

Field- and X-Ray-Measurement for Passenger Airbag System Analysis



Open Technology Forum at **CRASHTEST EXPO
EUROPE 2008**

Session: Measurement, Calibration and Test Data Acquisition



Fraunhofer Institut
Kurzzeitdynamik
Ernst-Mach-Institut



A Methodical Project to Establish and Combine new Testing Technologies to Verify Numerical Simulations

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EMI-Dep. Material Dynamics, Experimental Ballistics and Numerical Simulation

characterization



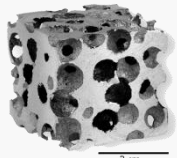
metals



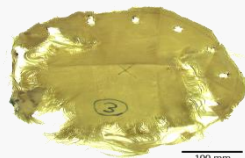
thermoplastics



elastomere



metal foams



airbag textiles



composites

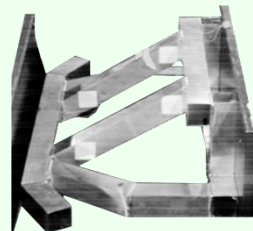
component tests



aluminum tubes

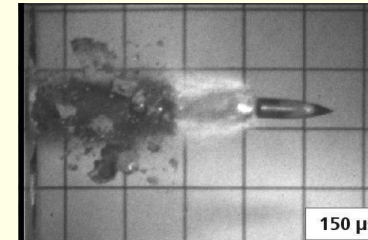


passenger airbag systems



space frame geometry

measurement



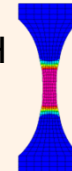
high speed photography and measurement



high speed x-ray cinematography

num. simulation

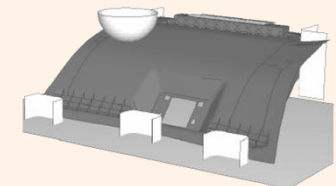
PAM-CRASH



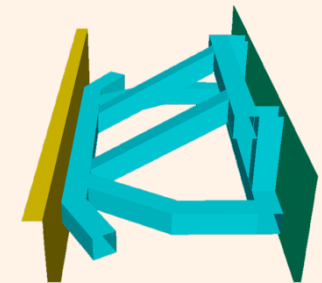
LS-DYNA



ABAQUS explicit



SOPHIA (EMI)



APOLLO (CFD), AUTODYN

Field- and X-Ray-Measurement: Motivation und Ambition for OEMs

challenge:

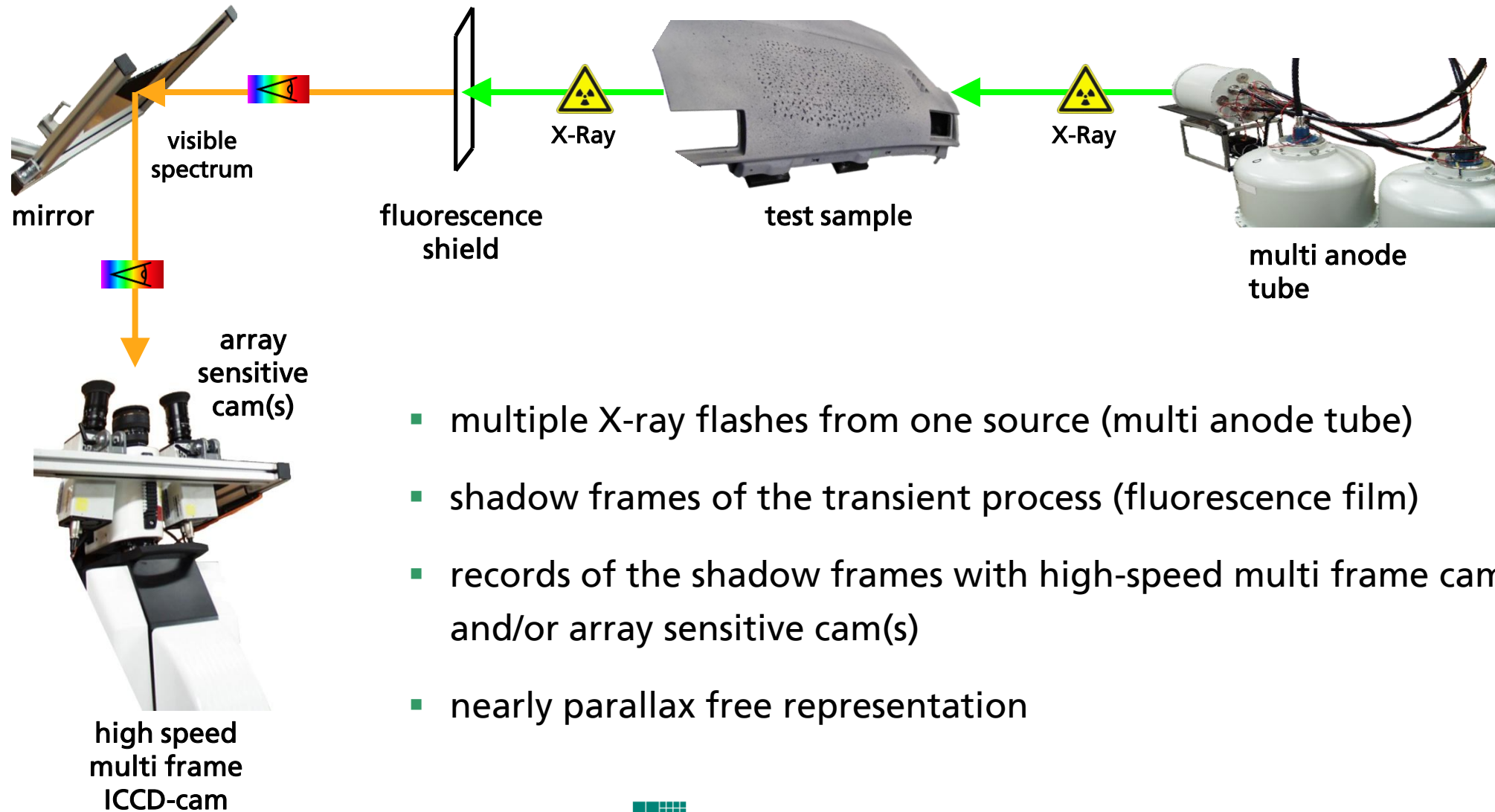
- evaluations of airbag tests are very complex regarding the development behavior of airbags and the strains of the passenger airbag system
- no quantitative statements
- no quantitative validating possibility for numerical simulations for the passenger airbag system opening



solution:

