Development of an LS-DYNA model of a bicycle helmet by reverse engineering

Ketuo Zhou[a,c], Anja Wagner[a], Klaus Bauer[a], Felix Roesler[a], Shanshan Wu[a], Steffen Peldschus[b], Fabian Duddeck[c]

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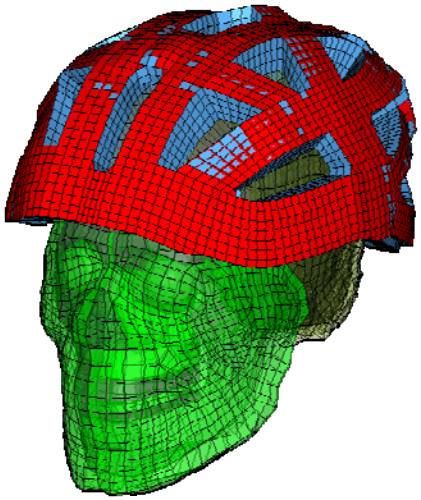
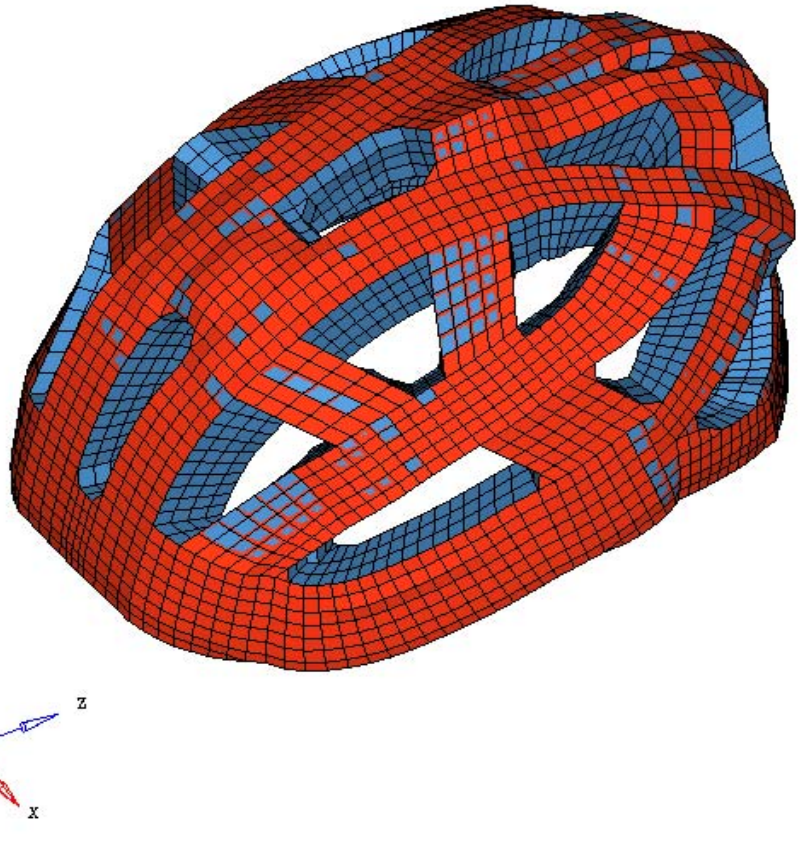


