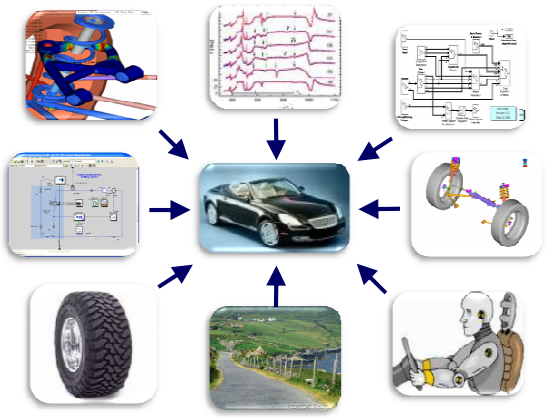


Co-Simulation -
Customer Benefits Illustrated by Some Use Cases

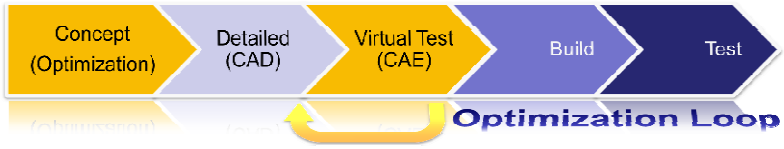
Dr. Michael Hoffmann
Vice President European Operations

Challenges

- Increasing
  - Product complexity
  - Product diversity
  - Product quality
- Decreasing
  - Development time
  - Development resources

Challenges - Consequences

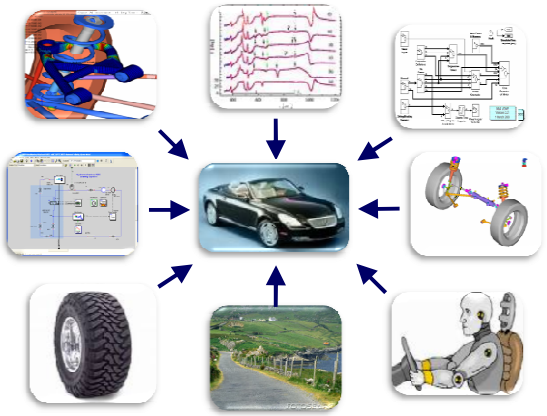
- Product Development
  - Simulation driven



  - Multi-disciplinary
    - Parallel vs. Sequential
    - "Balanced" vs. "One-sided"
  - ➢Co-simulation

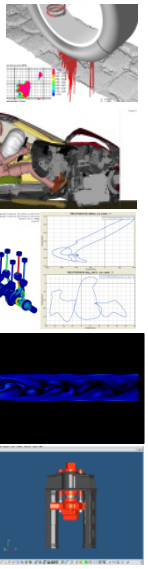
Co-Simulation

- Benefits
  - Accuracy
  - Quality
  - Efficiency
- Types
  - One solver
  - Multiple solvers

