DYNAmore GmbH
LS-DYNA

Information Day:
Multiphysics Applications using LS-DYNA

Stuttgart, 4 March 2013

DYNAmore - The Company

- Countries and Main Offices
  - Germany - headquarters in Stuttgart
  - Sweden – headquarters in Linköping
  - Switzerland – headquarters in Zurich
- Further Offices
  - Ingolstadt
  - Dresden
  - Langlingen (Wolfsburg)
  - Berlin
  - Gothenburg
- On-site Offices
  - Sindelfingen
  - Untertürkheim
  - Weissach
  - Ingolstadt
  - Gothenburg

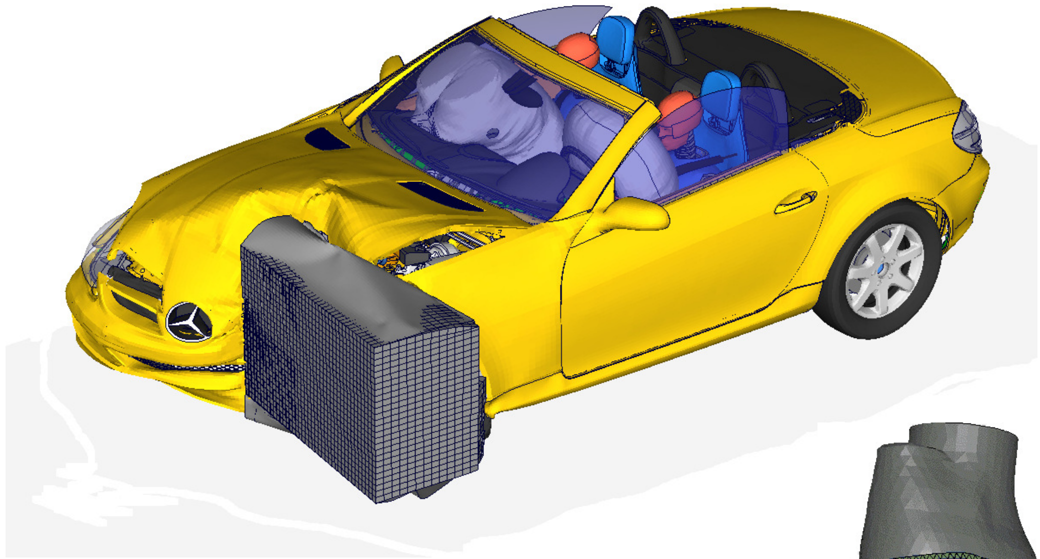
Stuttgart [Headquarters]

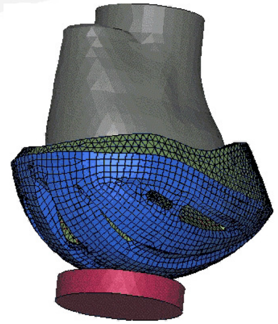
DYNAmore – The People

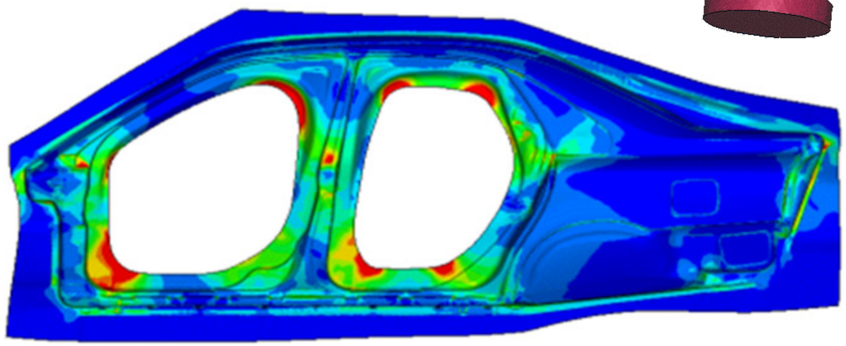
- Who we are
  - In total 80 people
  - Civil and mechanical engineers, mathematicians, computer scientists,…
  - The employees are from 13 different countries
  - The percentage of female staff is above 25 %
  - The fluctuation of employees is below 2%
  - The company is financially stable since its foundation