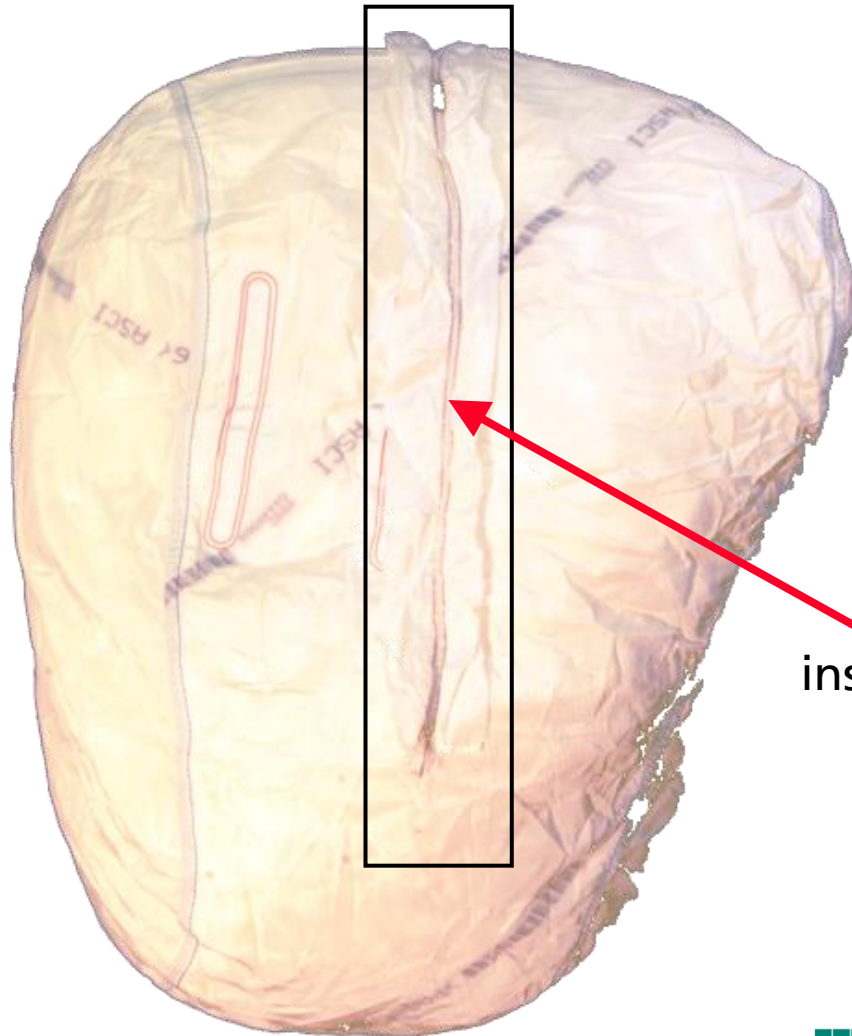
- impact tests on passenger airbag system with field-measurement of the strains and validation of numerical simulations
- field-measurements of the strains of the passenger airbag system at airbag ignition
- testing the passenger airbag system with X-ray measurement pictures of the inflation behavior

X-Ray-Measurement: Construction



- multiple X-ray flashes from one source (multi anode tube)
- shadow frames of the transient process (fluorescence film)
- records of the shadow frames with high-speed multi frame cam and/or array sensitive cam(s)
- nearly parallax free representation

X-Ray-Measurement: Preparation of the samples



airbag marked with a lead wire to get better contrast in the X-Ray-frames.

inserted marker



X-ray frame of passenger airbag system with marked airbag.

X-Ray-Measurement: Optical Resolution

Array sensitive cam(s) with cooled CCD:

resolution: 1280 x 1024 pixel,
number of single frames during test = number of available cams (max. 8)