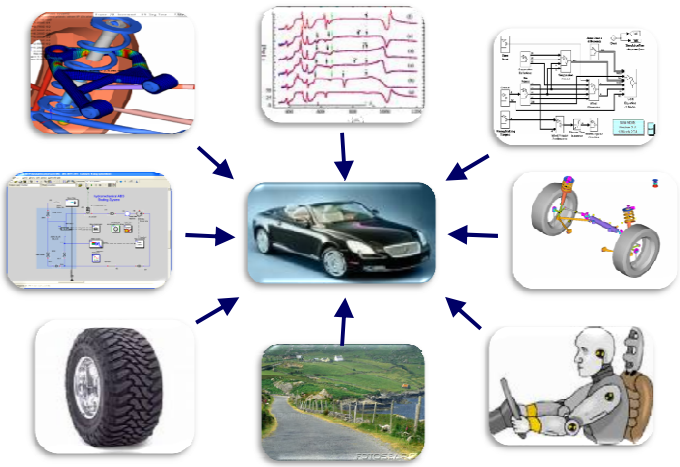


Co-Simulation – Case Studies

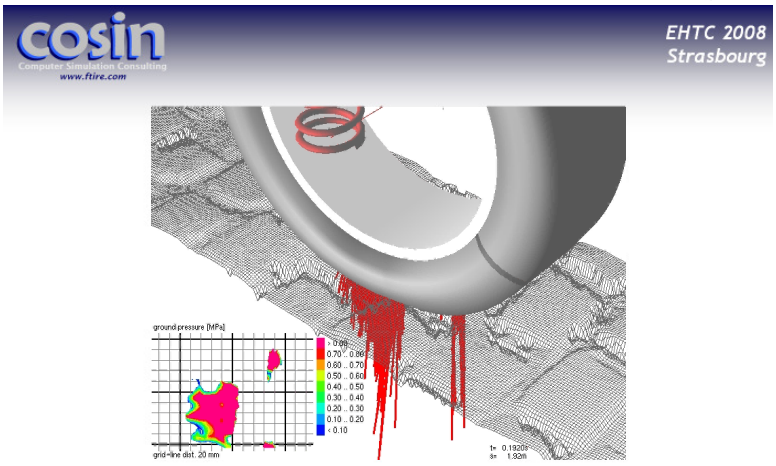
- Automotive
  - Vehicle Dynamics
  - Pedestrian Safety
  - Passenger Safety
  - Crank Shaft Dynamics
- Fluid Structure Interaction
- General Machinery



Case 1: Vehicle Dynamics



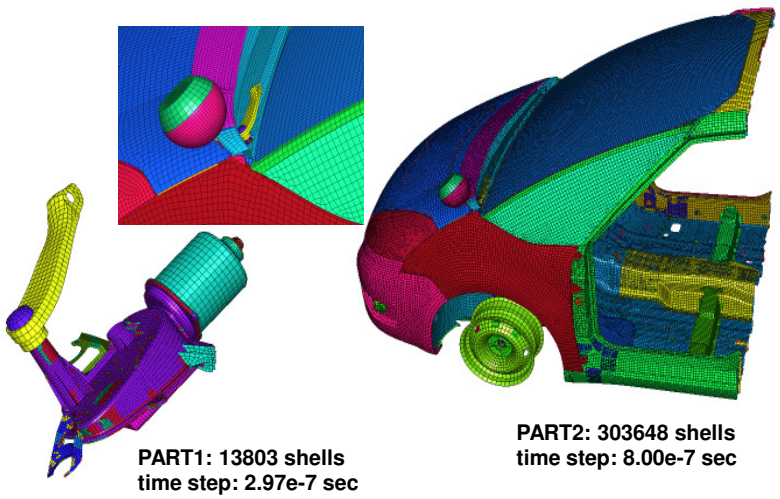
Case 1: Vehicle Dynamics



CTI: Next Generation Tire Model Interfacing

Michael Gipser, Esslingen University of Applied Sciences, Germany

Case 2: Pedestrian Safety – Head Impact

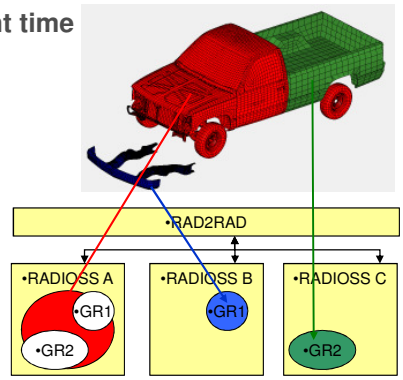


PART1: 13803 shells
time step: 2.97e-7 sec

PART2: 303648 shells
time step: 8.00e-7 sec

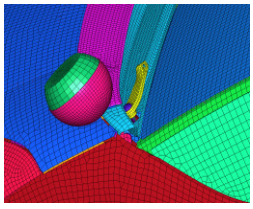
Case 2: Pedestrian Safety – Head Impact

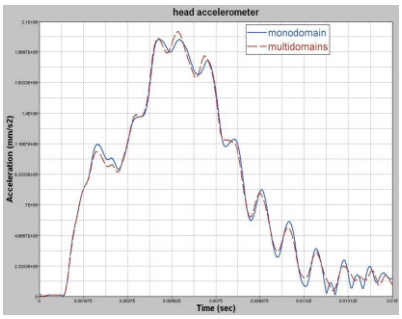
- **Multi-domain support in RADIOSS**
  - Arbitrary number of domains can be specified
  - Each domain can have different time step
  - Optimized CPU-usage
  - Incredible speed-up
- **Vision:**
  - Allow implicit domains
  - Allow third party solvers like CFD to solve a domain



