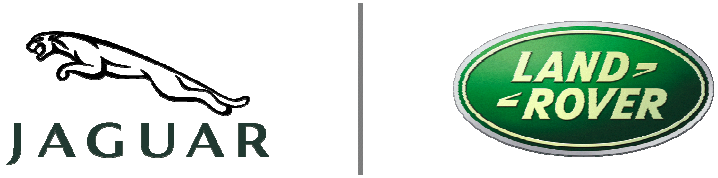

A New Method for CrachFEM 'Damage' Parameter Calculation & Transfer from Autoform to LS-Dyna

8th European LS-DYNA Users Conference
May 23rd – 24th 2011
Strasbourg

Michael Buckley

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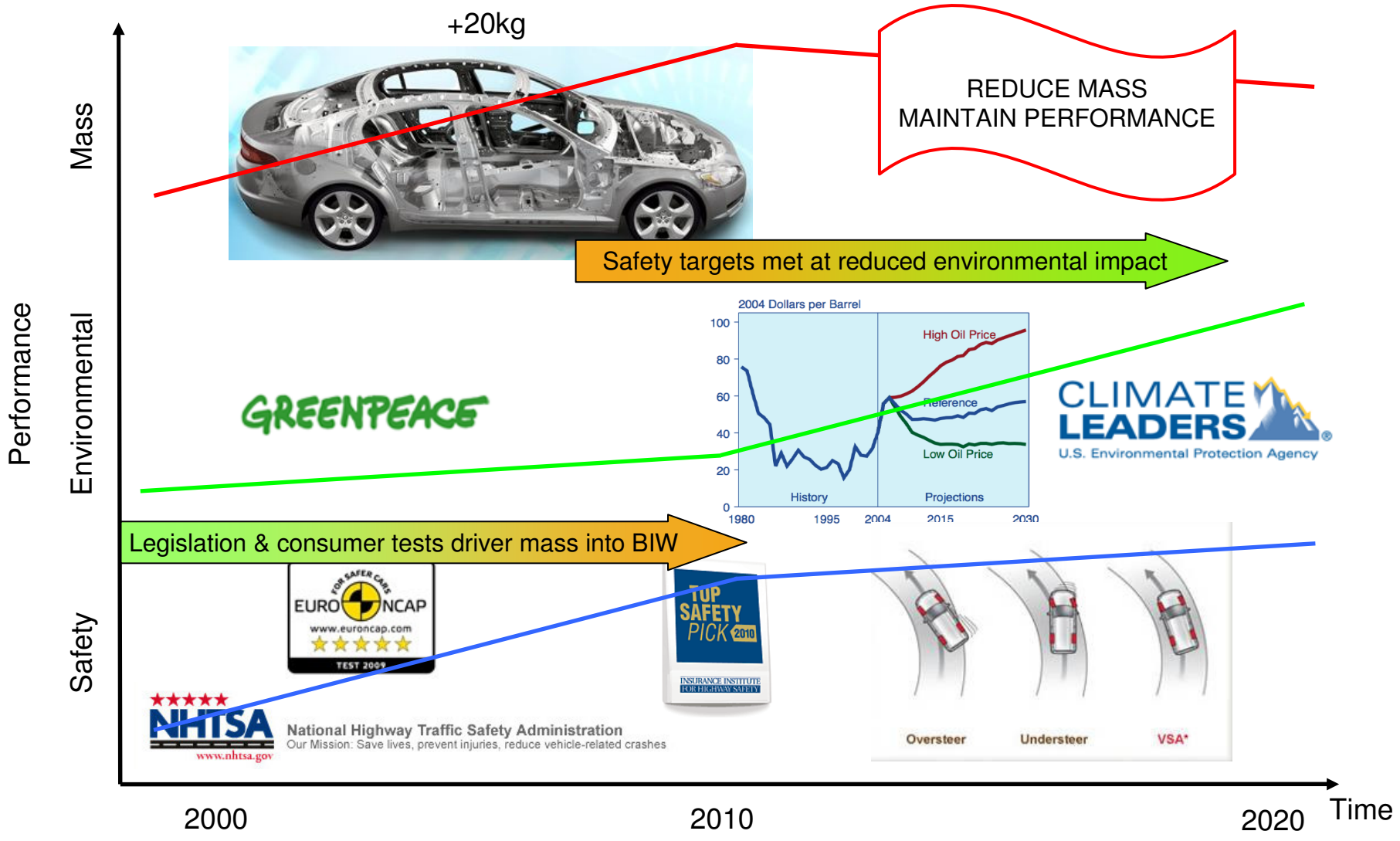
Project Engineer
MATFEM
Germany

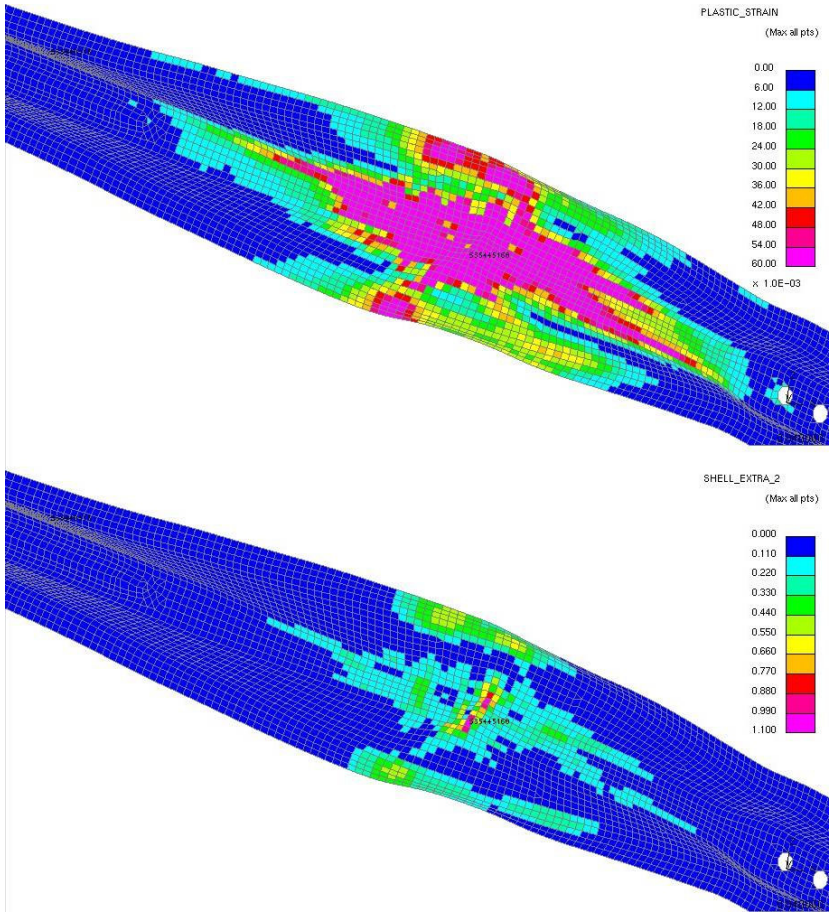
Agenda

- Statement of the Issue
- Partners
- Technical Solution
- Example
- Summary
- Questions