before ignition



t=0 ms

slush-skin opens



t=8 ms

airbag comes out

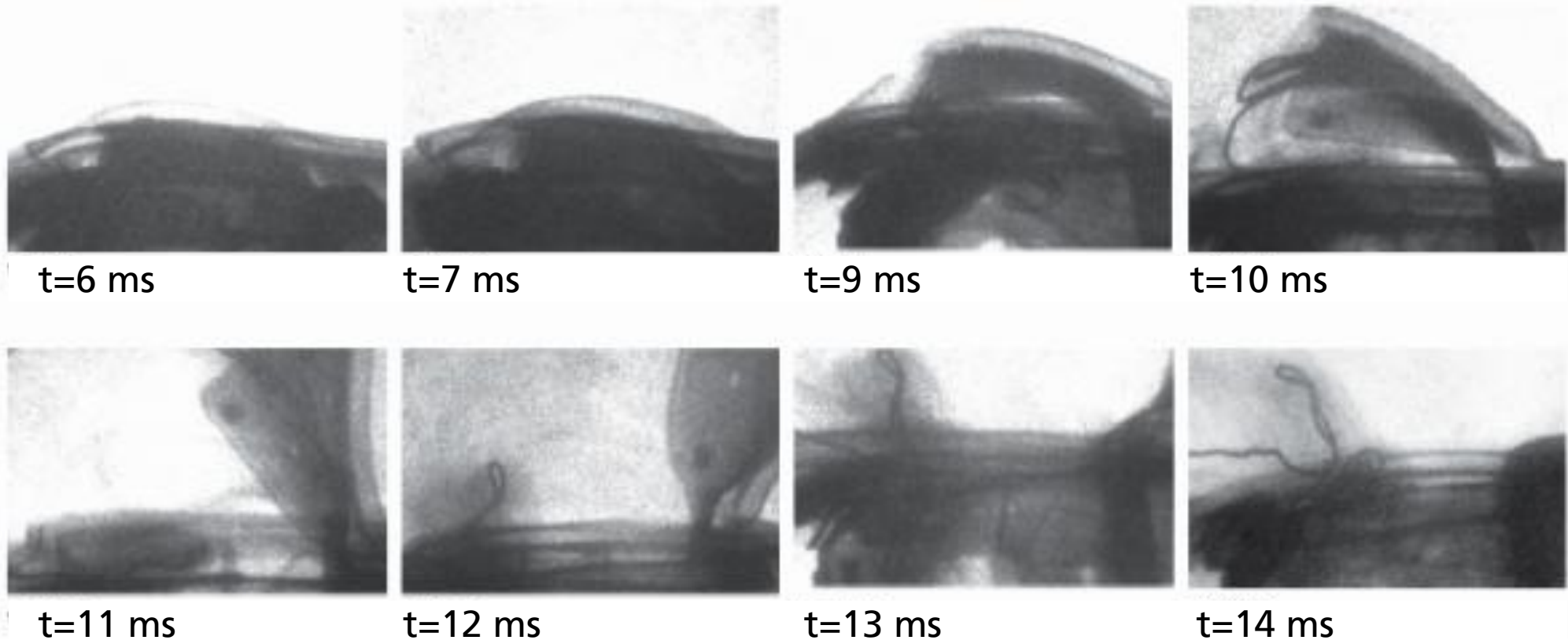


t=10 ms

X-Ray-Measurement: Time Resolution

High-speed multiframe ICCD-cam:

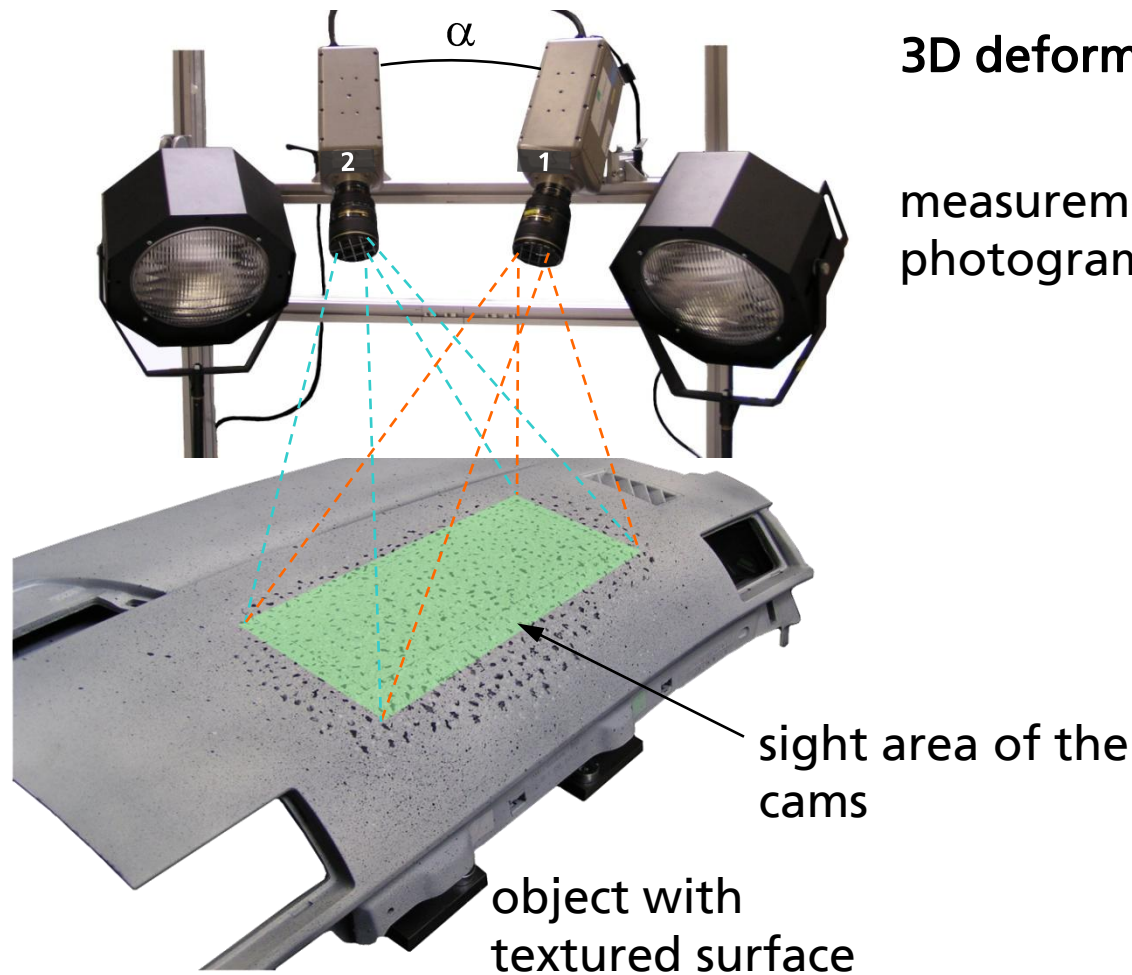
resolution: effectively 320 x 256 Pixel,
number of single frames during test = max. 8



Results, comparison, evaluation, possibilities (validating the simulation)

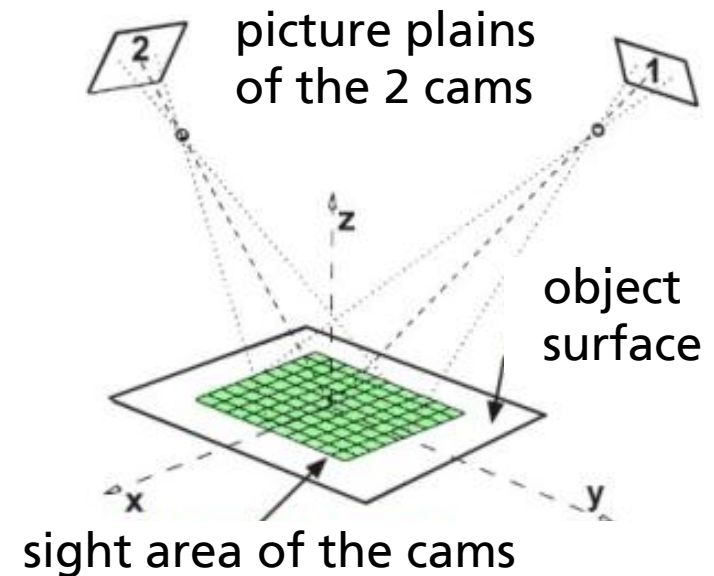
- procedure for the extensive characterization of opening the passenger airbag system
- quantitative method for validating numerical simulations
- numerical simulation of airbag and gas generator requires innovative approaches for modeling
- X-ray-measurement techniques enables the visualization of the beginning inflation behavior of passenger airbag systems