Case 2: Pedestrian Safety – Head Impact

Performance	Single-domain RADIOSS	Multi-domain RADIOSS
Elapsed time (1 core)	63501 s	27260 s
Elapsed time (4 cores)	14776 s	7323 s





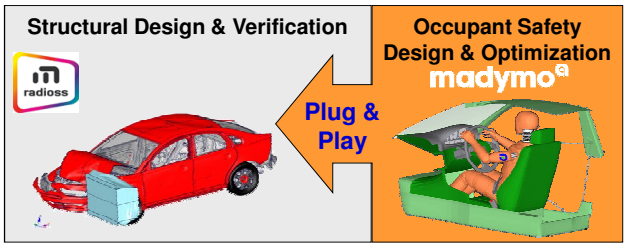
Case 3: Passenger Safety

Selected slides from EHTC09 presentation.

Complete presentation at http://www.altairhtc.com/europe

What is Coupling?

- FE crash codes are typically used for structural design
  - Accurate predictions of deformations, but long run times
- MADYMO is specialized in restraint design & optimization
  - Fast run times & accurate dummy models
- TASS aims to offer its customers the best of both worlds by harmonizing MADYMO with FE crash codes through a plug & play solution



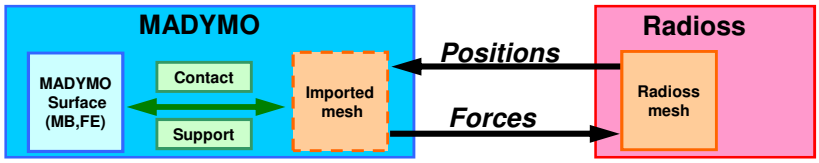
What is Coupling?

① FE data (nodal positions) is sent to MADYMO every time step.

② MADYMO makes a copy of the coupled Radioss FE objects.

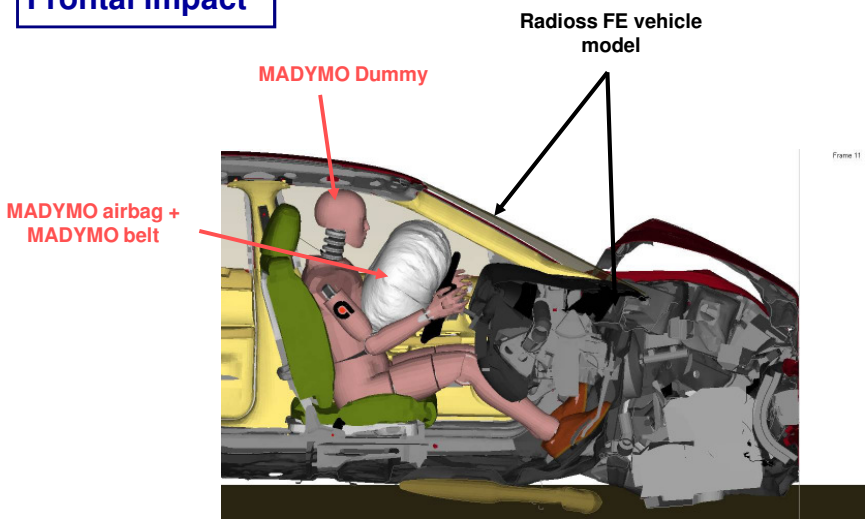
③ Contact evaluations / Constraints are performed in MADYMO.

④ Calculated forces are sent back to Radioss.



