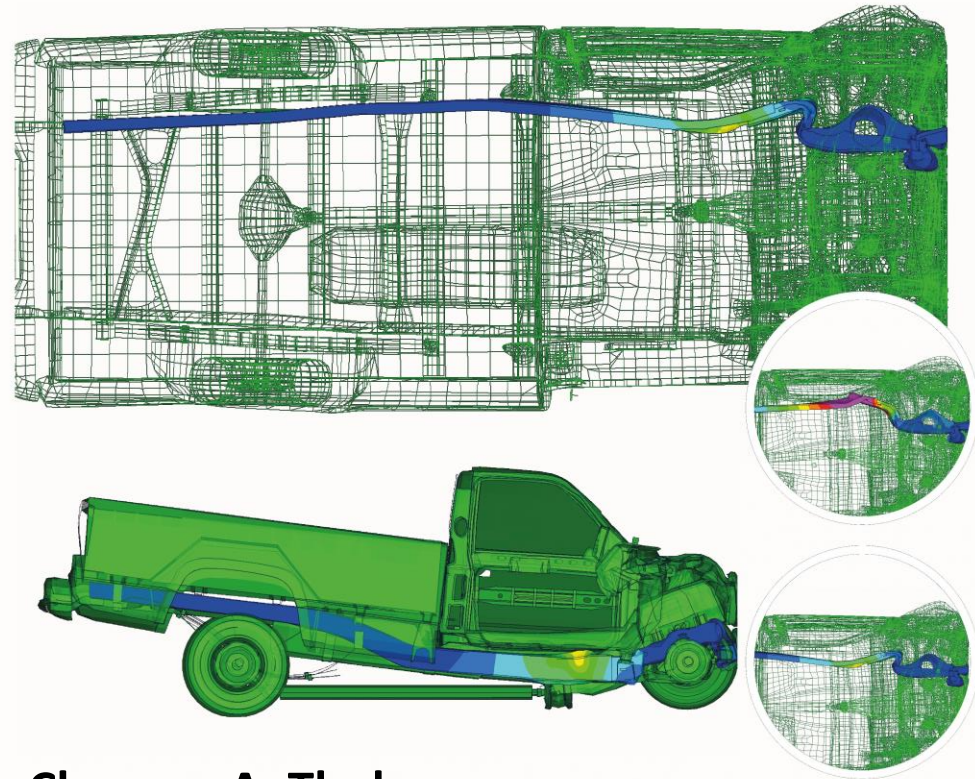# Significant reduction of scatter occurrence