Optical Field-Measurement: 3D-Deformation-Analysis



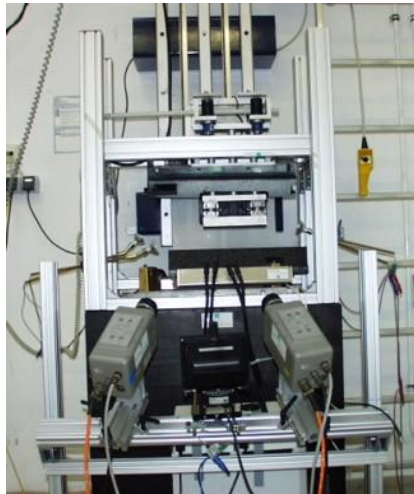
3D deformation analysis by grey scale correlation

measurement principle:
photogrammetry, stereovision and image analysis

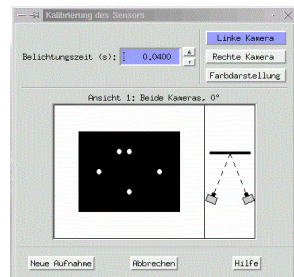


Optical Field-Measurement: Airbag Replacement Test for Simulation

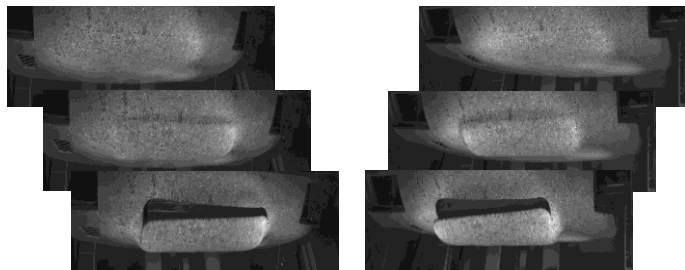
experimental model: impact test



test facility



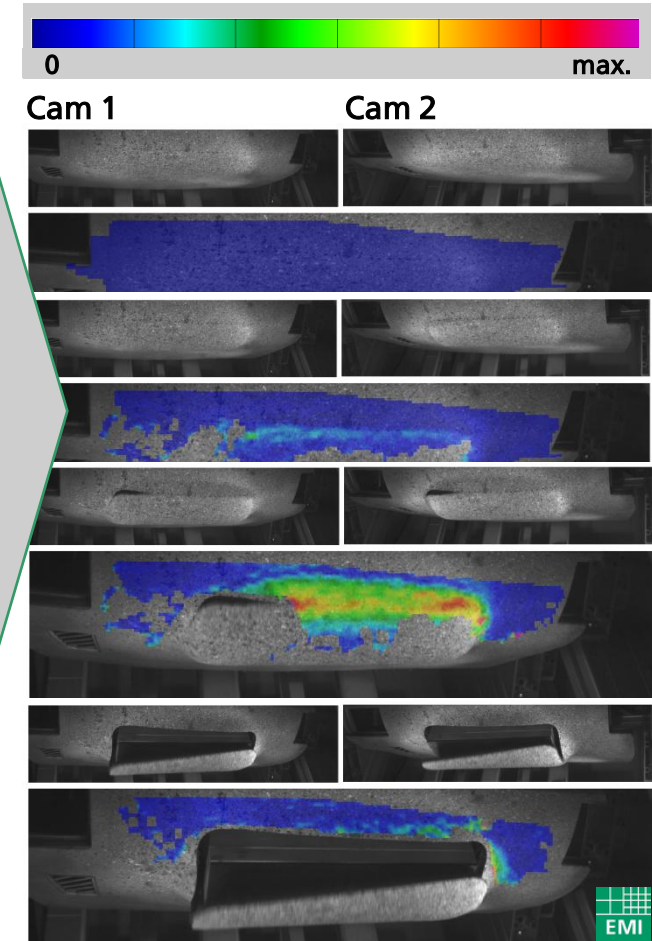
calibration



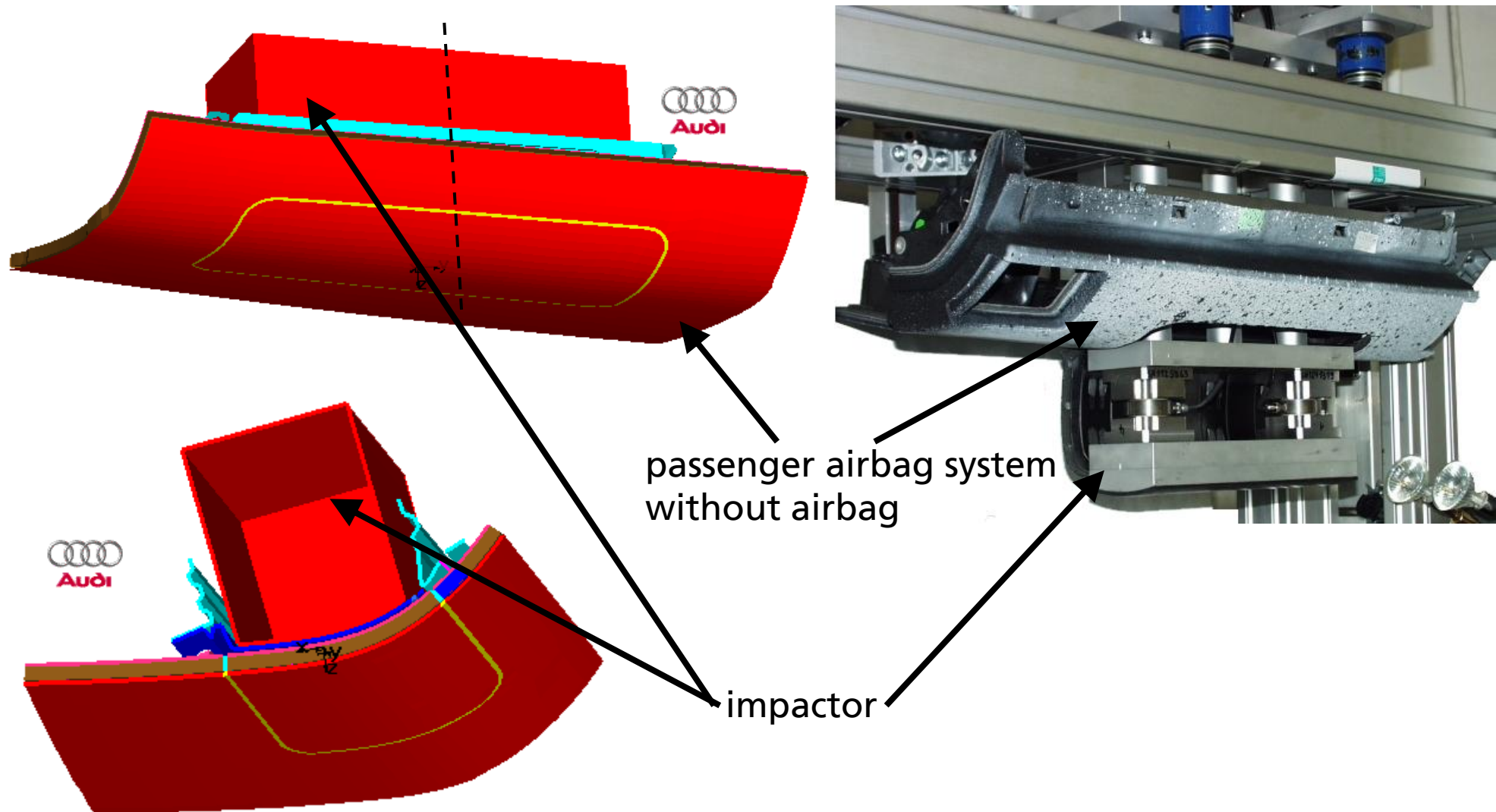
2 synchronized serial frame series