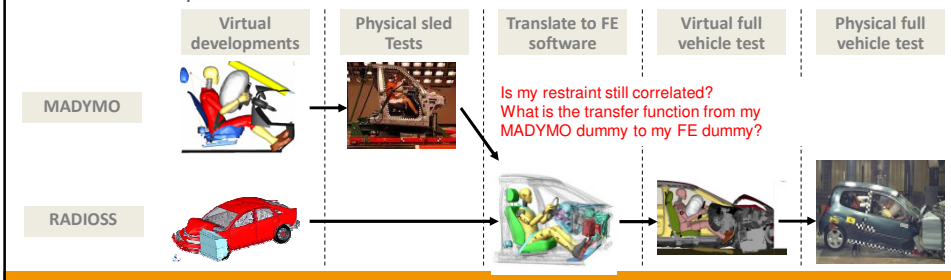
Example

Frontal impact



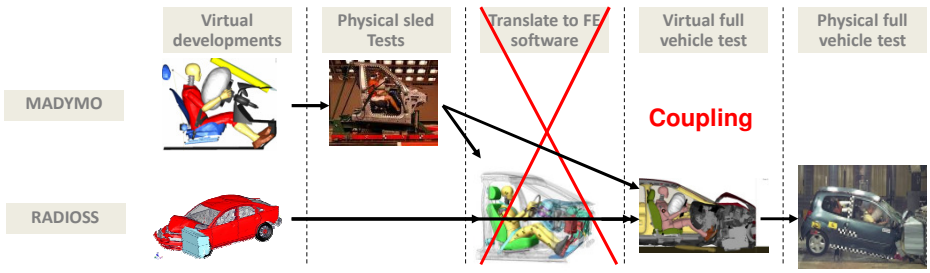
When to use Coupling?

- Within each development cycle a number simulation activities are performed
  - Vehicle structure and its related components (seats, instrument panel…)
  - Restraint system
- The structural development team has need to integrate the outcome of the restraint system development within its numerical model to assess the vehicle performance



When to use Coupling?

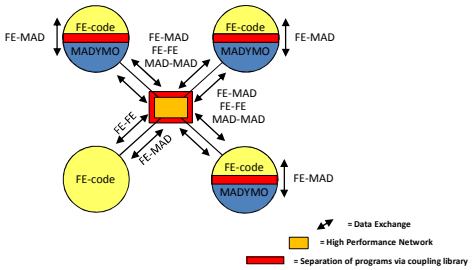
- Coupling allows
  - Usage of the same dummy within the structural development and within the restraint system development
  - Focus on restraint system development without having to account for translation phases every time a new



MPP Coupling

- A new MPP “indirect” coupling interface has been developed by Altair and TASS

- MPP coupling
  - MADYMO in MPP
  - Data exchange in MPP
  - Parallel communication
- Increased ease-of-use
- Wider platform support



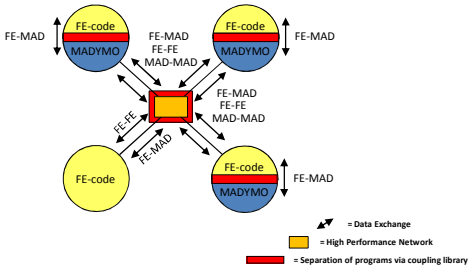
MPP Coupling

- The new communication interface consists of two parts:
  - High-level coupling protocol:

    The coupling protocol describes which data is sent and how this data is structured. This protocol is based on the current coupling interface.

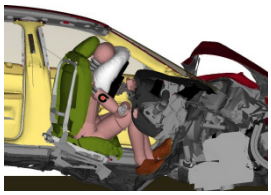
  - Low level coupling library:

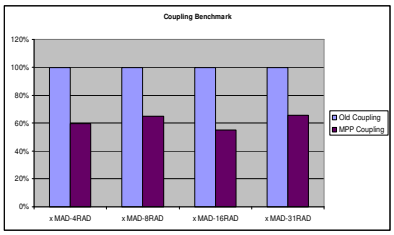
    The coupling library handles all communication between the MADYMO processes and the external FE processes.

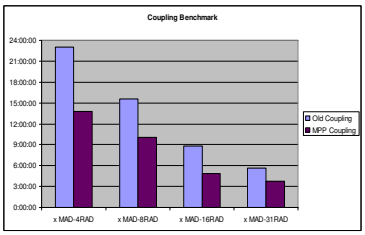


MPP Coupling

- Benchmark with model incl. MADYMO dummy, airbag and belts shows a **30% - 50% runtime improvement** against the 'traditional' coupling.