Dominik Borsotto, Robin Strickstrock, Clemens A. Thole

Dominik Borsotto
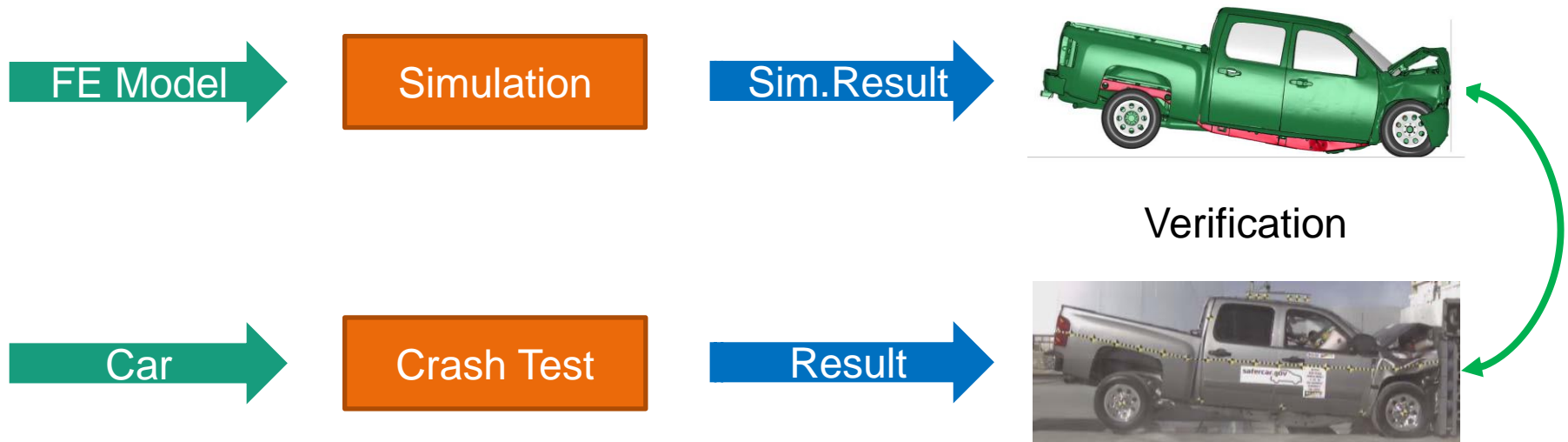
SIDACTGmbH

Agenda

Background

Methods

Example

Summary

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Background

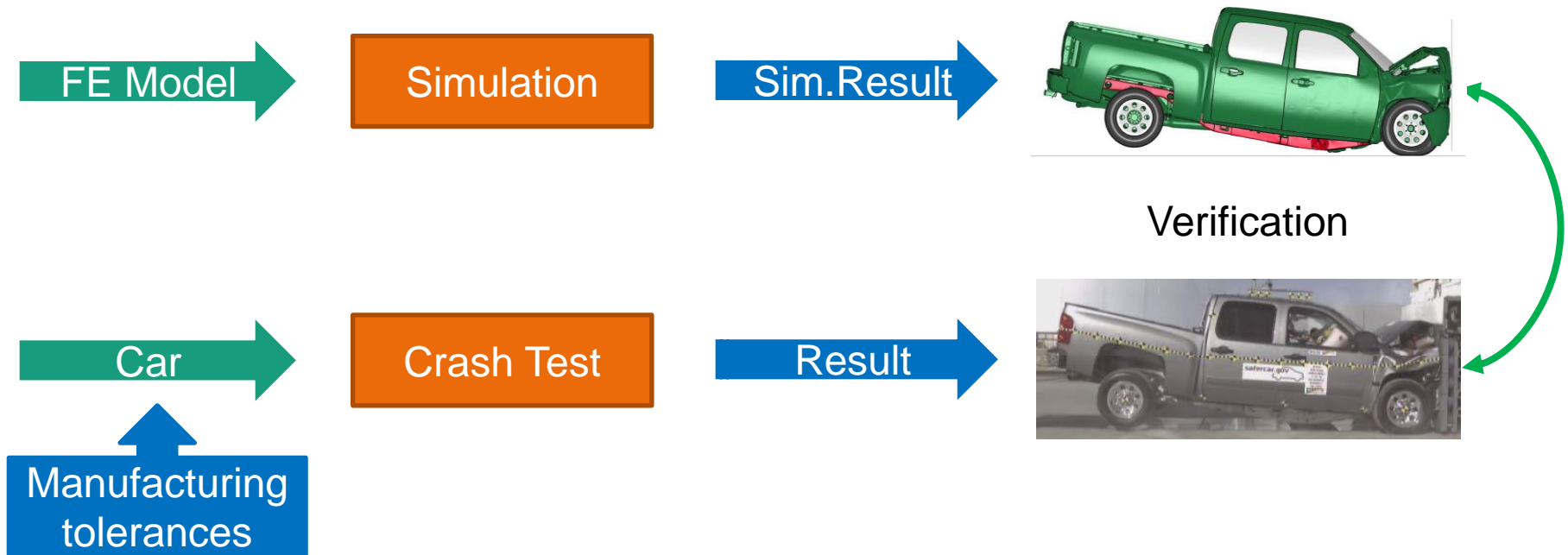FE Model → Simulation → Sim.Result →

Verification

Car → Crash Test → Result →

"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

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Background

FE Model → Simulation → Sim.Result →

Verification

Car → Crash Test → Result →

Manufacturing tolerances

"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"
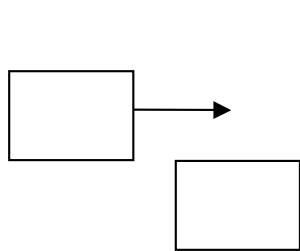http://www.ncac.gwu.edu/vml/models.html

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Background

FE Model → Simulation → Sim.Result

Emulate m.-tolerances

Car → Crash Test → Result

Manufacturing tolerances

Verification

"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"
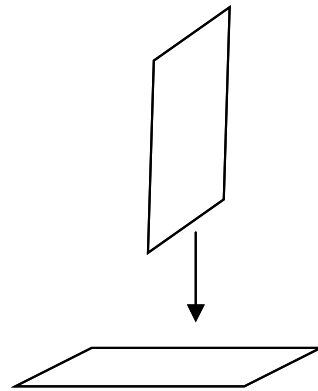http://www.ncac.gwu.edu/vml/models.html

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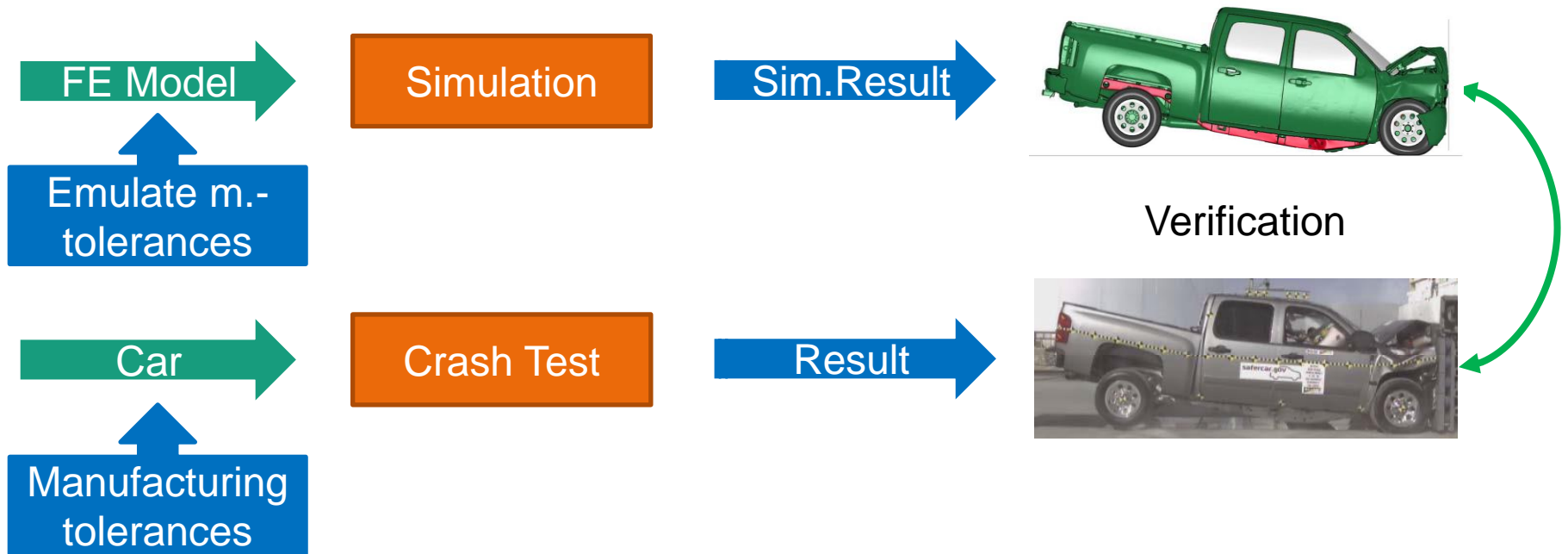
Background