Numerical Models

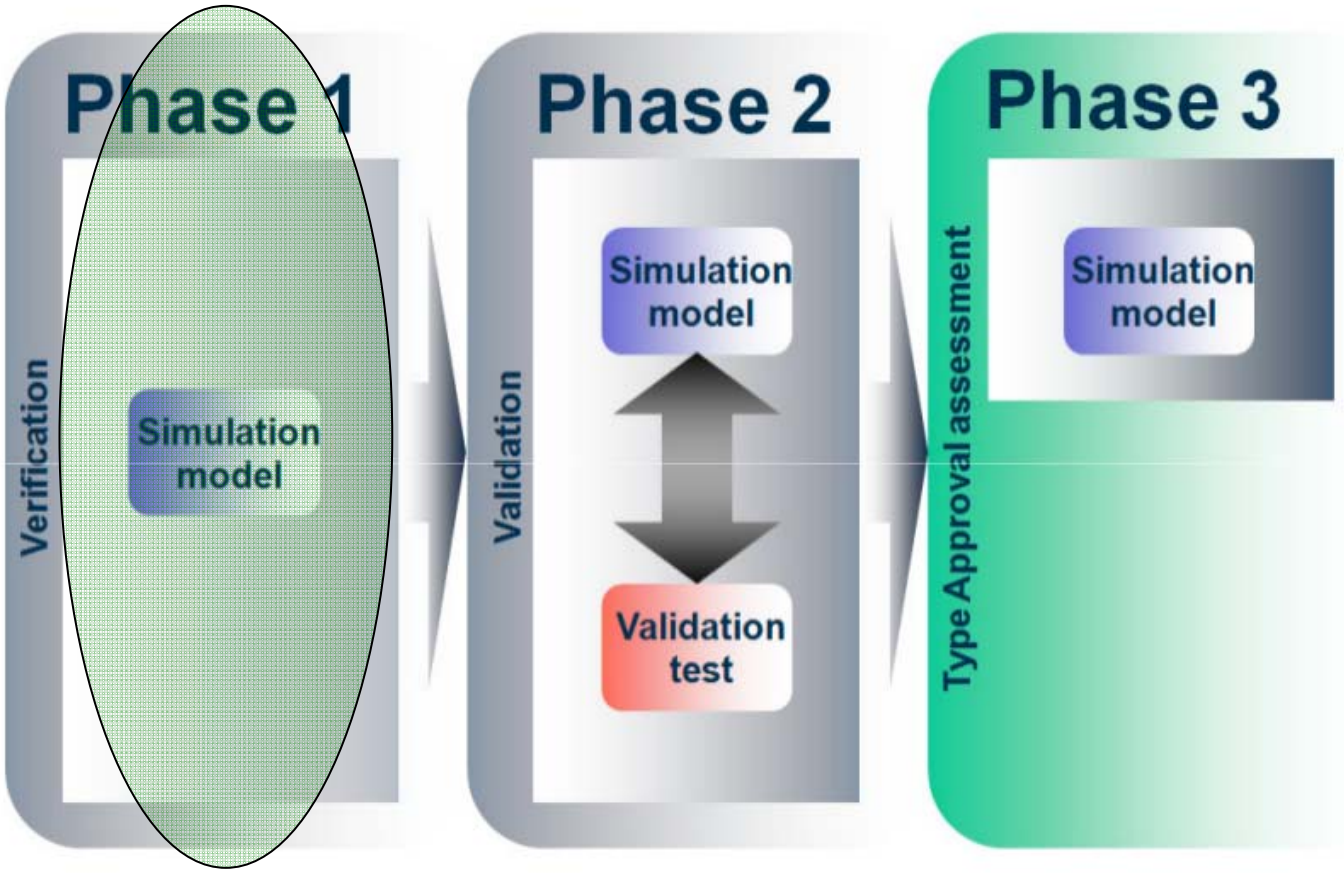
The geometry model

The FE model



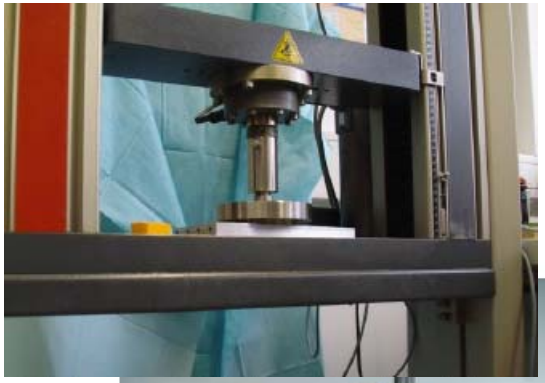
Virtual test Approaches

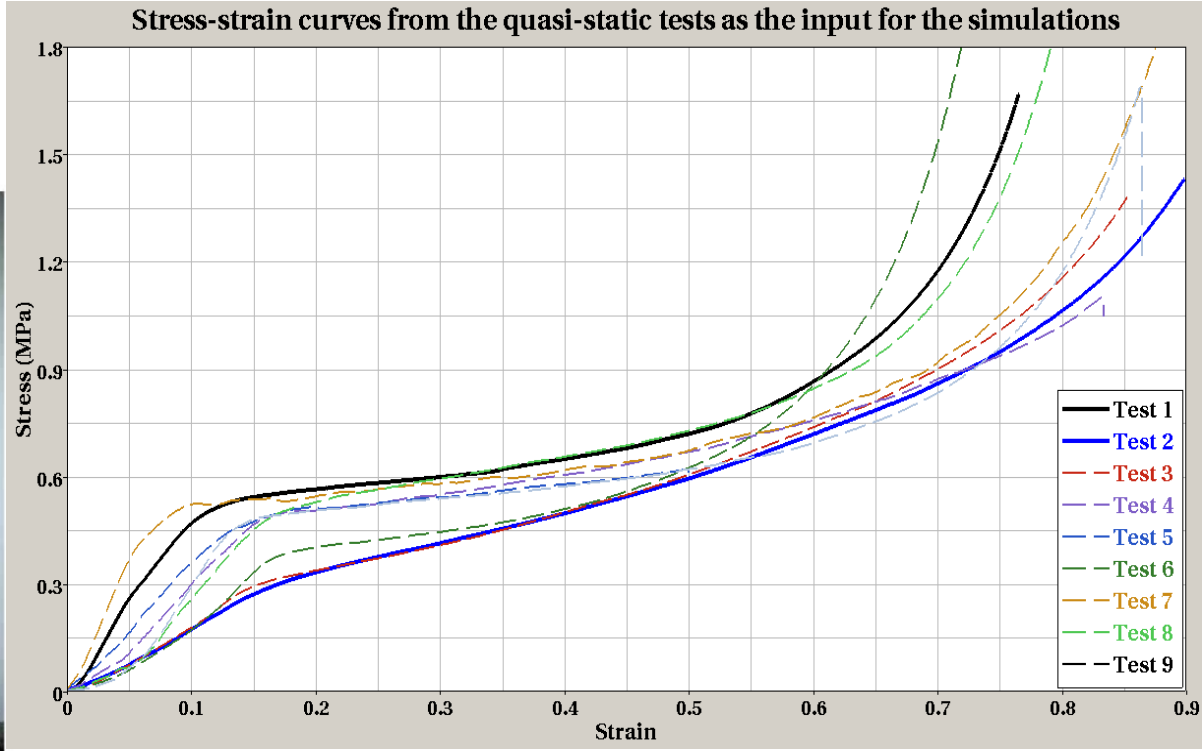
Full VT approach



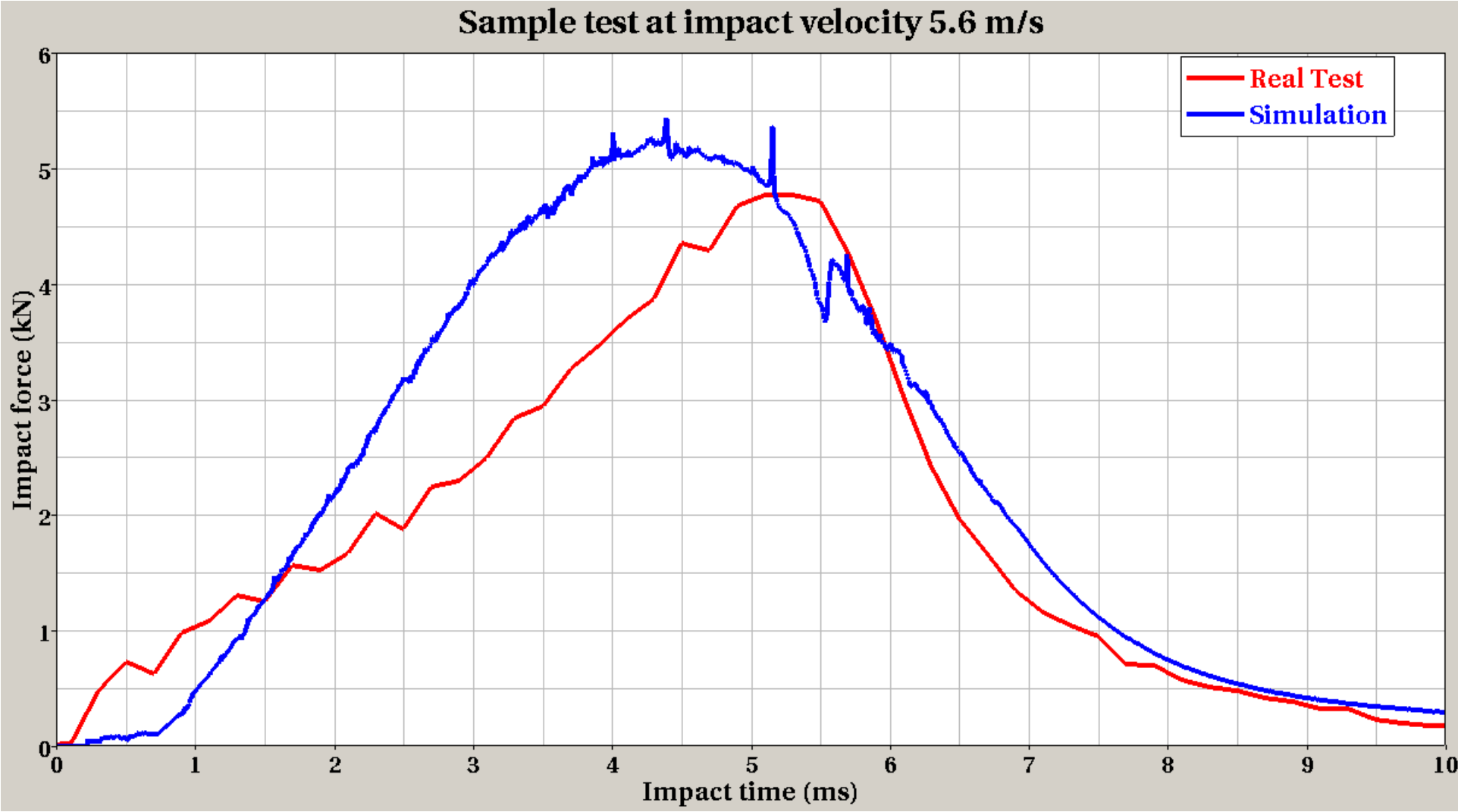
Quote from A. Eggers, imviter 2012

Experimental Tests *(quasi-static & dynamic)*





Model Development and Verification



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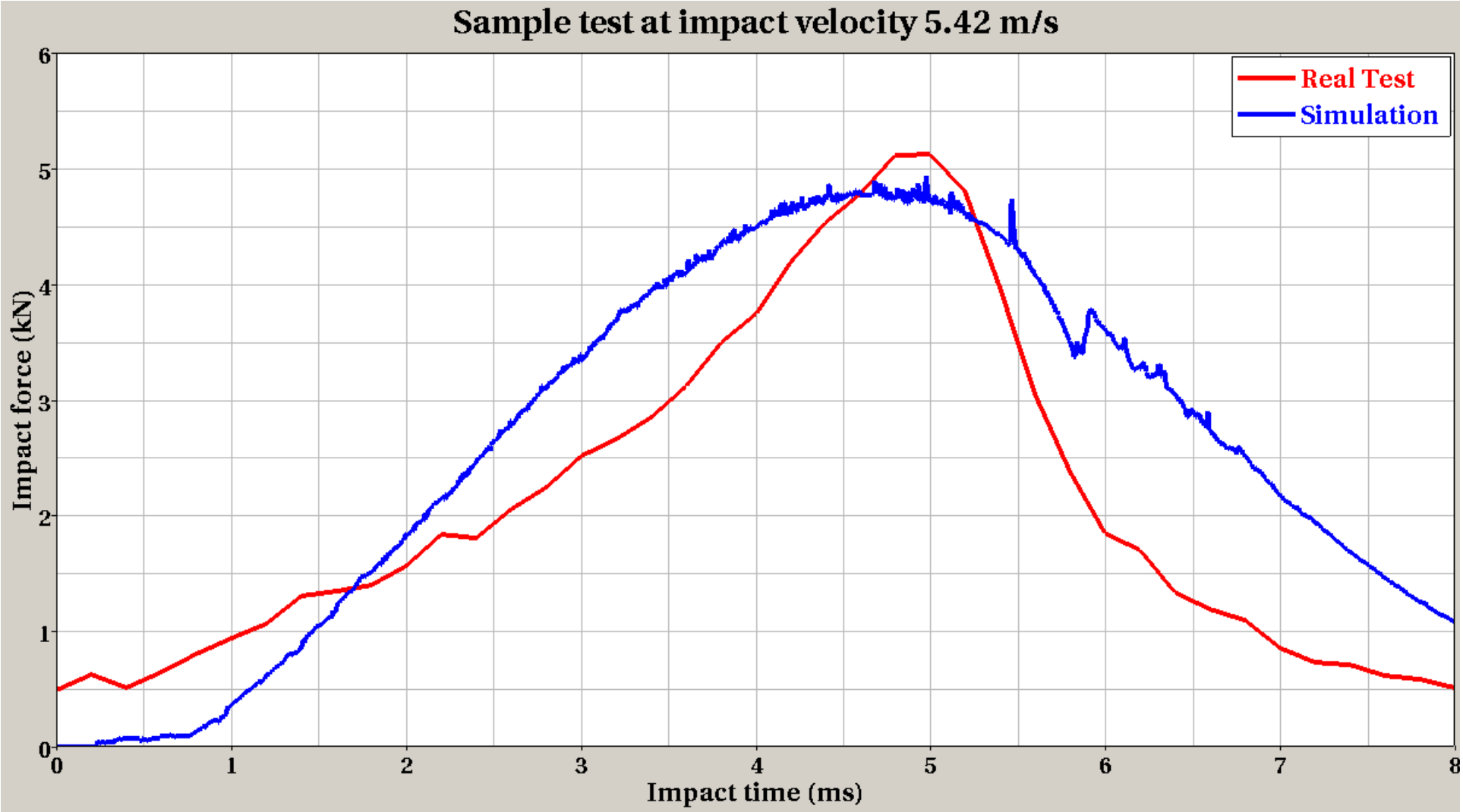

