Recent and Ongoing Developments in LS-DYNA®

Presented by
Jason Wang

http://ftp.lstc.com/anonymous/outgoing/jason/Slides

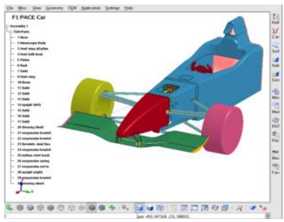
LSTC
Livermore Software Technology Corp.

2018 Oasys LS-DYNA UK User's Meeting,1/24/2018, Warwickshire

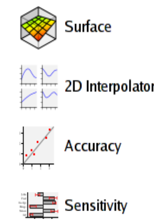
Outline

- Introduction
- User requests/enhancements — Jason Wang
- Tire Development — Suri Bala
- Implicit — Roger Grimes
- SPH, DEM — Jason Wang
- CPM — Jason Wang
- LS-OPT — Nielen Stander
- Mortar Contact — Thomas Borrvall
- EM — Pierre L'Eplattenier
- ICFD — Facundo Del Pin

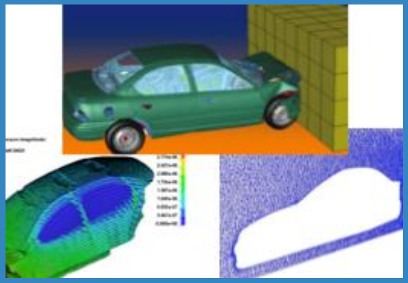
LSTC Products



LS-PrePost

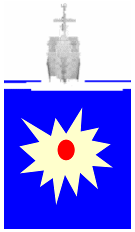


LS-OPT/LS-TaSC



LS-DYNA

Dummies & Barriers



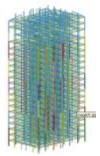
USA

No additional license cost

LS-DYNA Applications

Development costs are spread across many industries

Automotive
Crash and safety
NVH & Durability
FSI

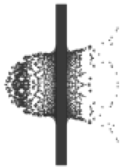


Structural
Earthquake safety
Concrete structures
Homeland security

Aerospace
Bird strike
Containment
Crash

Electronics
Drop analysis
Package analysis
Thermal

Manufacturing
Stamping
Forging
Welding



Defense
Weapons design
Blast and Penetration
Underwater Shock Analysis

Consumer Products

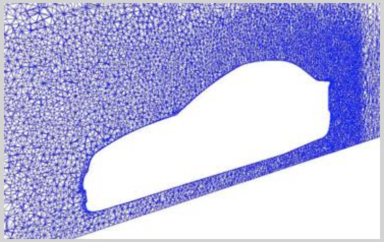
Biosciences

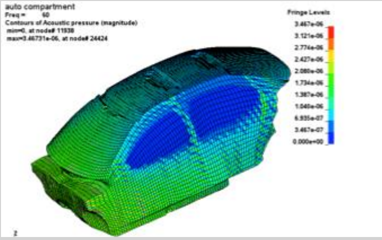
LS-DYNA - Current Capabilities

Includes coupled Multi-Physics, Multi-Scale , and Multi-Stage in one Scalable Code

- Explicit/Implicit
- Heat Transfer
- ALE & Mesh Free
  i.e., EFG, SPH, Airbag Particle
- User Interface
  Elements, Materials, Loads
- Acoustics, Frequency Response, Modal Methods
- Discrete Element Methods
- Incompressible Fluids
- CESE Compressible Fluids
- Electromagnetics
- Control Systems

LS-DYNA - One Code, One Model





Single Model for Multiple Disciplines

Manufacturing, Durability, NVH, Crash, FSI

Multi-physics and Multi-stage

Structure + Fluid + EM + Heat Transfer

Implicit + Explicit ….

Multi-scale

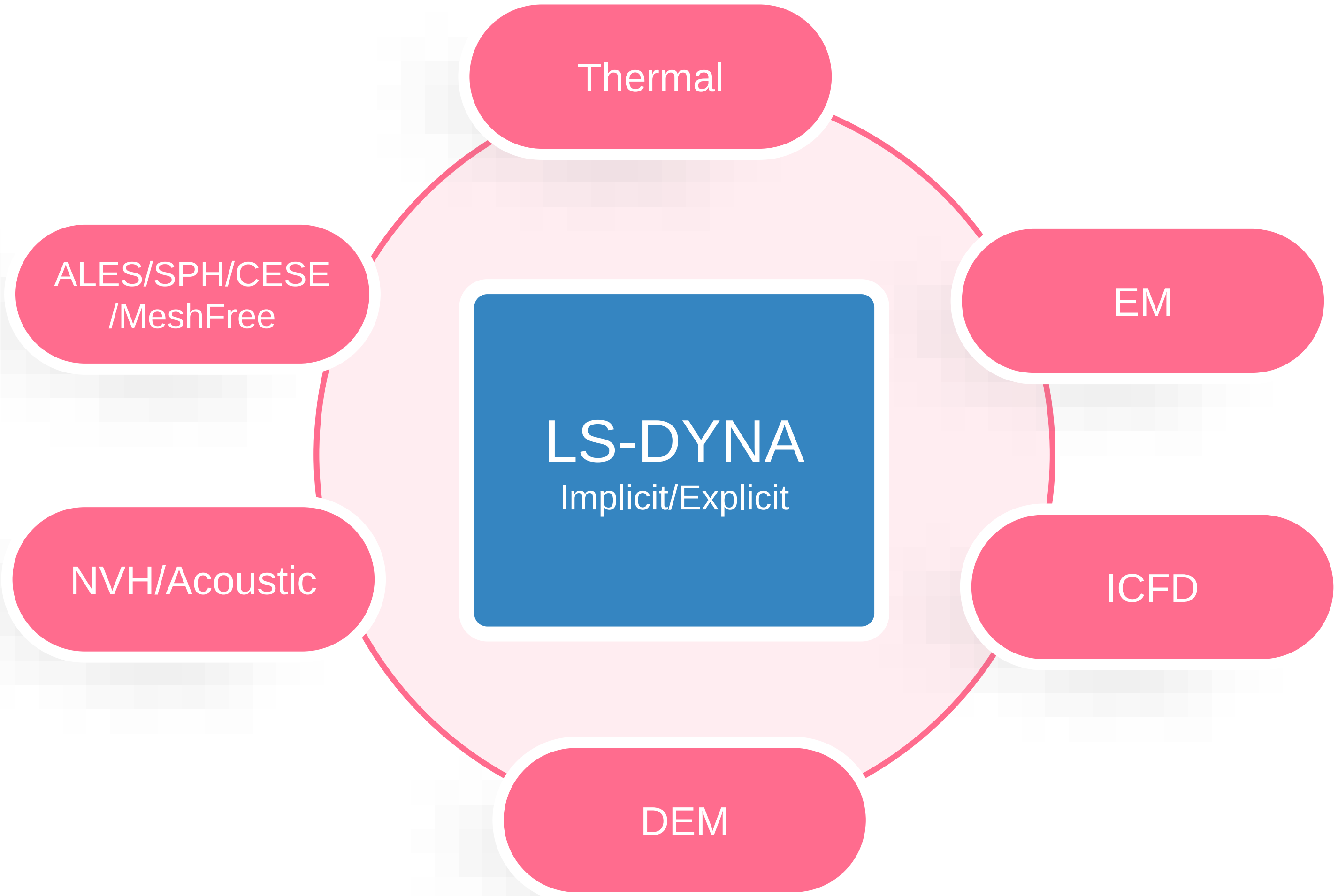
Failure predictions, i.e., spot welds

Multi-formulations

linear + nonlinear + peridynamics + …

The Neon crash model is courtesy of FHWA/NHTSA National Crash Analysis Center

Strong Coupled Multi-Physics Solver



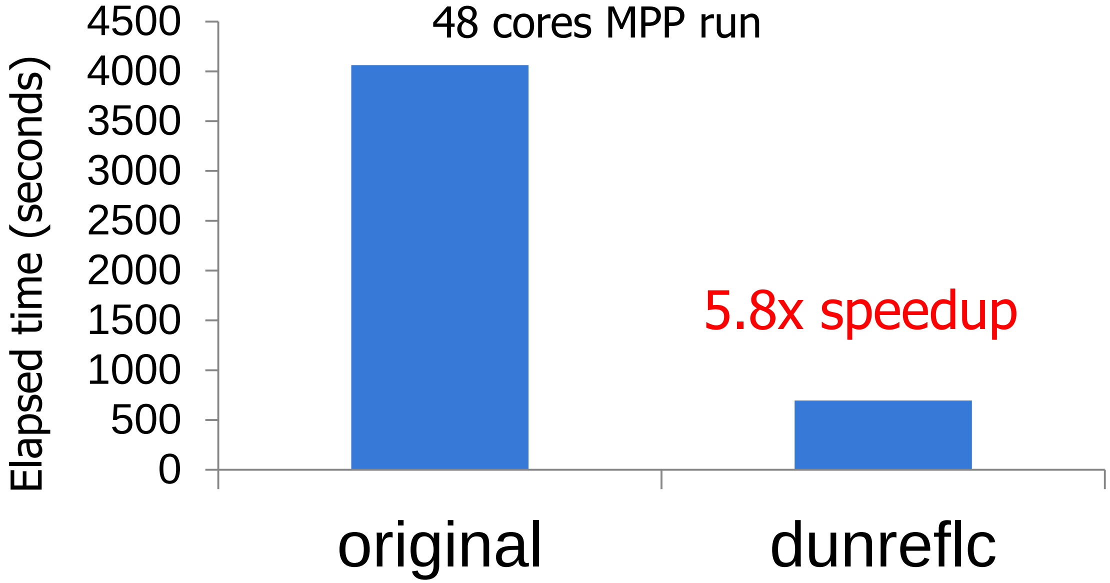
Computers that can handle multiphysics simulations are becoming affordable
Scalability is rapidly improving for solving multi-physics problems

User requests/ enhancements

*CONTROL_MPP_DECOMPOSITION_DISABLE_UNREF_CURVES

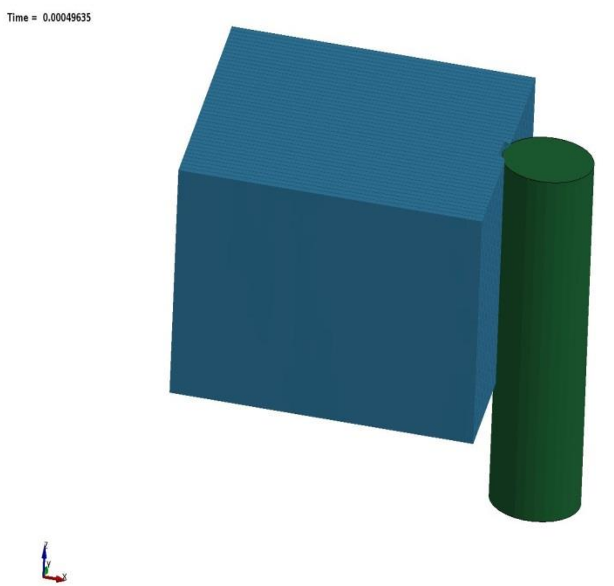
Multistep/Component analysis

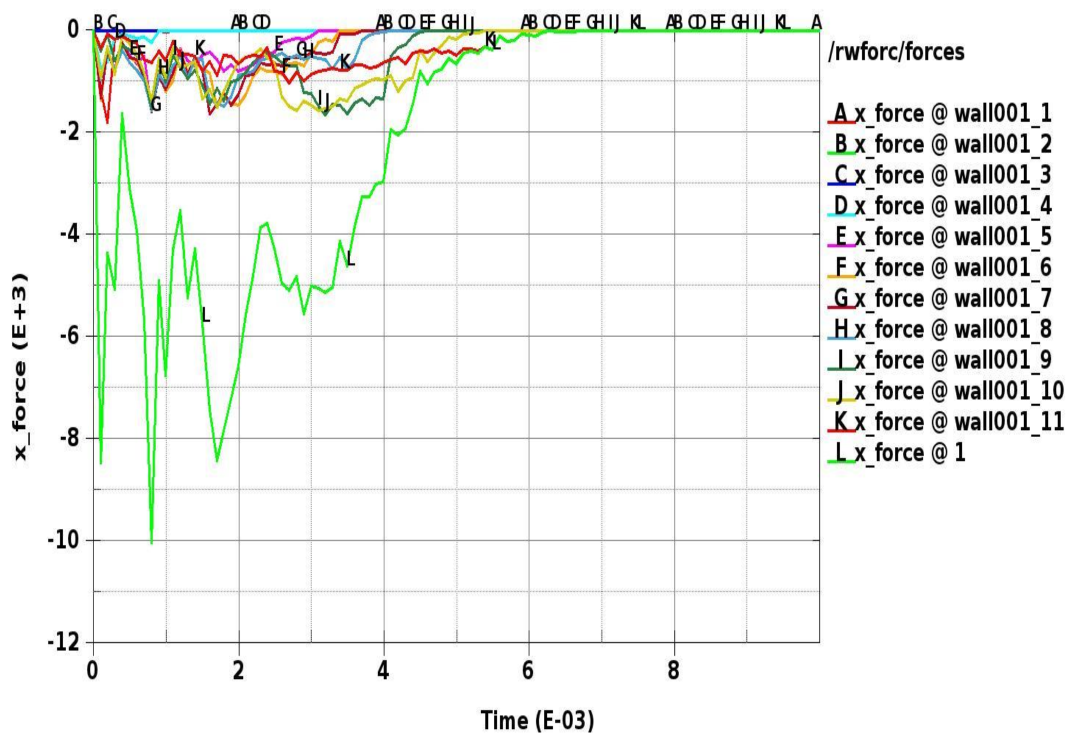
- 1st run generate the segment pressure, nodal forces, etc and saved in time history file
- 2nd applied the load to structure by one of the following way
  - *BOUNDARY_PRESCRIBED_MOTION_NODE*
  - *LOAD_NODE*
  - *LOAD_SHELL_ELEMENT*
  - *LOAD_THERMAL_VARIABLE_NODE*
- 2nd run greatly speed up by skipping those unused curves.



*RIGIDWALL_GEOMETRIC_CYLINDER with multiple sections

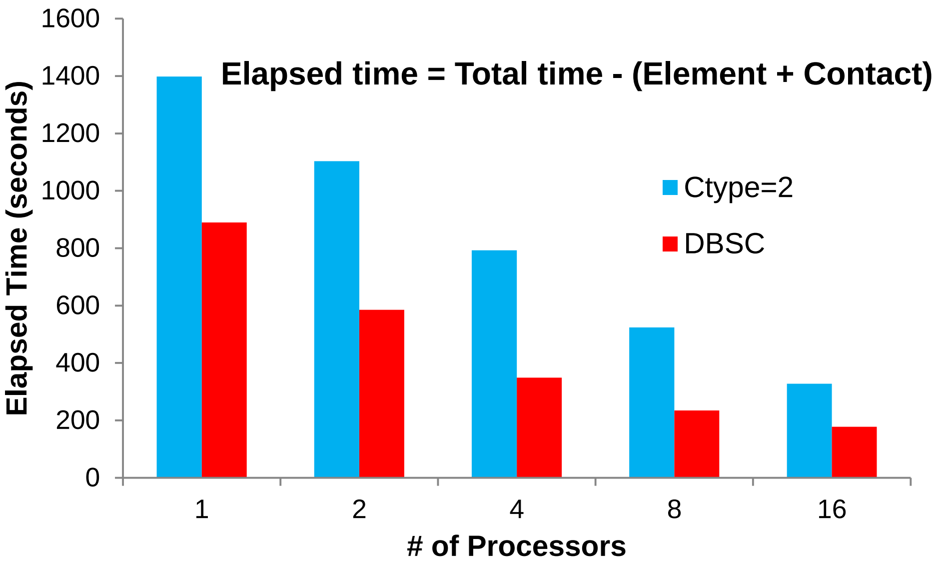
- Allow using one cylinder and subdivided it into many sections (please check keyword for the new options)
- Section's forces are reported in rwforc using the same format as regular segment set
- Shorter runtime by reducing number of CYLINDER definitions



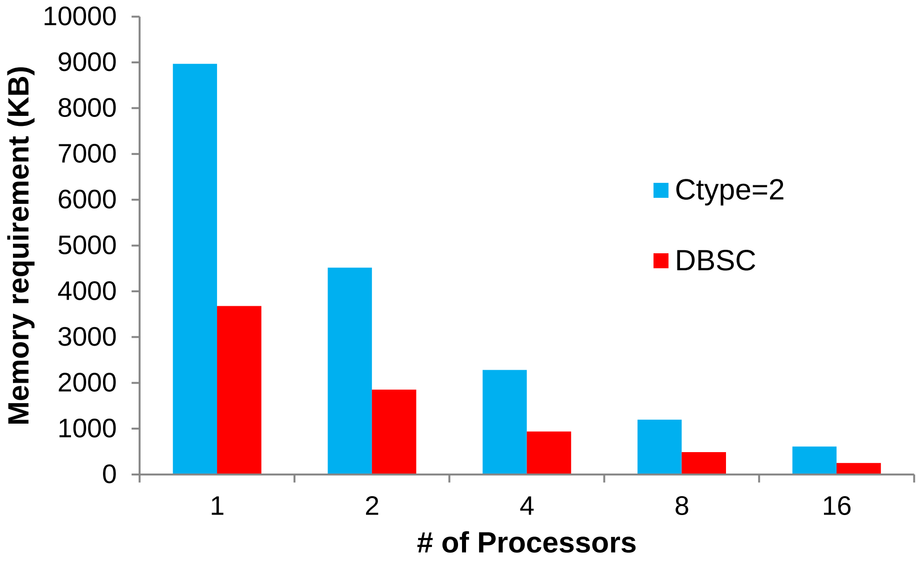


*DEINFE_BEAM_SOLID_COUPLING

- New implementation to replace *CONSTRAINED_LAGRANGIAN_IN_SOLID for CTYPE=2 for embeded structures in solid (rebar in seats)
- Easy setup, better performance and less memory
- Supports constraint and penalty formulations
- Available in R9.2



