Occupant Simulation for the Mercedes-Benz S-Class

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Occupant Simulation at Mercedes-Benz Cars

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Occupant Simulation at Mercedes-Benz Cars
History Frontal Impact (1991-2009)

Start 1991: MADYMO (Dummy)

1991-2009: Madymo Models
Example W140, W220 and C207

1994: knee bolster investigations for W220

1994: dummy kinematic investigations for W140

since 2004: LS-Dyna-Models for Sled- and integrated crash simulation (Example W212)
Occupant Simulation at Mercedes-Benz Cars

Evolution of Side Impact Simulation:

First airbag deployment simulations W210 (1994)

Continuous model optimization and refinement:

- increasing number of applications and investigations for virtual development of interior and restraint components
Occupant Simulation at Mercedes-Benz Cars
Status Digital Investigations – Interior / Occupant Safety

Scope Levels

Vehicle Level
- Crash Simulation with Front and Rear Occupants in Frontal + Side Impacts
- Child Safety
- Head Impact FMVSS201u

Subsystem Level
- Whiplash (seats)
- Airbag Deployment (head liner, IP, seats)
- Airbag – out of position

Component Level
- Fracture and Deformation behavior, Stiffness and Durability
- Safety related Functionality
Occupant Simulation at Mercedes-Benz Cars Integration into “Digital Prototype”

- Occupant simulation is part of the digital prototype development with assessments in all digital development phases.
- Iterative component development / optimization between suppliers and occupant simulation.
- Increasingly parallel development between digital and hardware phases.
- Need of “on-time” delivery of adequate simulation models and material data by all process participants to meet DPT timelines and targets.
Occupant Simulation for the New S Class
Involved Objectives within Frontal Occupant Simulation

- Airbag Systems
- Dummies
- Belt Systems
- Instrument Panel with knee bolster
- Structure Input
- Steering
- Floor room, Pedals
- Seat
Occupant Simulation for the New S Class
Modell Abstraction Frontal Impact – 40% Offset Barrier Test

I: Integrated structure- and occupant simulation
Full Integrated Model: 6 Mio. elements (shells/solids)
Computing time: 30h (150ms on 192 CPUs)

II: Model reduction to occupant cell (sled) model with vehicle movement
Sled Model: 2 Mio. elements (shells/solids)
Computing time: 6 - 8h (150ms on 96 CPUs)
Occupant Simulation for the New S Class
Model content frontal impact Driver and Passenger

Sim-Model with FEM subsystems of:
• Vehicle structure (stiff or dynamic)
• FEM dummy 5%, 50% and 95% occupant
• Driver airbag
• Kneebag (US-Version) with CPM
• Passenger airbag
• Steering wheel and steering column
• Instrument panel assembly including:
  IP w. airbag door, cross car beam, glove box, knee bolster, HVAC, control units, ...
• Seat (structure and cushion assembly) incl. Primer® adjustment kinematics
• Floor room incl. carpet, support brackets, padding and pedals

Model size: (1,3 -) 2 Mio. elements
Computing time: 6 - 8h (150ms on 96 CPUs)
Occupant Simulation for the New S Class
Scope of investigations frontal impact driver and passenger

Contents BR222:
- Airbag geometry / performance (incl. static and adaptive vents)
- Secure cushion deployment (head, chest and knee contacts)
- Belt retractor with pre-tensioning and force limitation.
- Innovative PRE-SAFE_Impulse anchor and buckle pre-tensioner with force limitation.
- Analysis und optimization of several crash load cases
Occupant Simulation for the New S Class
FEM-Models of Innovative Components

**Impulse Pre-Tensioner:**

**Problem:** No feasible function of integrated double pre-tensioner by using the conventional model definition (forces/distances by time). Piping reactions influence forces and travels.

**Task:** Implementation of a simulation model adapted to physical results

**Solution:** Implementation of the airbag-related CPM method also for belt component

Quelle: TRW ORS Alfdorf
Occupant Simulation for the New S Class
Scope of investigations frontal impact driver and passenger

Contents BR222:

- Analysis und optimization of several crash load cases
- Effect of intrusions: fire wall, floor structure and steering system
- Dynamic interior behavior (seat, knee bolster, floor room)
- Euro-NCAP knee-mapping
Occupant Simulation for the New S Class
Involved Objectives within Side Impact Occupant Simulation

- Side Airbag Systems
- Dummies
- Belt Systems
- Seat
- Interior Trim Parts
- Structure Input
- Door Trim
Occupant Simulation for the New S Class
Side Impact: IIHS – Barrier (5% SID-IIIs Occupant)