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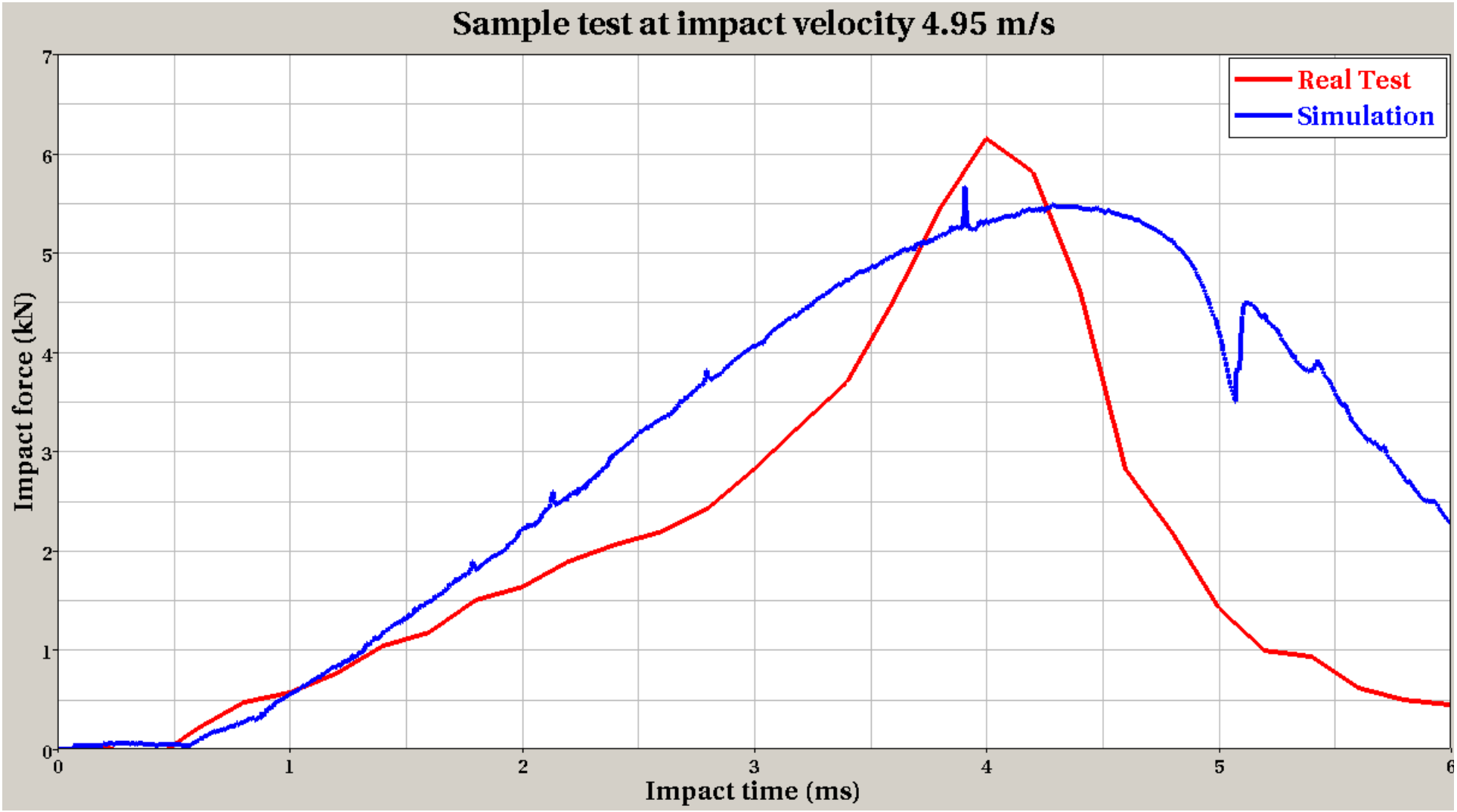

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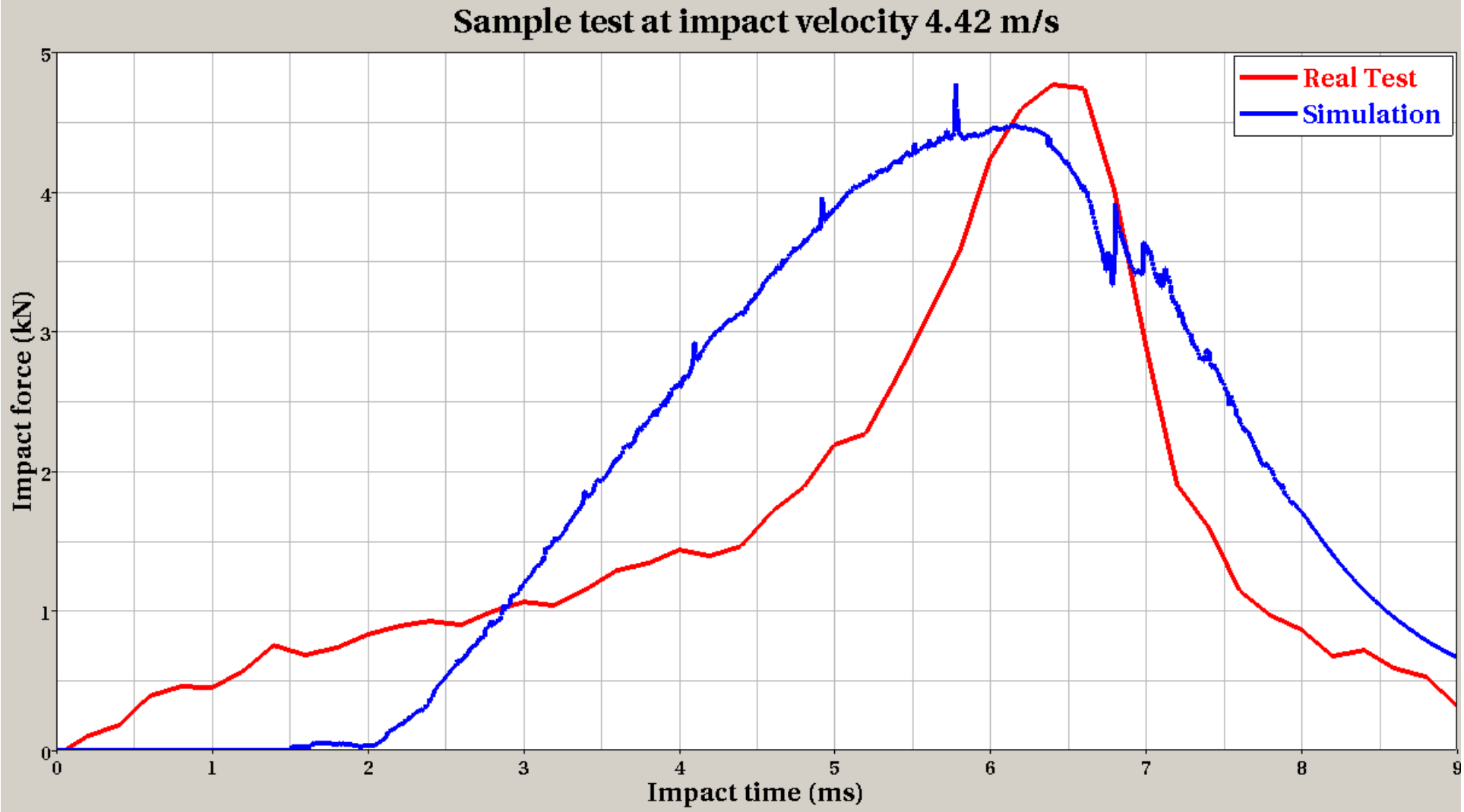