CPU cost



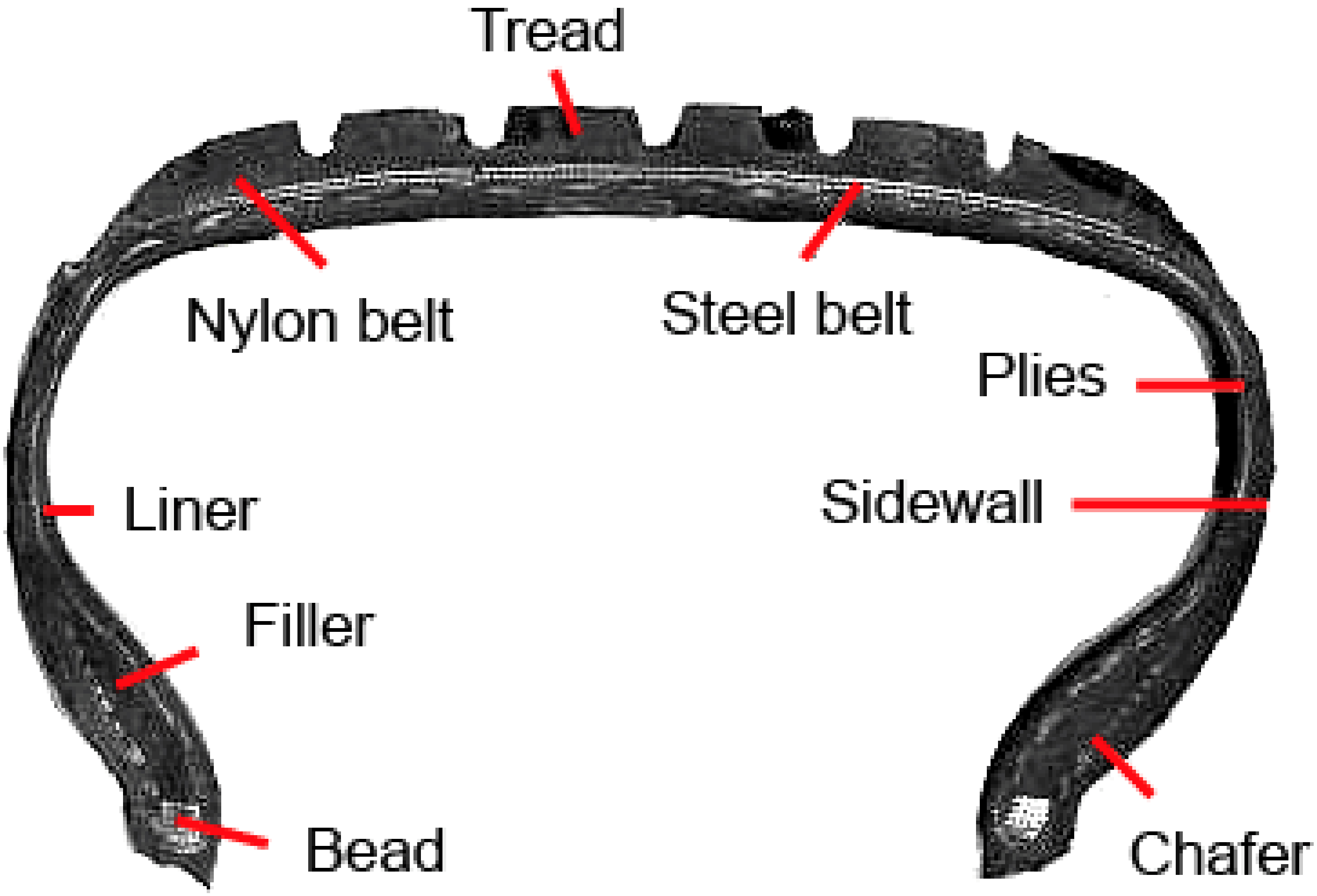
Memory requirement

Tire Development

Hamid Keshtkar[1], Kevin Thomson[1], Michael Reeves[1]
Mike Berger[2], Dilip Bhalsod[2], Srikanth Adya[2], Suri Bala[2]
Paul Du Bois[3]

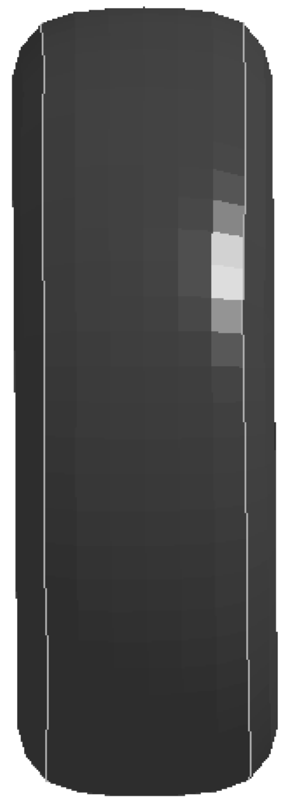
[1] FCA, [2] LSTC, [3] Independent Consultant

Small Overlap


Tread
Nylon belt
Steel belt
Plies
Liner
Sidewall
Filler
Bead
Chafer

Shell based Tire Model

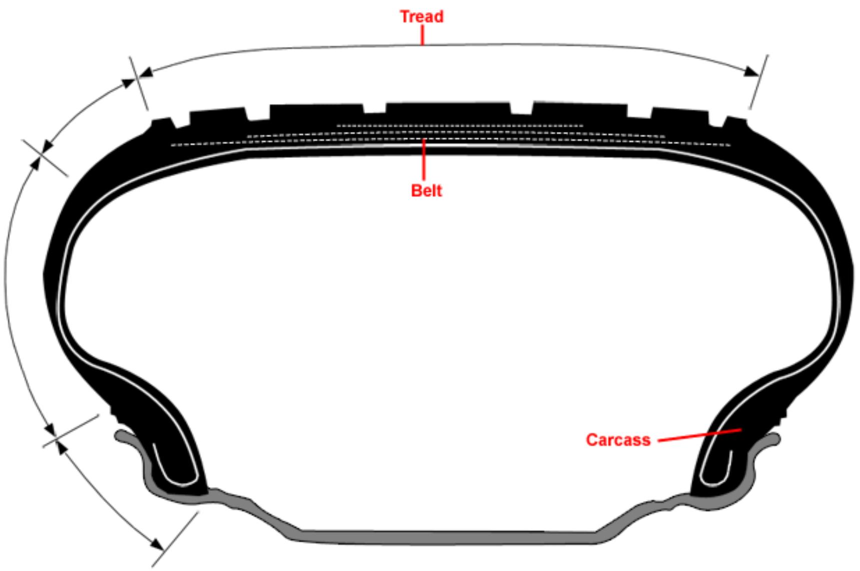
Left View

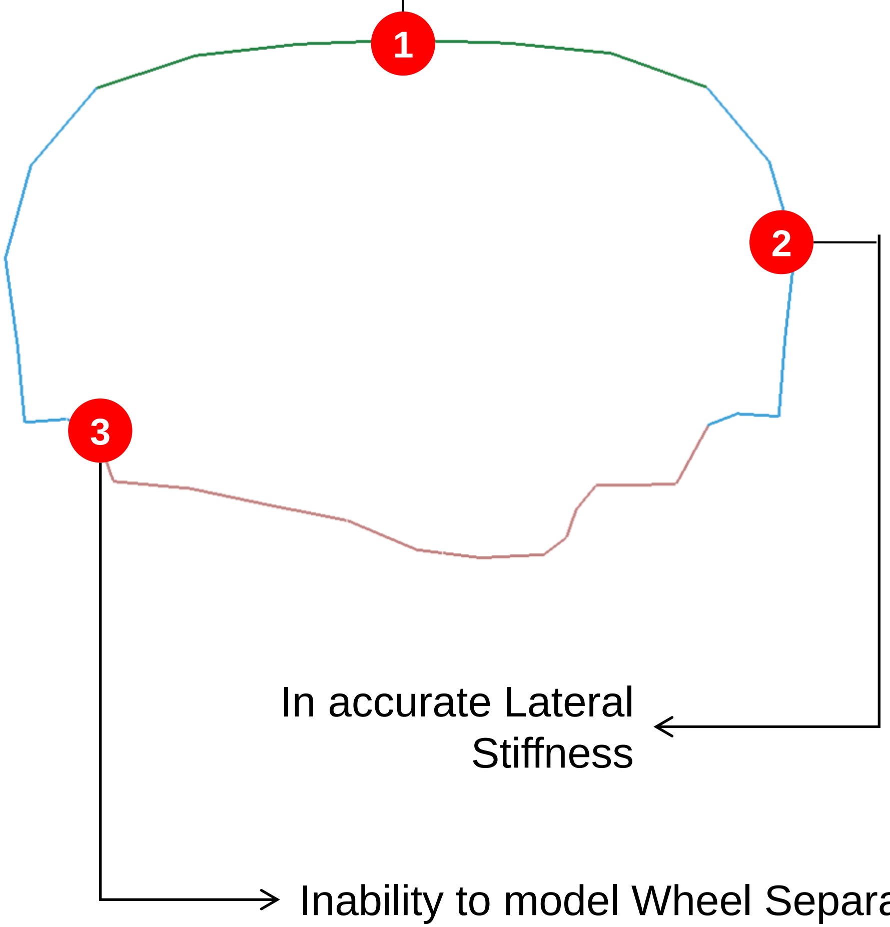


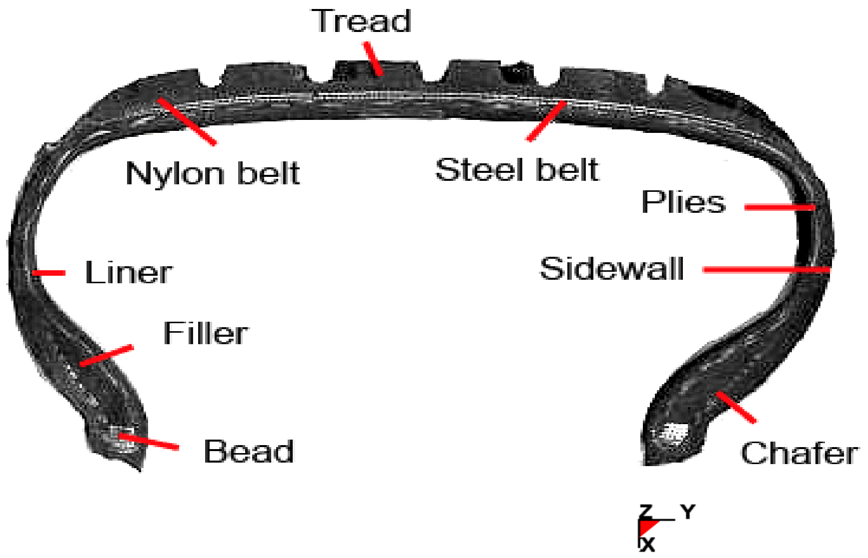
Front View

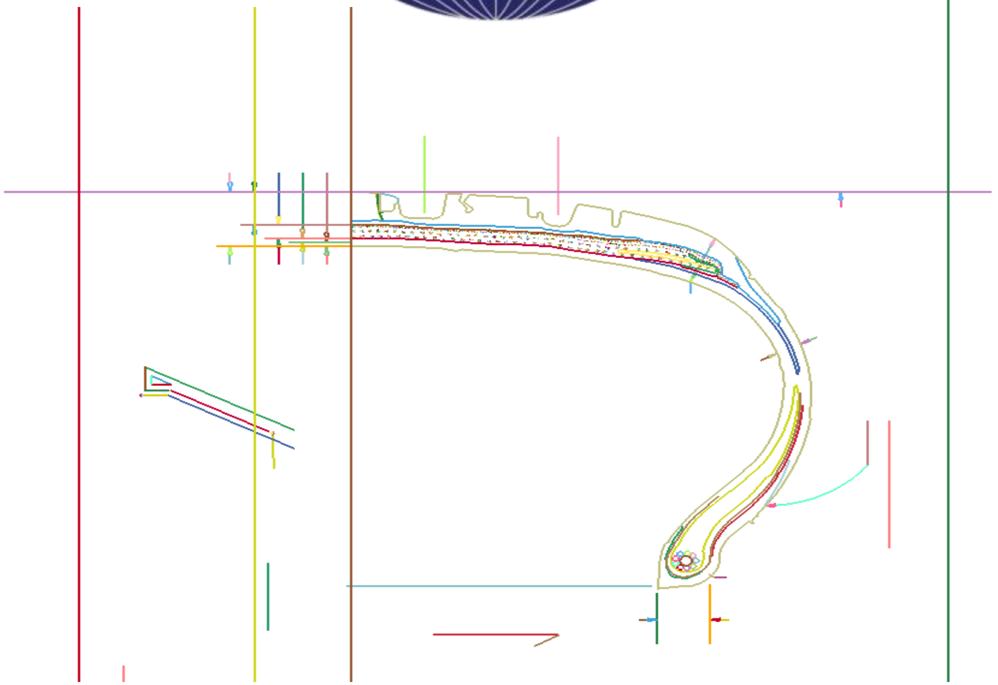
Section View

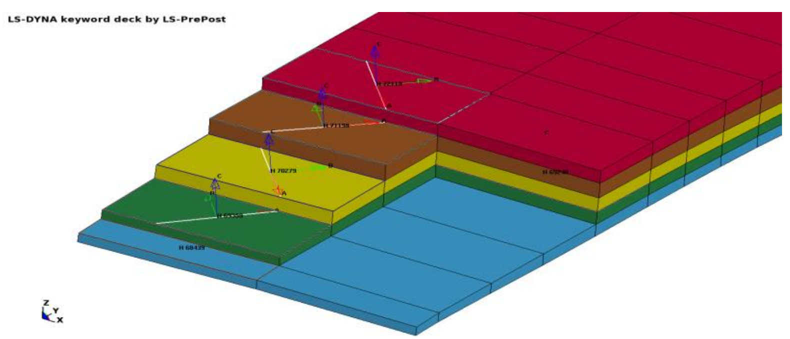
Shell Based Tire Model






Tread
Nylon belt
Steel belt
Plies
Liner
Sidewall
Filler
Bead
Chafer
Z
Y
X




LS-DYNA keyword deck by LS-PrePost

Material Characterization Tests

Tread, SubTread, Inner Liner, Apex (MAT_181)

Rubber → Tension

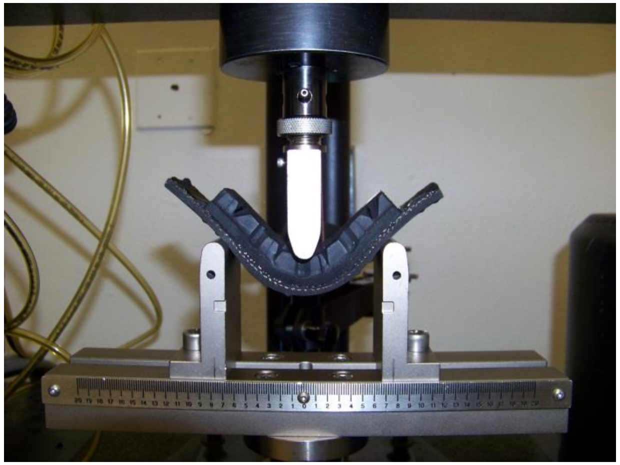
Rubber → Compression

Belt Overlay, WireBelt, Body Ply (MAT_002)

Plies → Tension → 0

Plies → Tension → 90

Plies → Shear

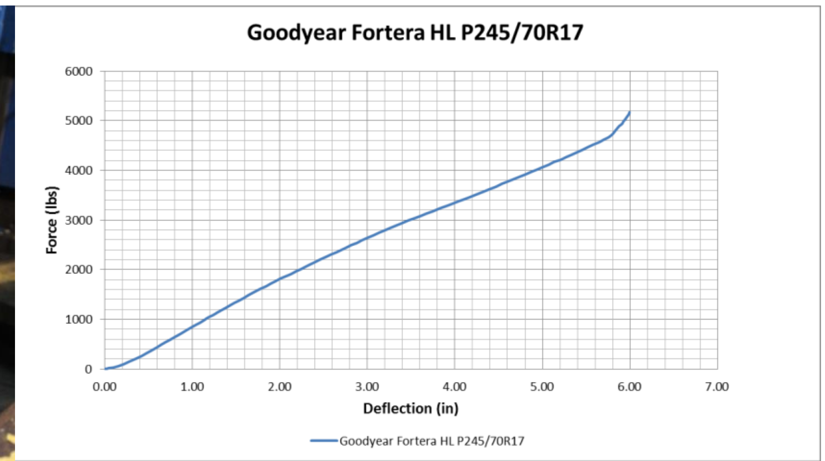


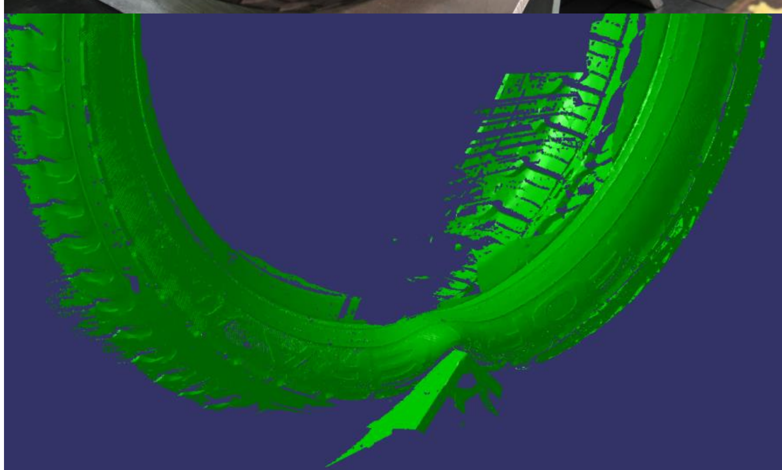
Bead (MAT_001)