Contact / no contact   90° contact   buckling

Element failures   friction

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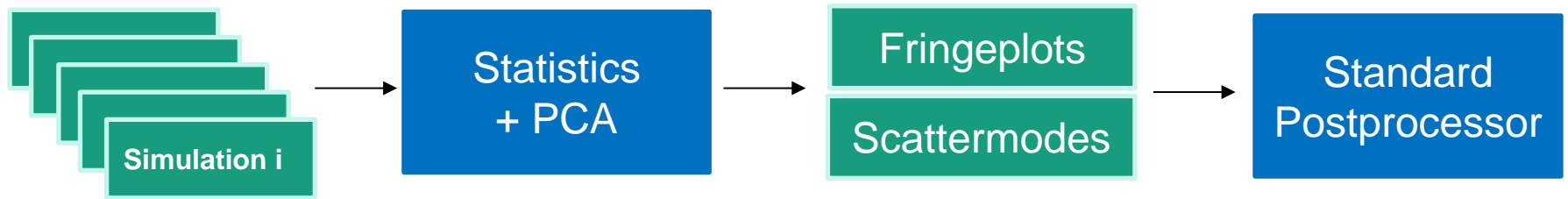
Background

Approach:

- Part based thickness variation representing production tolerances

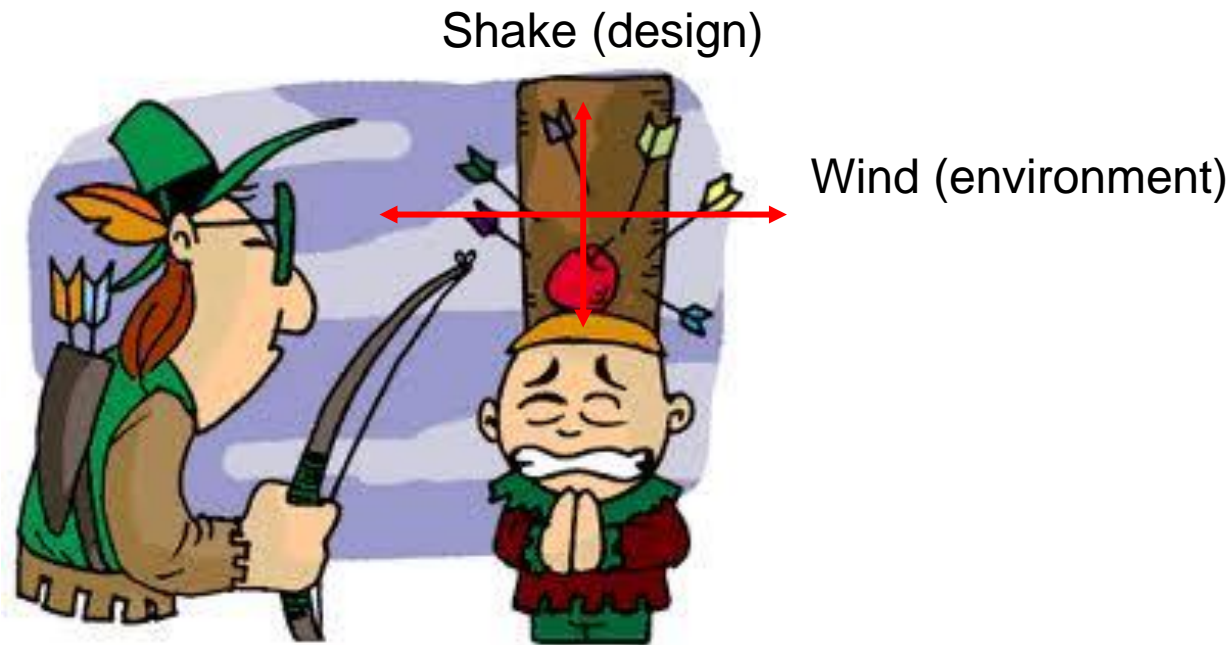- Generate series of simulations

- Analyze all simulations at once

Methods

Managing variability can be important

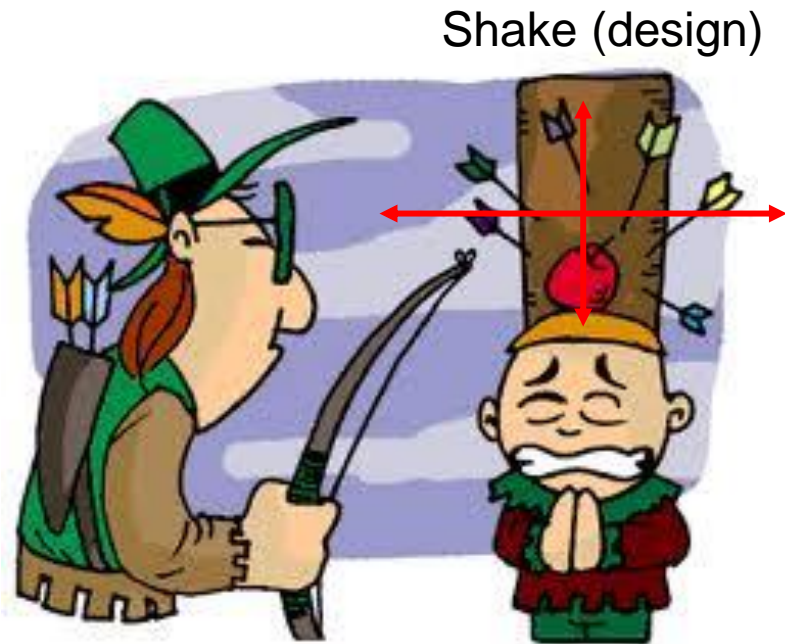R. Brown, JLR at LS-Dyna conference 2013: "Relating Scatter in Occupant Injury to Airbag Behavior"

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Methods

Shake (design)

Wind (environment)

