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6th German LS-DYNA Forum

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**Chances and Challenges by detailed
Occupant Crash Simulation Models**

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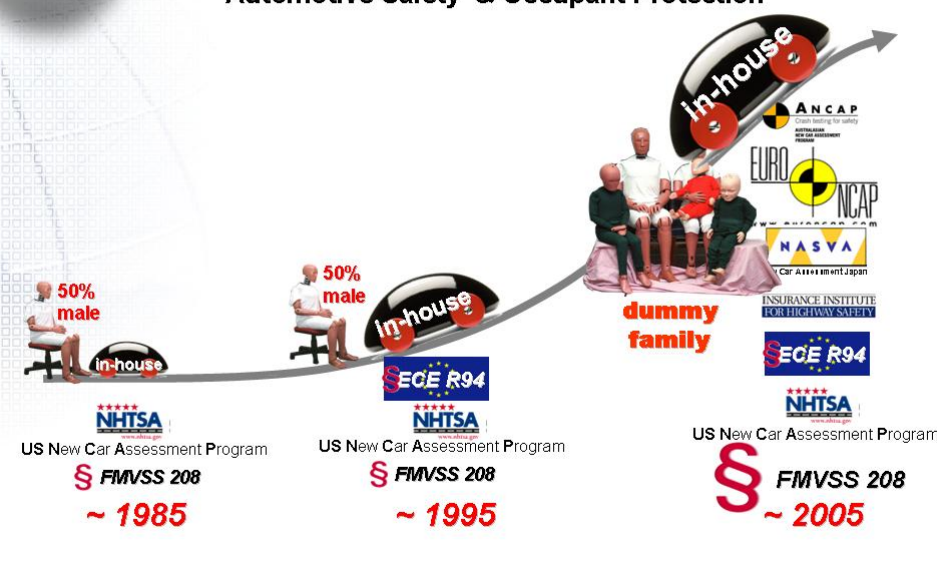
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Automotive Safety & Occupant Protection



50% male **In-house**
NHTSA
US New Car Assessment Program
§ FMVSS 208
~ 1985


50% male **In-house**
ECE R94
NHTSA
US New Car Assessment Program
§ FMVSS 208
~ 1995

dummy family **In-house**
ANCAP
EURO
NCAP
NASVA
Car Assessment Japan
INSURANCE INSTITUTE FOR HIGHWAY SAFETY
ECE R94
NHTSA
US New Car Assessment Program
§ FMVSS 208
~ 2005



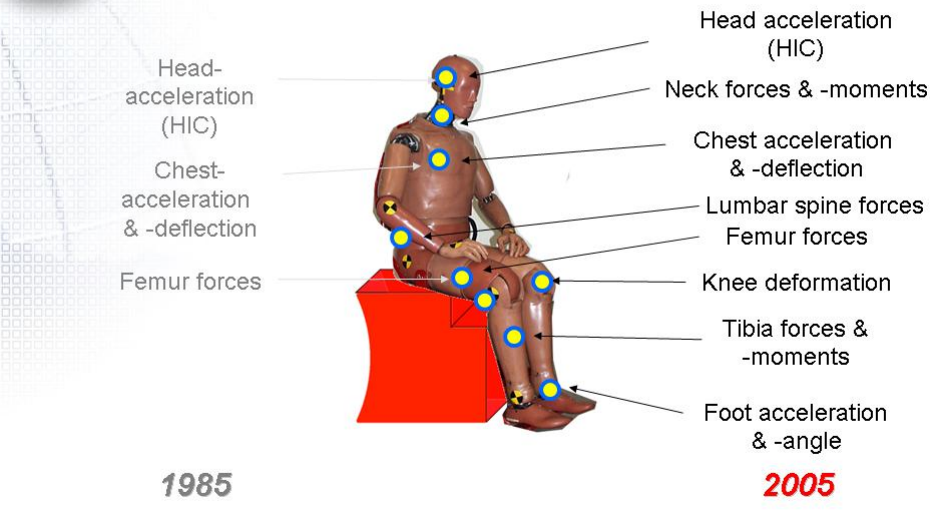
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Automotive Safety & Occupant Protection



Head acceleration (HIC)