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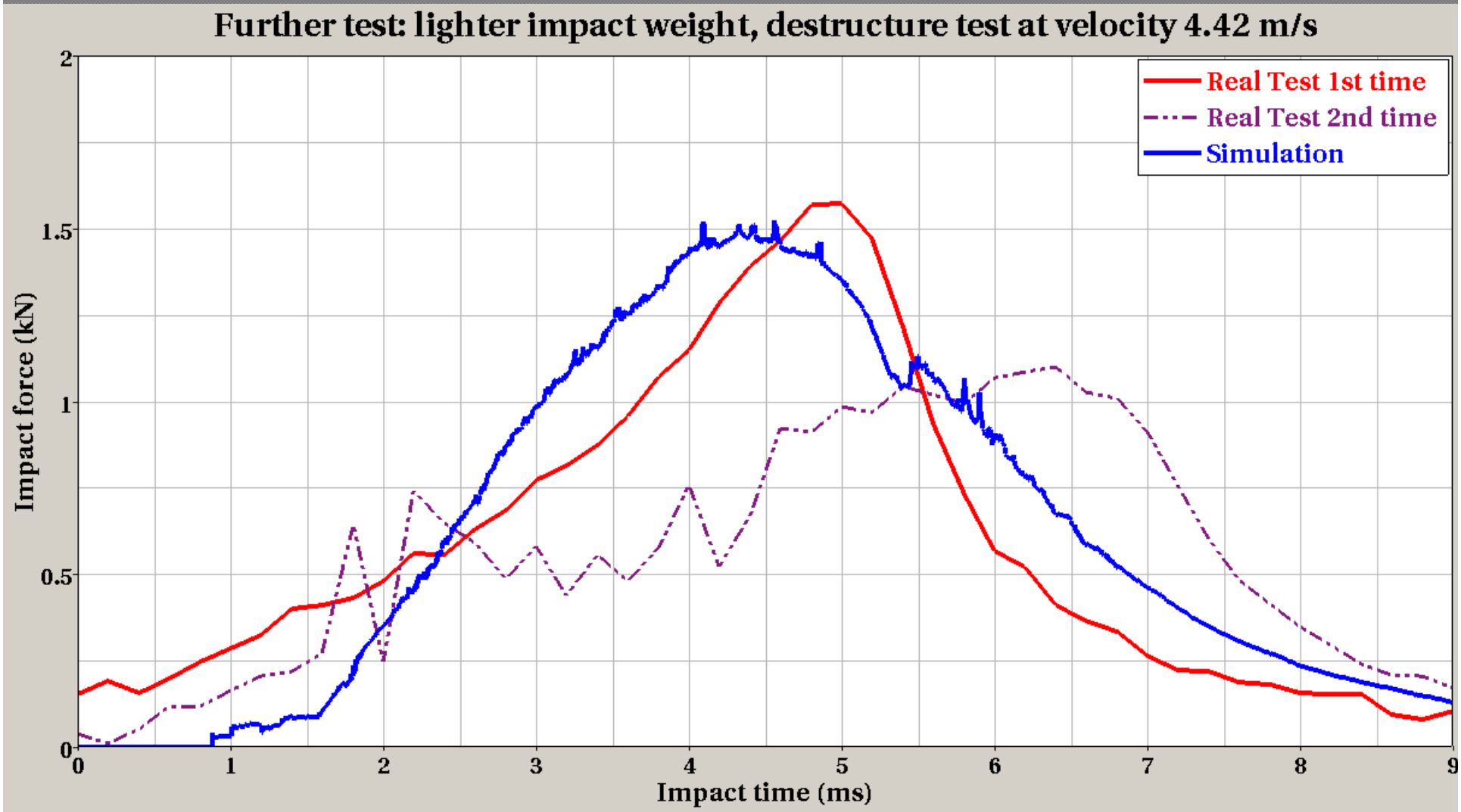


Further validation tests with multi-impact at the same sample

Model Development and Verification

Material Card

EPS, the closed-cell polymeric foam :

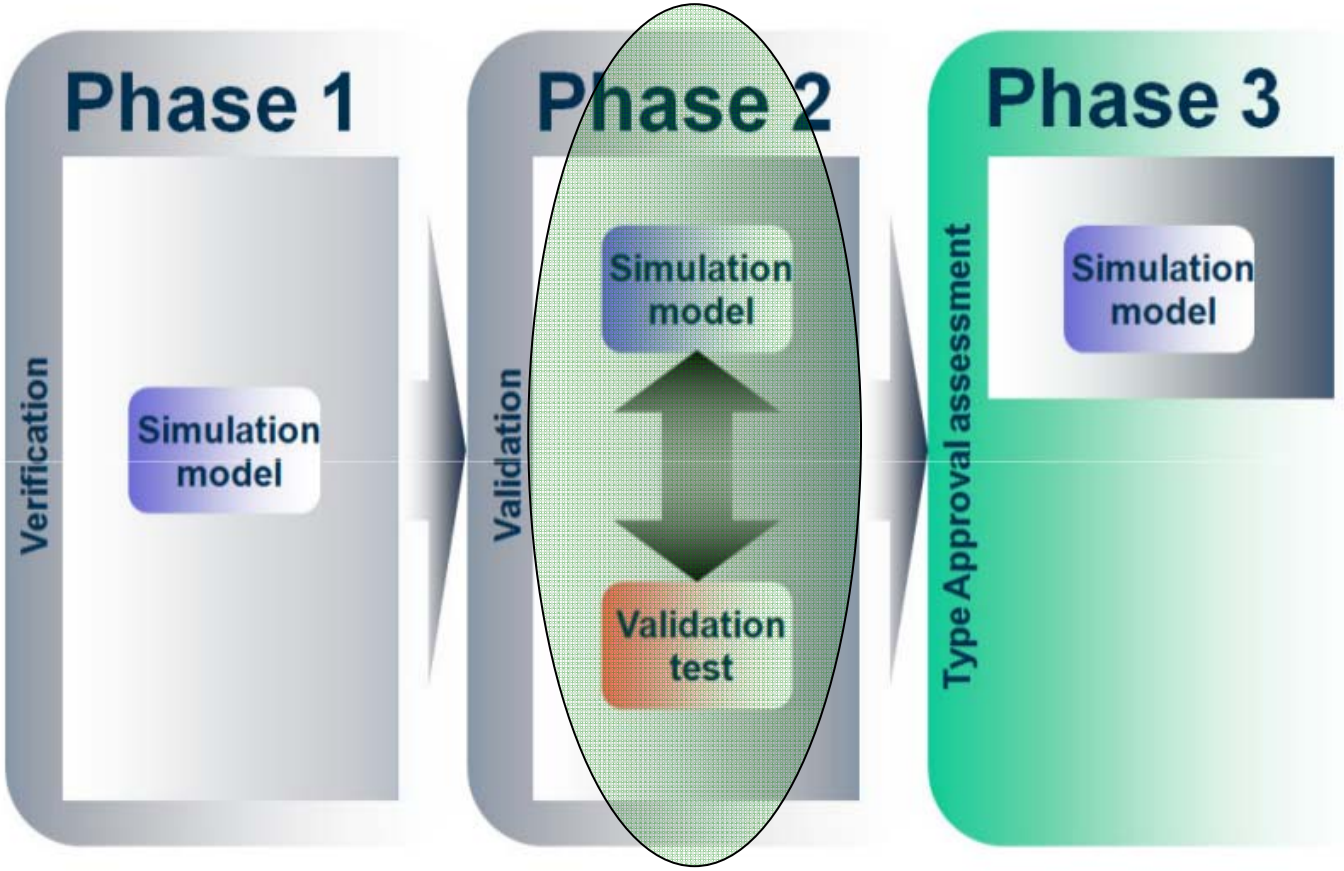
- Three regimes in compressive stress-strain curve.
- Strain-rate dependent material, Mat_FU_CHANG_FOAM applied.
- Cowper-Symonds Law employed.
- Scaled stress-strain curves at differe $\frac{\sigma_d}{\sigma_s} = 1 + \left(\frac{\dot{\varepsilon}}{C}\right)^{\frac{1}{P}}$ rate as the input.