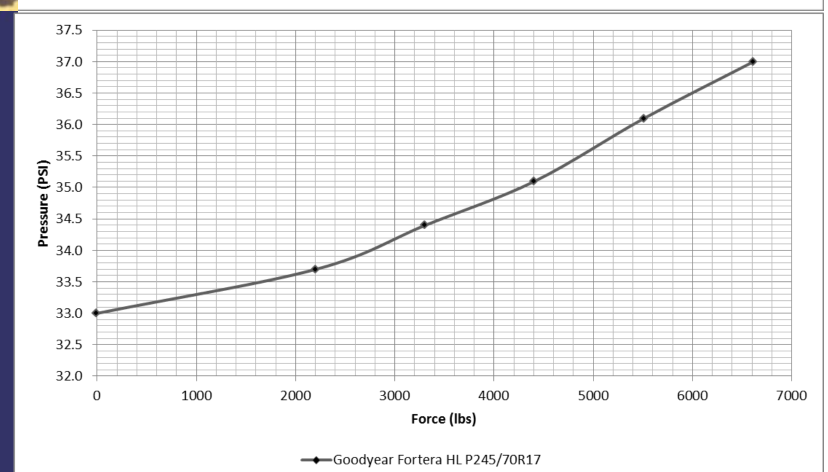
Beads → Tension

Tire Tests

- Static and Dynamic Tests

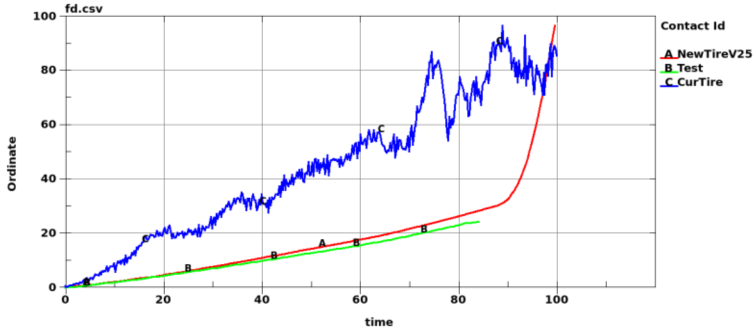


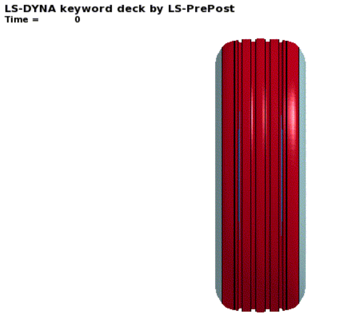


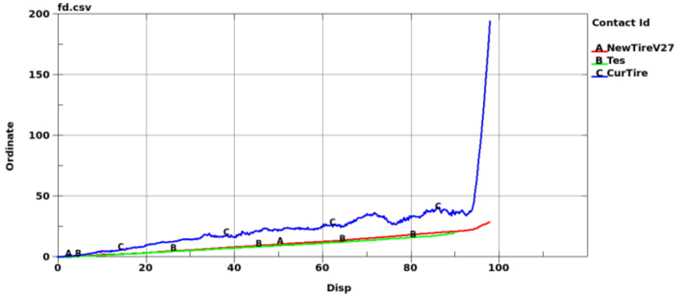


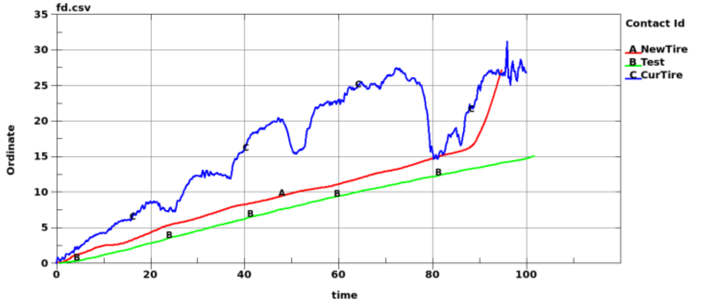
Static Tests

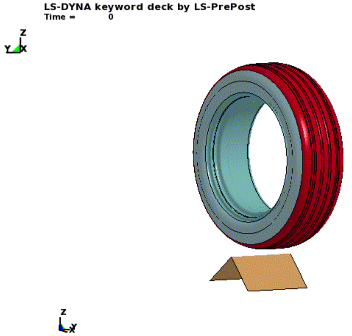
Test
New tire
Current tire

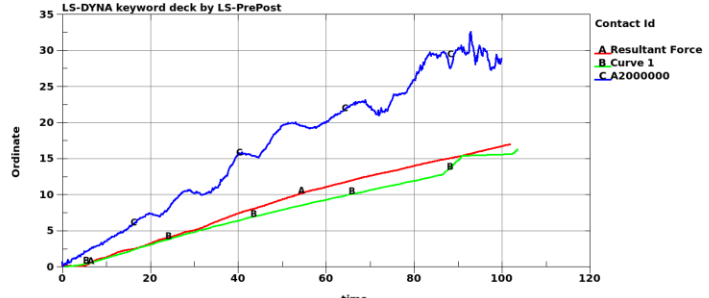


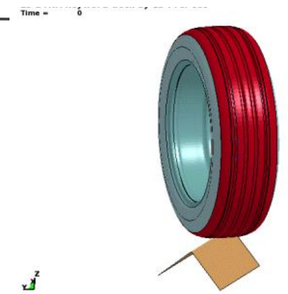




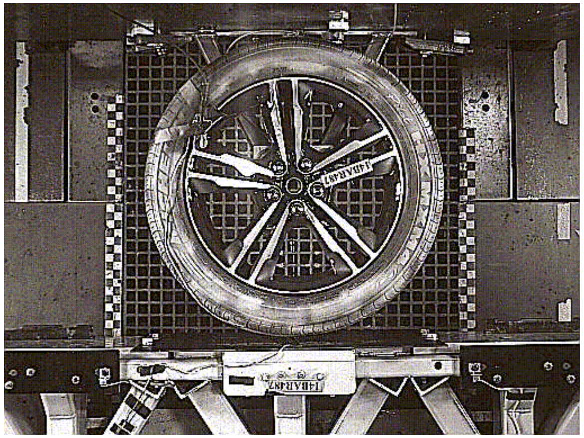


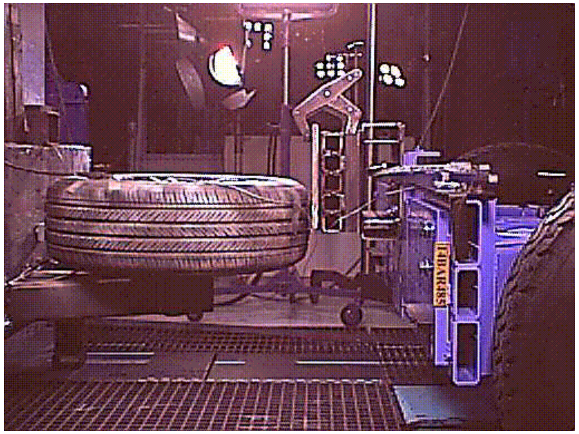


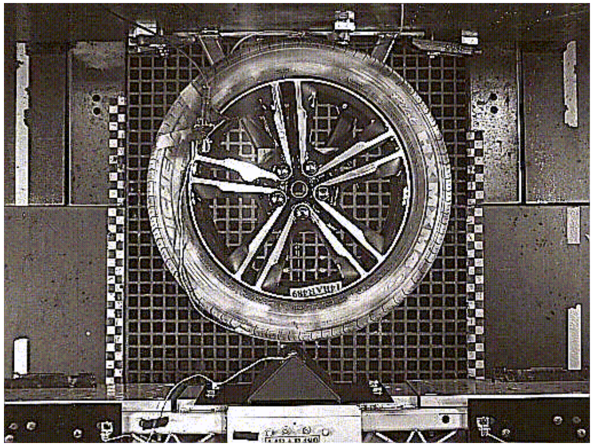


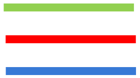


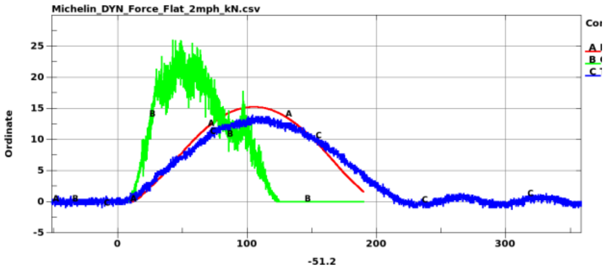
Dynamic Tests

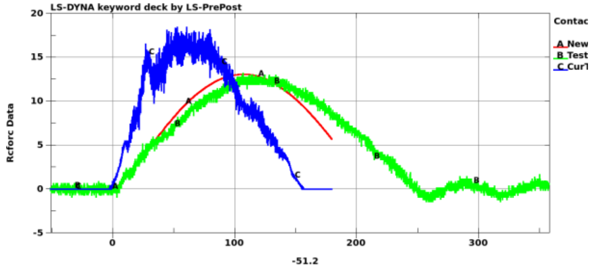


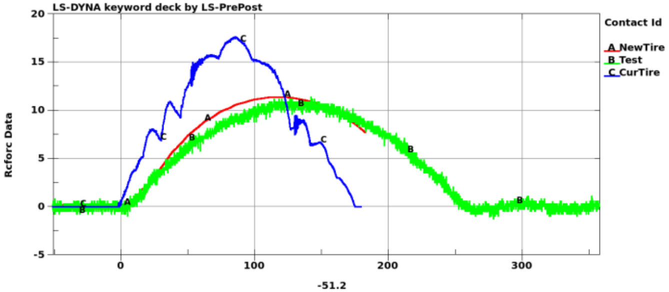


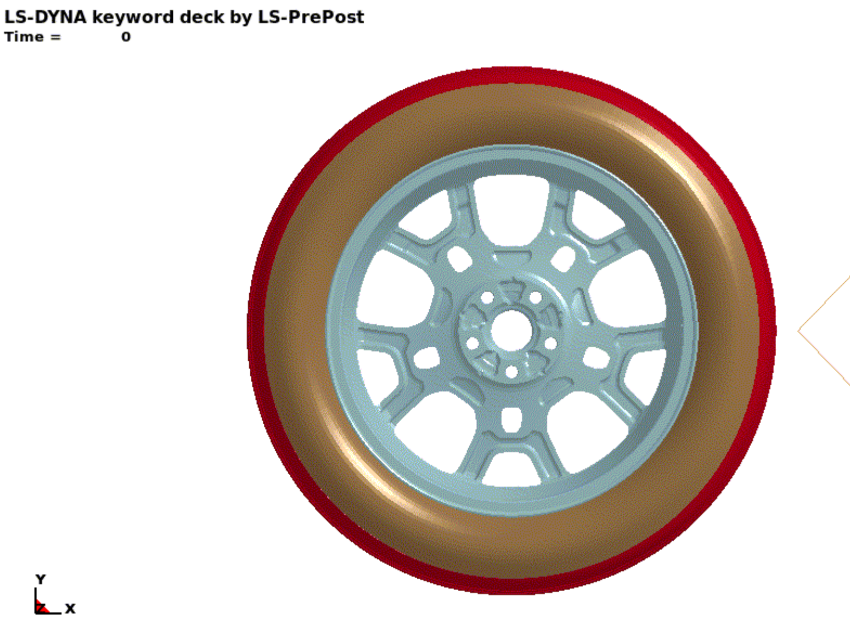


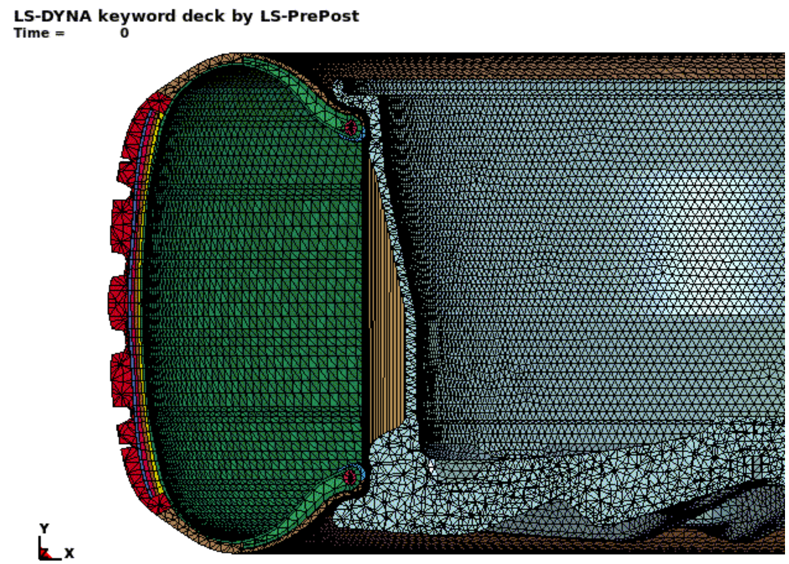


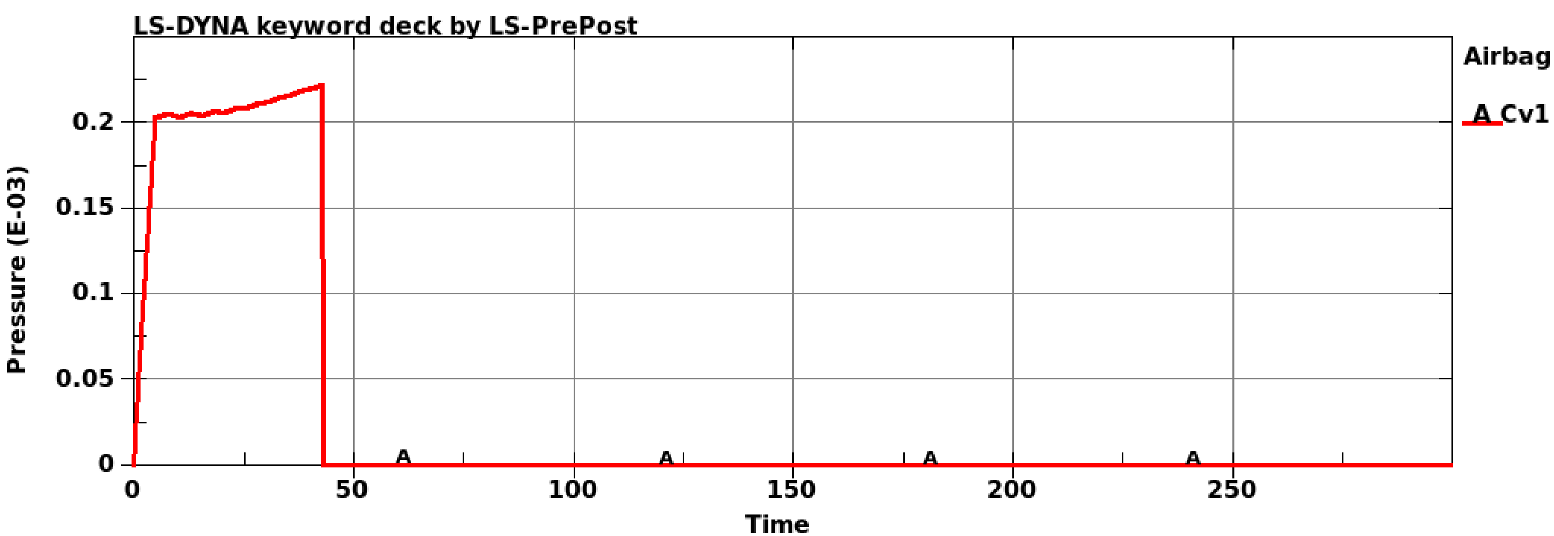




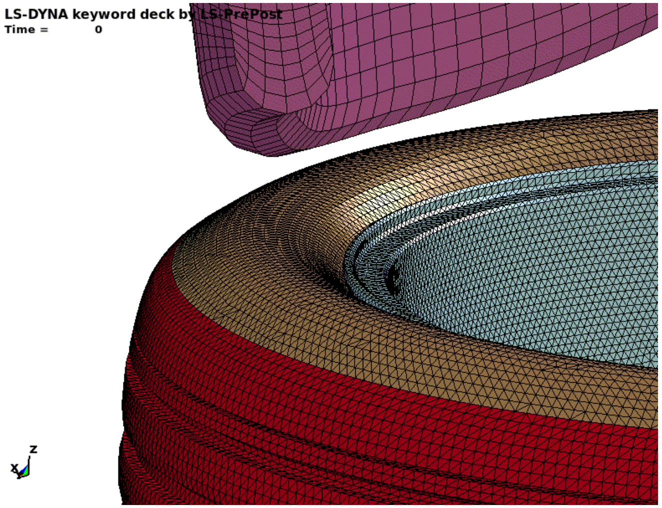



LS-DYNA keyword deck by LS-PrePost
Time = 0
Y
X

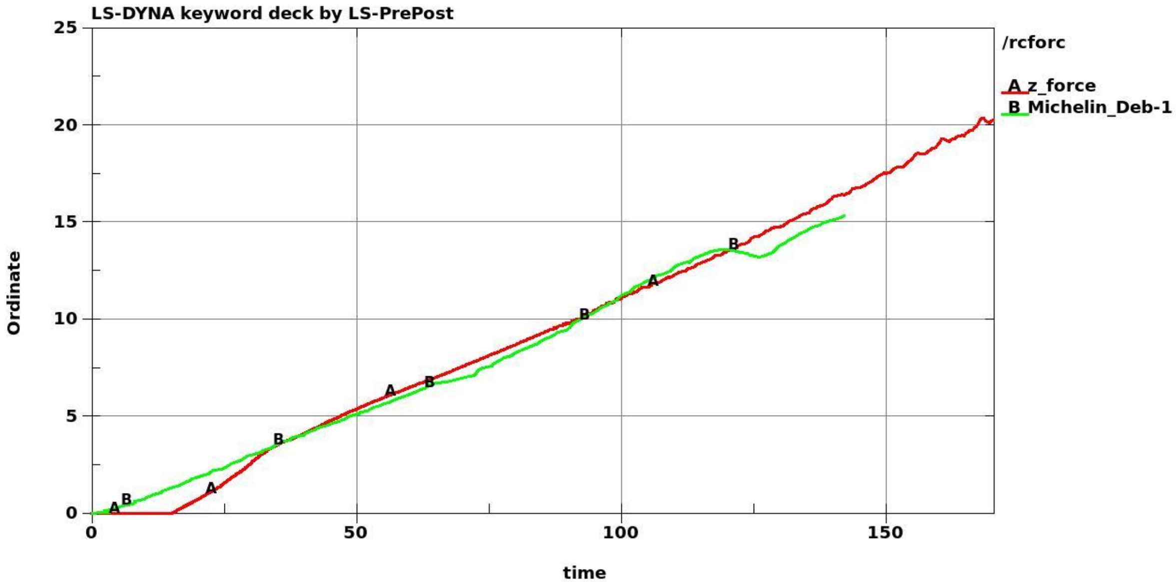

LS-DYNA keyword deck by LS-PrePost
Time = 0
Y
X


LS-DYNA keyword deck by LS-PrePost
Airbag
A Cv1
Pressure (E-03)
0
0.05
0.1
0.15
0.2
0
50
100
150
200
250
Time
A

De-beading

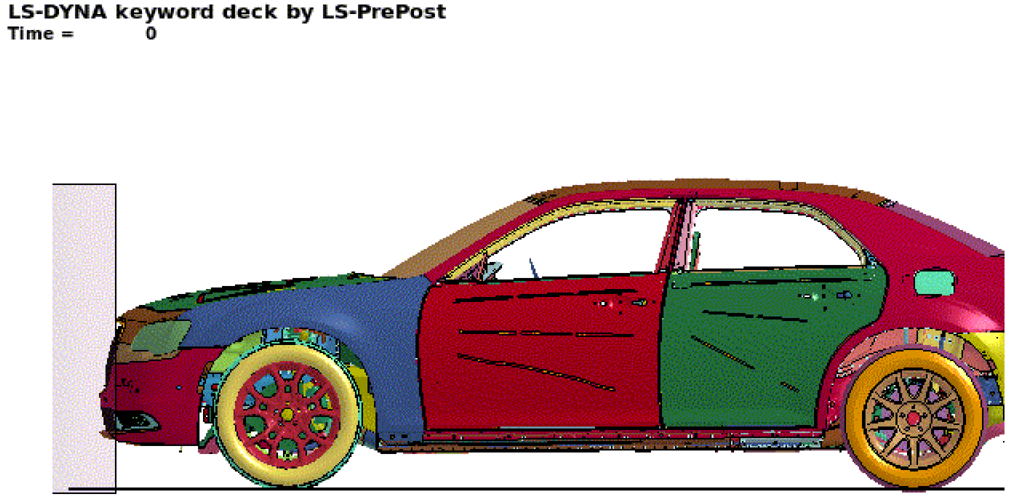


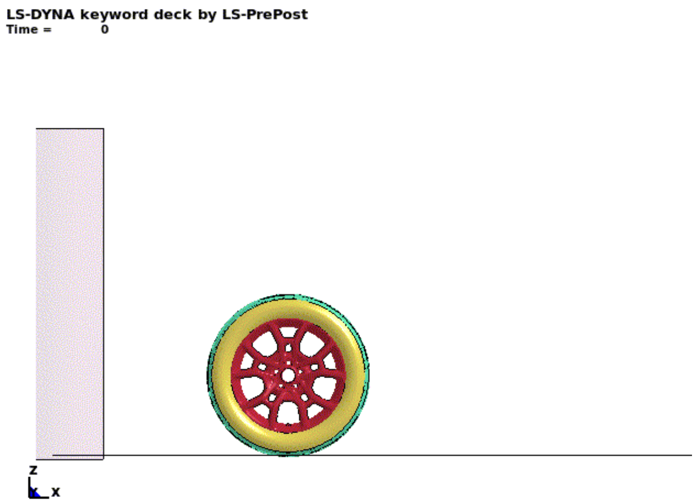
LS-DYNA keyword deck by LS-PrePost
Time = 0