Neck forces & -moments

Chest acceleration & -deflection

Lumbar spine forces

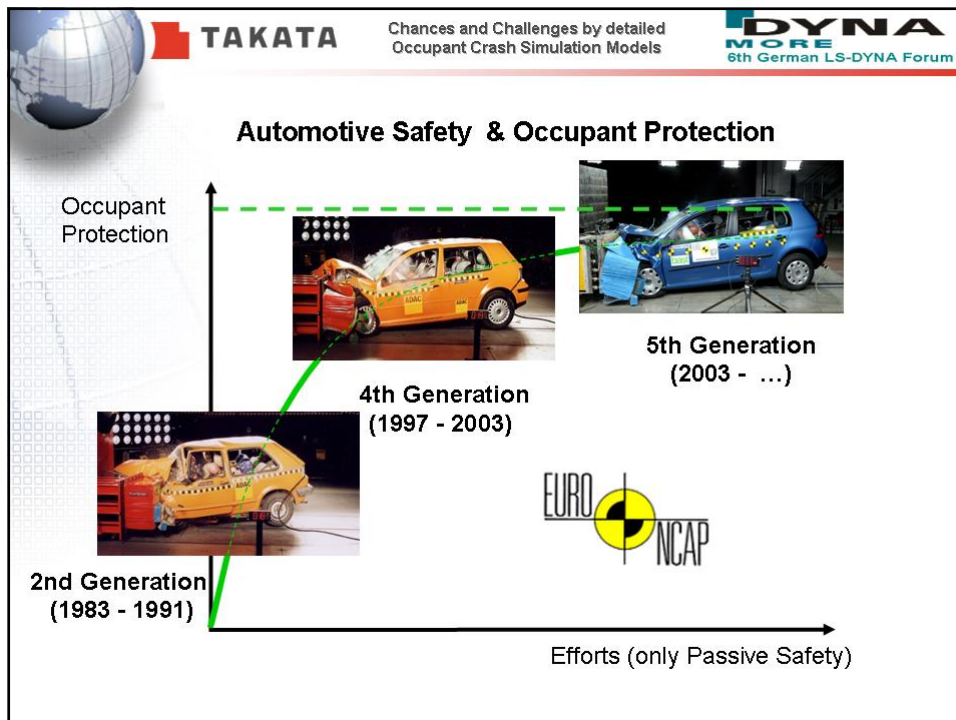
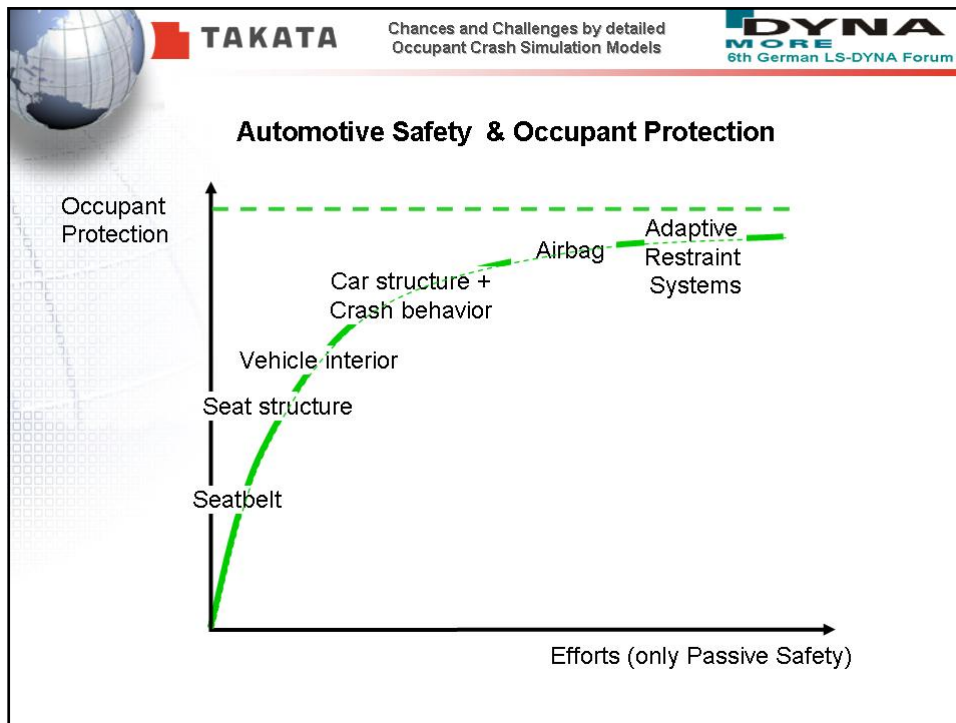
Femur forces