Benefits

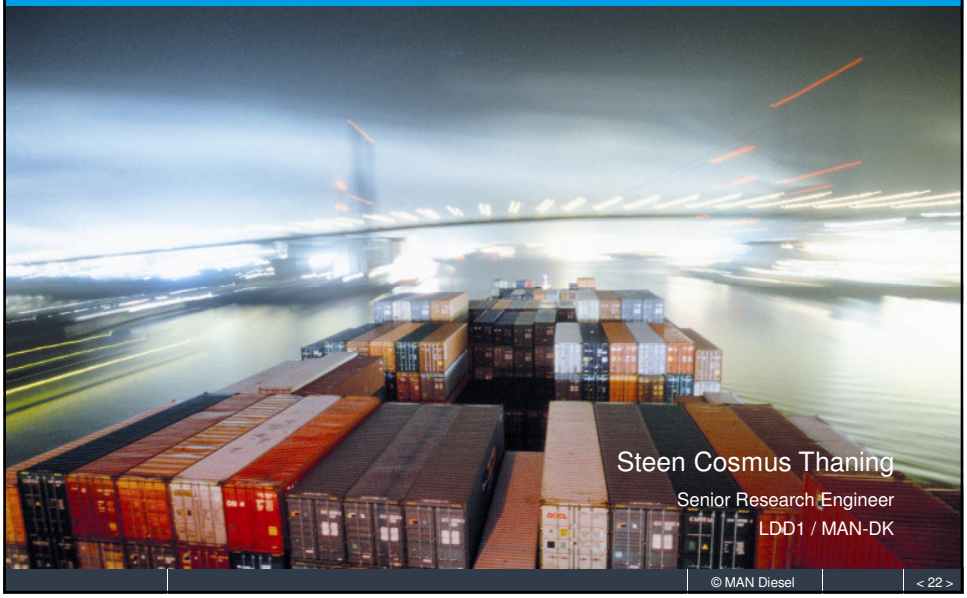
- Consistency
  - Reduced risk of design conflicts because one validated restraint system model can be used throughout the entire design process.
- Efficiency
  - No need to translate and re-validate the dummy and restraint models in the verification phase.
  - If CPU time is dominated by the FE dummy model, the use of MADYMO ellipsoid or facet models can reduce the total CPU time.
- Quality
  - Proven accuracy of the MADYMO dummy and restraint models.
- Robustness
  - MADYMO dummy models are numerically stable, so multiple re-runs of a simulation to resolve FE dummy model stability issues no longer needed.
- Flexibility
  - All dummy models, human models and pedestrian models are available for all FE codes using a token licensing system.

Case 4: Crank Shaft Dynamics

Selected slides from EHTC09 presentation.