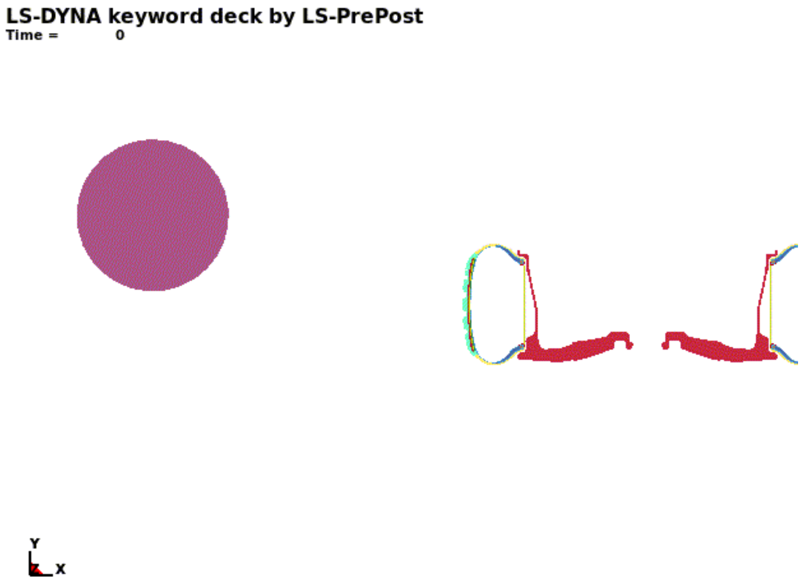


LS-DYNA keyword deck by LS-PrePost
Ordinate
time
/rcforc
A z_force
B Michelin_Deb-1

Full Vehicle Integration







Availability

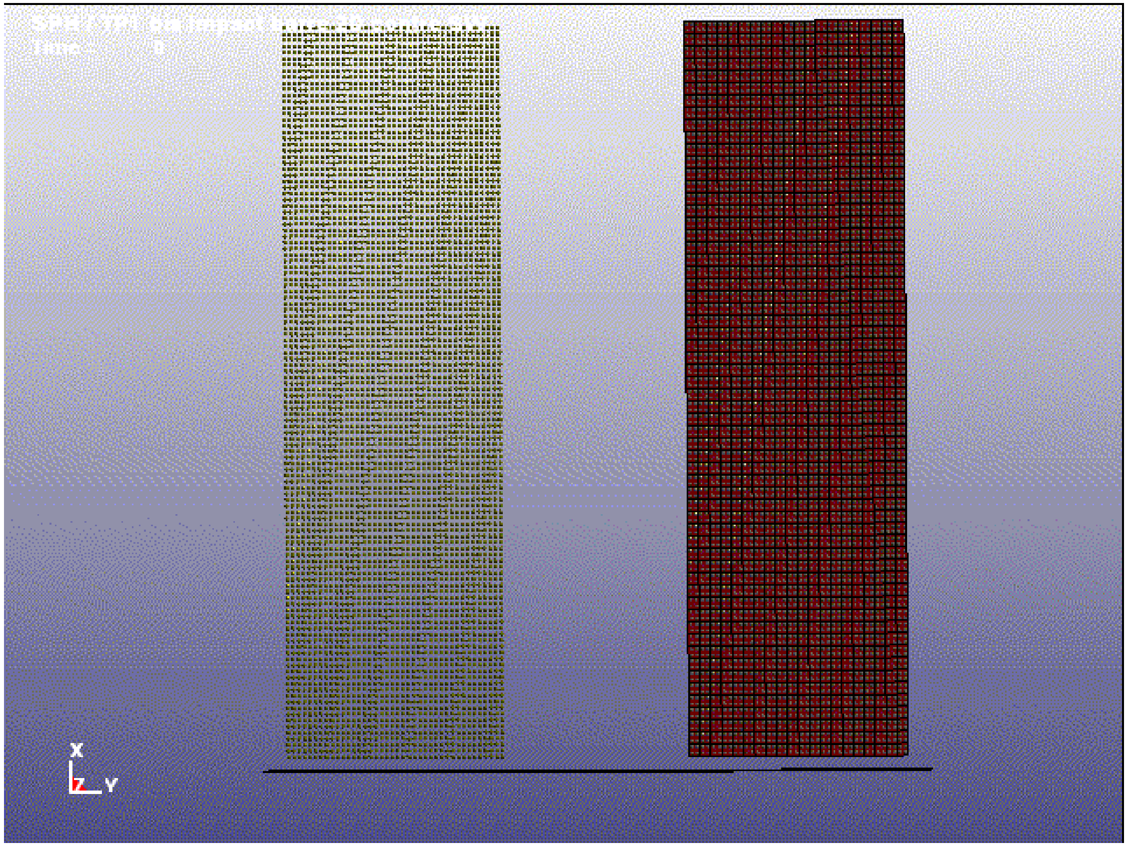
- January 2018
- Model I
  - 400K solid elements, 1 Self Contact, 1 Surface 2 Surface Contact
  - Sensors to turn-off airbag based on tire pressure, wheel failure and contact separation
- Model II
  - With material failure MAT_181_WITH_DAMAGE
  - Eroding single surface contact
  - Option to switch failed elements to DES/SPH for rubber

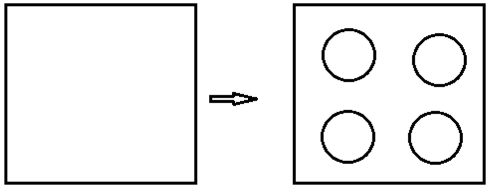
- Requesting tests from customers

SPH, DEM

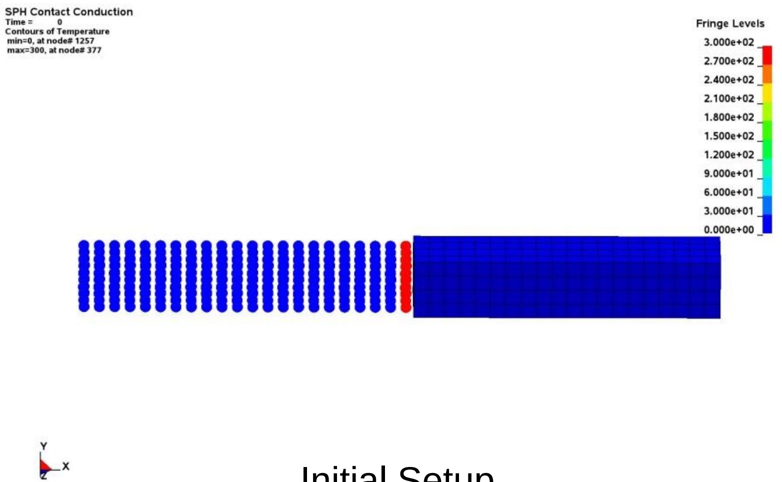
*DEFINE_ADAPTIVE_SOLID_TO_SPH for 2D Solids

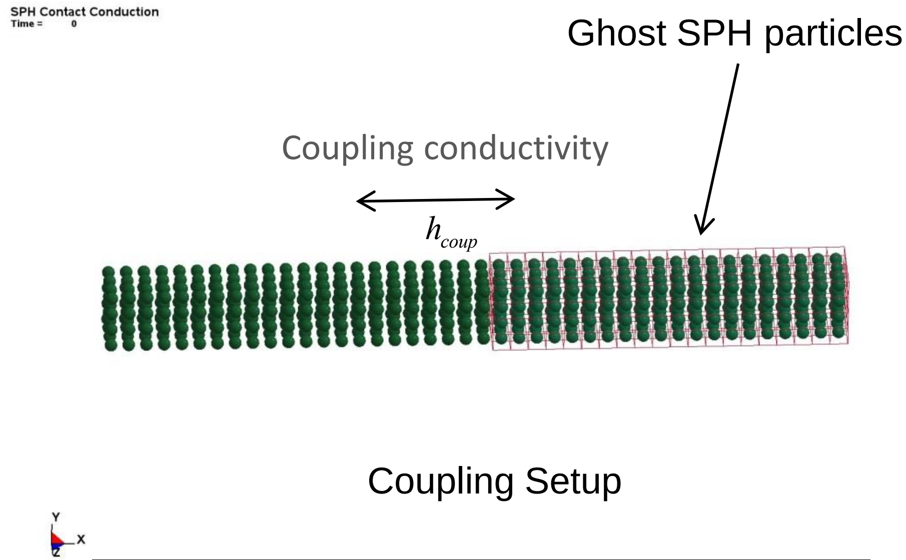
Adaptively transforms a 2D Solid part into 2D SPH particles with coupling or non-coupling options (works for 2D plane stress, 2D plane strain and 2D axisymmetric formulations, and supports all ICPL and IOPT options in this keyword).





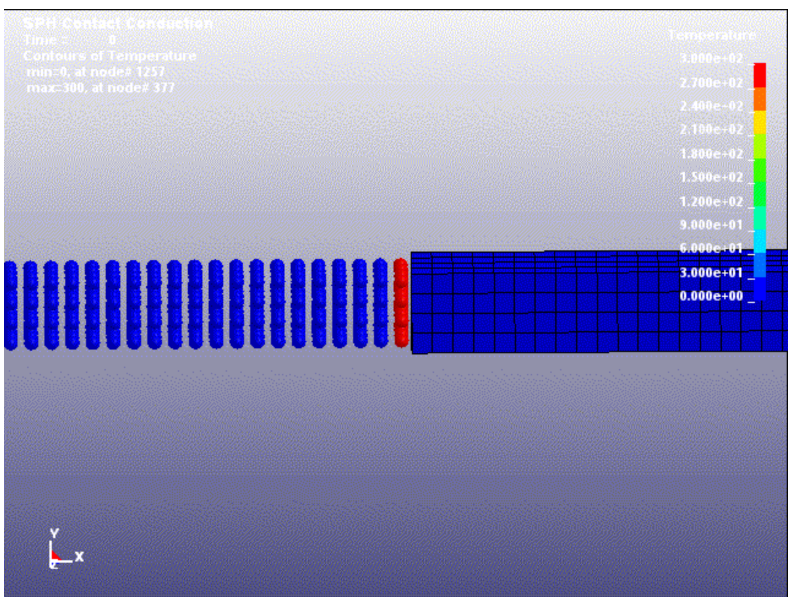
Pure thermal coupling between SPH and Solid

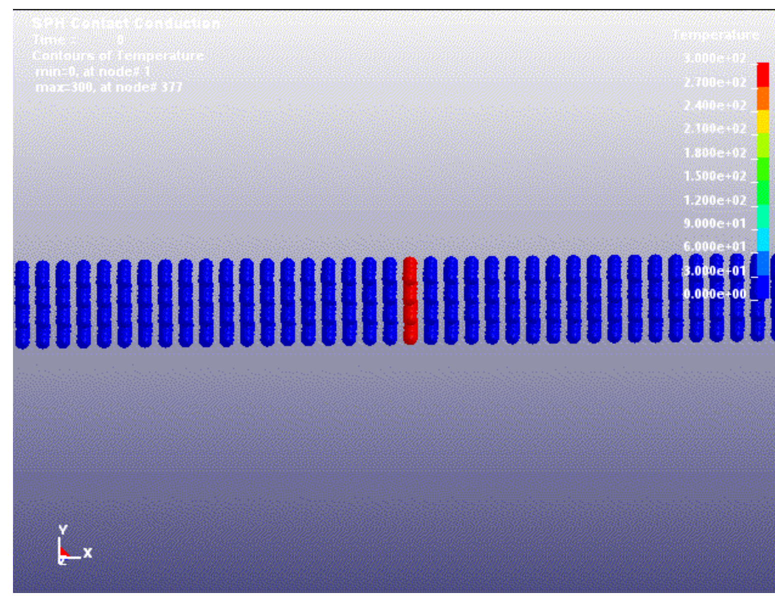




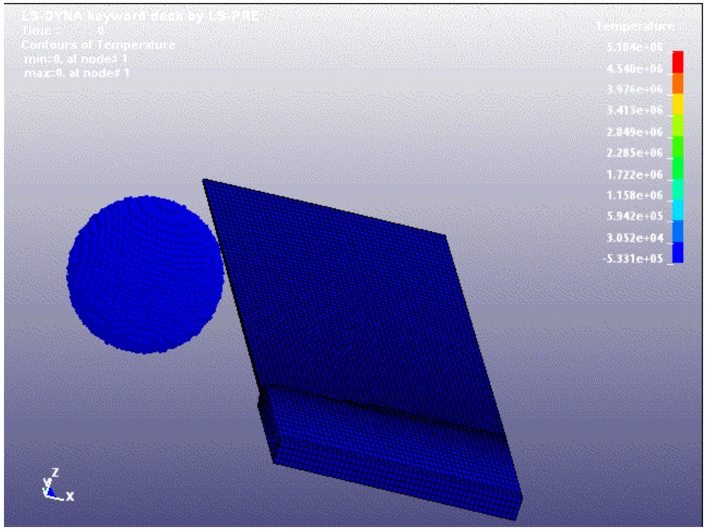
Initial Setup

Coupling Setup

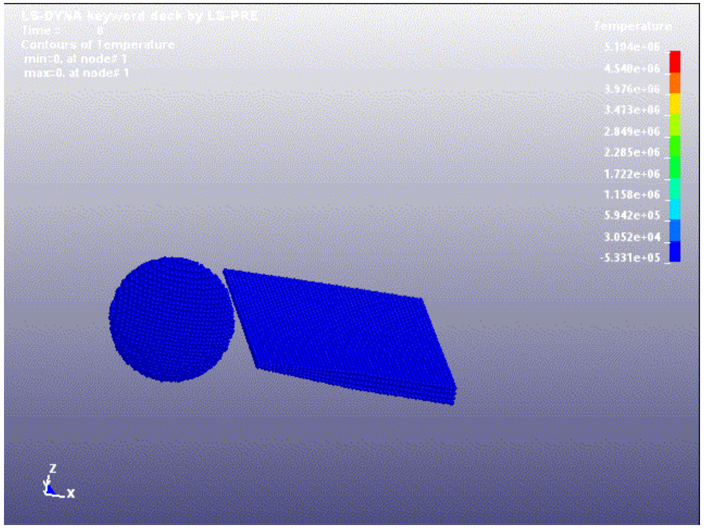




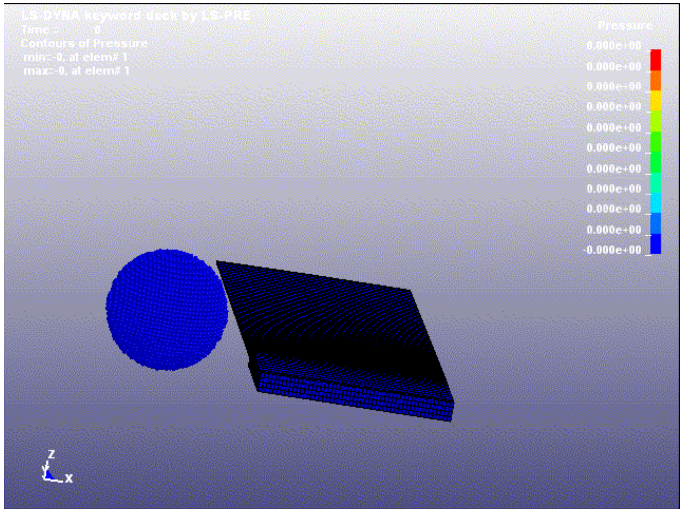
High Velocity Impact with Solid Plate



Thermal contour



Thermal coupling between original and ghost SPH particles



Pressure contour

Heat from contact friction and the conversion of the mechanical work into heat.