Variability may have a structure

R. Brown, JLR at LS-Dyna conference 2013: "Relating Scatter in Occupant Injury to Airbag Behavior"

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Methods
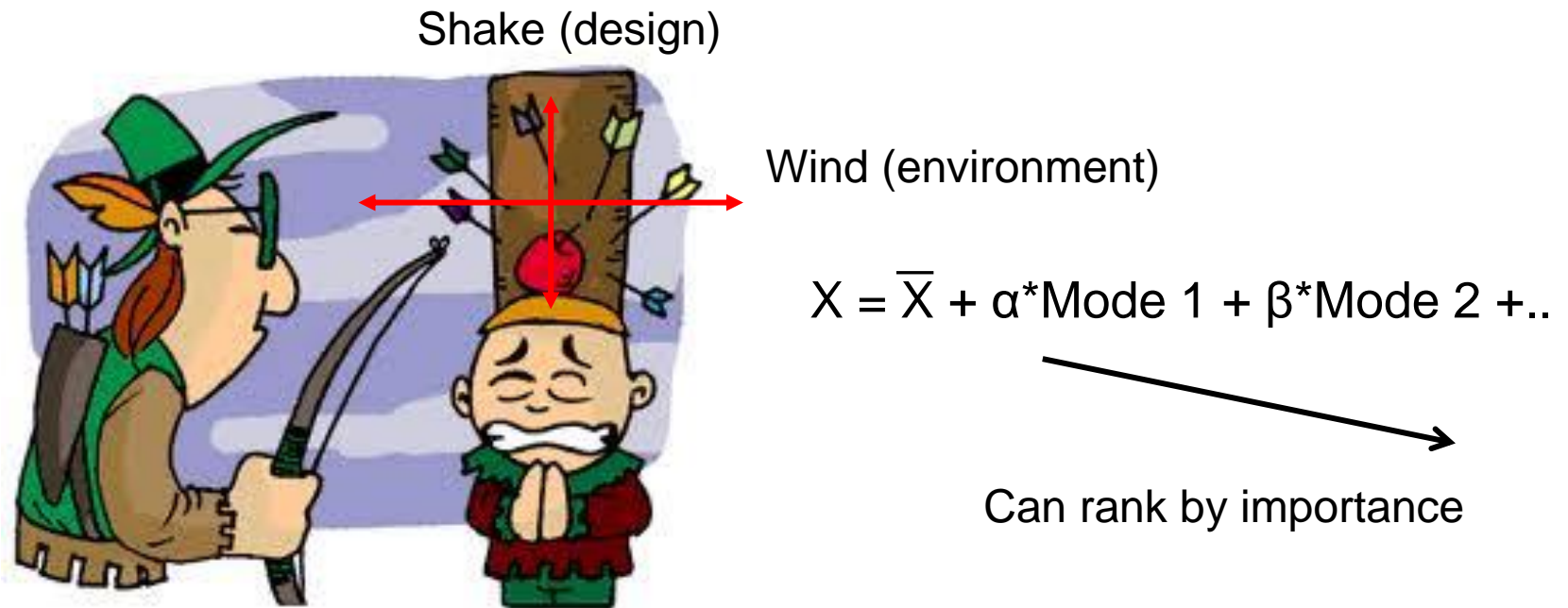
Shake (design)

Wind (environment)

$$X = \overline{X} + \alpha*\text{Mode 1} + \beta*\text{Mode 2} +..$$

- Mode 1 => horizontal scatter

- Mode 2 => vertical scatter

Scatter mode representation

R. Brown, JLR at LS-Dyna conference 2013: "Relating Scatter in Occupant Injury to Airbag Behavior"

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Methods

Shake (design)

Wind (environment)

$$X = \overline{X} + \alpha*\text{Mode 1} + \beta*\text{Mode 2} +..$$

Can rank by importance

Principal Component Analysis

R. Brown, JLR at LS-Dyna conference 2013: "Relating Scatter in Occupant Injury to Airbag Behavior"

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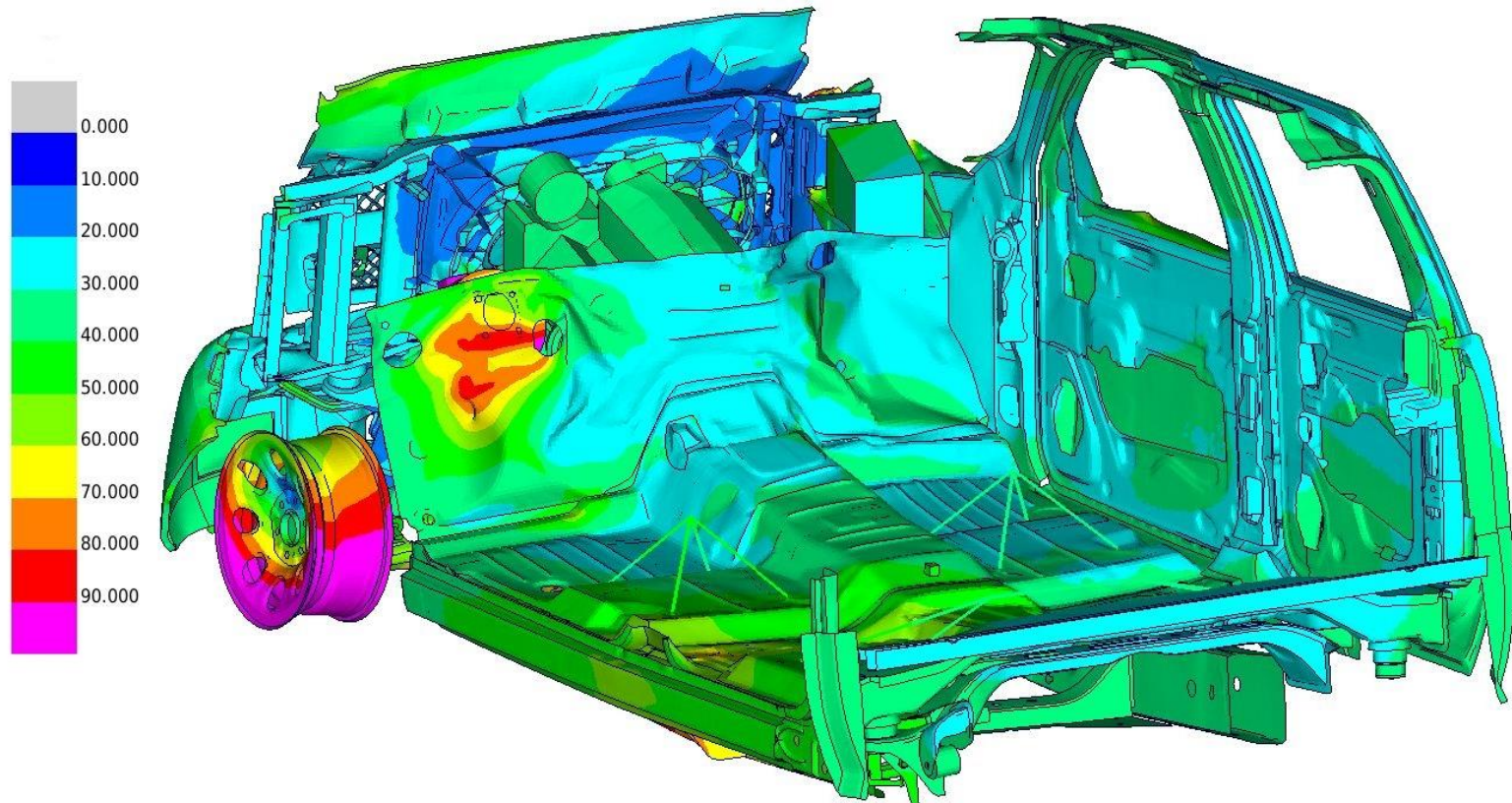
Example: Chevrolet Silverado