Complete presentation at http://www.altairhtc.com/europe

Oil Bearing Calculations in Ship Diesel Engines Using MotionSolve

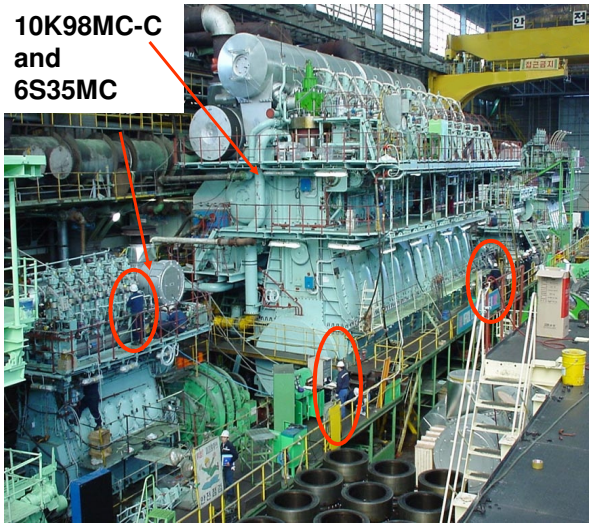


Steen Cosmus Thaning

Senior Research Engineer

LDD1 / MAN-DK

Introduction: The Product
Large Two-Stroke Diesel Engines

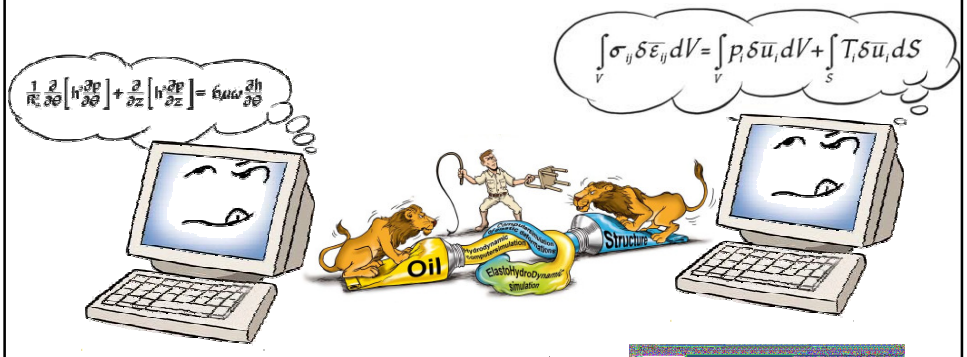


- Two-stroke
- Crosshead
- Turbo charged
- Low speed, 61-250 RPM
- Bore from 26 to 108 cm
- Stroke from 0.98 to 3.45 m
- Engine height from 5 to 16 m
- 4 to 14 cylinders
- Engine weight from 32 to 2800 tonnes
- Engines range from 2.100 to 132.000 BHP
- Continuous demand for cost reduction
- Reliability is crucial

Illustration of crankshaft revolutions

Coupled Calculation

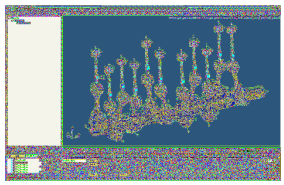
Oil Film **vs.** **Structure**



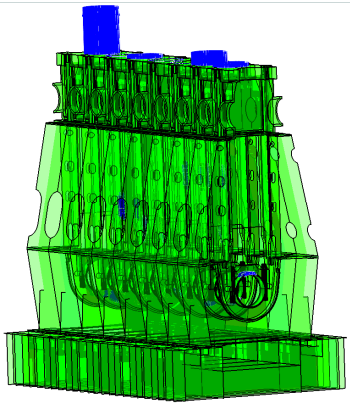
VFOSUB (MAN-BEAST)

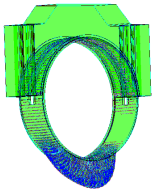
Fx Fy

x y dx/xt dy/dt



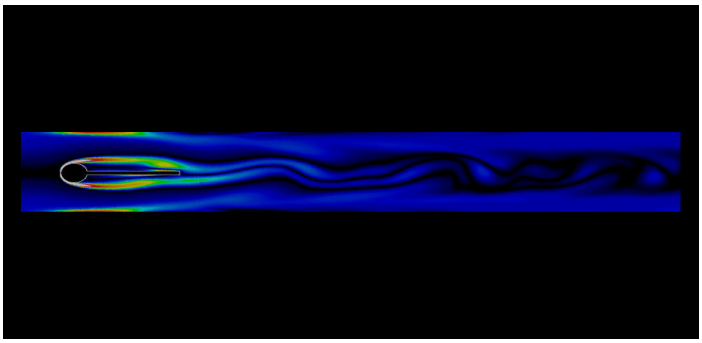
Motionsolve
The loading of engine structure





Main bearing loads along with other loads are used to optimise the engine structure

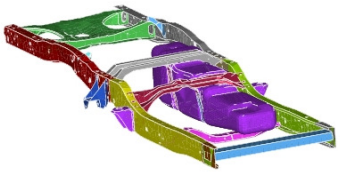
Case 5: Fluid Structure Interaction



Source: http://www.acusim.com

Fatigue Life Simulation of Fuel Tank

- **Challenge**
  - Identification of the fuel tank and its strap movement under proving ground conditions
- **Solution**
  - RADIOSS with Arbitrary Lagrange-Euler Method (ALE) for stress distribution.
  - FE-Fatigue, commercial fatigue code, to predict the fatigue life of the fuel tank straps.
- **Results**
  - The use of ALE method in RADIOSS shows reasonable fuel sloshing.
  - It can accurately predict the sequence and location of crack initiation