DYNAmore - The Products

- Software
  - LS-DYNA
  - LS-OPT und LS-TASC
  - LS-PrePost
  - eta/DYNAFORM
  - FEMZIP
  - Digimat
- Models
  - FAT/PDB dummy models
  - Humanetics dummy models
  - THUMS human model
  - Arup barrier and impactor models
  - Daimler/Porsche impactor models
  - LSTC models

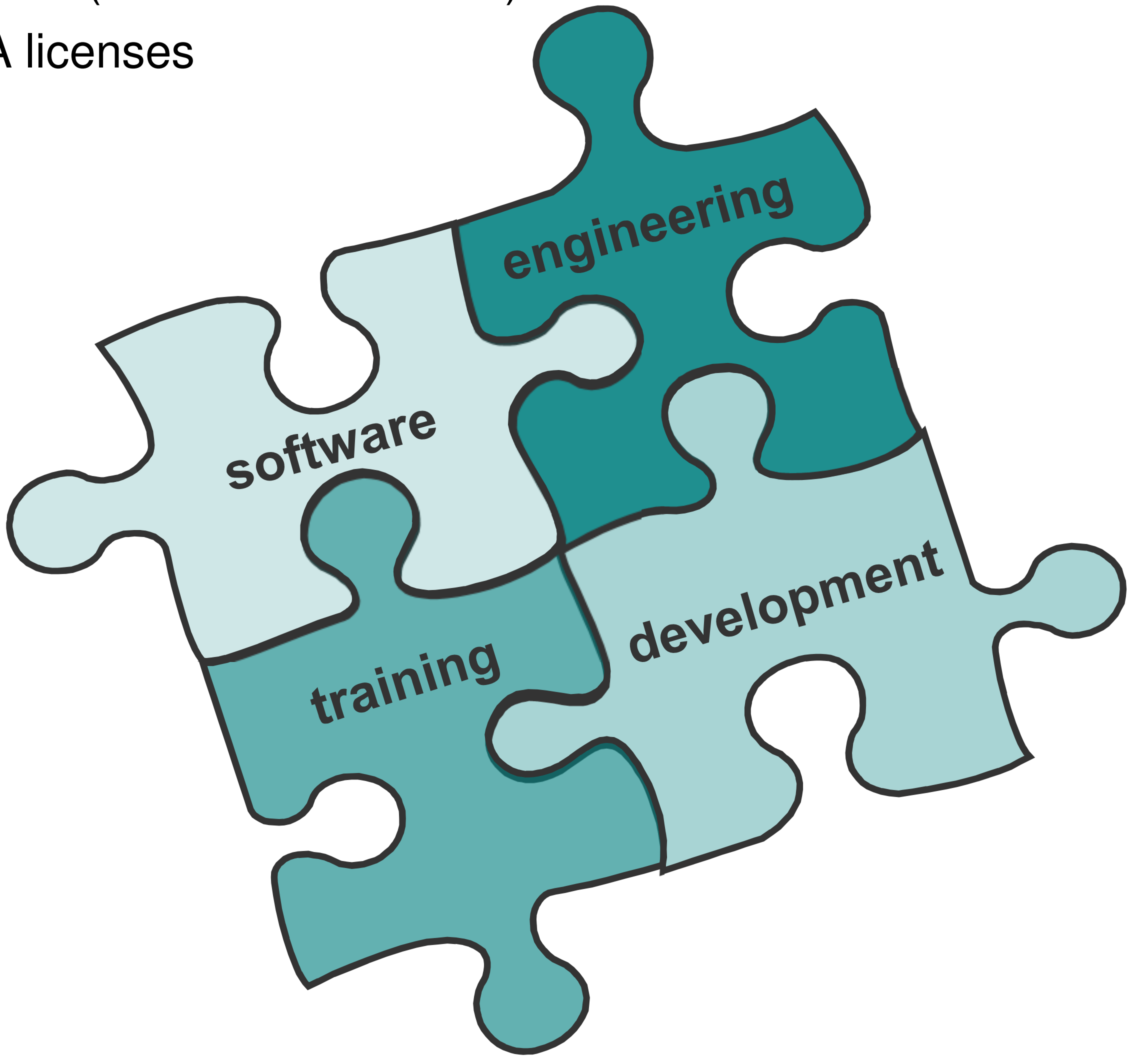






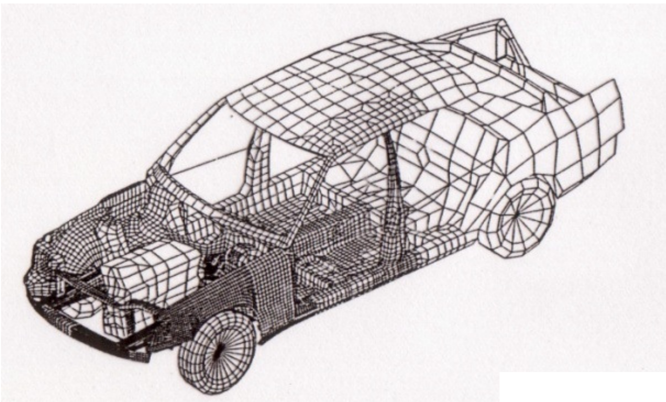
DYNAmore - The Services

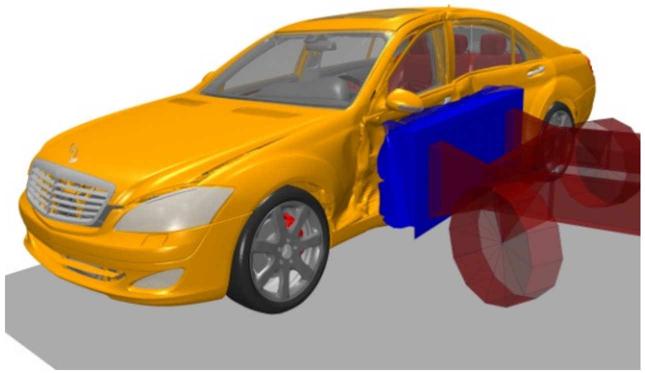
- Software
  - European master distributor for LSTC (w/o UK and France)
  - about 10000 maintained LS-DYNA licenses
- Engineering
  - Benchmarking