Outer plastic shell :

- Energy dispersion
- Little affect within different materials
- Low-cost material, Mat_ISOTROPIC_ELASTIC_PLASTIC applied.

Virtual test Approaches

Full VT approach



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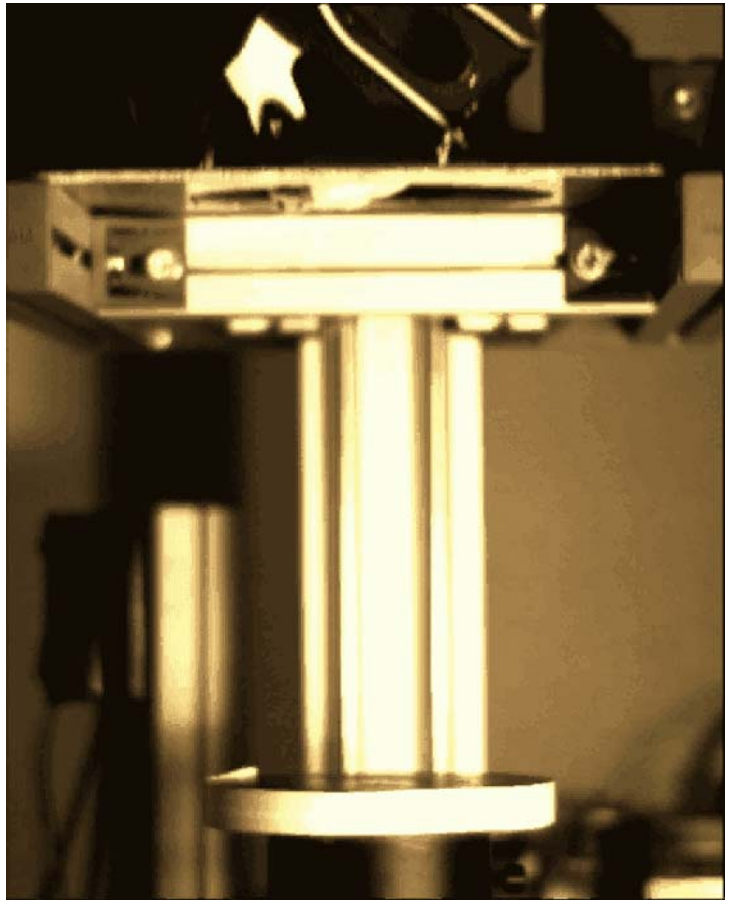
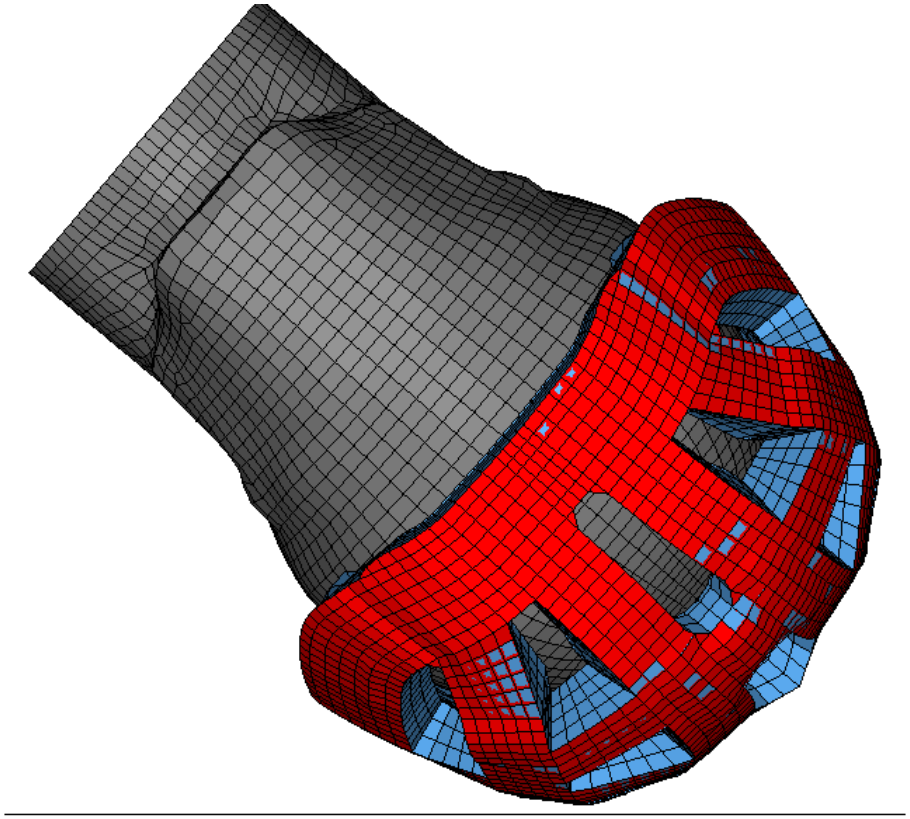
Model Validation





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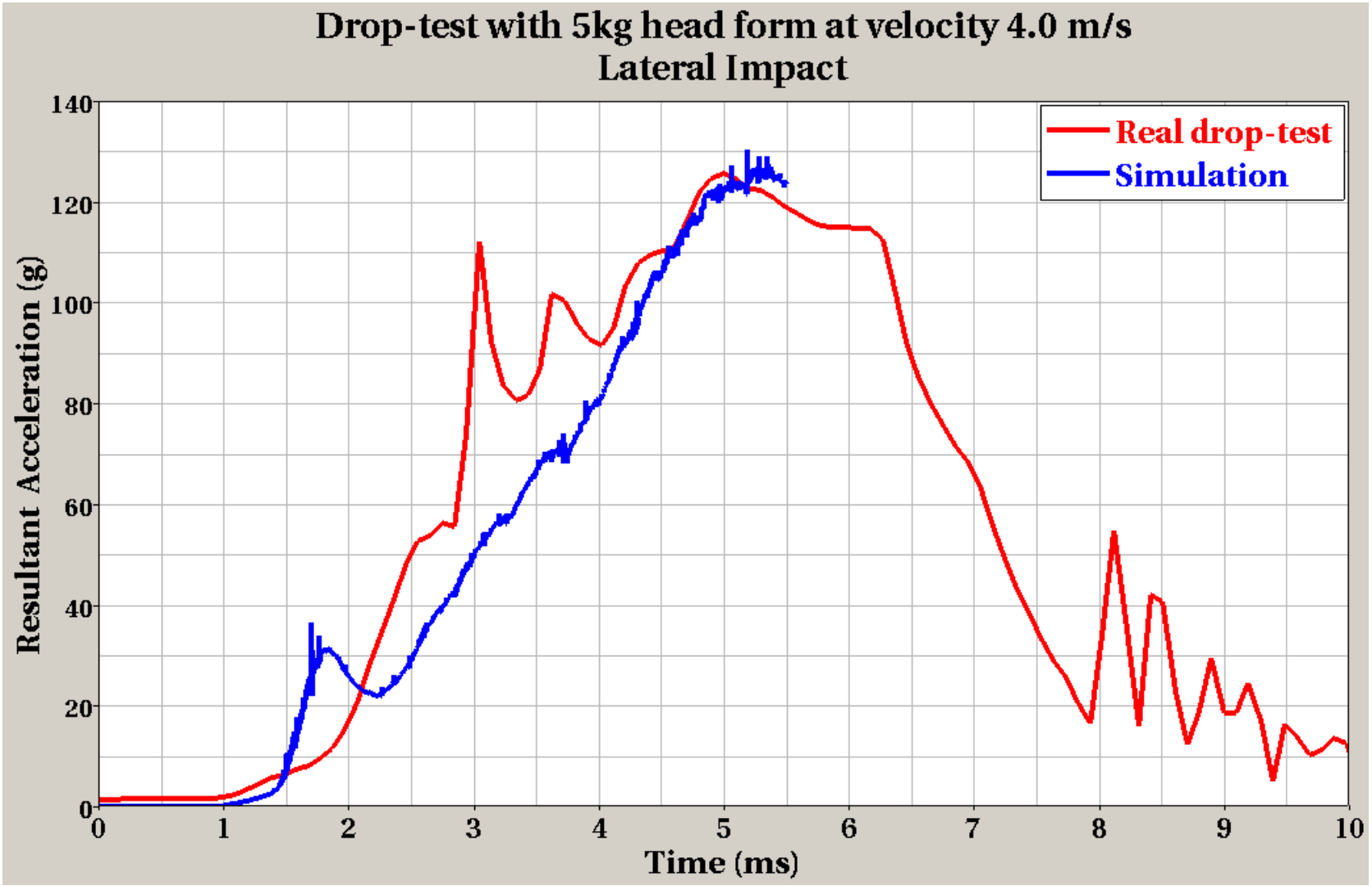