Automotive Industry Challenges



JLR: Fracture Prediction in Hot Formed Part



Very high risk using EPS => large change in thickness to fix the issue

Very small area of risk using CrachFEM => small change in thickness to fix the issue

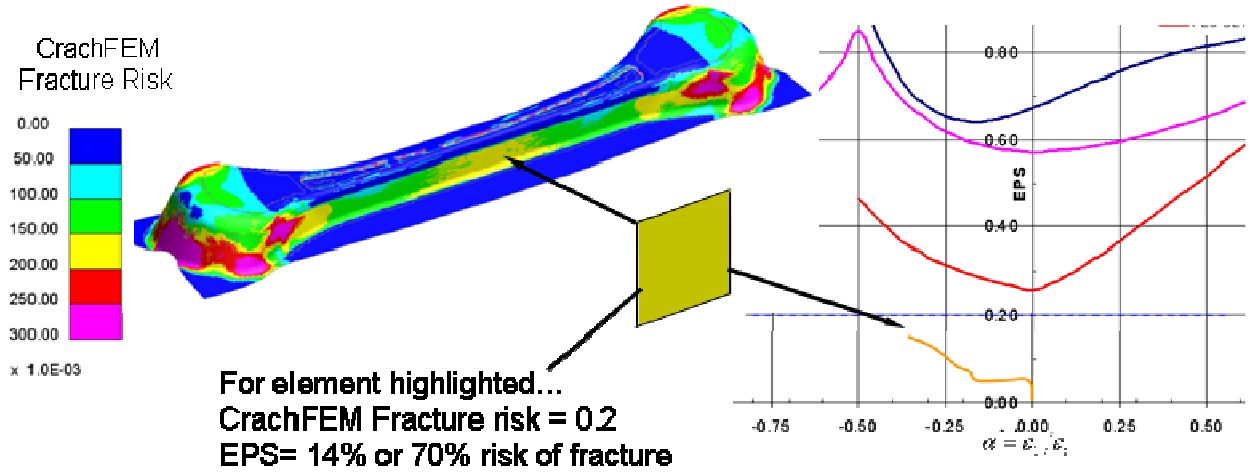
Demands on vehicle mass & performance drive new demands on CAE technique

A key enabler for reduced mass is improved prediction of fracture

JLR: Cold Formed Parts - New Data Requirements

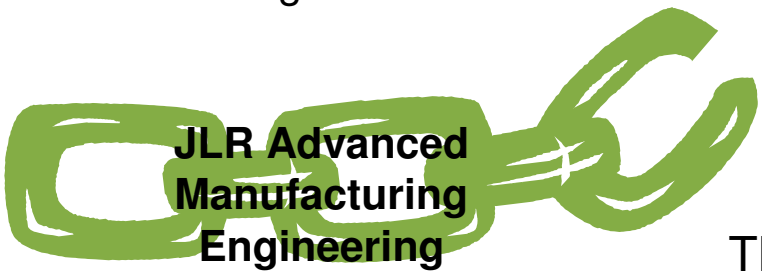
- Thinning
- EPS
- Strain path information
- Stamping ‘Damage’

All required to perform fracture assessment



Process Current State

Autoform is the standard tool at Jaguar/Landrover for deep-drawing simulations.

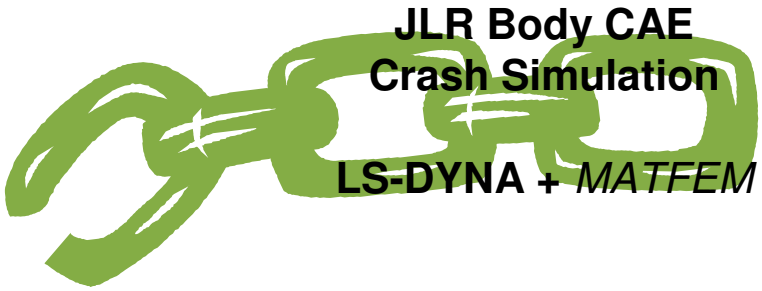


JLR Advanced Manufacturing Engineering

AUTOFORM
Forming Reality

!

The process chain is broken



JLR Body CAE Crash Simulation

LS-DYNA + ***MATFEM***

LS-DYNA & CrachFEM are the standard tool for fracture risk assessment in crash

Ideal State: A Single CAE data & process chain from virtual manufacturing to virtual test, using fully compatible codes.

Benefit: Full inclusion of manufacturing artefacts in BCAE analysis accurately capturing performance & failure modes

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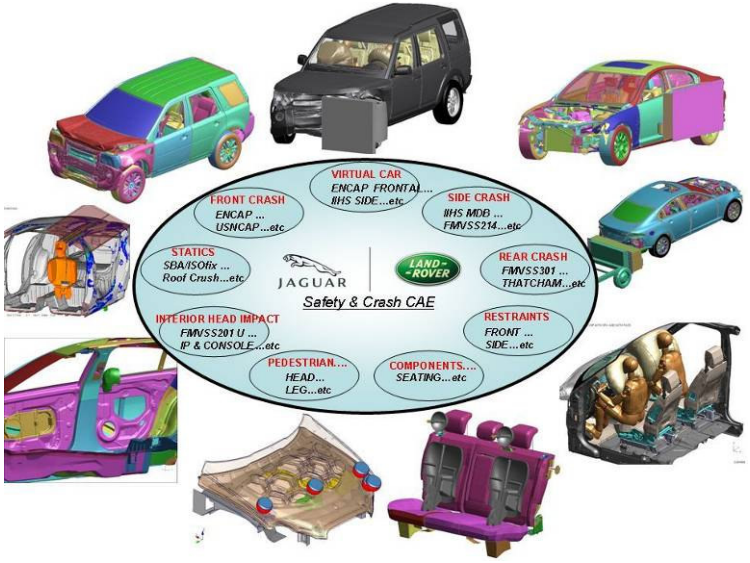
JLR

JLR: Body CAE & Manufacturing



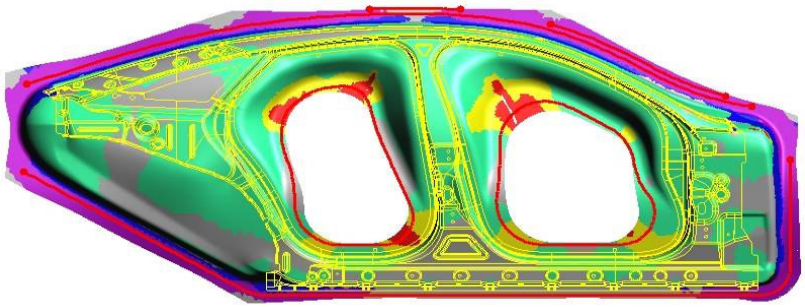
Body CAE

Full vehicle development & virtual sign off for safety attribute using LS Dyna.