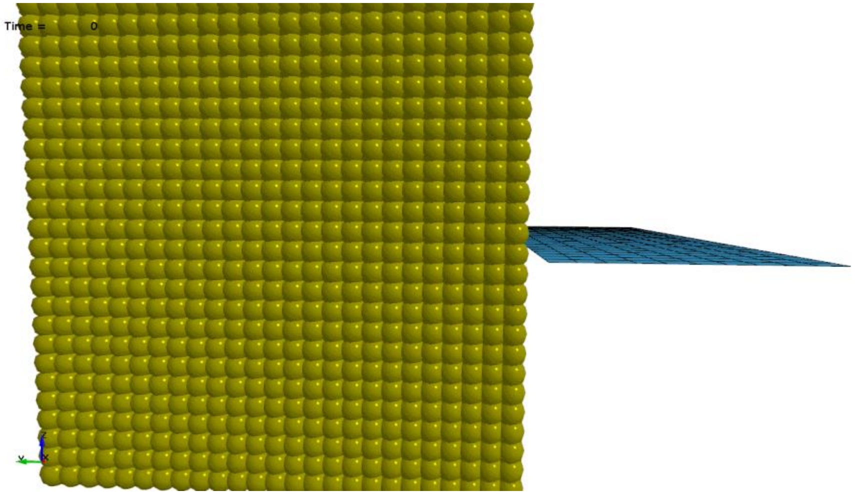
*DEFINE_ADAPTIVE_SOLID_TO_SPH:
ICP =3 and IOPT = 0

Shell Edge Contact

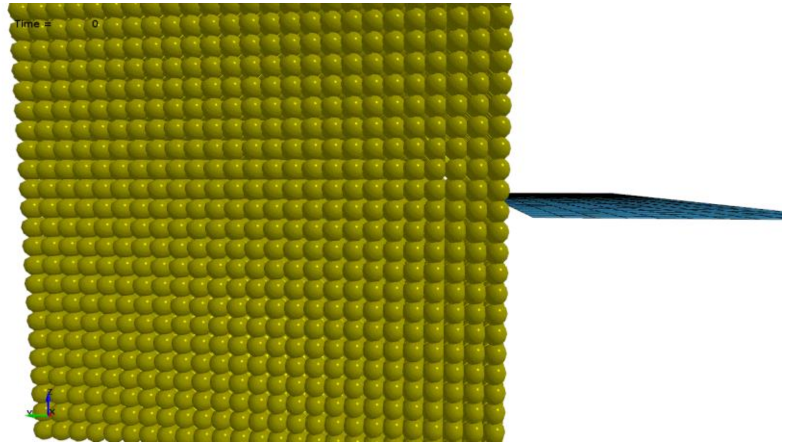
*Contact_Automatic_Nodes_To_Surface

Optional card E, parameter SRNDE

- SRNDE = 0 Usual edge treatment



- SRNDE = 2 Square shell edges

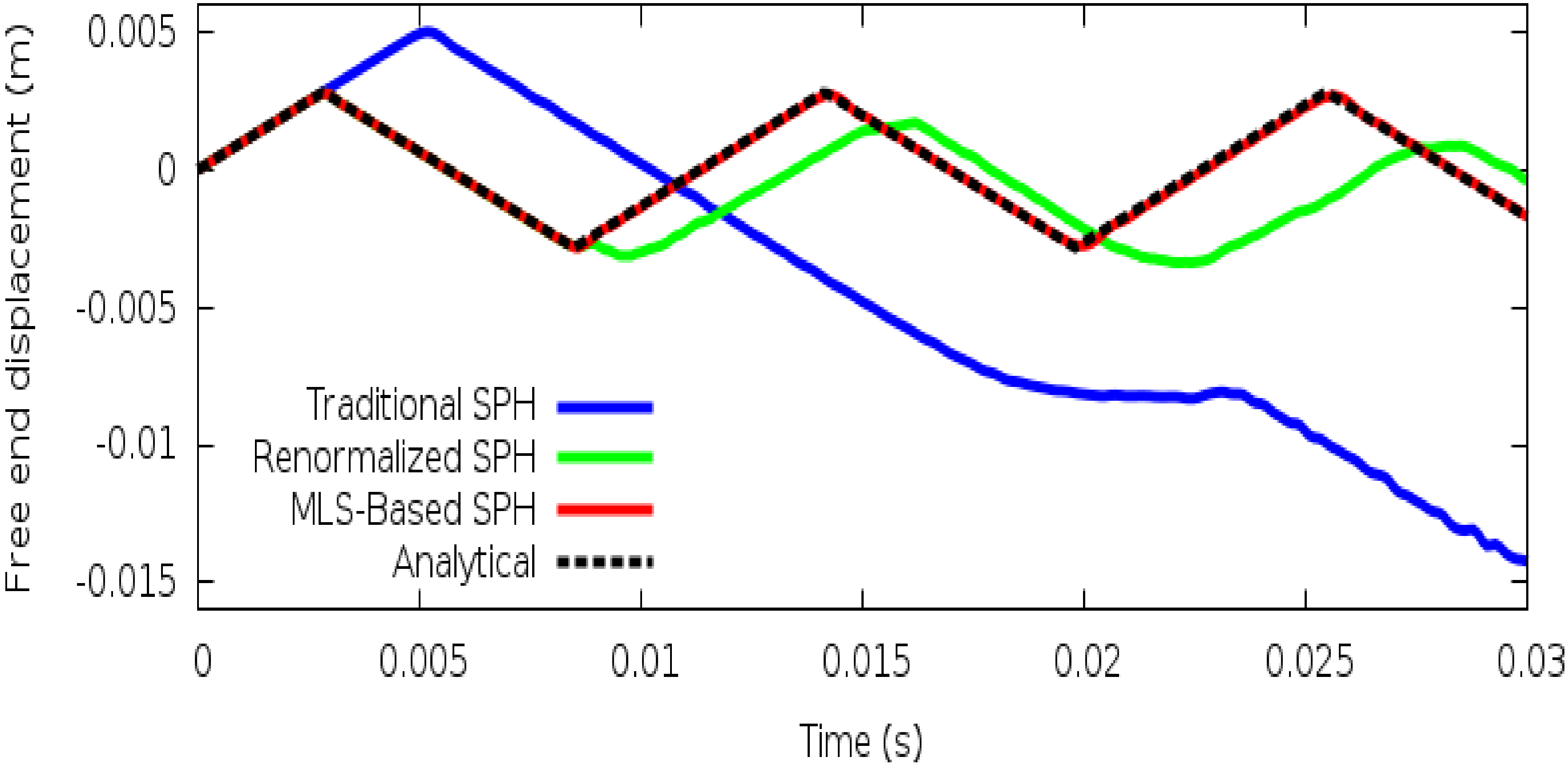


MLS-Based SPH Formulation 12

*Control_SPH parameter IFORM = 12

✓Better accuracy

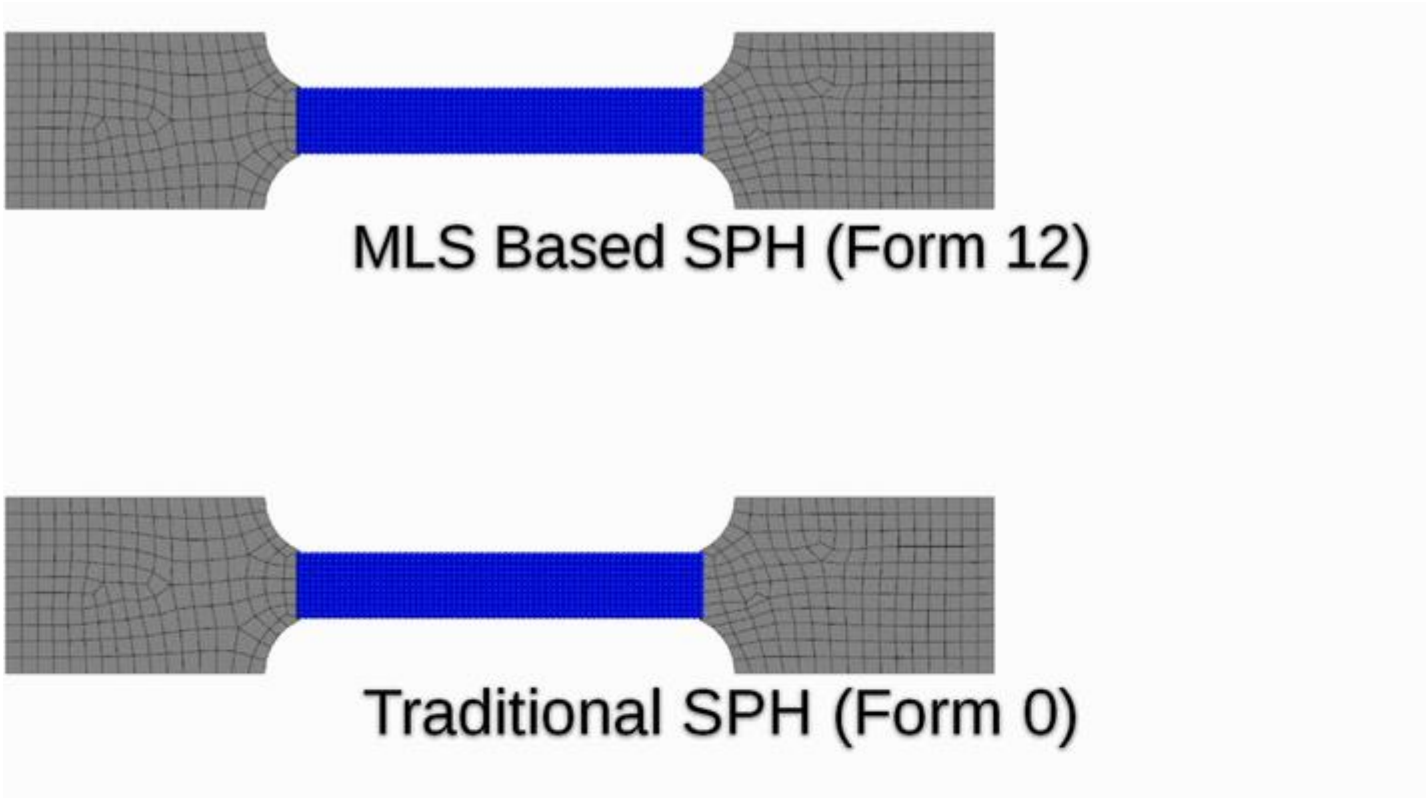
Wave Propagation problem



MLS-Based SPH Formulation 12

- ✓Better accuracy
- ✓Less tensile instability

- ✗More CPU-intensive



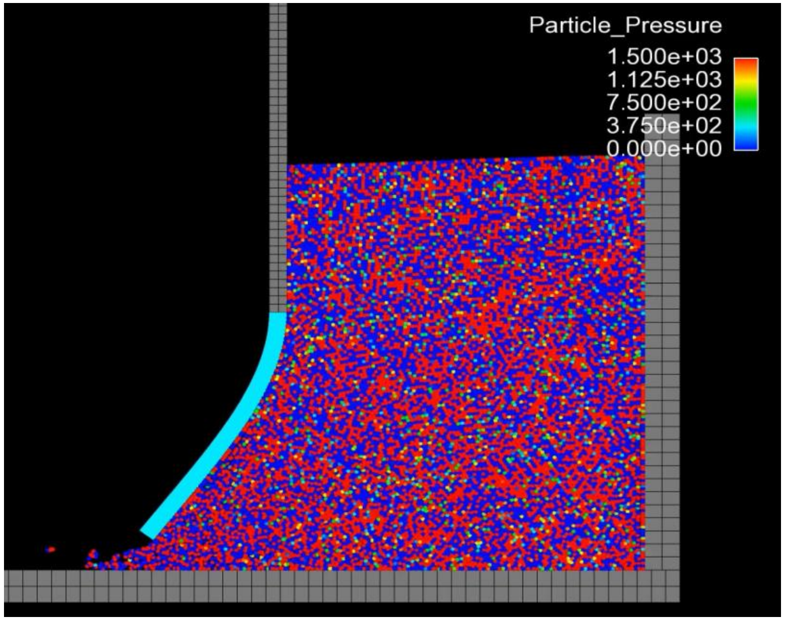
SPH Enhancements

*CONTROL_SPH

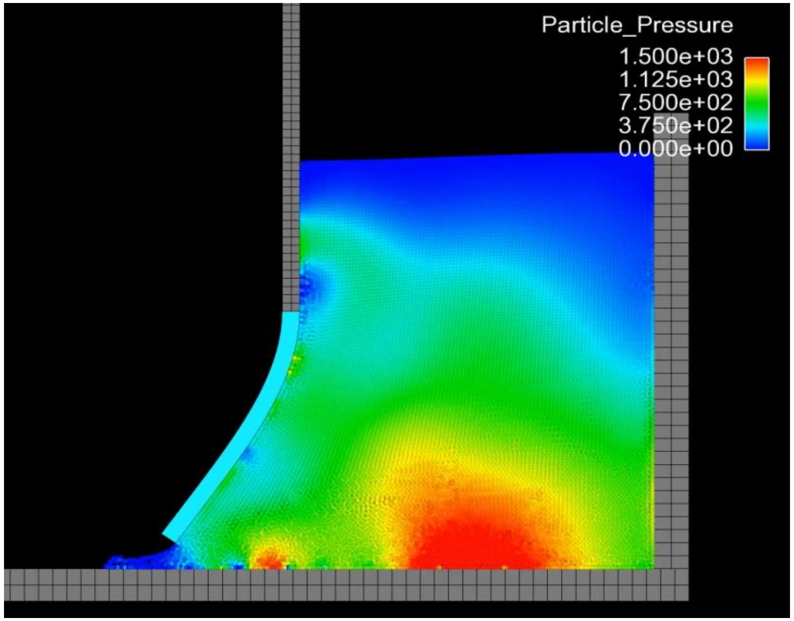
IFORM = 15/16 Enhanced fluid formulation wo/w kernel renormalization

Density smoothing: $\tilde{\rho}_I = \dfrac{\sum_J \rho_J \phi_{IJ}}{\sum_J \phi_{IJ}}$ with $\phi_{IJ} = W_{IJ} m_J / \rho_J$

→ Smooth pressure field



IFORM=0

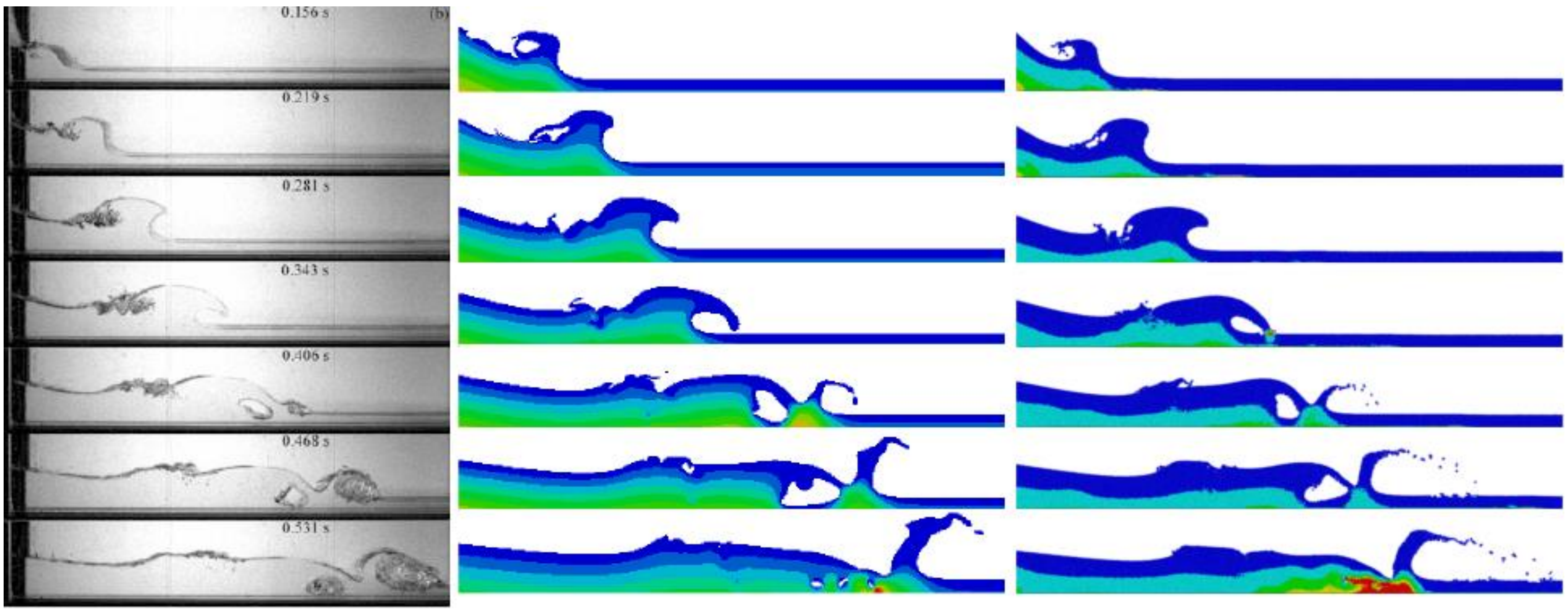


IFORM=15

SPH Enhancements

Murnaghan Equation of State

- Weakly compressible formulation to numerically reduce the sound speed, and consequently increase the time step size
- Enforce low compressibility
- Validation: 2D dambreak, free surface flow

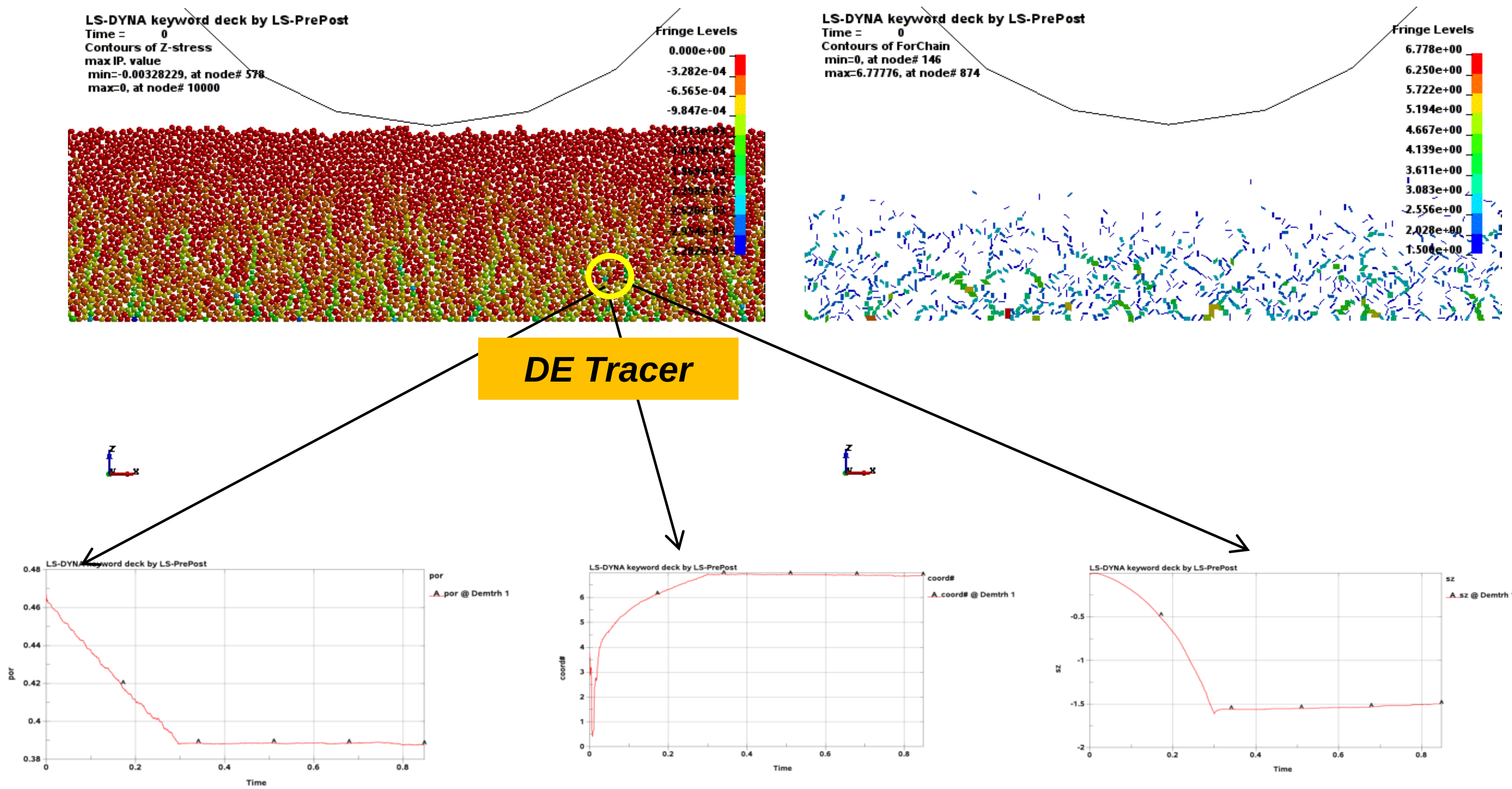


Experiment [1] ICFD SPH

[1] Janosi, I. M., Jan, D., Szabo, K. G. and Tel, Tamas. “Turbulent drag reduction in dam-break flows”. Experiments in Fluids, 37: 219-229, (2004).