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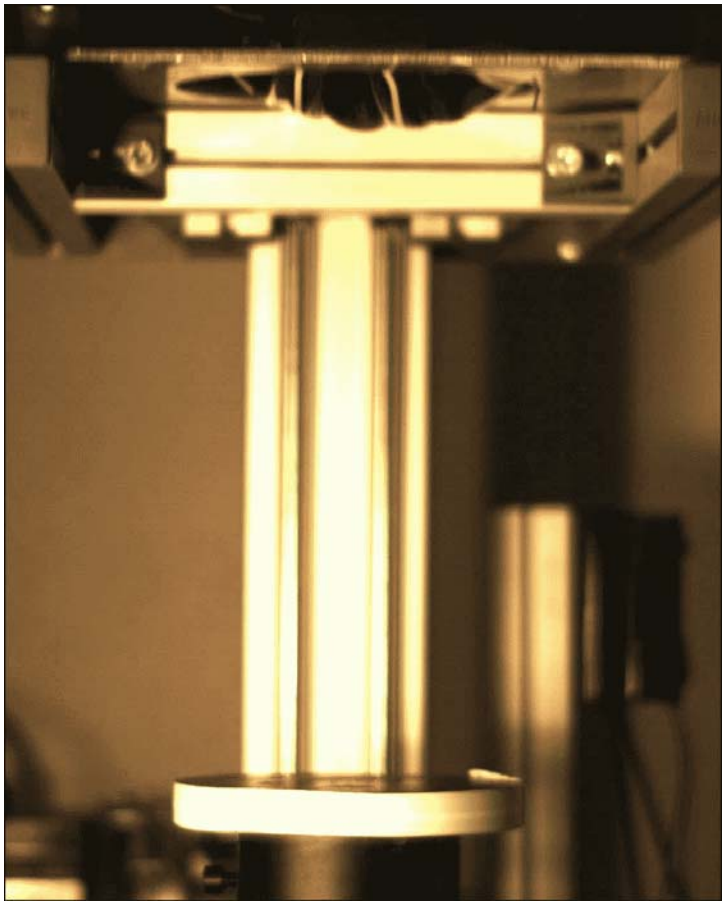

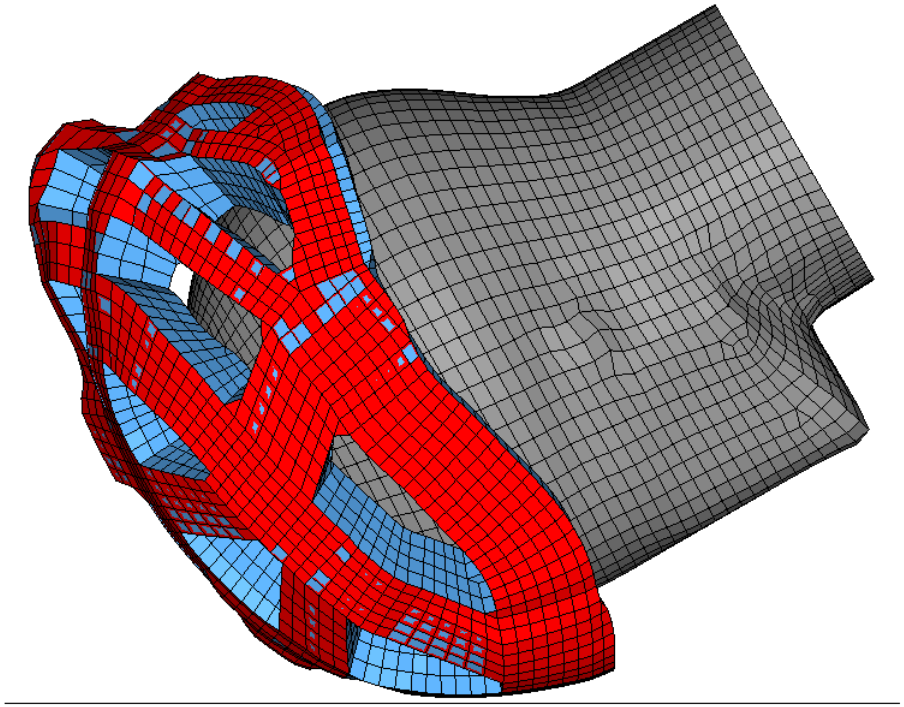

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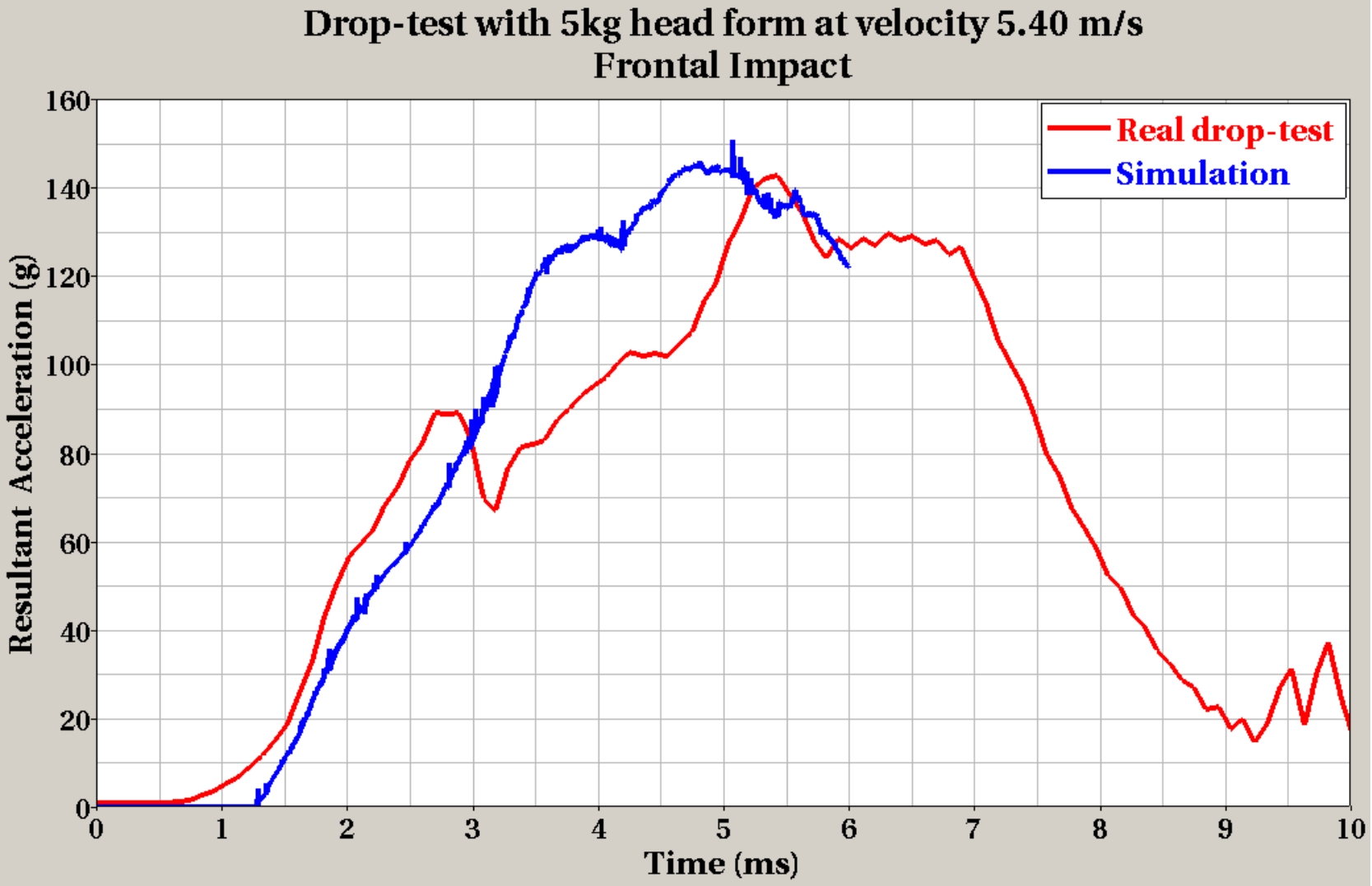