analysis of serial frames
with software ARAMIS
⇒ 3D-displacement fields
for every pair of frames
of the object surface
⇒ calculation of
the strains

techn. strain v. Mises [%]

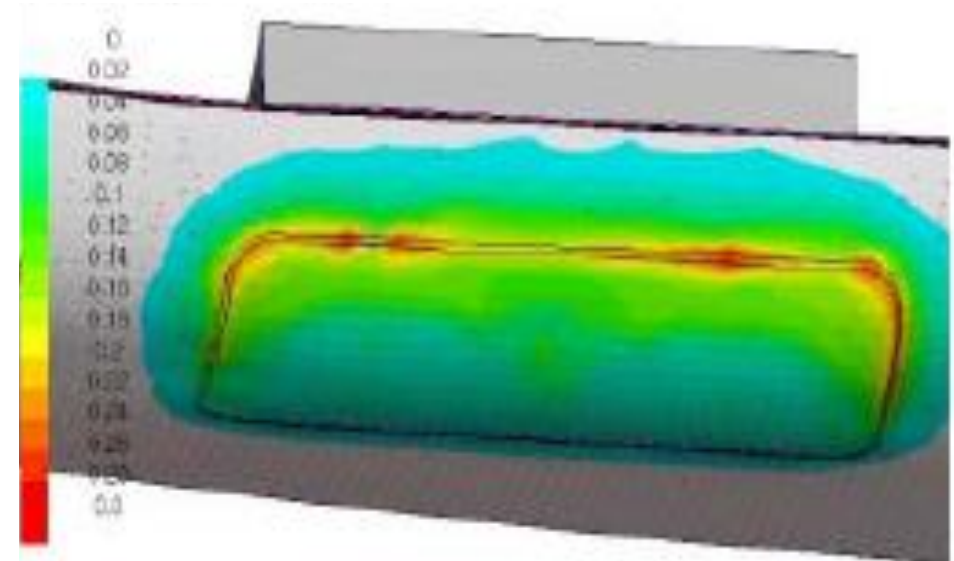
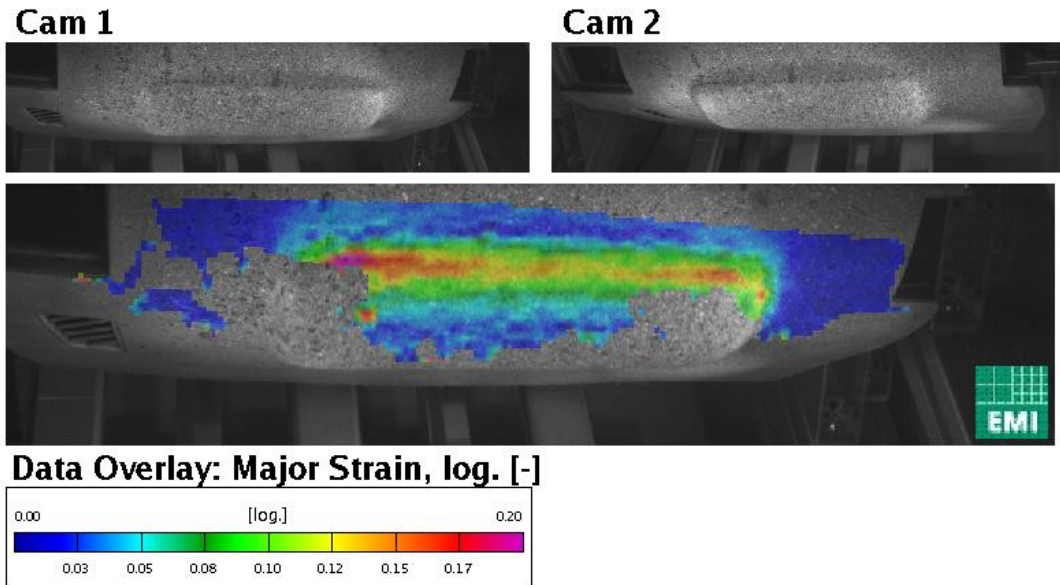


Optical Field-Measurement: Airbag Replacement Test for Simulation



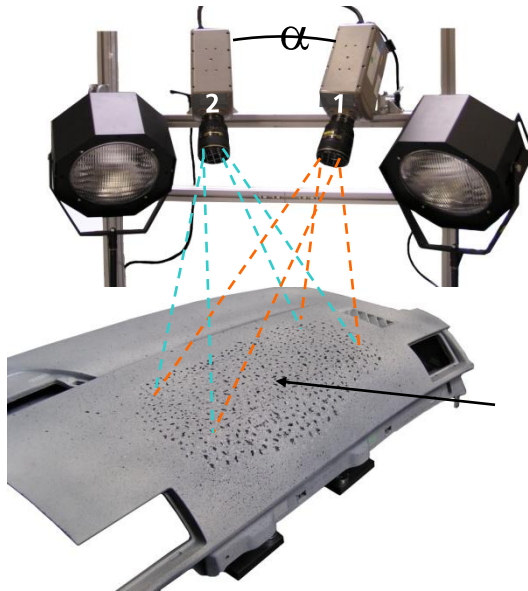
Optical Field-Measurement: Airbag Replacement compared with Simulation

Comparing the test and simulation results in the moment of breaking the skin.