DEM General Features

- Force chain fringe plot
- Porosity, stresses and coordination number can be traced



Porosity

Coordination Number

Stress

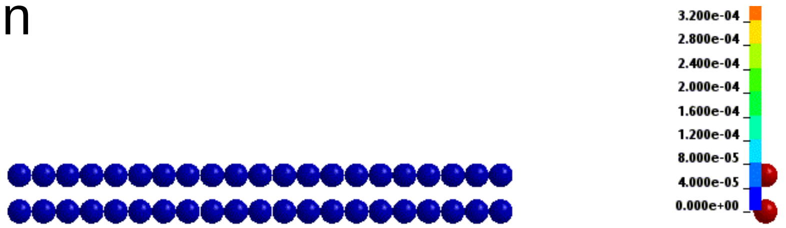
DEM General Features

- Non-reflecting B.C. used on the exterior boundaries of an analysis model of an infinite domain

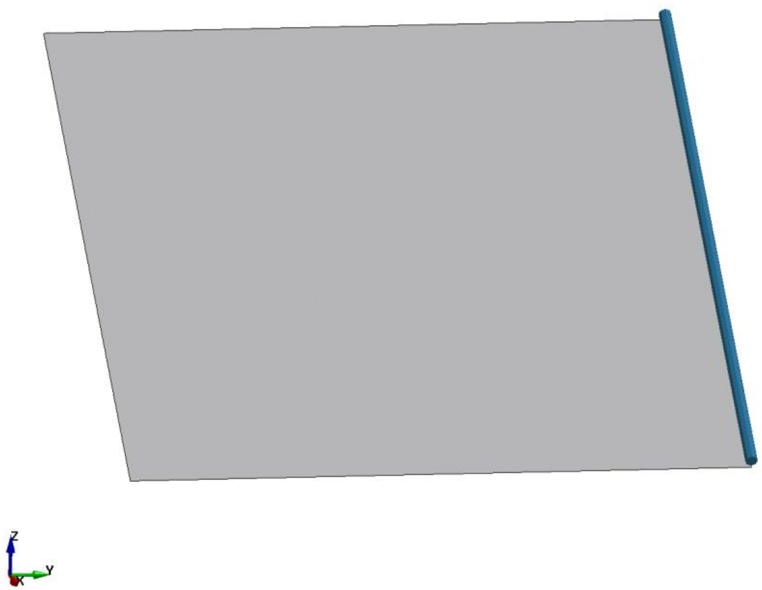
Without

NRBC

With

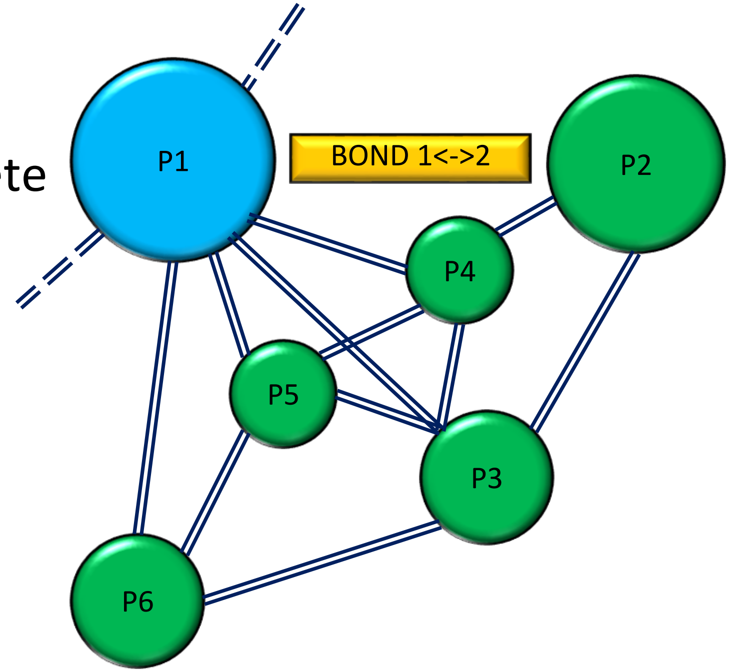


- *DEFINE_DE_TO_SURFACE_COUPLING

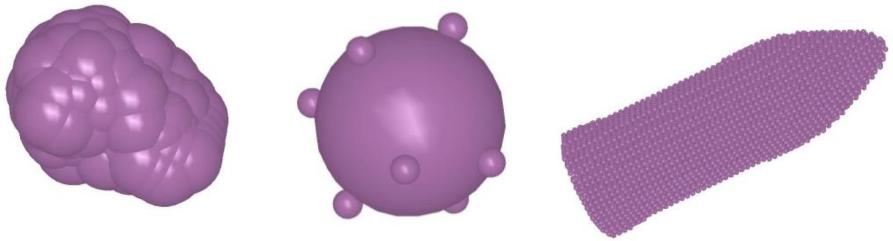


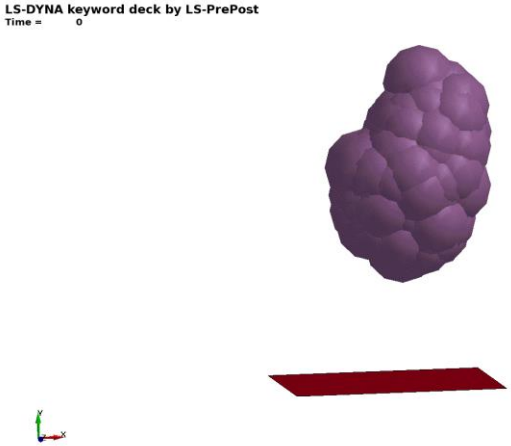
DEM – Bonded DEM

- Particles are linked to their neighboring particles through bonds within a specified range.
- The properties of the bonds represent the complete mechanical behavior of Solid Mechanics.
- The bonds are independent from the DES model.
- They are calculated from Bulk Modulus and Shear Modulus of materials.
- Contact is disabled between bonded pair
- Contact is reactivated after bond broken

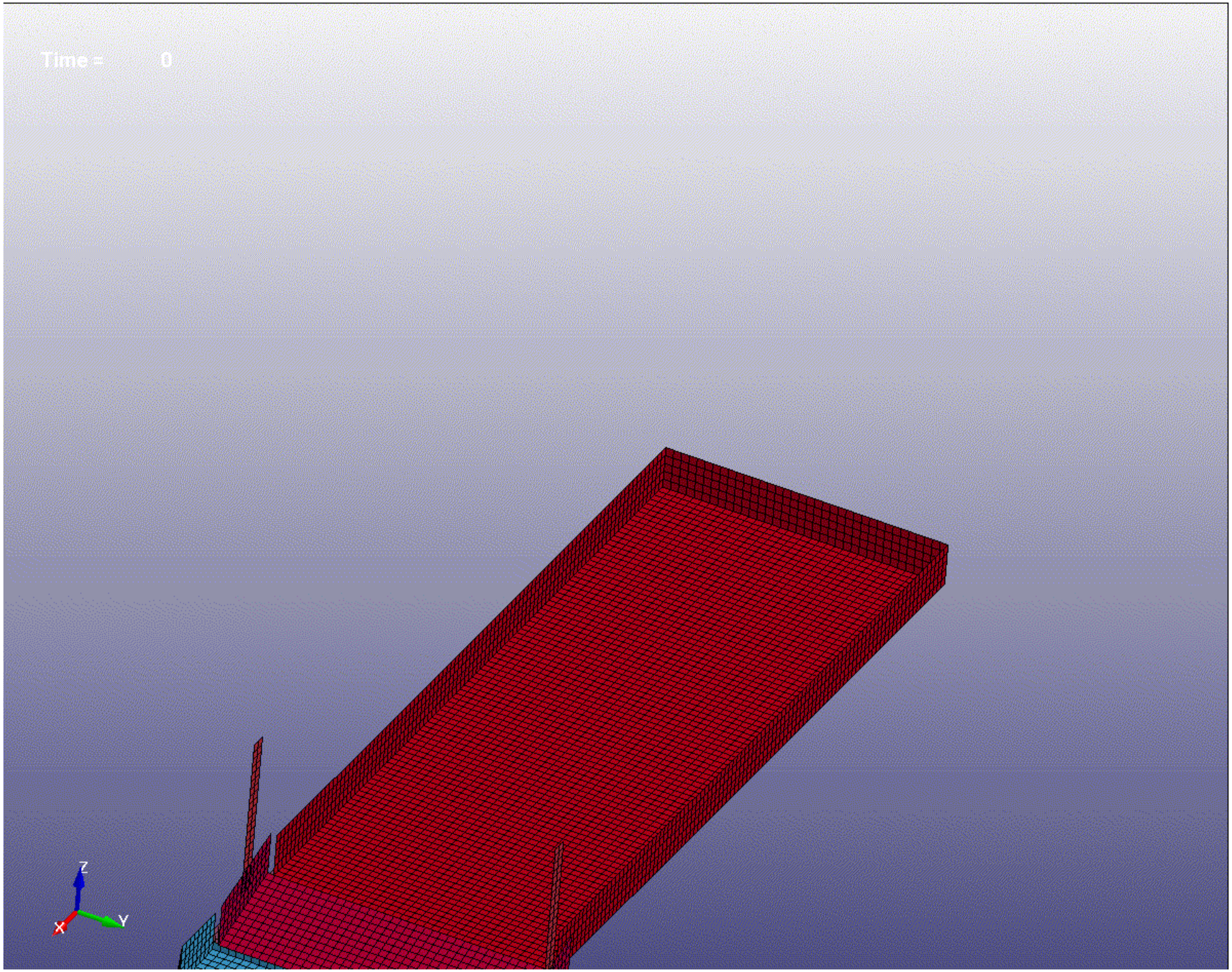


Use bonds to form other shapes





DEM – Food sorting process

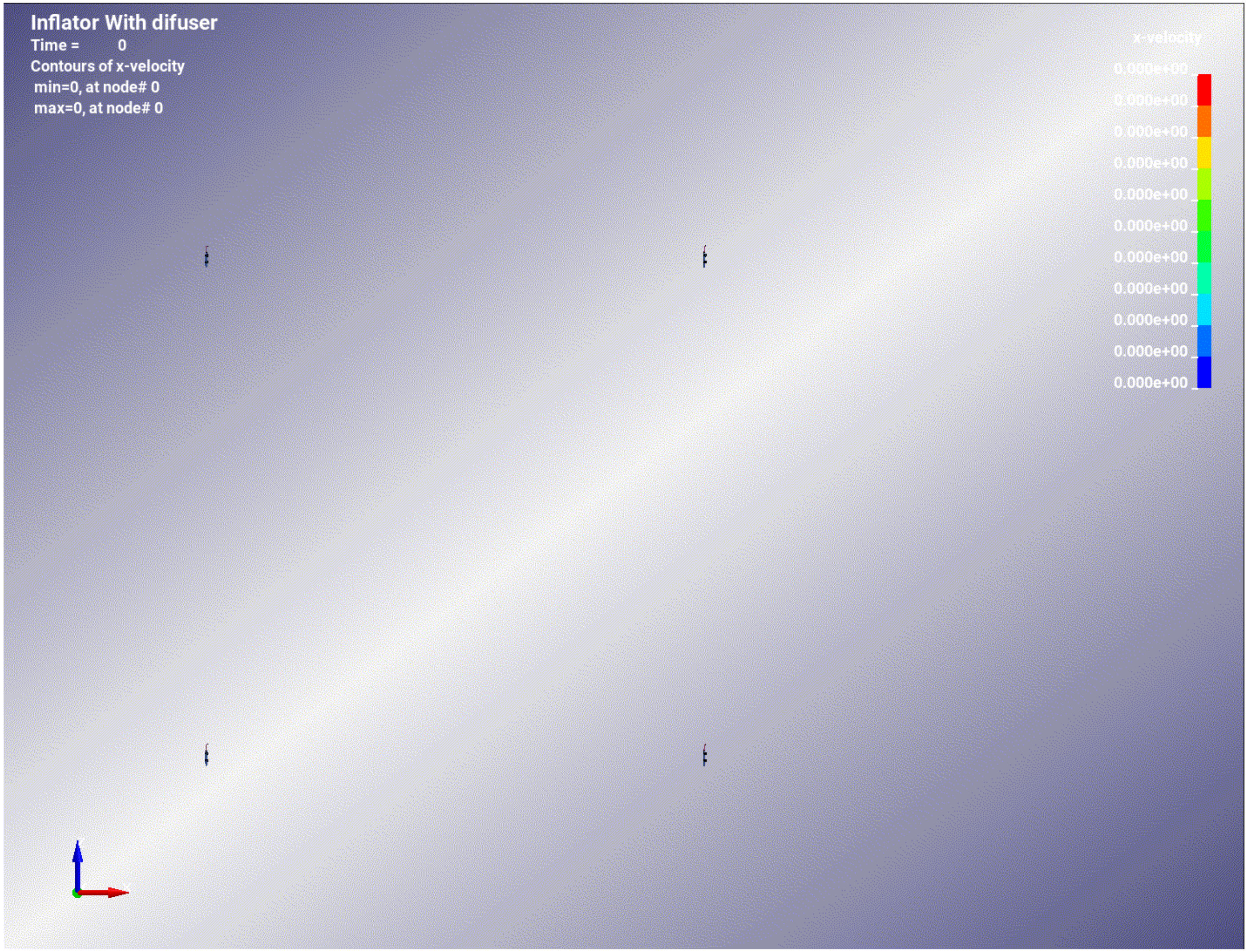


CPM
Airbag_particle

*DEFINE_CPM_VENT, Internal vents with cone angle

Vang=-1,-1

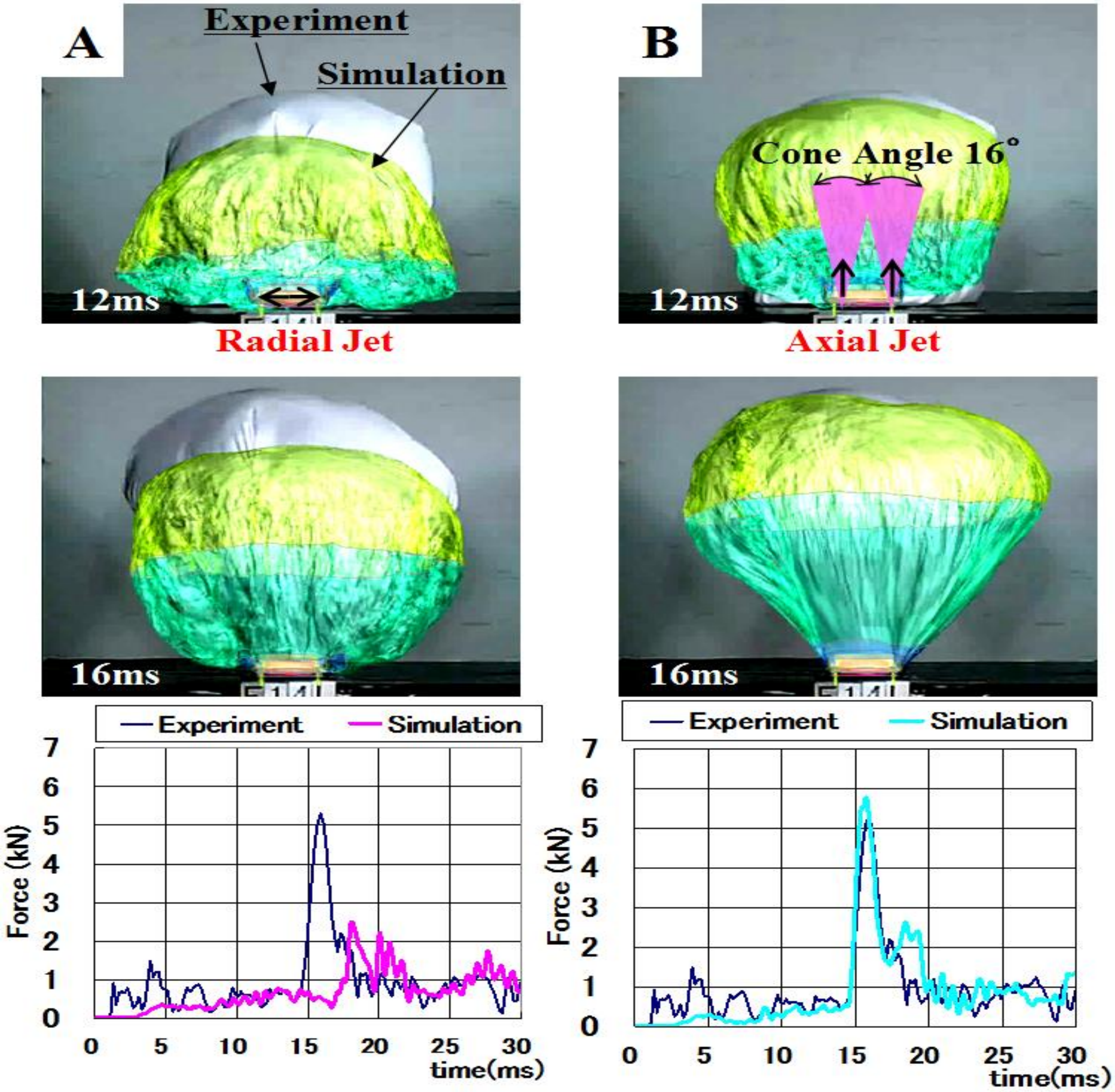
Vang=-1,-2(with local system)



Default

Vang=10,30

*DEFINE_CPM_VENT
Internal vent with cone angle



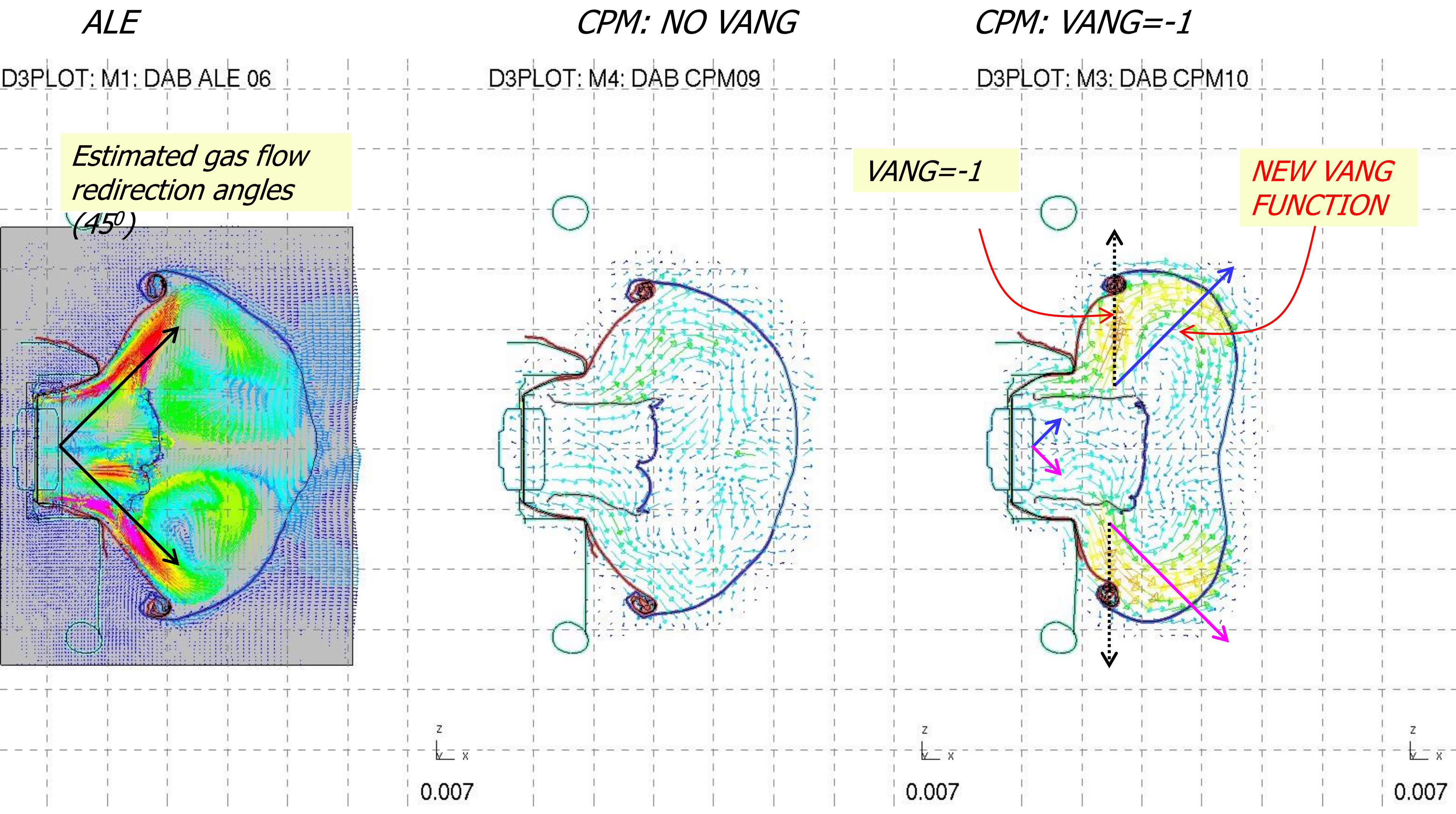
Deployment force of "A"   Deployment force of "B"

This new option greatly helps to improve the correlation between tests and simulations

1. Cone angle is defined by using above keyword card.
2. Additional option VANG=-1 will allow code to adjust the release based on the vent condition

H. Ida, M. Aoki, M. Asaoka, K. Ohtani,"A Study of gas flow behavior in airbag deployment simulation",24th International Technical Conference on the Enhanced Safety of Vehicles(ESV). No. 15-0081, 2015.