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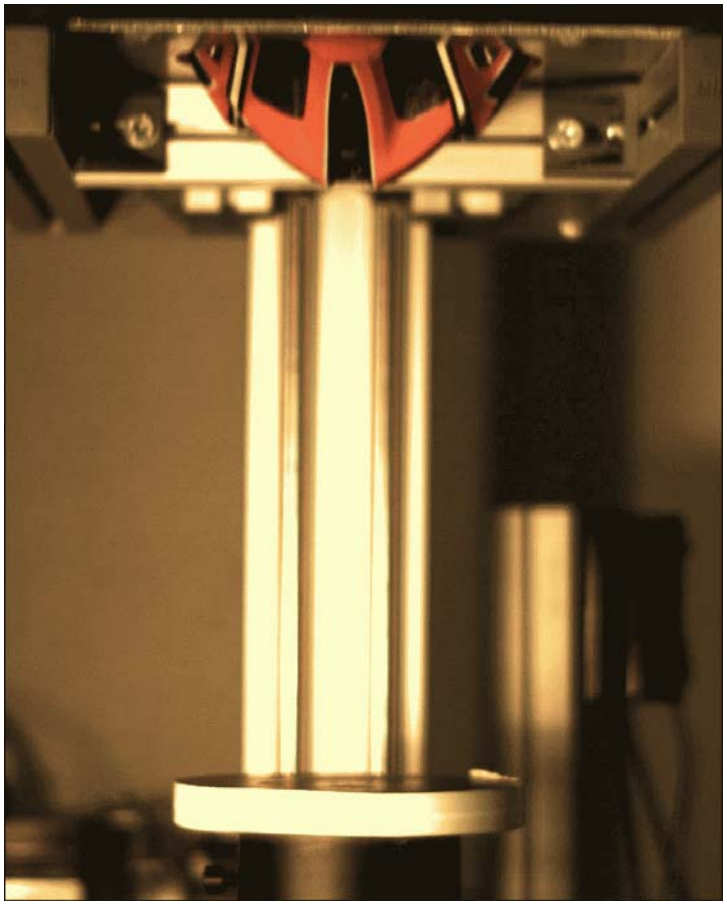

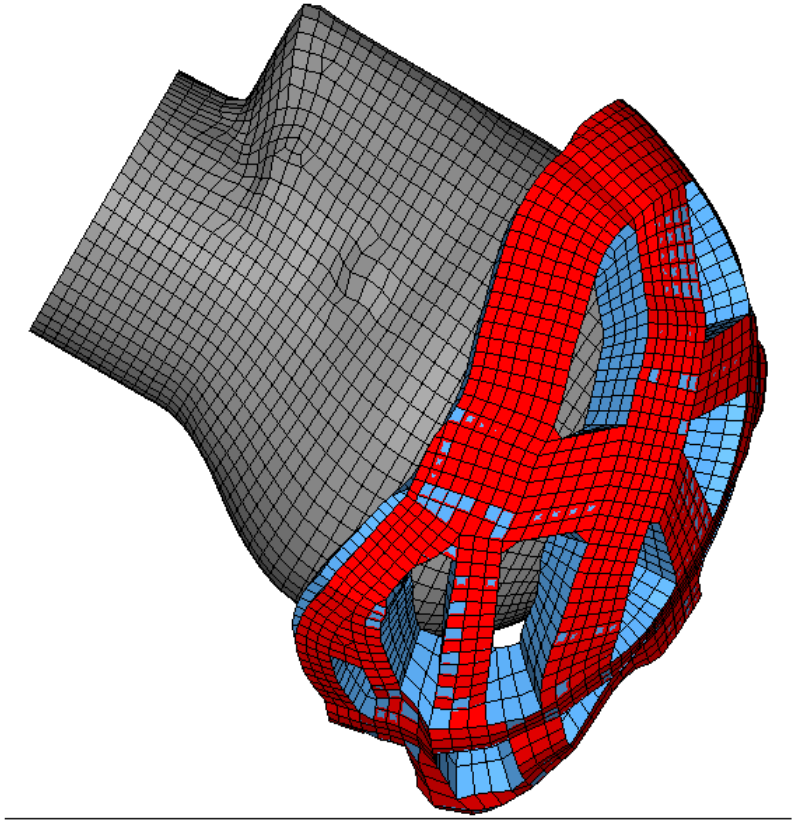

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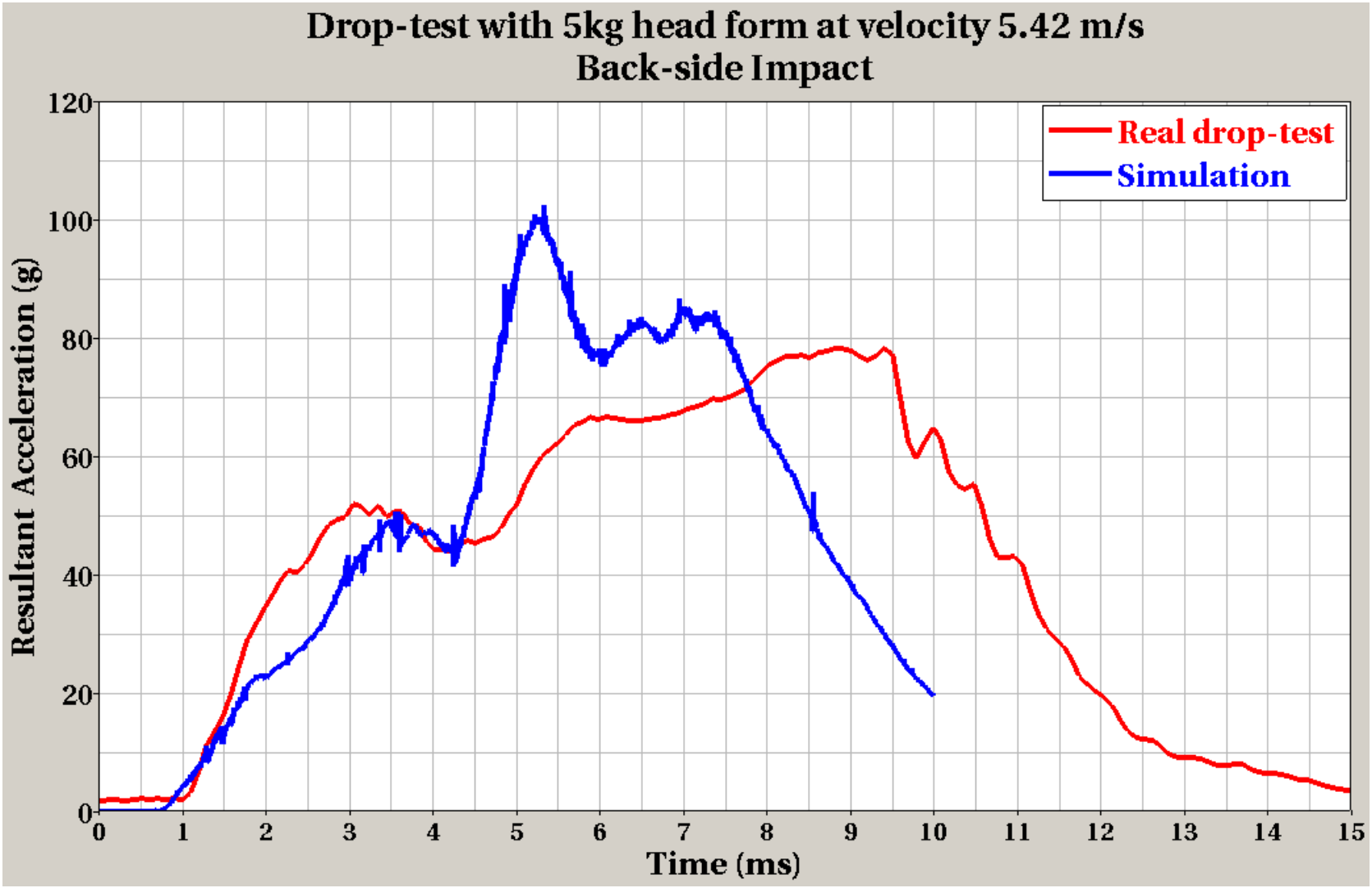