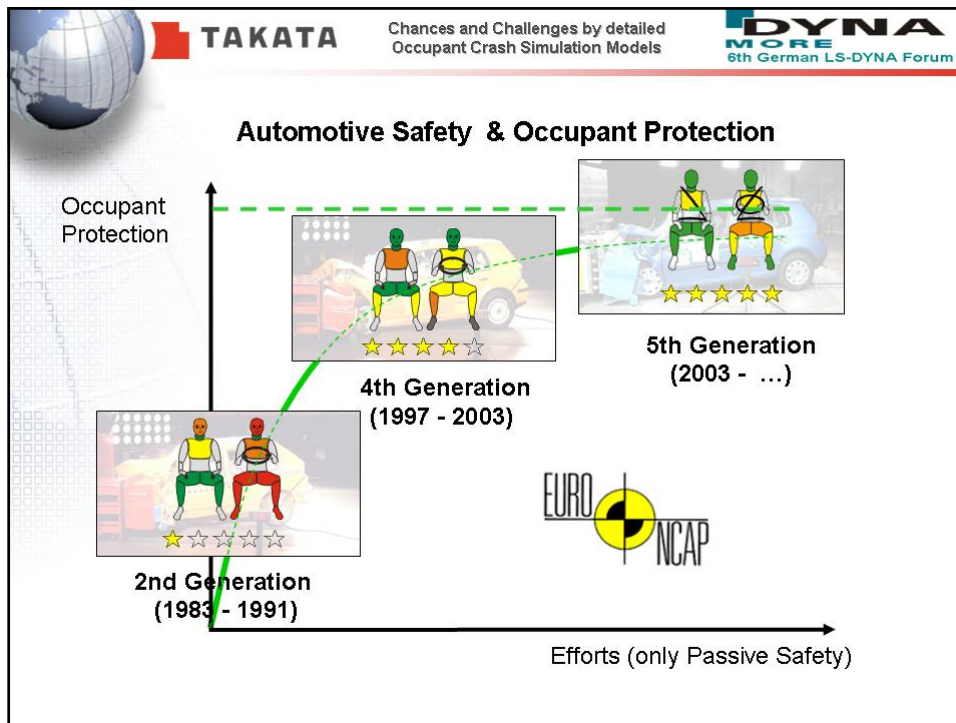
Knee deformation

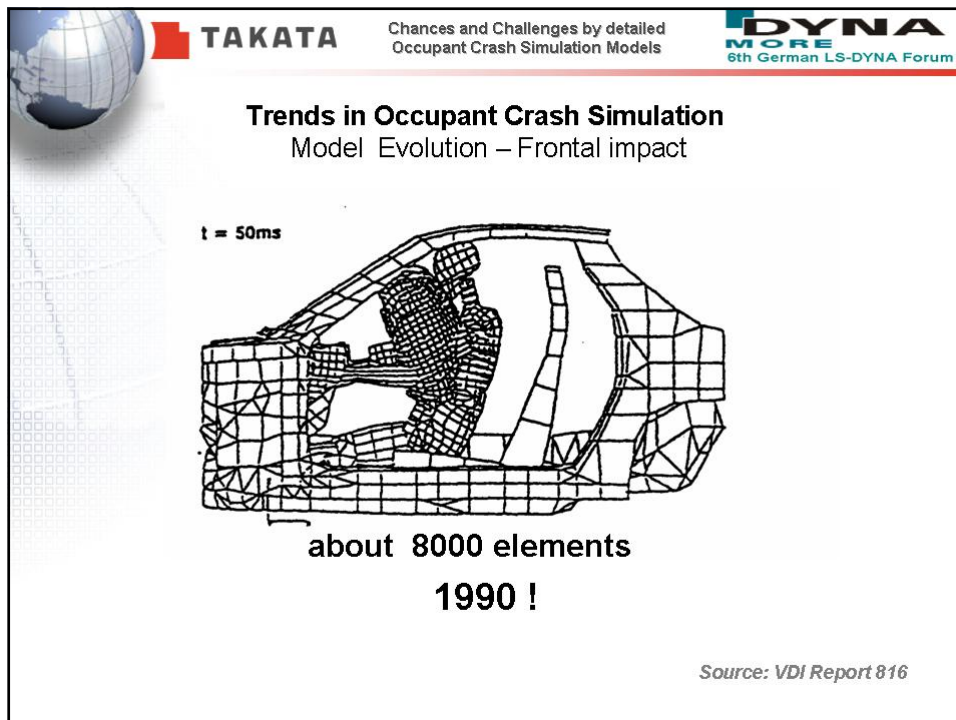
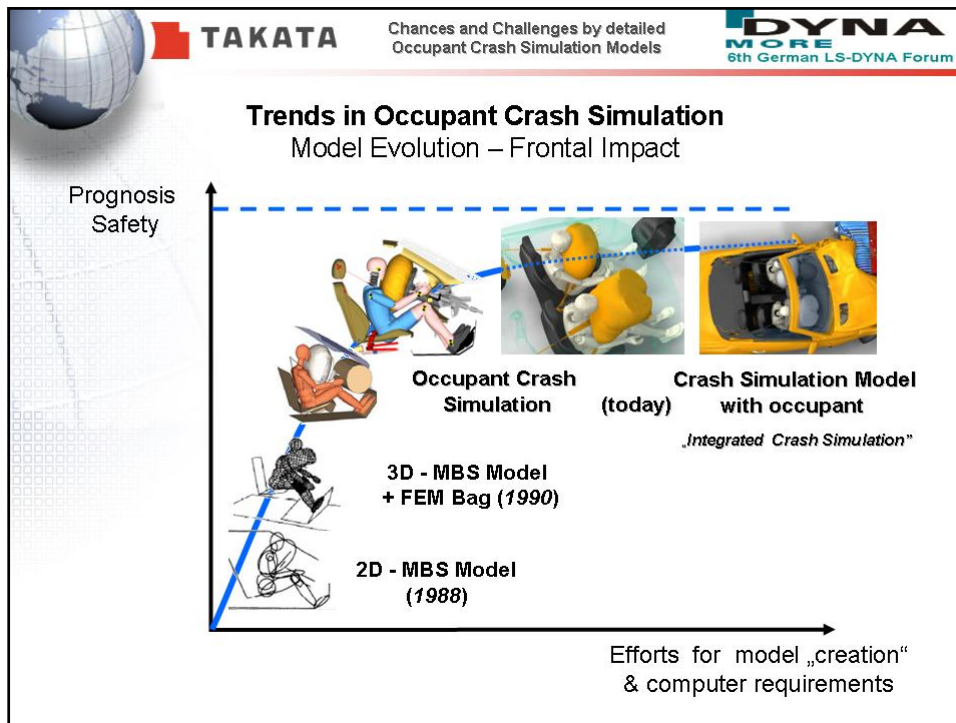
Tibia forces & -moments