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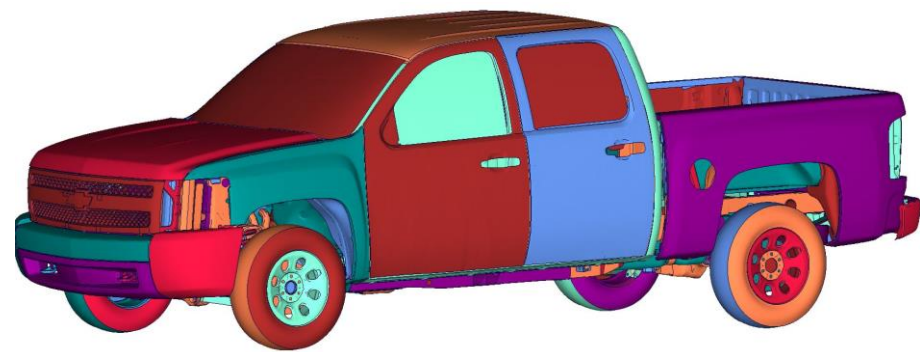
Model	Chevrolet Silverado
Year	2007
Number of Parts	679
Finite-Elements	929,131

"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"
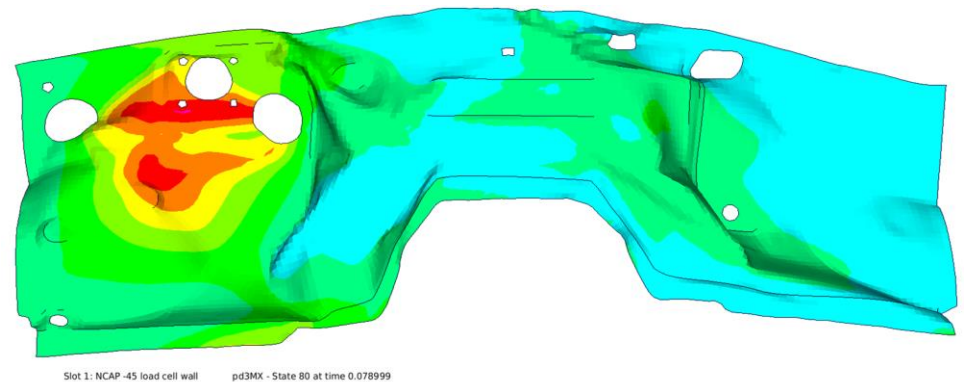http://www.ncac.gwu.edu/vml/models.html

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Example: Chevrolet Silverado

Maximum variation of node position in [mm]

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Example: Chevrolet Silverado

Slot 1: NCAP -45 load cell wall   pd3MX - State 80 at time 0.078999

X = X + α*Mode 1 + β*Mode 2 +…   → Firewall mode information?

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Example: Chevrolet Silverado

Importance Factors

□ Part Of Interest

Slot 1: NCAP -45 load cell wall   pd3MX - State 80 at time 0.078999

→ 1 dominating mode

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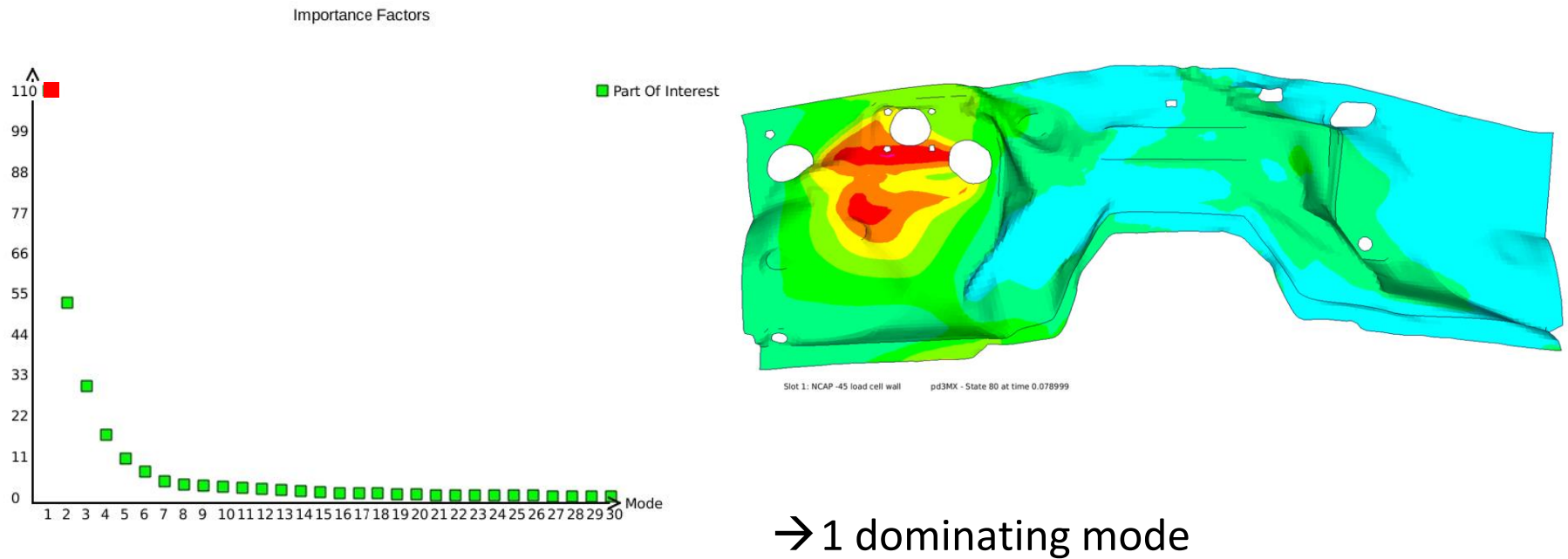
Example: Chevrolet Silverado