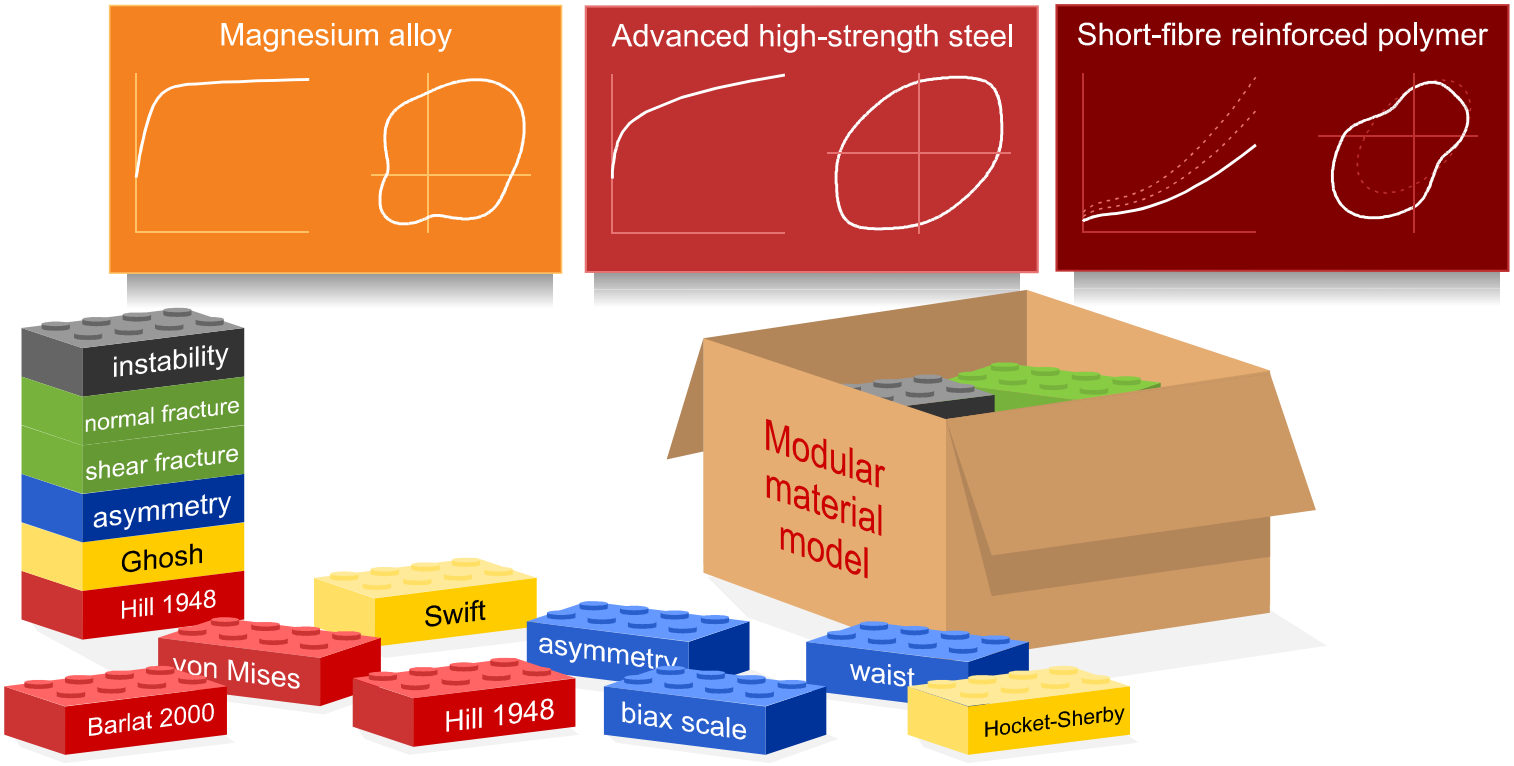
- Front, Side, Rear crash including occupant simulations
- Roof crush, Seat Belt Anchorage
- Interior Head Impact, Pedestrian

JLR Advanced Manufacturing Engineering

Management of all tooling and stamping feasibility development for large body panels.



MATFEM: General Approach using MF GenYld + CrachFEM

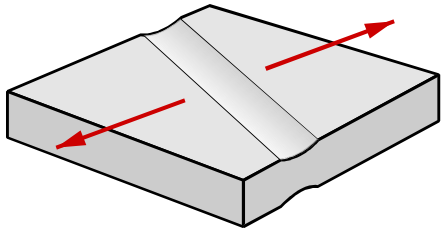


The *MATFEM* product 'MF GenYld + CrachFEM' is a modular material model for explicit FEM analyses.

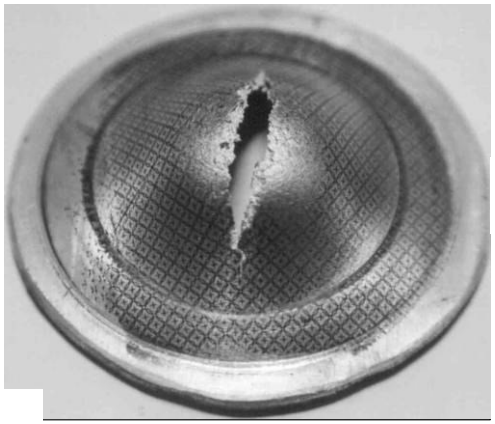
Elasto-plastic behaviour and failure of both metals and polymers can be modelled using 'MF GenYld + CrachFEM'.

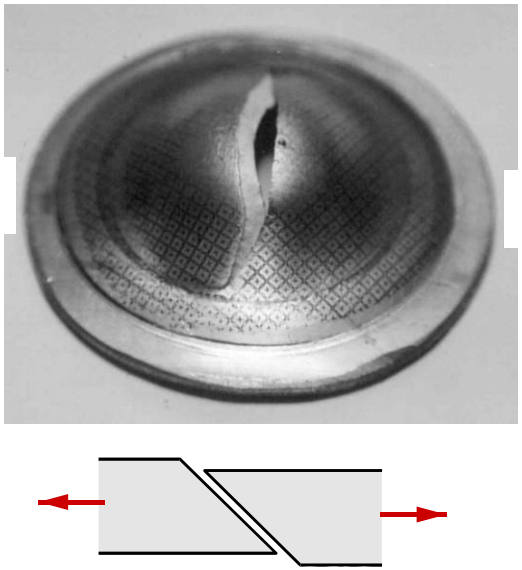
MATFEM: Failure Prediction using MF GenYld + CrachFEM