Benchmark DAB Models

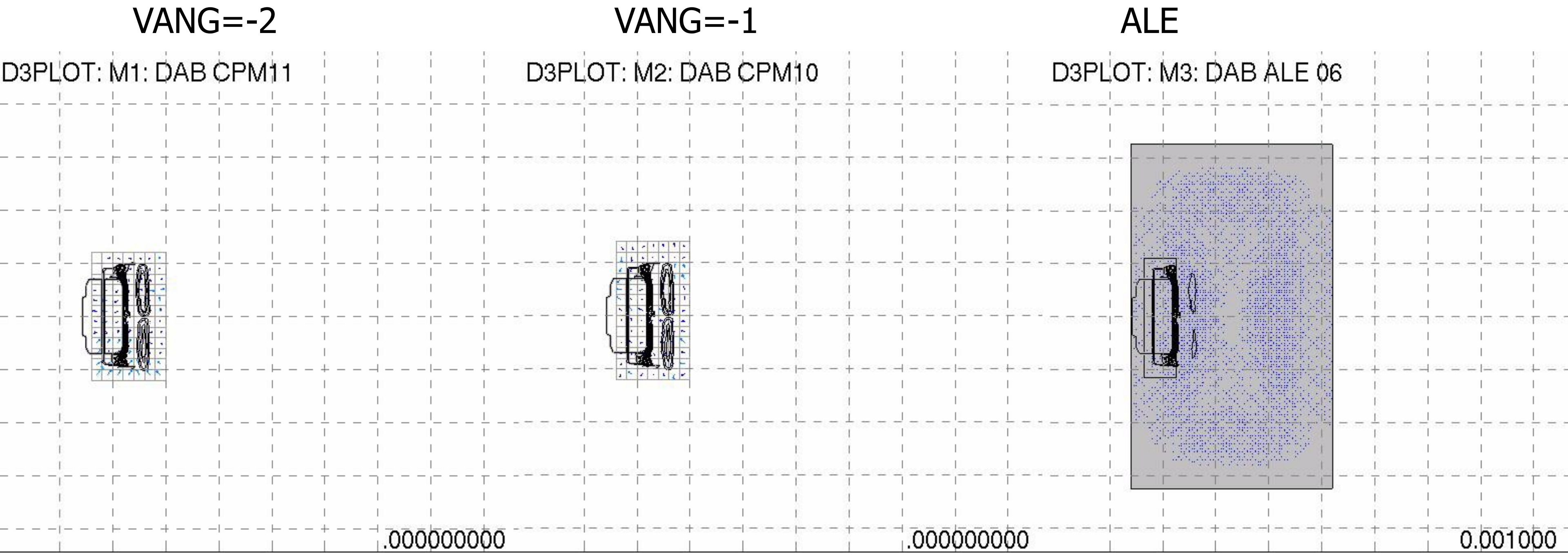


Velocity contour
0~340m/s

Side View

Courtesy of: Richard Taylor, Arup

*DEFINE_CPM_VENT VANG=-2



Under development, VANG=-2
user can define a local coordinate system for ‘jet’ to follow.

*DEFINE_CPM_VENT, Internal vent with cone angle

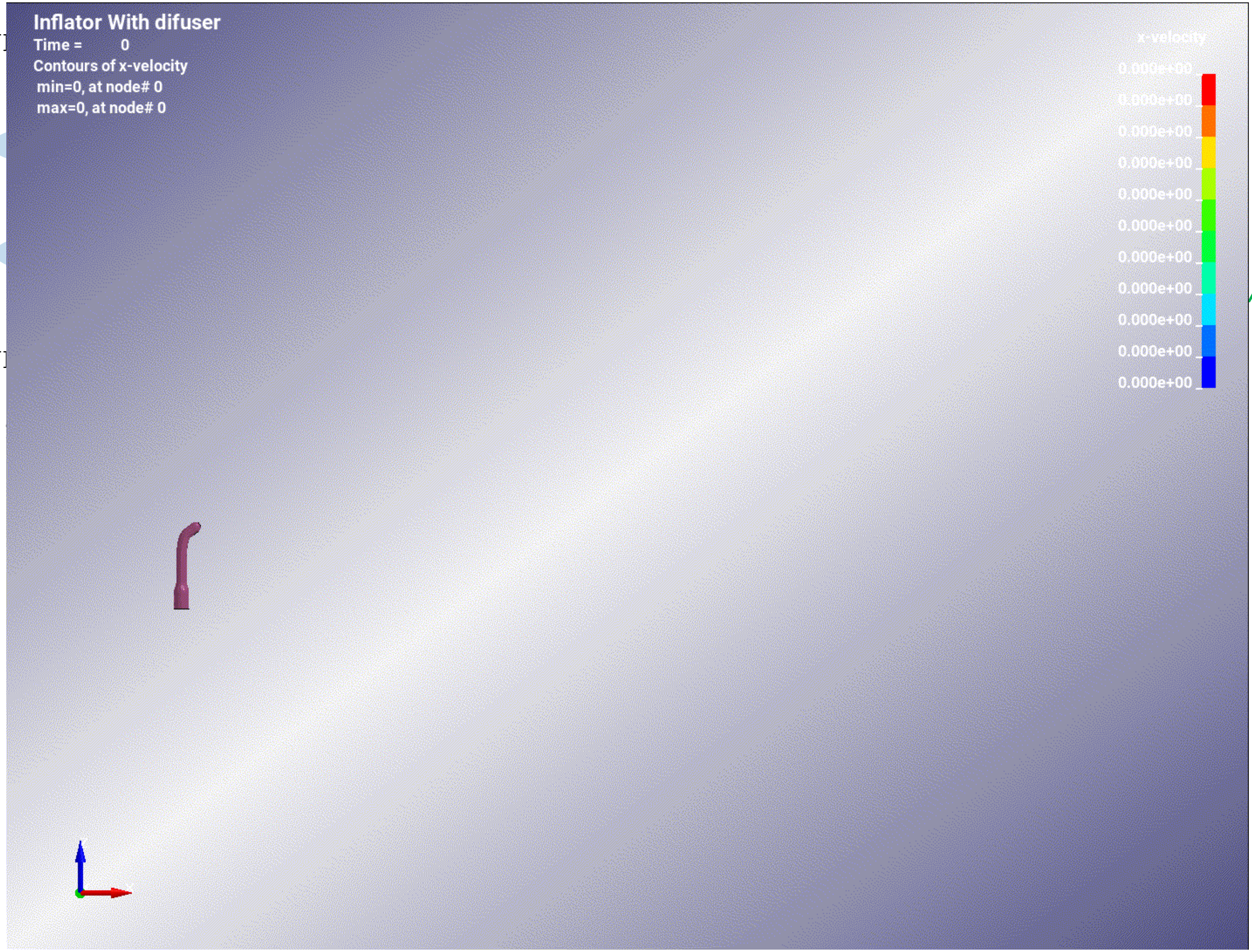
*DEFIN

1

1

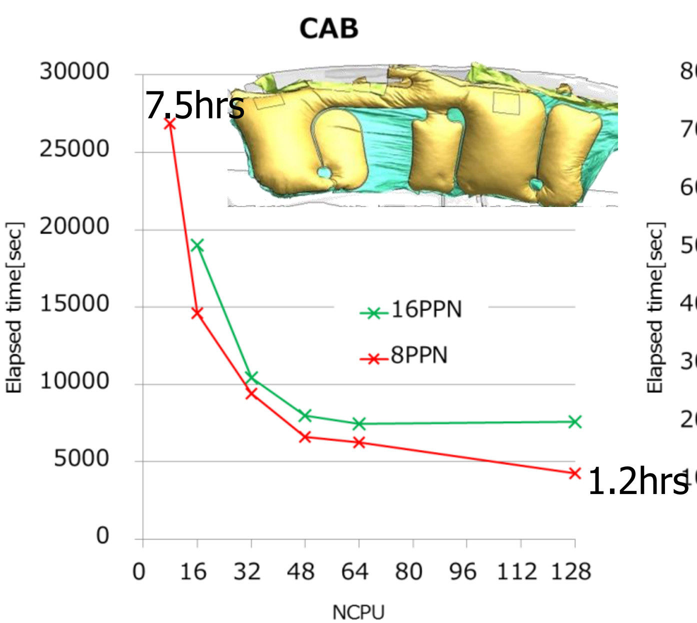
ve.

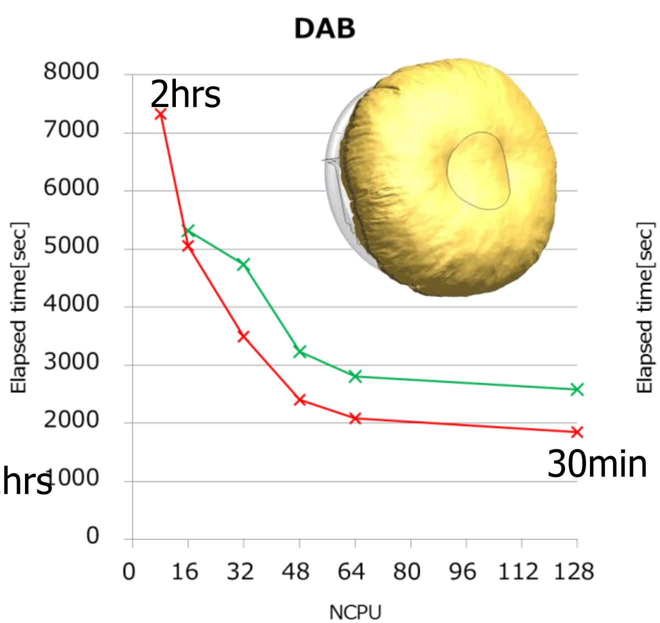
*DEFIN
redir

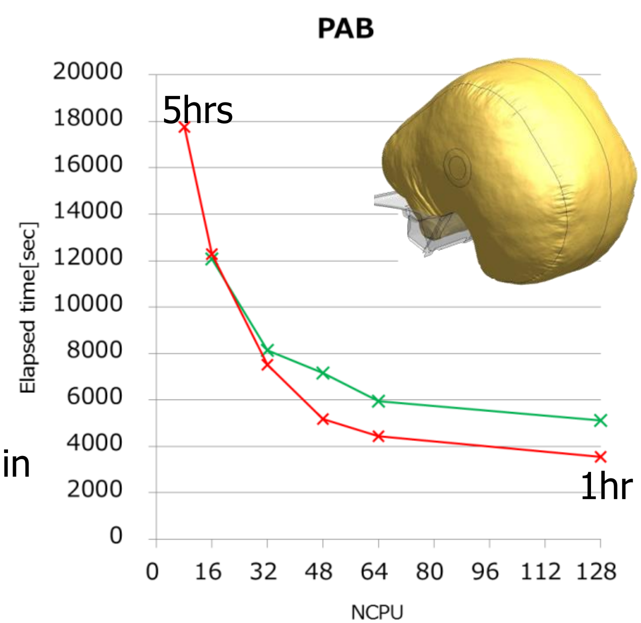


Baseline Airbag Models

- Baseline airbag models created by JSOL/Arup for demo/research purposes.
  - CAB = curtain airbag, DAB = driver’s airbag, PAB = passenger airbag
- All models have typical size, shape, inflator & fabric.
- All have been developed to be robust (insensitive, repeatable, not prone to error) and inflate with no issues.





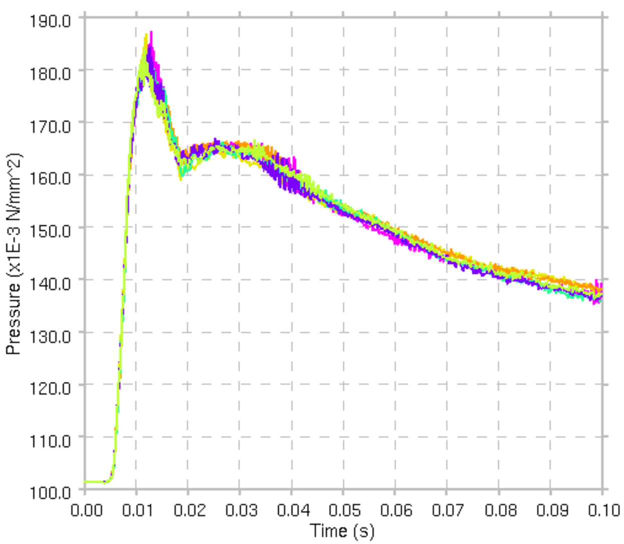


Courtesy of: Richard Taylor, Arup

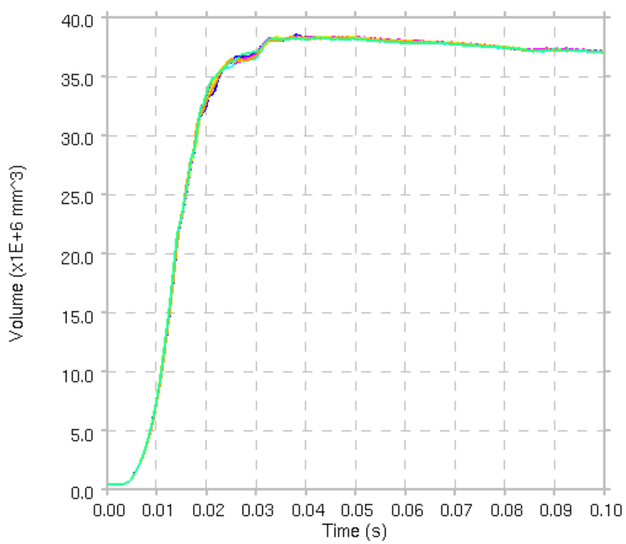
CAB – Results Check (R9)

- The CAB model has no external vents and no porosity.
- It also has a constant decomposition pattern: particle domain divided along X-axis
- Results are very consistent across all analyses.
- The reason for the slight increase in internal energy in all cases is unknown.

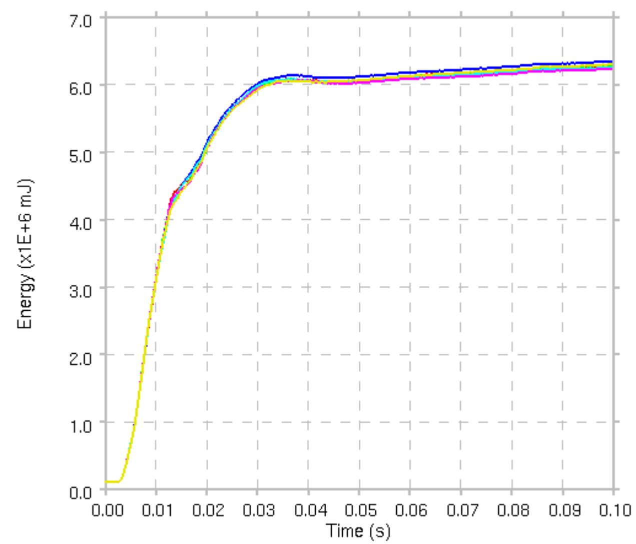
Pressure



Volume

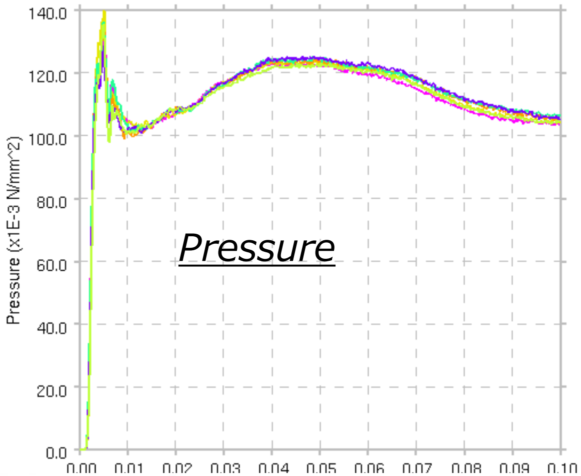


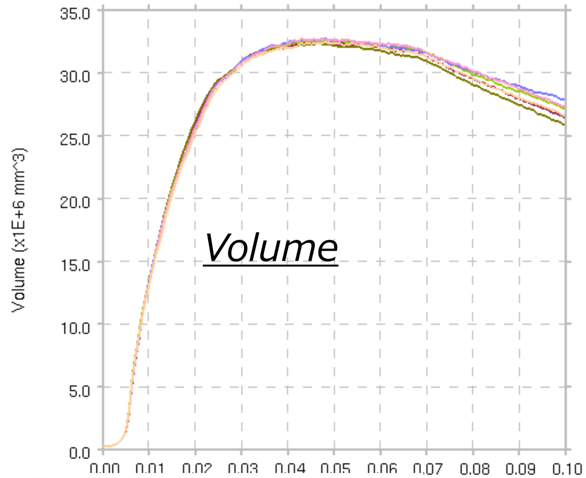
Internal-Energy

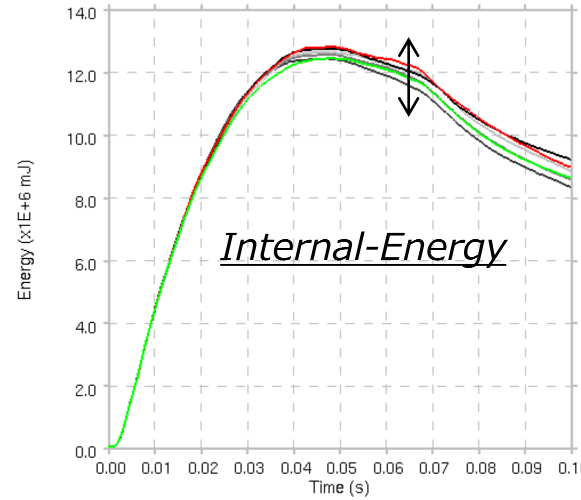


DAB – Results Check (R9)

- The DAB model has two external vents, fabric and seam line porosity, all affected by contact blocking. Despite this results are very similar for all analyses.