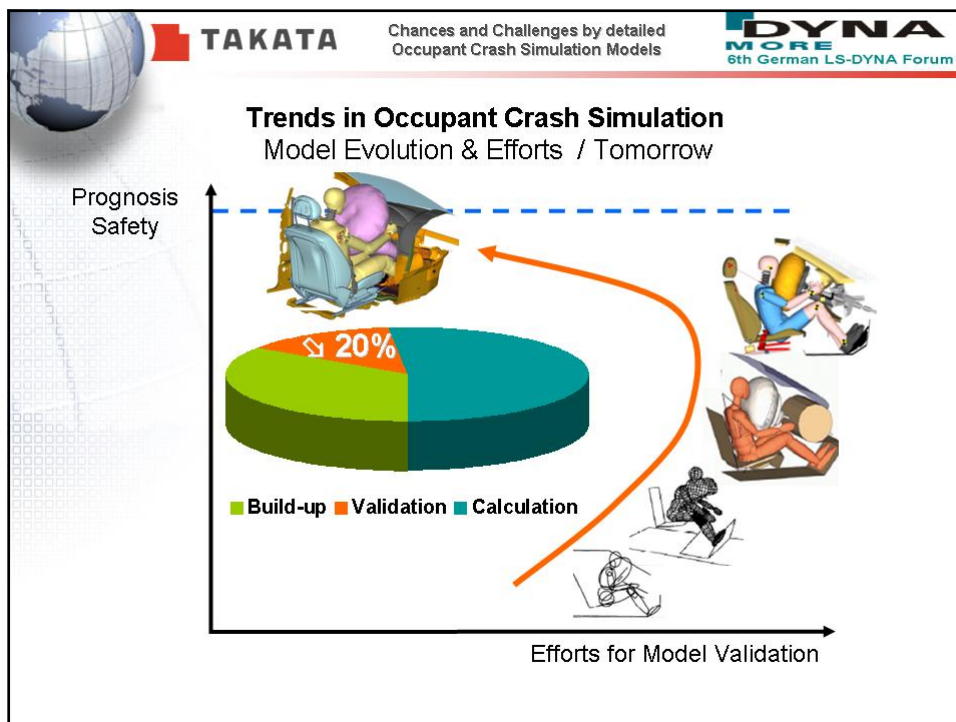
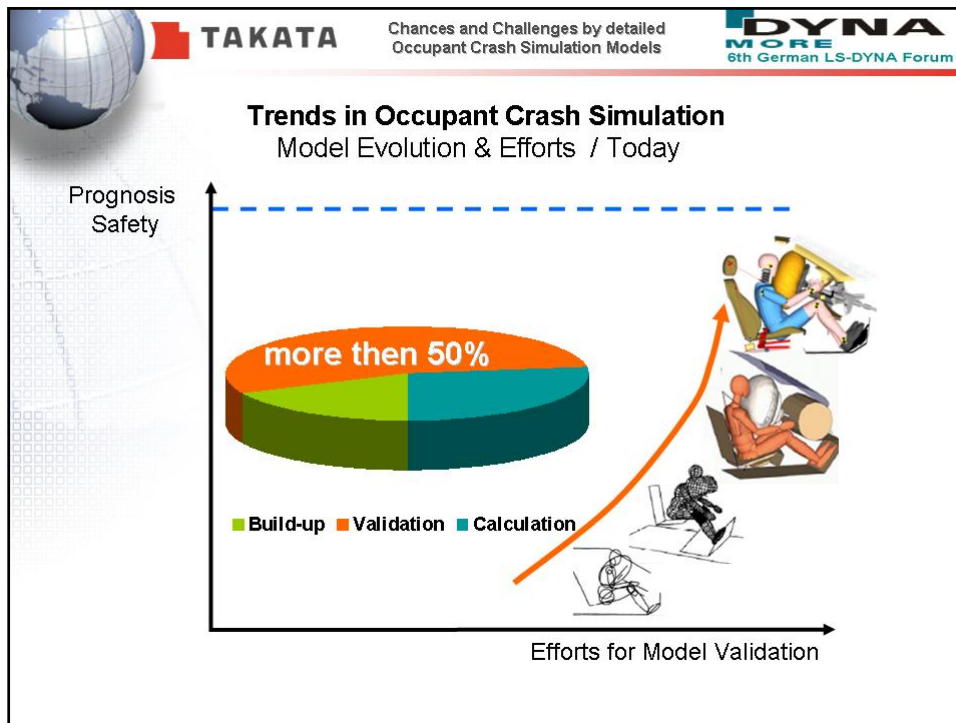
Foot acceleration & -angle

1985 **2005**









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Trends in Occupant Crash Simulation

Occupant Crash-Simulation

Component Simulation

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Model Validation – Example Airbag Model