sheet instability | normal fracture | shear fracture



local necking ultimately leads to fracture

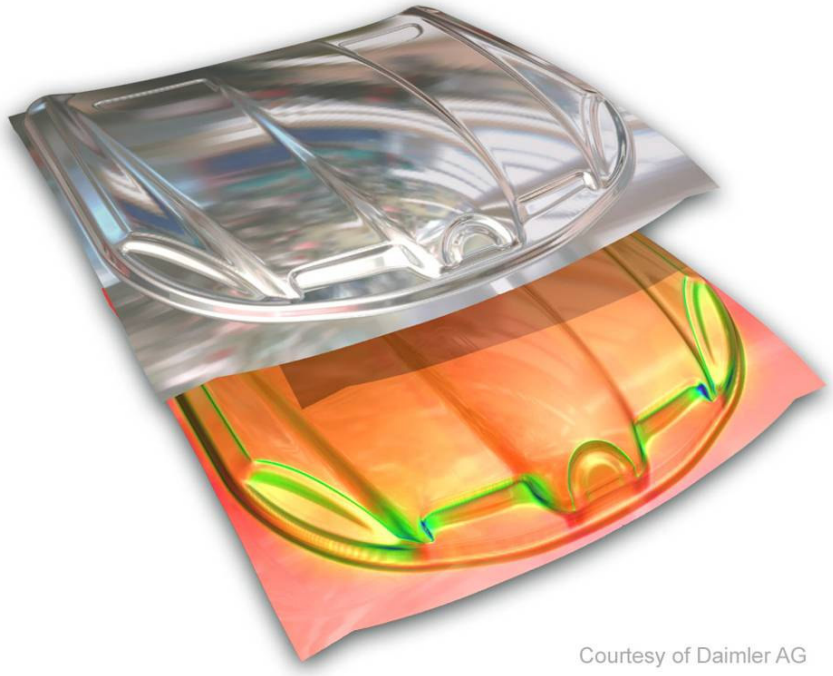




Failure depends on:

- material
- load case: stress state, strain state, strain rate
- process history: pre-strain, heat treatment

Autoform: First Choice for Stamping Simulation



Courtesy of Daimler AG

- Development and Sales of Software Solutions for…
- … the Sheet Metal Forming Industry
  - Simulation and Optimization of sheet metal forming processes
  - Modeling of tooling geometries
  - Cost calculation of tools/parts
- Customers:
  OEMs and suppliers of automotive industry

AutoForm: Extensive Customer Base

- 100% of the Top 20 automotive manufacturers
- 80% of the Top 50 automotive manufacturers
- > 450 suppliers: Tools & dies, steel & aluminum, components, engineering, design
- 2500 users worldwide in 40 countries

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Requirements Summary

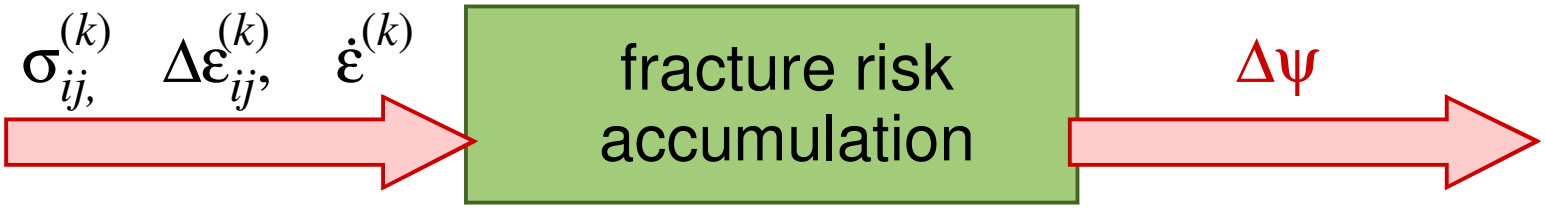
Autoform is the standard tool at JLR for deep-drawing simulations.

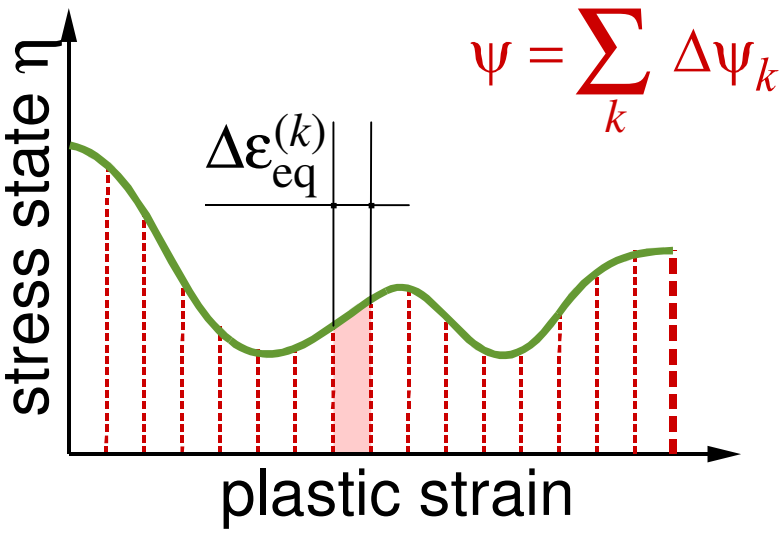
A new technique is required that creates a CrachFEM input file from an Autoform simulation.

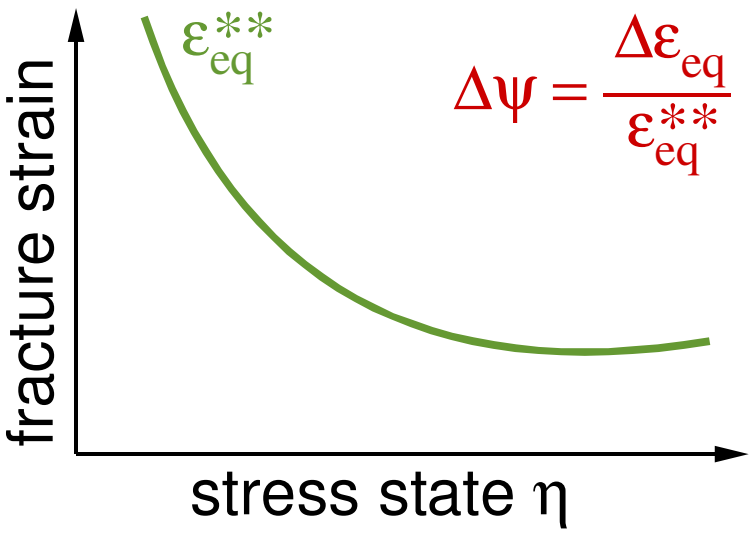
This technique should:

- be easy to use by stamping CAE engineer.
- have negligible resource overhead i.e. should be a fast, routine operation.
- export a dynain file in both binary & ascii formats.
- contain all data required for CrachFEM: 5 IP points & all fracture risks supported.