  - Pilot projects
  - On-site engineering
  - Consulting
- Development
  - Dummy models
  - Material models
  - Method development
- Training
  - Seminars
  - Conferences
  - Coaching on site

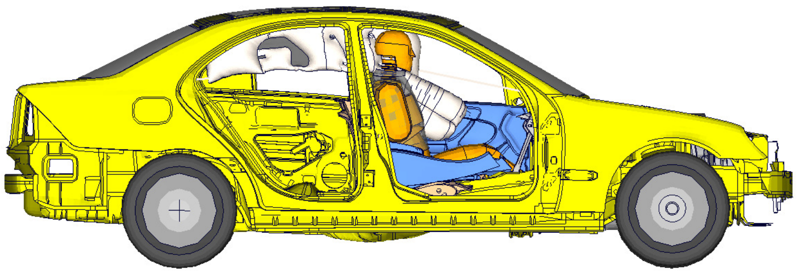


History of LS-DYNA and DYNAmore

- 1976: John Hallquist develops DYNA3D at Livermore Laboratories
- 1988: John Hallquist founds LSTC, DYNA3D becomes LS-DYNA3D
- 1988: Prof. Schweizerhof + co-workers start with crash simulations in Germany
- 2001: DYNAmore is founded
- 2011: DYNAmore acquires ERAB Nordic,
- 2011: DYNAmore assigned as master distributor