Material & Subcomponent

Component

Occupant Crash Model

Sub-supplier

Temperature

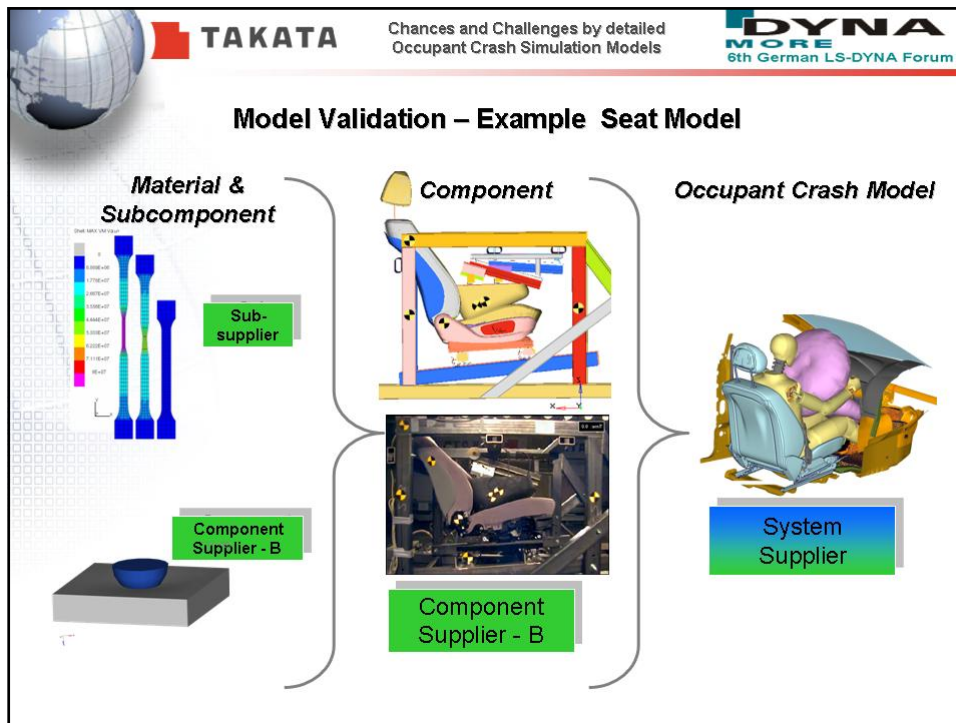
Mass flow

Time