Correlationplot of the 2 dominating modes
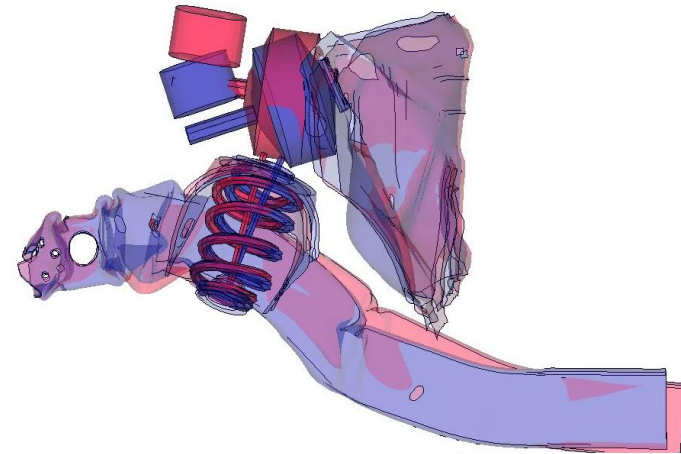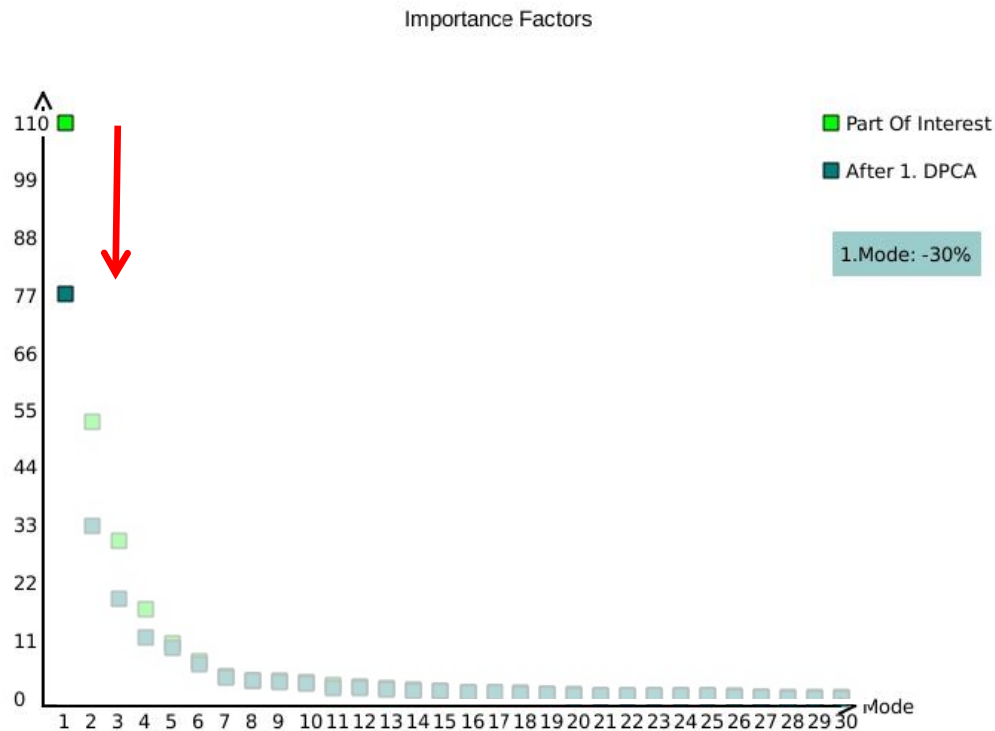
Part Of Interest