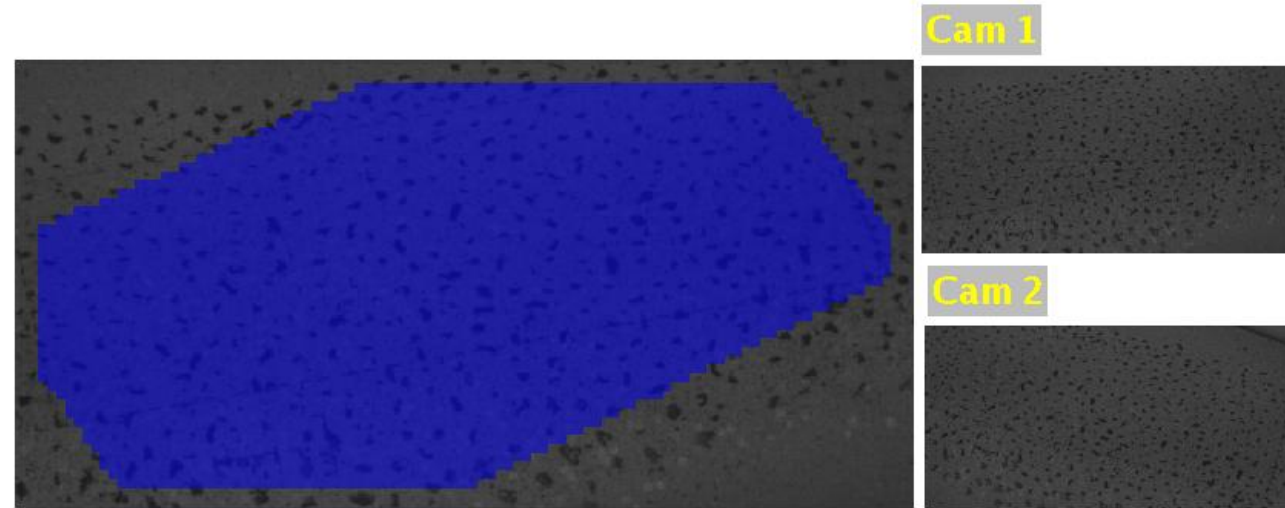


Optical Field-Measurement: Passenger Airbag System with Airbag

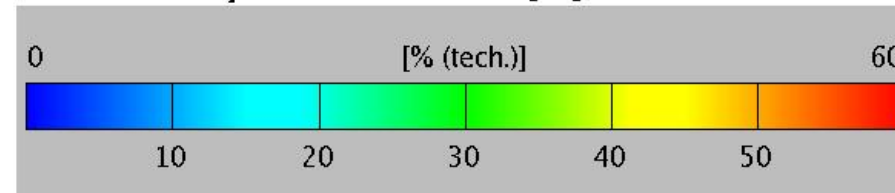
Passenger airbag system tested completely with airbag



results of the optical field-measurement



Data Overlay: v.Mises Strain [%]



passenger airbag system

load transmission by airbag inflation

resolution: 512x256 pixel

frame rate: 7390 fps (frames per second)

exposure-time: 40 μ s



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passenger airbag system



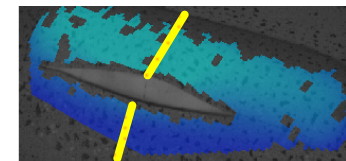
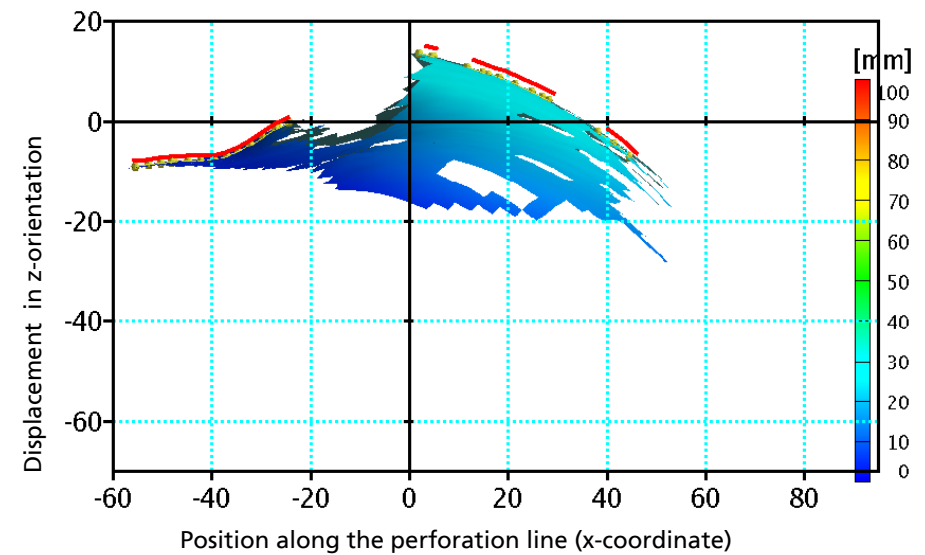
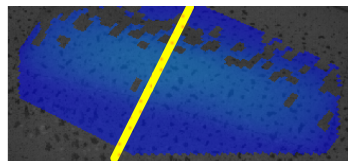
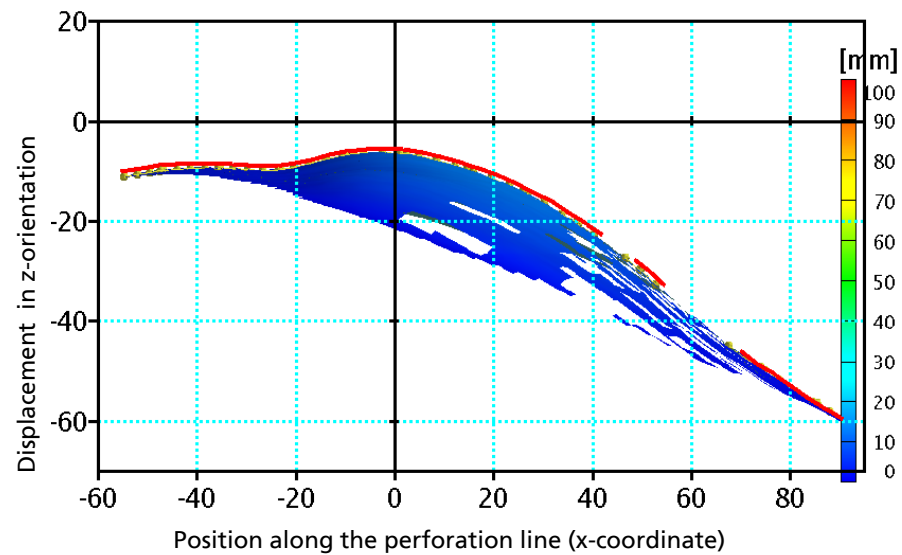
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Optical Field-Measurement: Test results