Component Supplier - A

Component Supplier - A

System Supplier

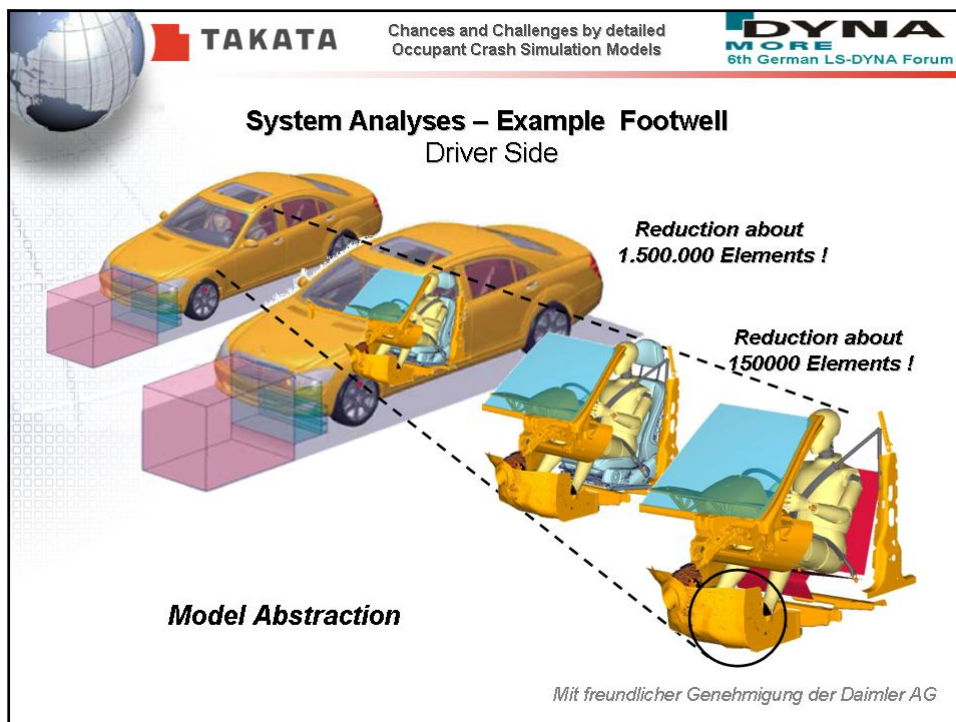
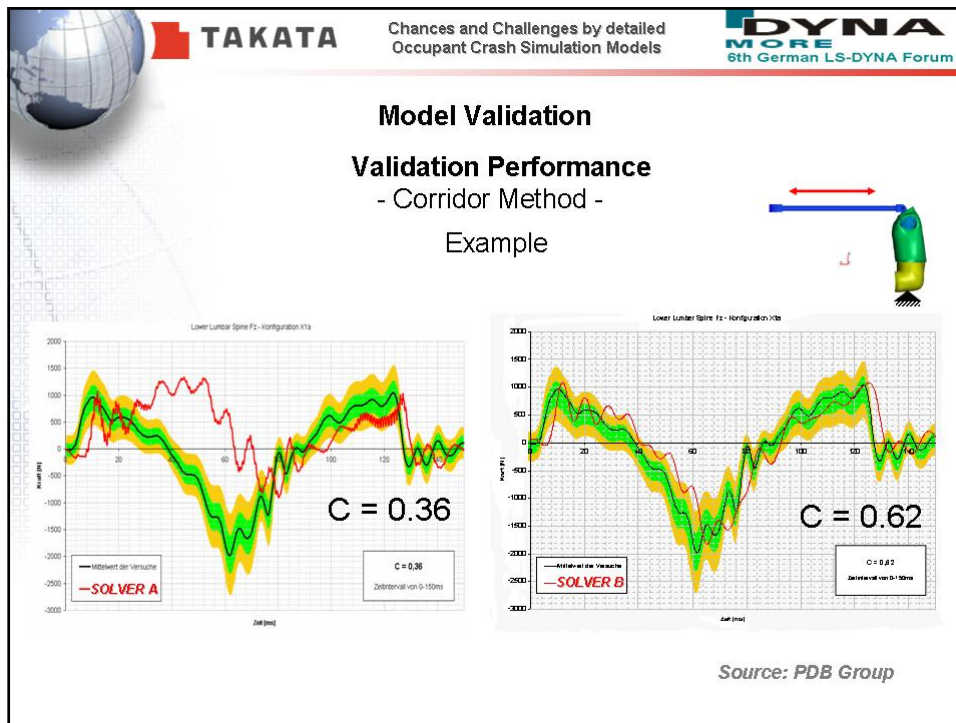