MF GenYld + CrachFEM : Fracture Prediction

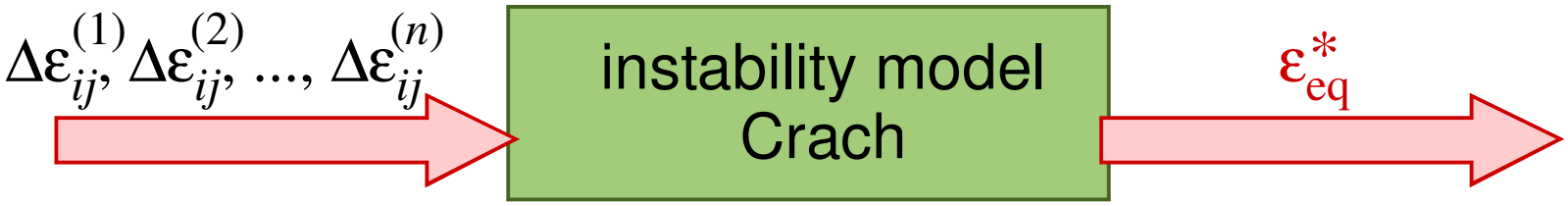


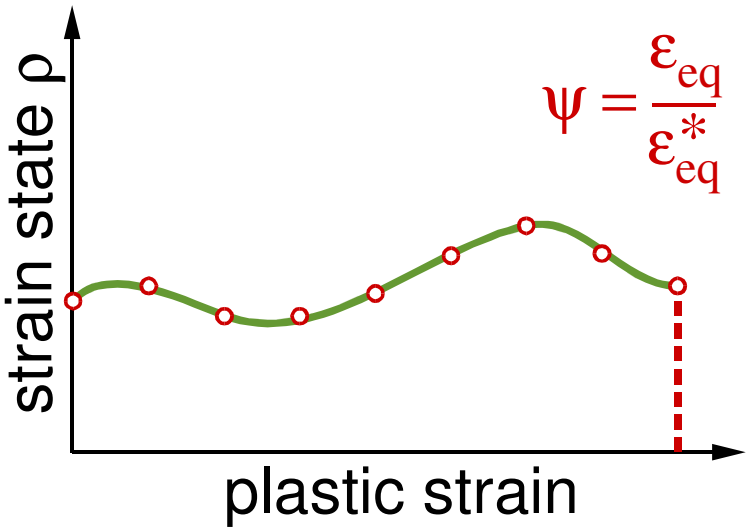




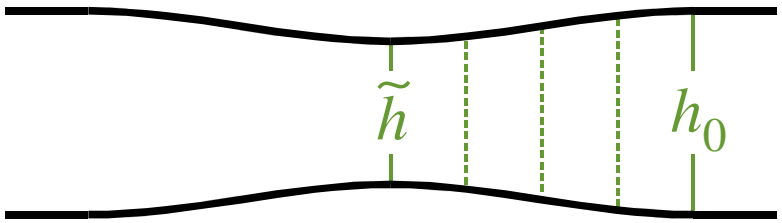
Strain tensor required for tensorial accumulation and stress tensor to determine stress state η.

CrachFEM: Instability prediction



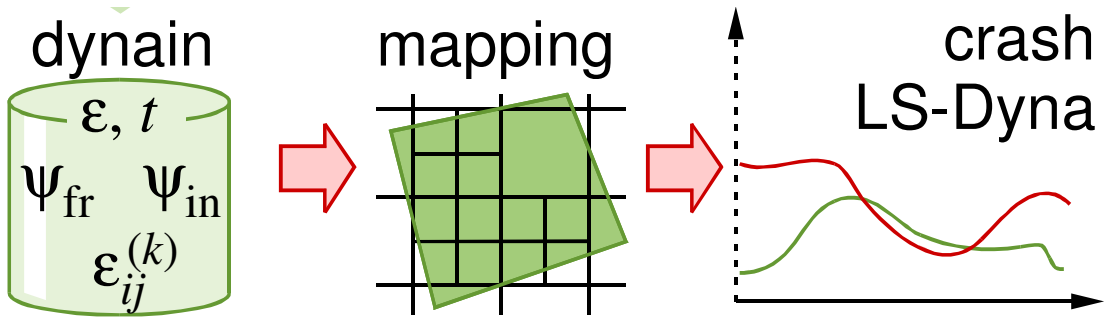


submodel: $F = \sigma_0 \cdot h_0 = \tilde{\sigma} \cdot \tilde{h}$



ε_{eq}^{*} strain at which equilibrium fails

Process chain



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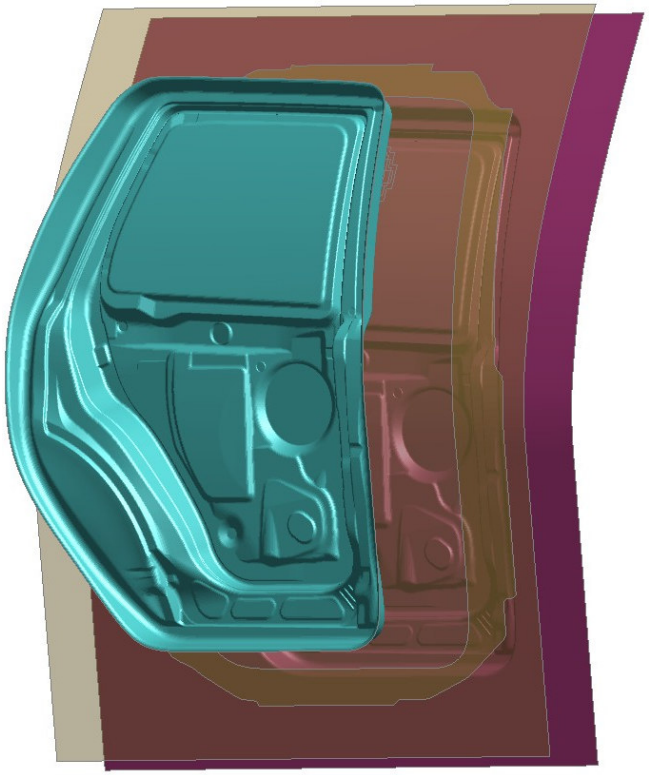
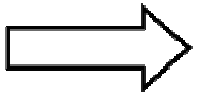
Validation Example: JLR Freelander Rear Door