Results of the optical field-measurement

diagram of the contour-cut (yellow), together with the optical displacement towards (red)

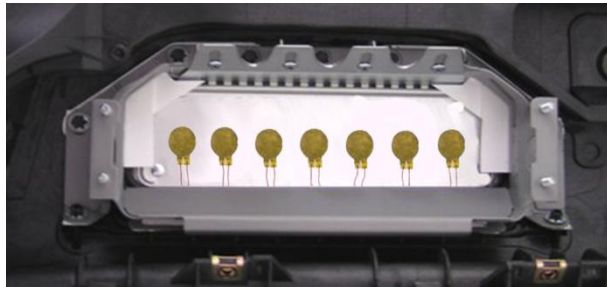


In-suite Flap Loading Measurement

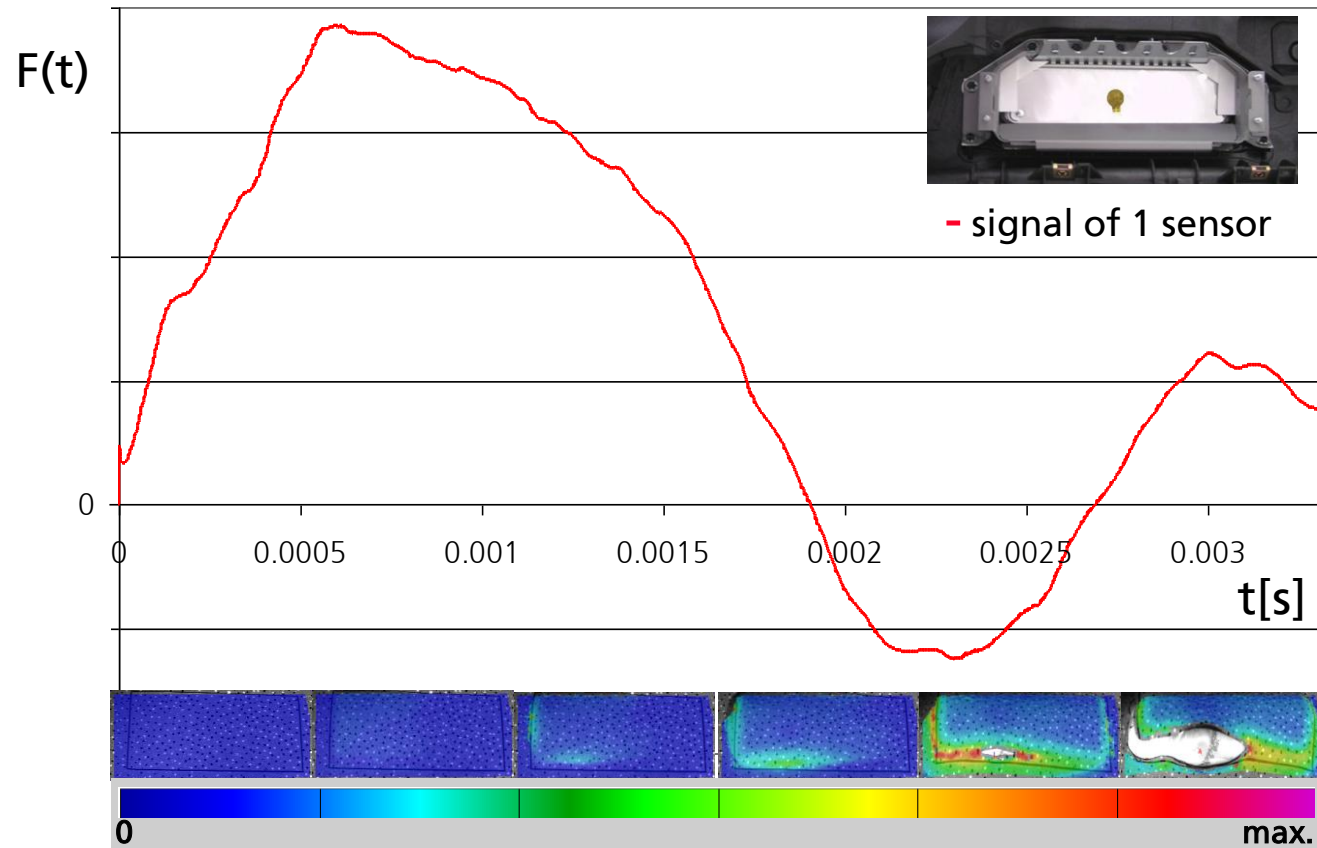
Force measurement of the flap loading during airbag inflation