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Model Validation

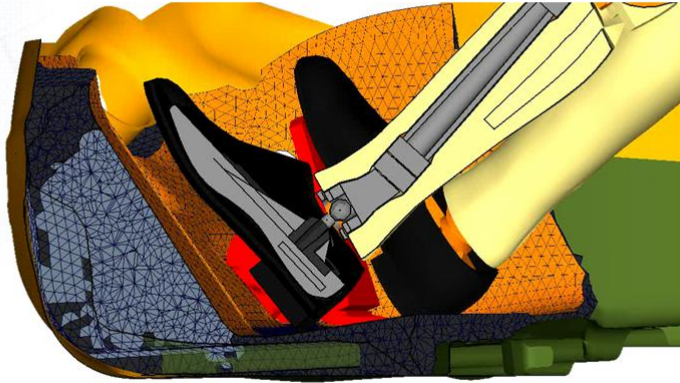
Quality Grades of the Validation Index
- SAE Proposed Validation -

Level 0	No congruence between model forecast and reference test
Level 1	Qualitative congruence - tendencies of predicted parameters are equal - kinematics correspond in quality - contacts between occupant and vehicle are equal
Level 2	3 ms values and comparable indicators deviate not more than 20 % from reference tests
Level 3	Peak values of important occupant loadings have a relative error quote of not more than 20%
Level 4	As level 3 but 5 %
Level 5	Time history of peak values of important occupant loadings has a relative error of not more than 5 %
Level 6	Time history of curves of important occupant loadings deviates at the most 10 % from the reference test
Level 7	As level 6 but 5 %
Level 8	1% relative error at the most over the whole time between simulation and reference test



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System Analyses – Example Footwell Driver Side




Mit freundlicher Genehmigung der Daimler AG

The image shows a detailed 3D finite element model of a driver's footwell. A yellow foot is positioned on a black pedal. The surrounding structure is a complex mesh of orange and grey elements. A small 3D coordinate system with X, Y, and Z axes is visible in the bottom left corner.

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System Analyses – Example 30° Crash Passenger Side