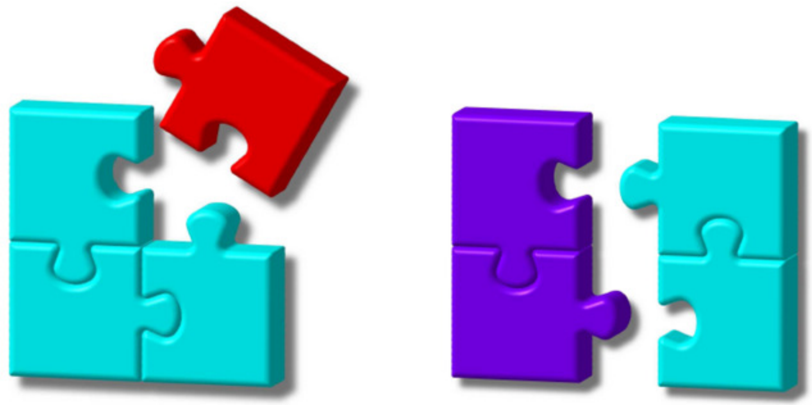


Multiphysics and Coupled Problems

- Coupled Multi-Field Problems
  - The individual field equations are also functions of the other field
    - Example: velocity and pressure fields for incompressible viscous flow
- Coupled Multi-Physics Problems
  - Multiple physical models or phenomena are handled simultaneously
  - Different discretization techniques are used for individual subproblems
    - Example: particle systems (DEM) interact with structures (FEM) on the same or multiple scales
  - Field variables represent different but interacting physical phenomena
    - Example: thermoelectricity combining heat conduction and electrodynamics

Park & Felippa: Partitioned analysis of coupled systems. In Belytschko & Hughes (eds.): Computational Methods for Transient Analysis. Amsterdam 1983, pp. 157–219

- Coupled Problems
  - Dynamic Interaction of physically or computationally heterogeneous components
  - Interaction is multi-way



Partitioning or splitting of a coupled problem

Classification of the Coupling

Volume Coupled

- Discretized field variables (DOF) are coupled on the same domain
- Weak coupling
  - Thermo-mechanical problem
    - displacement & thermal field
- Strong coupling
  - Incompressible fluid flow
    - velocity & pressure field
  - Electro-magnetical problem
    - electric field & magnetic flux density
  - Porous-media problems
    - displacement & pressure field
    - displacement, pressure & concentration fields

Surface Coupled

- Discretized field variables (DOF) are coupled at an interface surface
- Weak coupling
  - Mechanical contact
  - Heat transmission
  - Structural sound emission
  - Fluid-structure interaction (fluid/solid density ratio ≠1)
- Strong coupling
  - Fluid structure interaction (fluid/solid density ratio close to 1)

Solution of Coupled Problems

- Spatial semi discretization
  - Finite-Element Method (FEM)
  - Finite-Difference Method (FDM)
  - Finite-Volume Method (FVM)
  - Arbitrary Lagrange Eulerian (ALE)
  - Boundary-Element Method (BEM)
  - Discrete-Element Method (DEM)
  - Smoothed Particle Hydrodynamics (SPH)
  - Element-Free Galerkin (EFG)
- Time integration
  - Implicit and explicit time-stepping schemes
  - Monolithic or direct approach
    - the problem is treated monolithically
    - all components are integrated with the same scheme
  - Partitioned or iterative approach
    - system components are treated as isolated entities
    - separate time integration with arbitrary schemes
    - subcycling to account for different time scales
    - prediction, substitution, and synchronization techniques apply

Multiphysics in LS-DYNA

- One-Code Strategy for LS-DYNA

> "Combine the multi-physics capabilities into one scalable code for solving highly nonlinear transient problems to enable the solution of coupled multi-physics and multi-stage problems"
>
> -- John Hallquist (2012)

- Todays Presentations
  - CFD Solvers and Interaction possibilities in LS-DYNA R7
    - I. Çaldichoury (LSTC)
  - Interaction of bonded and loose particles in LS-DYNA
    - N. Karajan (DYNAmore)
  - EM field solver and its thermo-structural coupling in LS-DYNA R7
    - I. Çaldichoury (LSTC)
  - Advanced metalforming simulation using a thermomechanicsl coupling including phase changes
    - D. Lorenz (DYNAmore)