→ 2 Cluster

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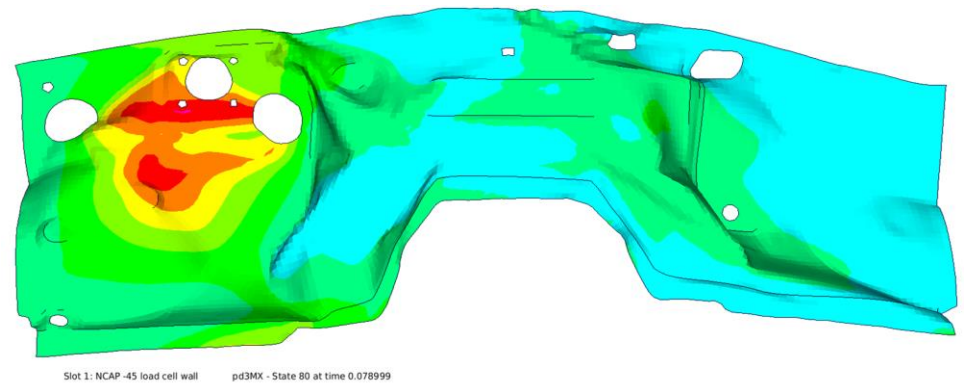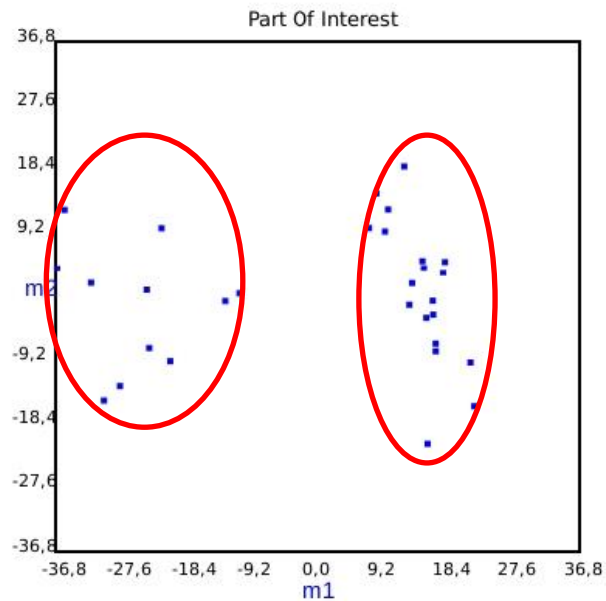
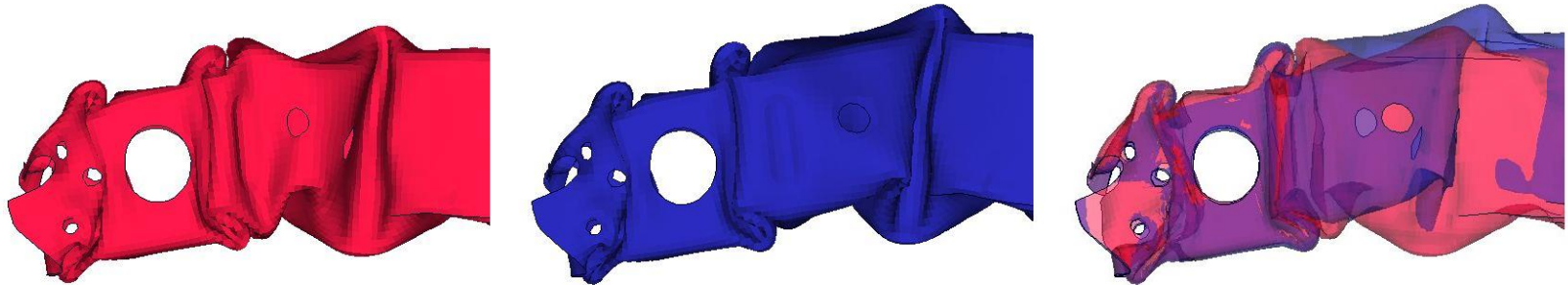# Example: Chevrolet Silverado
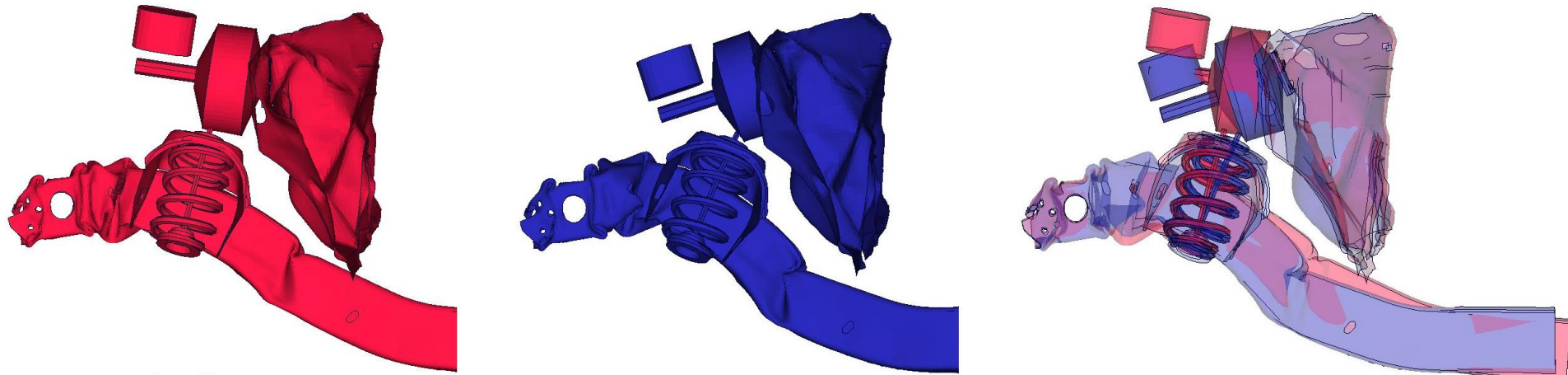
Dominating firewall scatter mode at power-brake
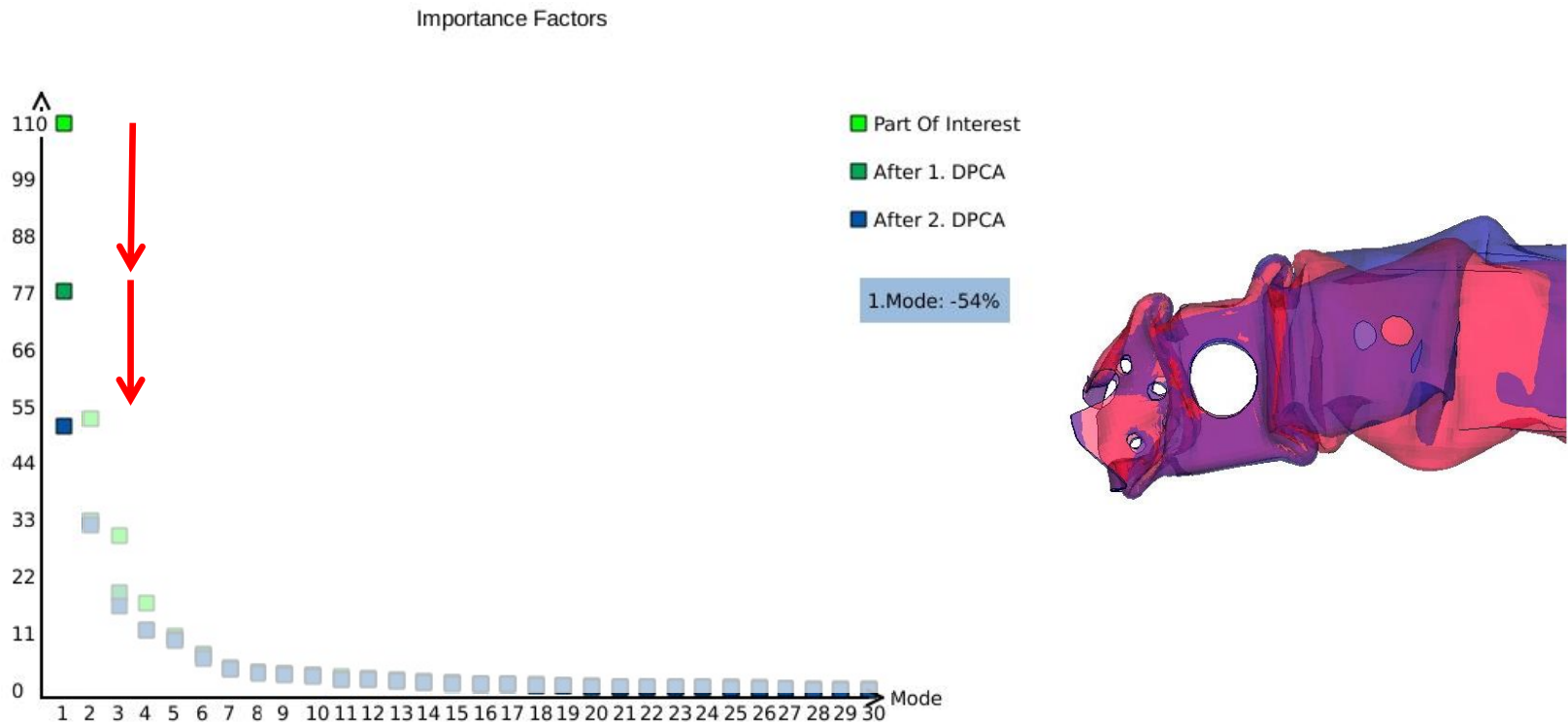
Example: Chevrolet Silverado