transient force distribution

applied PVDF sensors
between flap and airbag



passenger airbag system
interior view of the flap



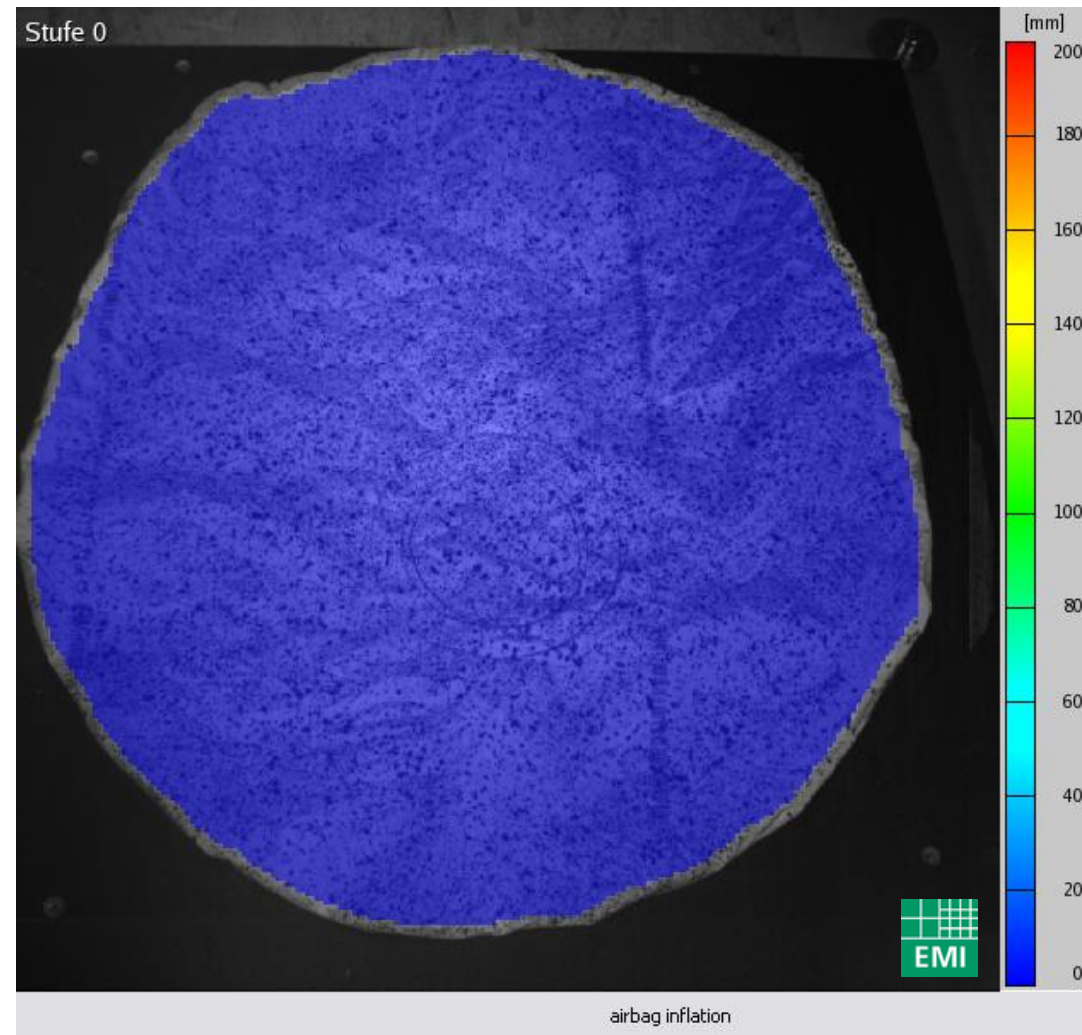
Optical Field-Measurement: Airbag Inflation

Inflation of an unfolded driver's airbag

results of the optical field-measurement.

analysis of the displacement field of the airbag during inflation

data overlay: displacement z
(out of plan)



Summary: Optical Field-Measurement and Simulation

Quantitative evaluation of the strains of the PVC skin:

- analysis of the spatial distribution of the strains
- characterization PVC
- indication concerning the place and the reproducibility of the point of opening

Quantitative evaluation of the flap kinetics:

- flap dents before opening
- important information for first-shot-behavior of OOP Dummies and windshield contact of the flap

Analyzing the airbag inflation:

- airbag shows wrinkling during the inflating
- important information about irregular inflating

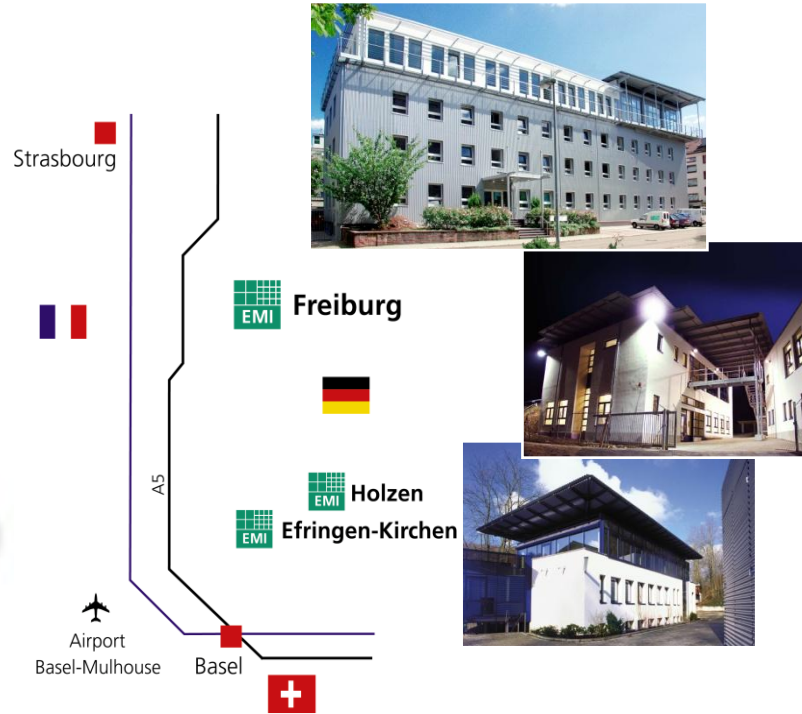
State of the art

- **forces** can be determined with flexible local resolution
- **X-ray measurement** enables the analysis of covered motions inside the structures

Not far away from

- **high speed CT extension** of X-ray measurement in 3D is under development (3D-viewings of internal structures under dynamic loads)
- **optical field-measurement** can be integrated as standard device into the development process and into the quality assurance
- **application for airbag textiles**, for example, with the distinction between tension failure and contact-induced failure

Thanks for your attention.



Special thanks to

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stand: C2036