Problems and Discussion

Problems:

✓The validated range of this model is considerably narrow.
(Impact velocity from ~4 m/s to ~6 m/s)

✓The behavior of the material model in the simulation can not fully represents the real behavior (they have different slopes at the initial phase of the loading curves)

✓In some cases, the real tests are not so easy to represent
(e.g., the 3rd validation test by back-forward impact)

Problems and Discussion

Discussion about the material types:

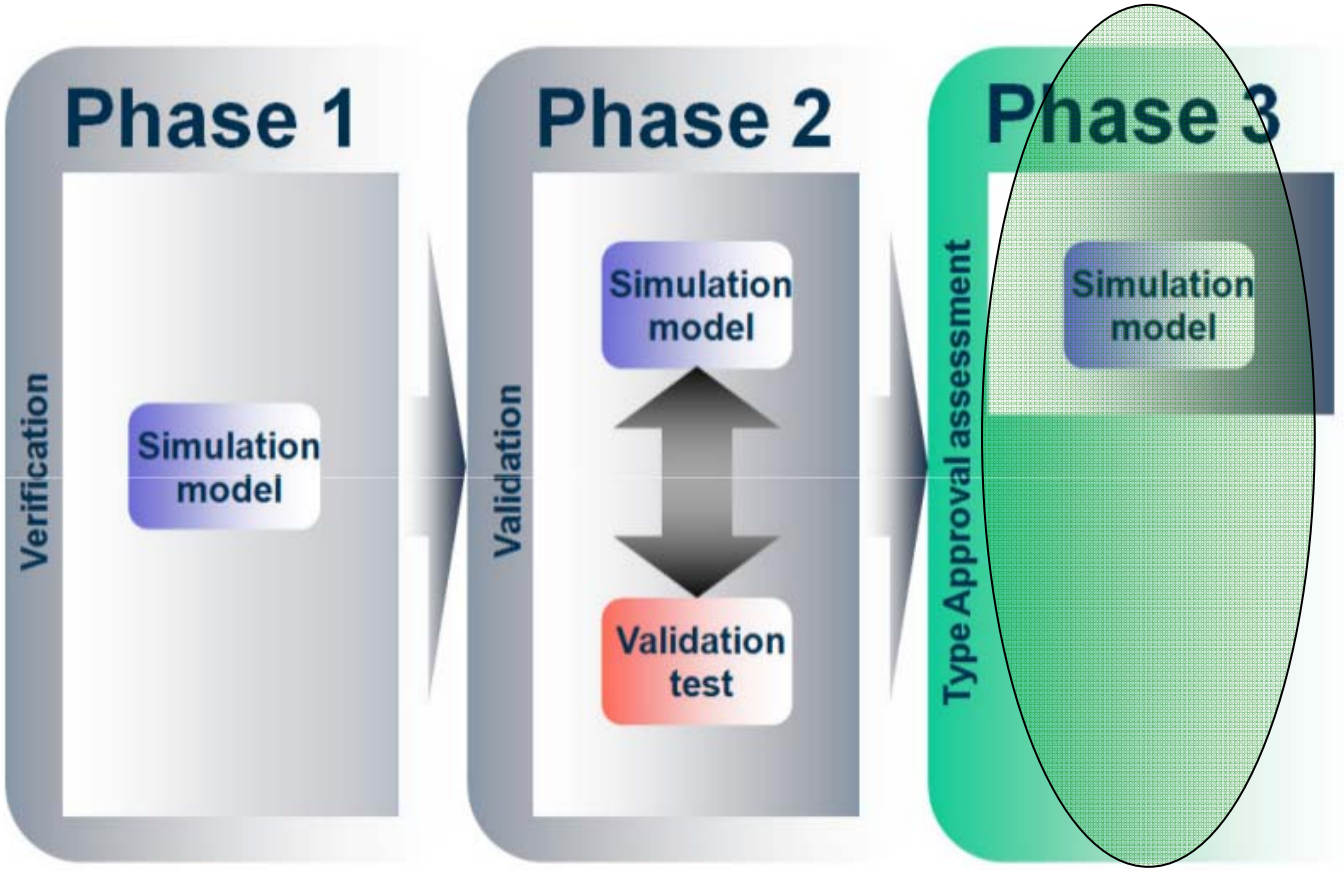
- ✓What is the sensitivity between the materials types, within the same stress-strain curve and the same strain-rate-dependency algorithm?

  (Material Type : Mat_Piecewise_Linear_Plasticity, Mat_Modified_Crushable_Foam, Mat_Fu_Chang_Foam)

- ✓What is the sensitivity in the solver's environment, e.g. processors / precisions / modes, within the absolutely same input?

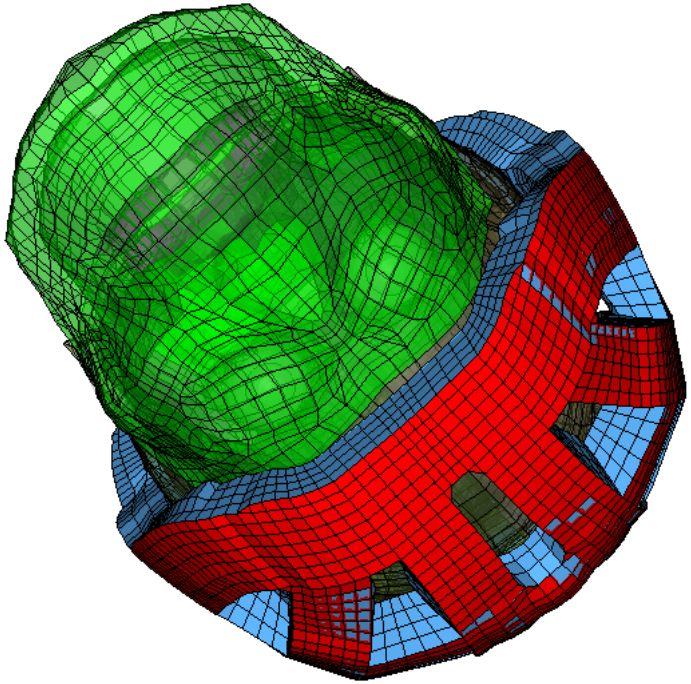
Virtual test Approaches

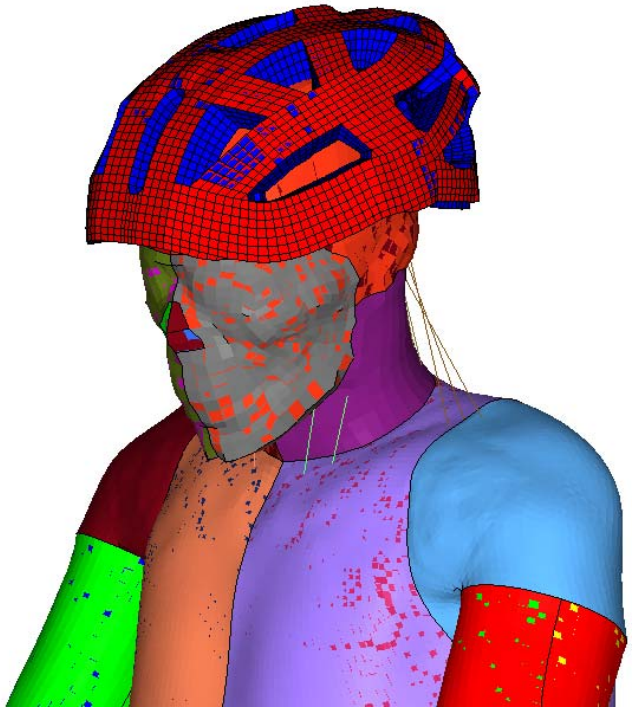
Full VT approach



Quote from A. Eggers, imviter 2012

Outlook: Virtual tests





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