Stamping

LS-DYNA
+
CrachFEM



Crash

LS-DYNA
+
CrachFEM

AUTOFORM
Forming Reality

Conversion

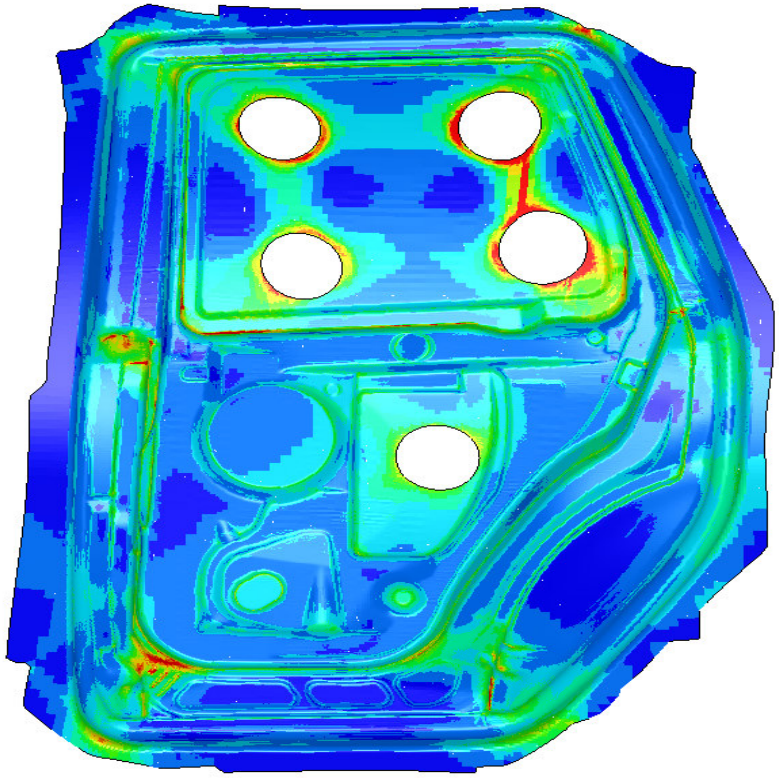
MF-CrachFEM
-AF2Dynain
+
Material

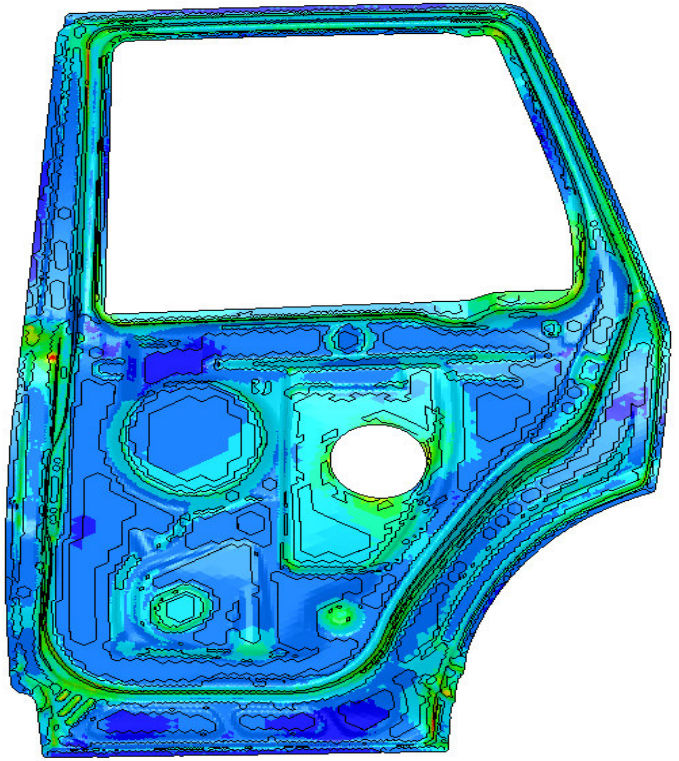
LS-DYNA
+
CrachFEM

Forming Simulation LS-Dyna vs Autoform: EPS

LS-DYNA

AUTOFORM





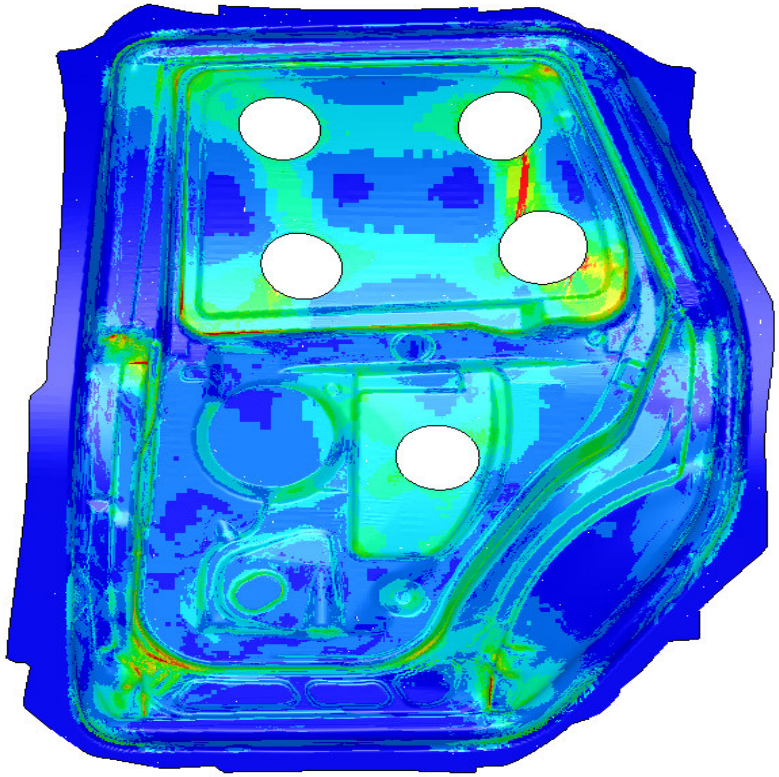
MESH: **STAMP** CRASH

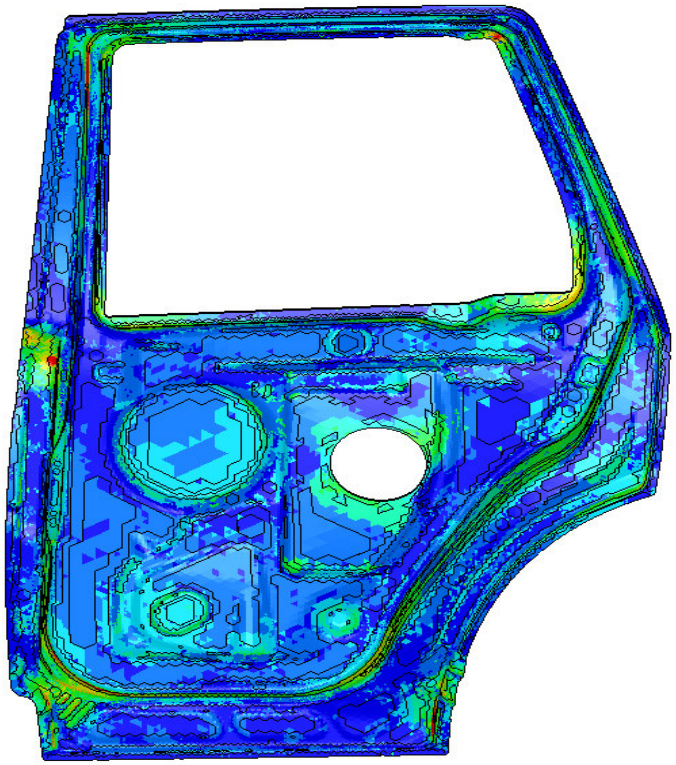
VARIABLE: **EPS** INSTABILITY

Forming Simulation LS-Dyna vs Autoform: Instability Risk

LS-DYNA

AUTOFORM





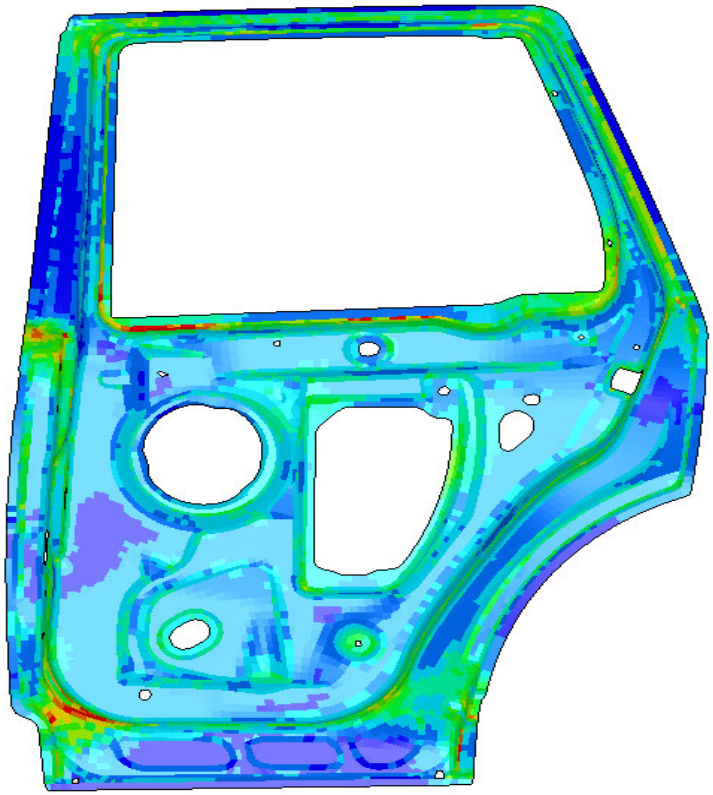
Instability risk

MESH: **STAMP** CRASH

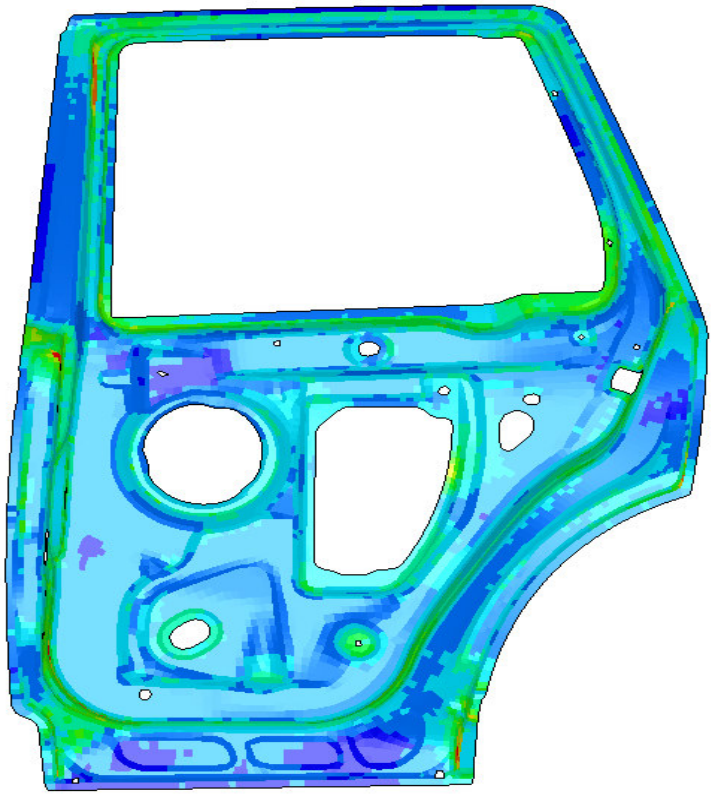
VARIABLE: EPS **INSTABILITY**

Mapped Data: EPS

LS-DYNA



AUTOFORM



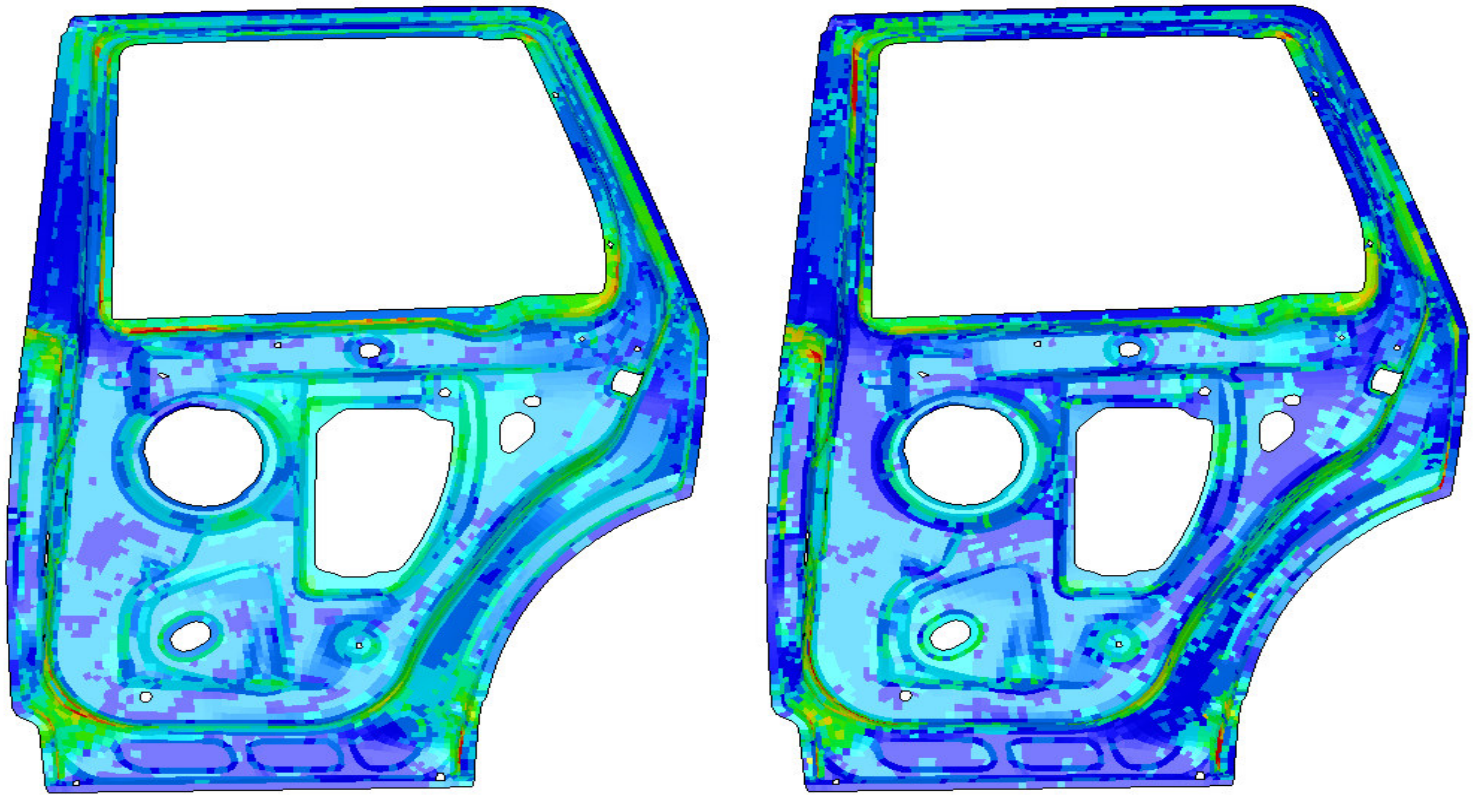
MESH: STAMP **CRASH**

VARIABLE: **EPS** INSTABILITY

Mapped Data: Instability Risk

LS-DYNA

AUTOFORM

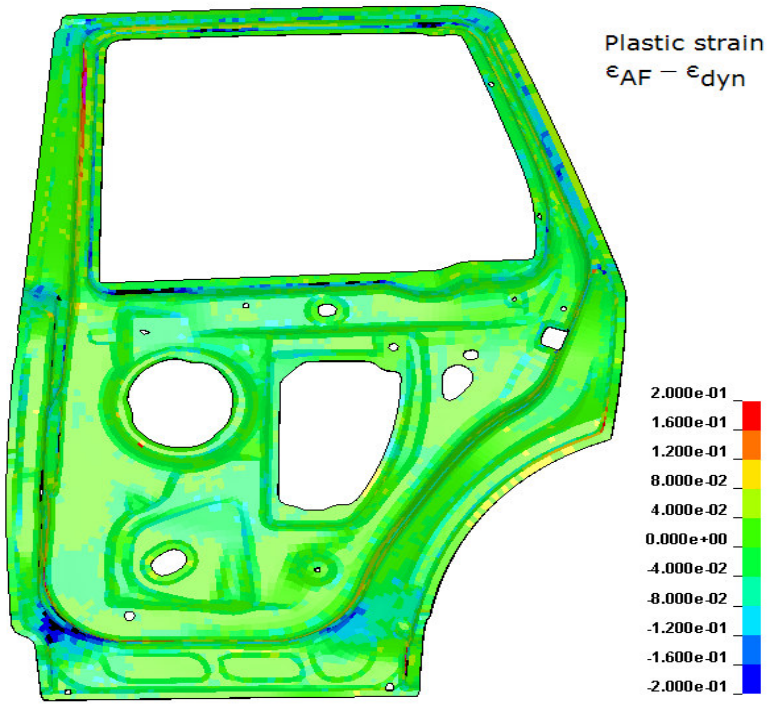


MESH: STAMP **CRASH**