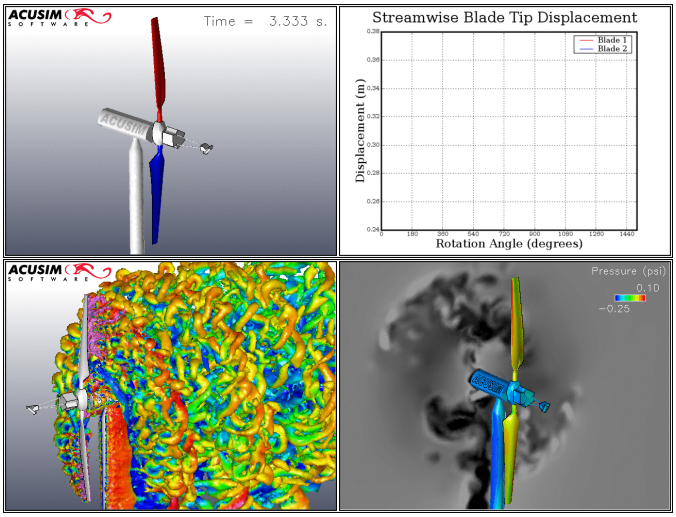


Fuel Sloshing Animation with Density

"The ALE CAE results in RADIOSS show good correlation with test, both in stress and fatigue life"

Dr. YongQuan Liu, Senior Engineer,
NVH CAE Method Section, FORD US

Wind Turbine



Altair

Case 6: General Machinery

Selected slides from EHTC09 presentation.

Complete presentation at http://www.altairhtc.com/europe

The Fluidtronic reference forging press

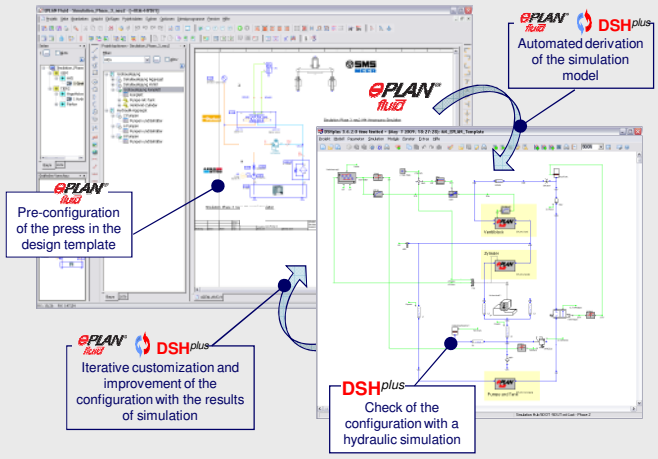
Push-down type forging press with two columns

Modern open-die forging plants consisting of the forging press and one or two rail-bound manipulators are highly dynamic production plants.

Apart from the pure production speed, the main focus today is on the achievement of minimum forging tolerances and a consistently high level of quality.

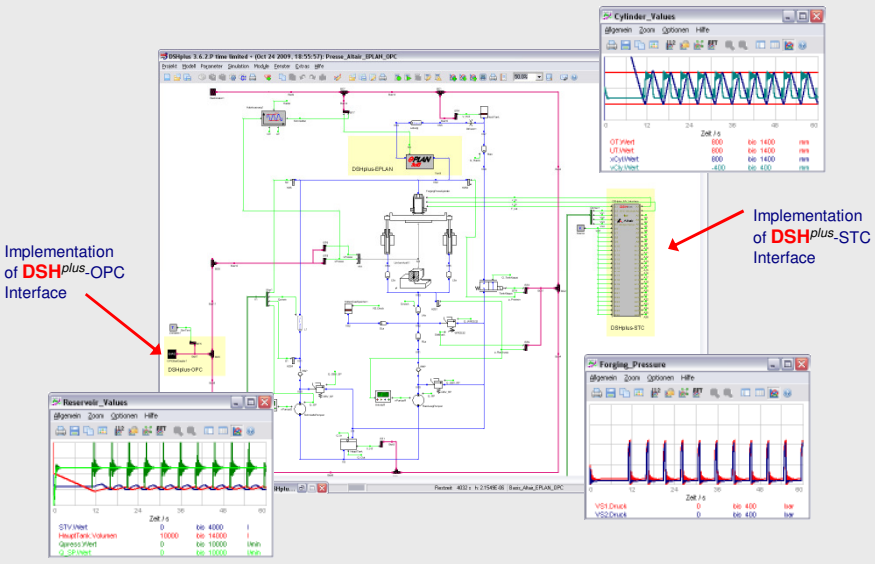
Furthermore, the logging of the production process and possible deviations from the specifications is demanded, in particular for products for energy engineering and for the aircraft and aerospace industries.