elapsed time approx. 5 min



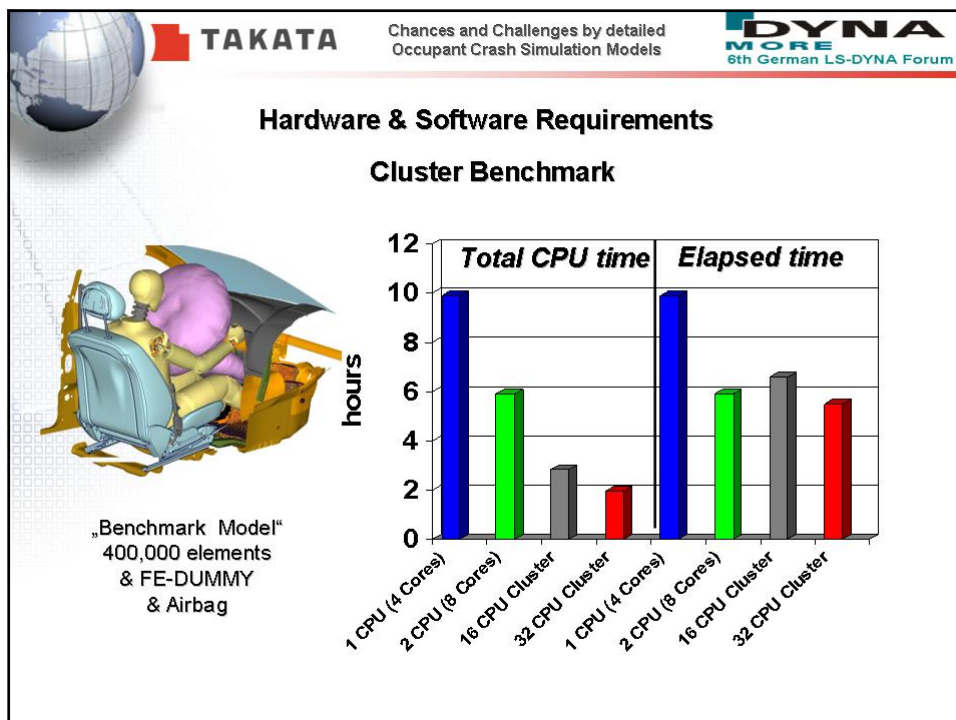
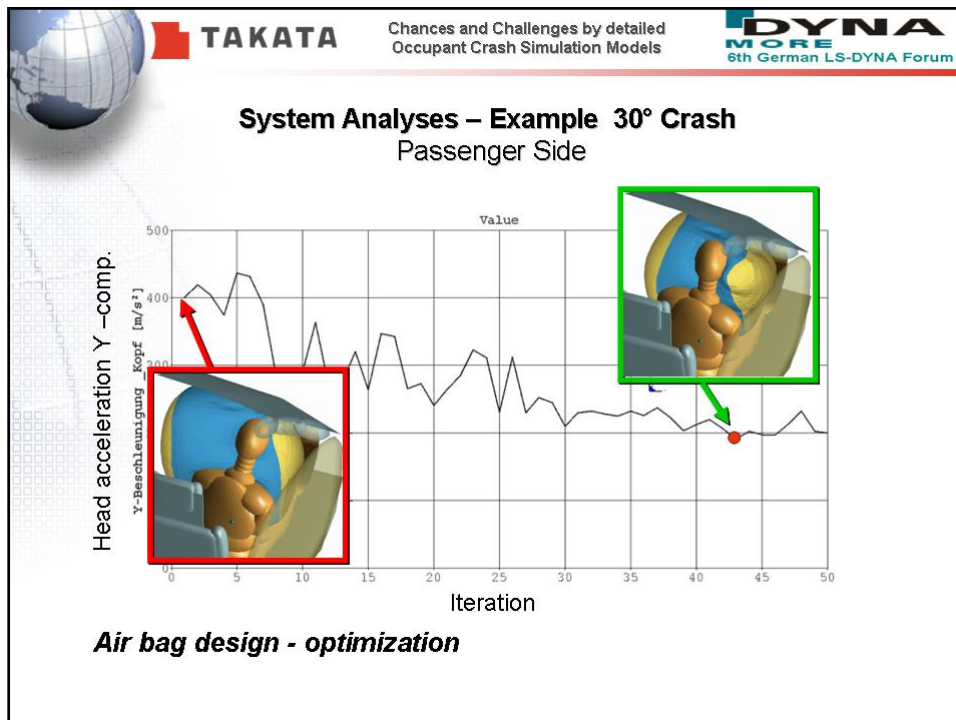
Multi Body System model with FE-airbag



elapsed time approx. 6 h




„pure“ FE model

The slide illustrates a comparison between two simulation approaches for a 30-degree passenger-side crash. On the left, a schematic shows a car tilted at 30 degrees with an orange occupant model. On the right, two simulation results are shown: a 'Multi Body System model with FE-airbag' (top) and a '„pure“ FE model' (bottom). The top model shows a simplified car body and a detailed occupant with an airbag. The bottom model shows a highly detailed finite element mesh of the car's interior and occupant.







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Summary

- Build-up of **simplified FE substitute** models for variation calculations in connection with a modular master model
- Increased **responsibility of the component supplier** for their model build-up and validation
- **Central responsibility** for occupant crash simulation models is at the **system supplier's**
- Drastic enlargement of **computer capacities** at restraint system suppliers
- **New license models** for FE-solvers & dummy-models necessary and significant improvement in **"job-parallelizing"** required



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Summary

- Over the past 10 years, the sum of legal requirements to **occupant protection** as well as demands resulting from consumer tests and internal rules has **increased at least tenfold**.
- The level of **detailing of occupant crash simulation** models will rise dramatically
- Significant **reduction of validation efforts** for simulation models and **increasing prognosis safety**
- Working out a **general standard** for quantification of **model validation**