Model size: 6-7 Mio. elements
Computing time: 20 h (150ms on 192 CPUs)
Occupant Simulation for the New S Class
Side Impact: IIHS – Barrier (5% SID-IIIs Occupant)

• All occupant simulations are running completely integrated into the structure model (no subsystem)
Occupant Simulation for the New S Class
Side Impact: IIHS – Barrier (5% SID-IIs Occupant)

- Focus on analyzing the crash interaction and design setup of side airbag systems, door trim (arm rest, pelvis support), seat assembly (esp. backrest), side trims and belt tensioning
Occupant Simulation for the New S Class
Side Impact: IIHS - Barrier (5% SID-IIIs Occupant)

- Focus on analyzing the crash interaction and design setup of side airbag systems, door trim (arm rest, pelvis support), seat assembly (esp. backrest), side trims and belt tensioning
Occupant Simulation for the New S Class
Involved Objectives within Rear Occupant Simulation

Several Rear Seat Variants

Dummies and Human Models

Belt Systems

Structure Input
Occupyant Simulation for the New S Class System Development Rear Occupants – Scope of Investigations

- Belt Fit Analysis (standard belt / Beltbag)
- Beltbag System Design: deployment characteristic, bag filling and pressure, consideration of belt buckle lifter
- Detailed filling process (+ pyro. belt tensioning)
- Beltbag geometry
- Deployment strategy
- Optimization of details:
  - Belt tongue geometry for optimized Beltbag filling
  - Belt guide / deflection
- Validation of multiple seat variants and backrest angles
Beltbag:
Problem: Assessment of Beltbag filling and deployment as well as analysis of interaction to the occupant needs a belt simulation model with deployment same as for an airbag.

Task: Implementation of a physical adapted simulation model adapted to physical results for the innovation “Beltbag”

Solution: Implementation of the airbag related CPM method also for the Beltbag component.
Occumant Simulation for the New S Class
System Development Rear Occupants in Frontal Impacts

Dummy
System development rear occupants with HIII 5% und 50% dummies

Human
Potential analysis and system performance investigations with Human Body Model (THUMS 5% und 50%)
Occupant Simulation for the New S Class
System Development Rear Occupants – “Human” Assessment

- Additional investigations of Beltbag System with virtual Human Body Model (THUMS) for 5% and 50% occupants:
  - Advanced analysis and confirmation of potentials and benefits for real life safety
- Inspection of human occupant kinematics
- Belt fit investigations

Model size: 1 Mio. elements
Computing time: 9 h (120ms on 192 CPUs)
Investigations of occupant loads with human body model:

Local rip deflection incl. display of “van Mises” equivalent strain
Occumant Simulation for the New S Class
In Development – Out-of-Position Simulation
Occupant Simulation for the New S Class In Development - OOP simulation passenger side

Summary
- Deployment kinematics and dummy interaction captured
- Trends in injury values captured, absolute values partially captured
- High quality FE models of airbag module, dummy, IP required

Lessons learned:
- Capture physical airbag parameters (folding, shape, leakage, etc.)
- Initial dummy positions w/o pre-stress
- IP: numerically robust behavior, proper material & failure definitions
- Valid seat / car geometry
Occupant Simulation at Mercedes-Benz Cars
Challenges – Material Modeling and new Dummies

- Seat
- Interior Trim Parts
- Airbag Systems
- Belt Systems
- Door Trim
- Dummies
Occupant Simulation at Mercedes-Benz Cars
Challenges for proper material modeling of innovative materials

Performance properties of new materials especially for interior parts: (non-linear behavior)
- Plastics
- Foams
- Fibers (natural and glass)
- Fracture behavior (plastics)
- Gas and fluid dynamics

Joining technique
- Clips, Rivets, Screws
- Plastic welding
- Plastic glueing
- Seams (fabric, leather)

Failure modes:
- Plastics
- Composite materials (plastics / fiber)
Occupant Simulation at Mercedes-Benz Cars

Conclusions

- Occupant simulation is a required and established development process for designing, optimizing and analyzing the function of the restraint systems as well as the crash performance for all interior components.

- Increasing contribution to ensure the level of maturity and the value of hardware testing.

- Proper component and material models for all parts and components are required to set up reliable simulations and virtual analysis.

- Occupant simulation allows quick reactions based on first test results and enables investigation of constructive optimization measures:
  - influence analysis
  - answers conflicts of goals
  - definition of optimal system components or best material usage.
Thank you very much for your interest and attention!

Your questions are very welcome.