Subtraction of power-brake
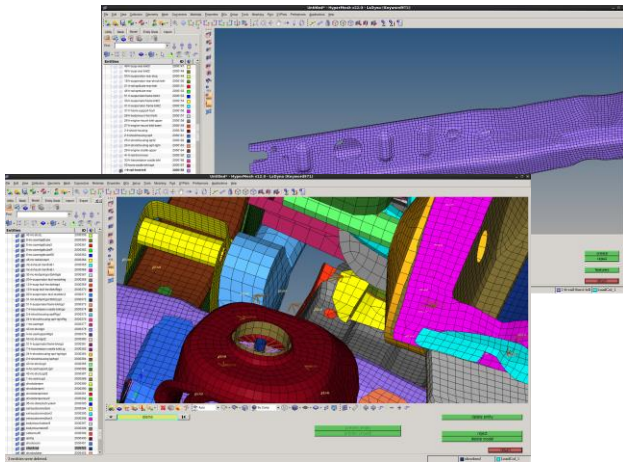
Example: Chevrolet Silverado

Dominating firewall scatter mode at longitudinal rail

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Example: Chevrolet Silverado
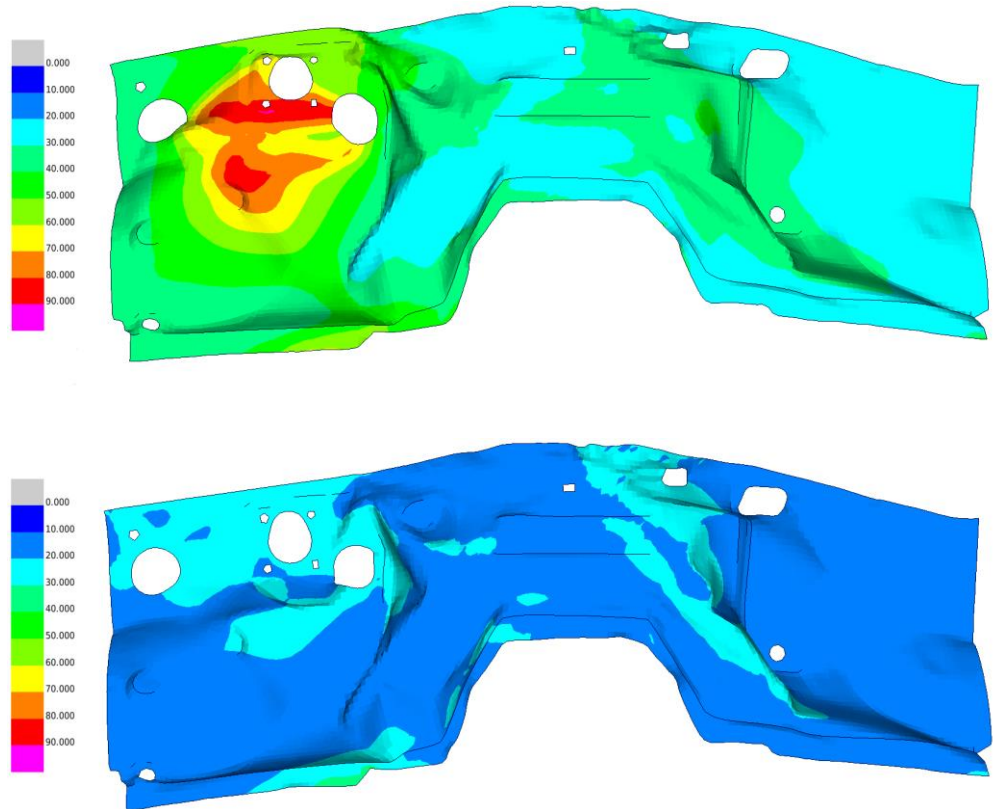

Subtraction of longitudinal rail

Example: Chevrolet Silverado

Design adaptations

Firewall scatter after design adaptations

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Summary

- Production tolerances can have a big impact on simulation results

- Easy emulation of thickness variation triggers model instabilities

- PCA based scatter modes reveal instabilities

- More robust design

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Thank you for your attention!

Dominik Borsotto

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