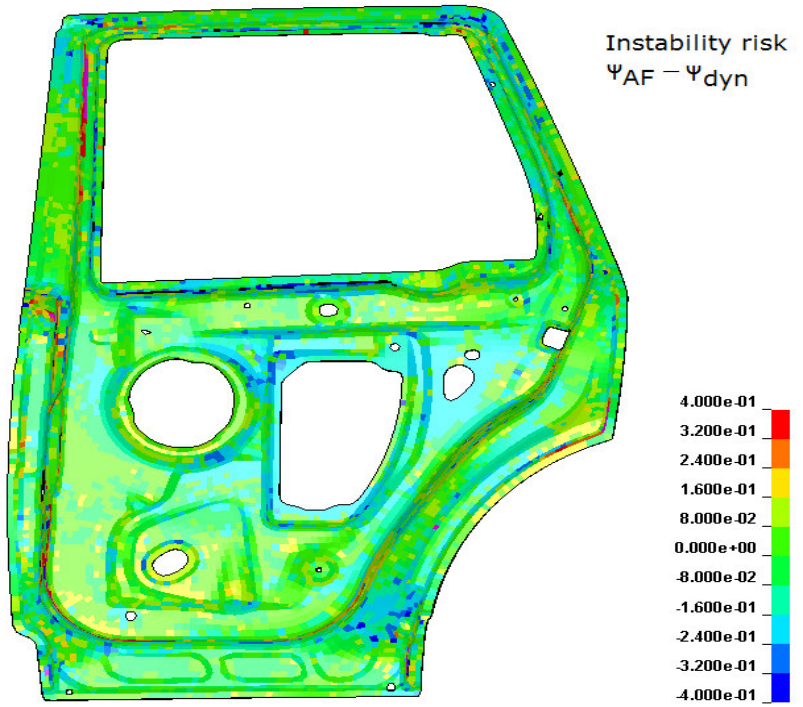
VARIABLE: EPS **INSTABILITY**

Difference: Autoform – LS-Dyna

EPS



INSTABILITY



MESH: STAMP **CRASH**

VARIABLE: **EPS** **INSTABILITY**

Results Summary

- Autoform & LS Dyna stamping simulation results are different when EPS is compared
- Fracture risk in the two processes is different but not significantly so
- Differences in calculated fracture risk can be attributed to the difference in predicted EPS *not* the fracture calculation methods
- The process is acceptable to use

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Process Summary

Autoform is the standard tool at JLR for deep-drawing simulations.

A new technique is required that creates a CrachFEM input file from an Autoform simulation.

This technique should:

- be easy to use by stamping CAE engineer. ✓
- have negligible resource overhead i.e. should be a fast, routine operation. ✓
- export a dynain file in both binary & ascii formats. ✓
- contain all data required for CrachFEM: 5 IP points & all fracture risks supported. ✓

Process Current State

Autoform is the standard tool at Jaguar/Landrover for deep-drawing simulations.

LS-DYNA & CrachFEM are the standard tool for fracture risk assessment in crash

A Single CAE data & process chain from virtual manufacturing to virtual test, using *fully compatible* codes has been created & has been proven to work

Future Developments

- AutoForm Crach-FEM support available in Version AutoForm^{plus} R3
  - Mapping file contains crash relevant data from forming simulation and all information necessary to map the data to a crash model is created using a *MATFEM* script
- API to read the mapping file is available as dynamic link library for Windows 32/64 bit and Linux 64 bit
- API will be made available for AutoForm customers as part of an AutoForm^{plus} installation

Thanks for listening