Step1: Initial System Design with EPLAN Fluid System Documentation

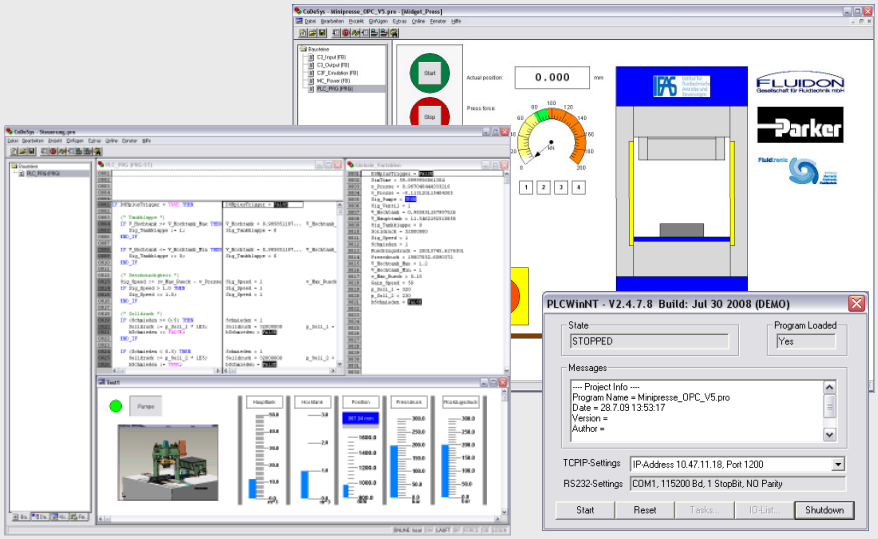


Development template = EPLAN design template and DSH*plus* simulation template

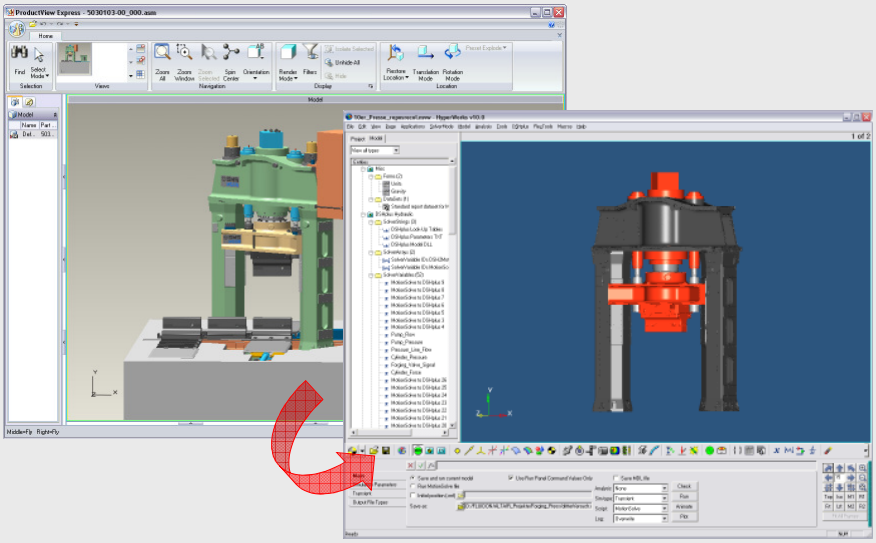
Step 2: Set-up of the DSH*plus* Hydraulic Model of the Forging Press



Step 3: Preparation of the CoDeSys PLC-Controller and Visualization



Step 4: Set-up of the MotionView Mechanical Model



Conclusion

- An optimization of the developments as well as a general development accompanying use of project planning and simulation software has the potential to overcome the deficits of conventional developments.
- The structured interaction of all technical domains, involved in the development, and their supply with detailed system information and current data leads to an acceleration of the developments at a simultaneous optimization of the overall system.
- A CAE Design Demonstrator has been builded in order to present the advantages of the new development environment for fluid-technical mechantronical systems.
- Have a closer look onto the CAE Driven Design Demonstrator at the FLUIDON booth (B12) in the exhibition area.

Fluidtronic

CAE Driven Design Demonstrator

Co-Simulation

- **Benefits**
  - Accuracy
  - Quality
  - Efficiency
- **➢Critical Enabler for**
  - Multi-disciplinary development
- **Caution**
  - Weak coupling may not require co-simulation