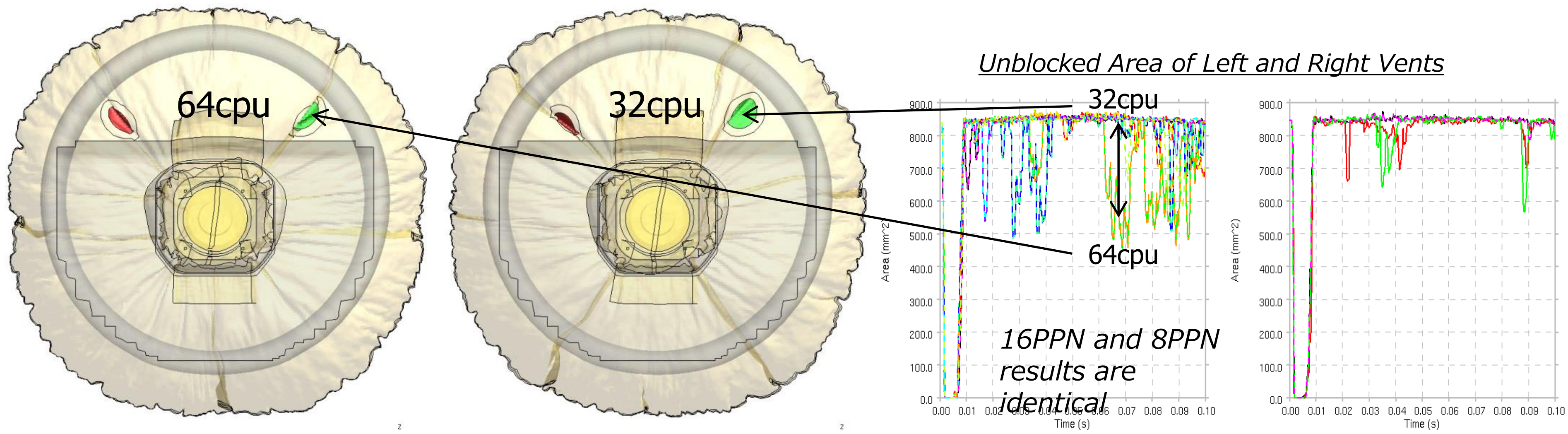






D3PLOT: M1: 64CPU (16PPN) D3PLOT: M2: 32CPU (16PPN)

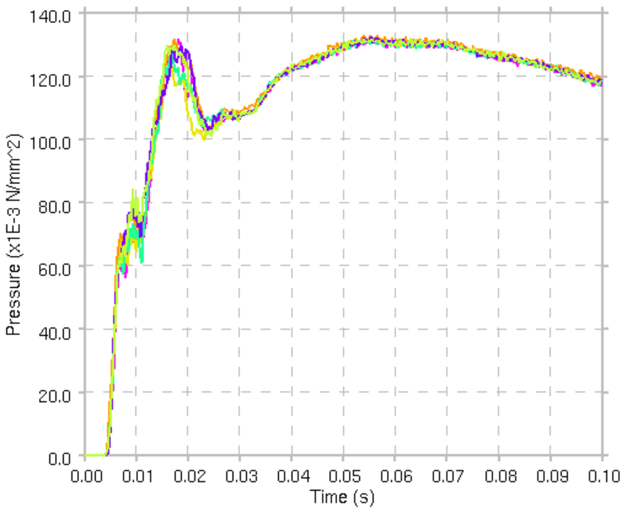
*The slight difference in internal energy is due to different levels of **vent contact blocking** by **different crease patterns**.*



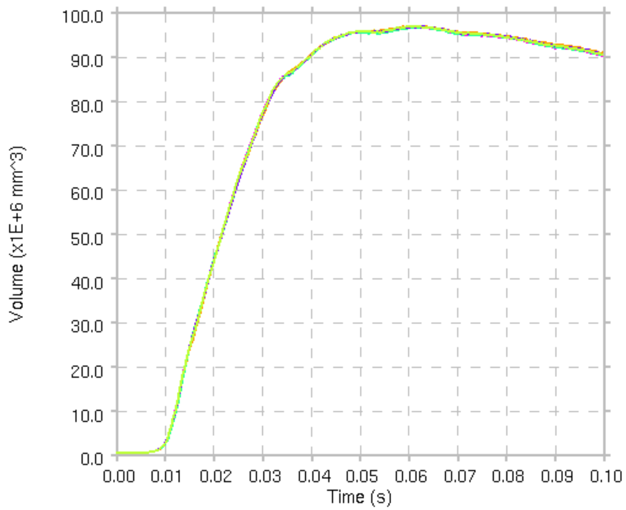
PAB Results Check (R9)

- The PAB model has two large external vents but no fabric or seam porosity.
- Creases are not generated in the fabric near the vents so the sensitive contact blocking seen in the DAB is not a problem.
  - Unblocked area and mass-flow from vents in all models is consistent

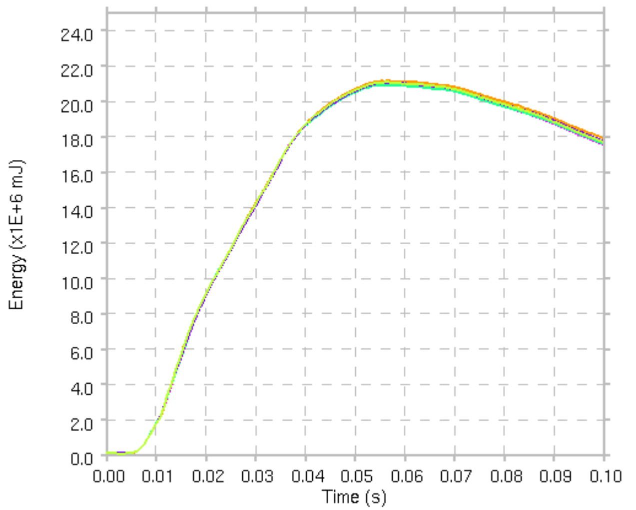
Pressure



Volume



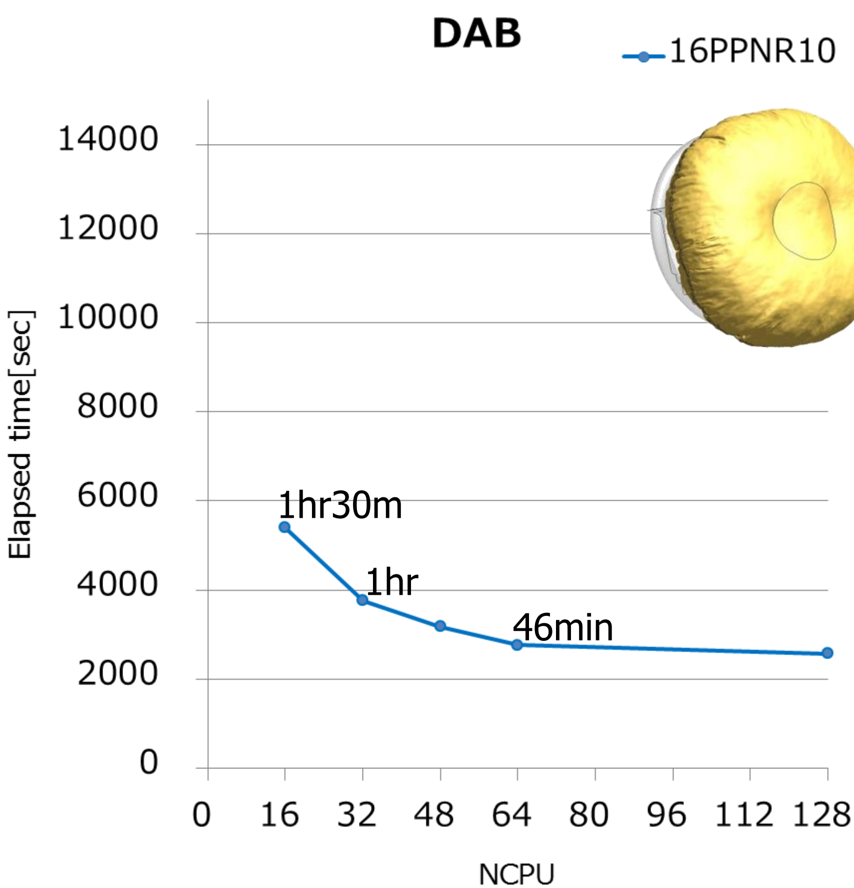
Internal-Energy

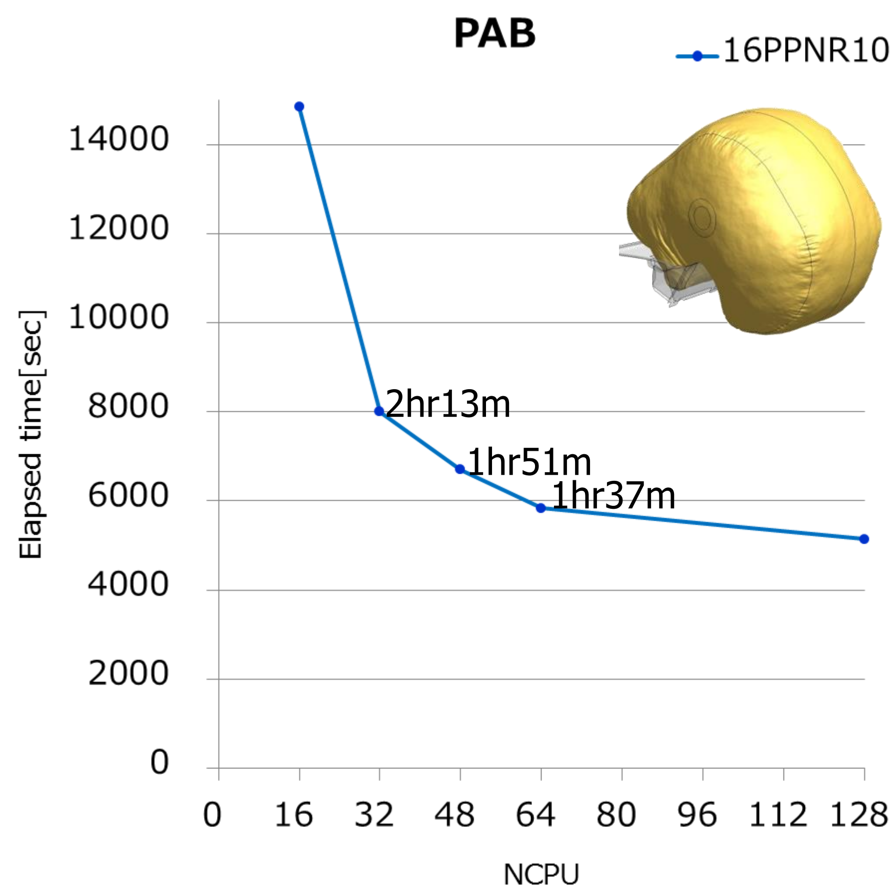


*CONTROL_MPP_DECOMPOSITION_ARRANGE_PARTS NPROC option with Two Bags Summary (R10)

- Two airbags deployed in one model
- Each airbag has its own *CONTROL MPP DECOMP ARRANGE PARTS.
- All models run on 64cpu in R10.

Elapsed Time when run separately (R10)





MPP Decomposition

*CONTROL_MPP_DECOMPOSITION_ARRANGE_PARTS

Part/Part Set ID, TYPE, NPROC, FRSTP

- Part/Part Set ID
- TYPE: `0 Part ID to be distributed to all processors`

  `1 Part Set ID to be distributed to all processors`

  `10 Part ID to be lumped into one processor`

  `11 Part Set ID to be lumped into one processor`
- PROC: `Evenly distributed elements in above Part/Part Set to number of NPROC processors`
- FRSTP: `Starting MPP rank`

These options only work with element distribution, Type=0/1

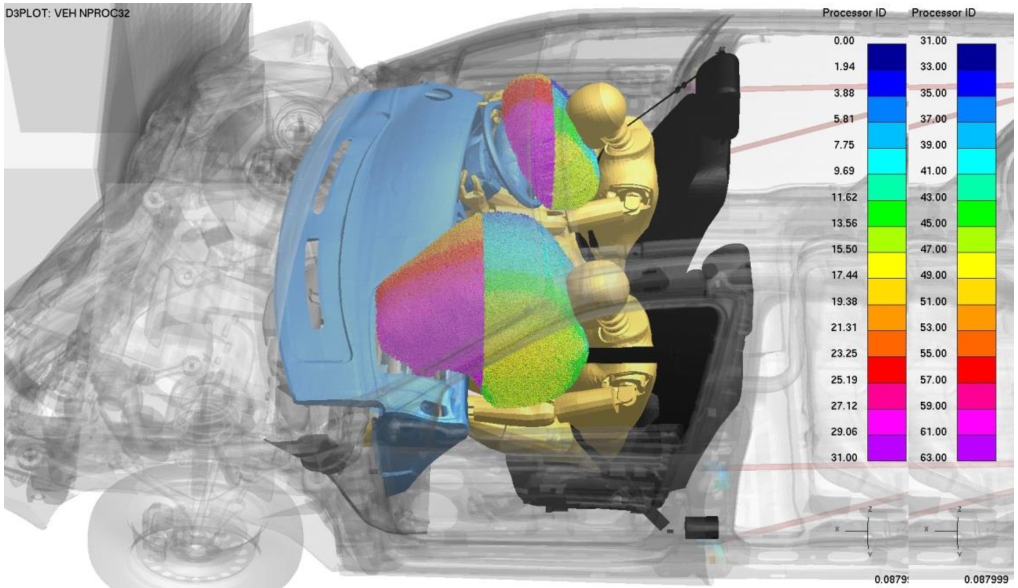
pfile options:

region { parts/partset *ID* nproc *# nfrst* }

Two Airbags in Full Vehicle (R10)

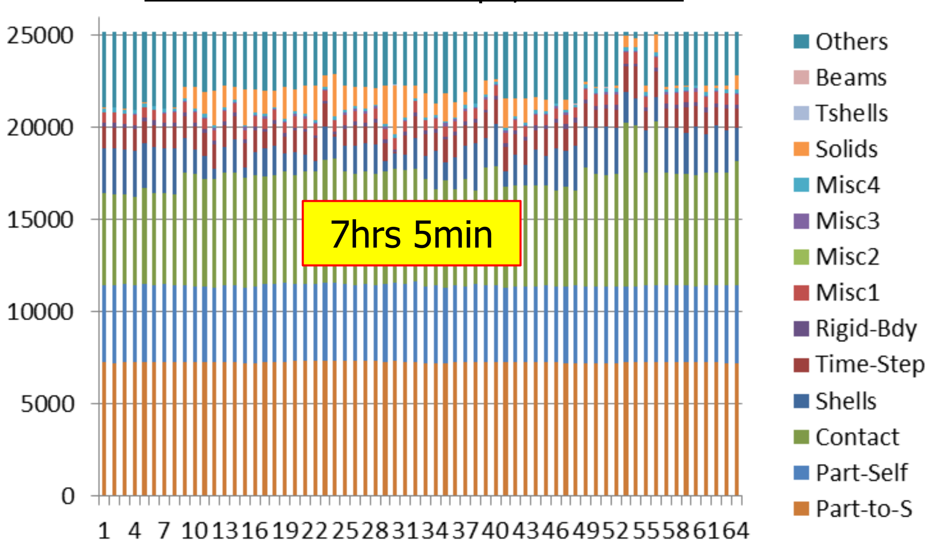
To try and reduce total run time we set NPROC=16 for the DAB and NPROC=48 for the PAB. We allocate the PAB from processor 16 (FRSTP=16).

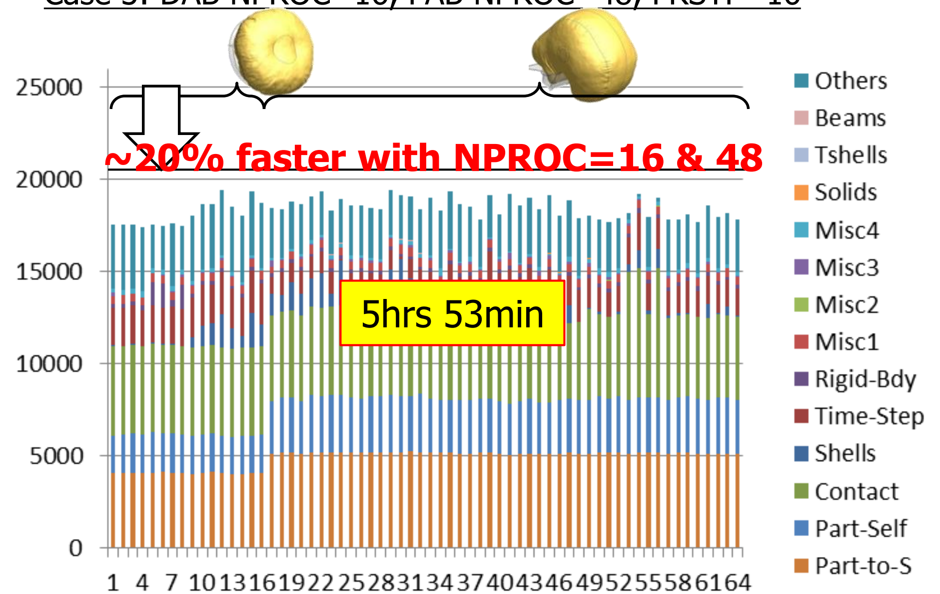
Runtime reduced from 7hrs 5min to 5hrs 53min. *20% faster.*

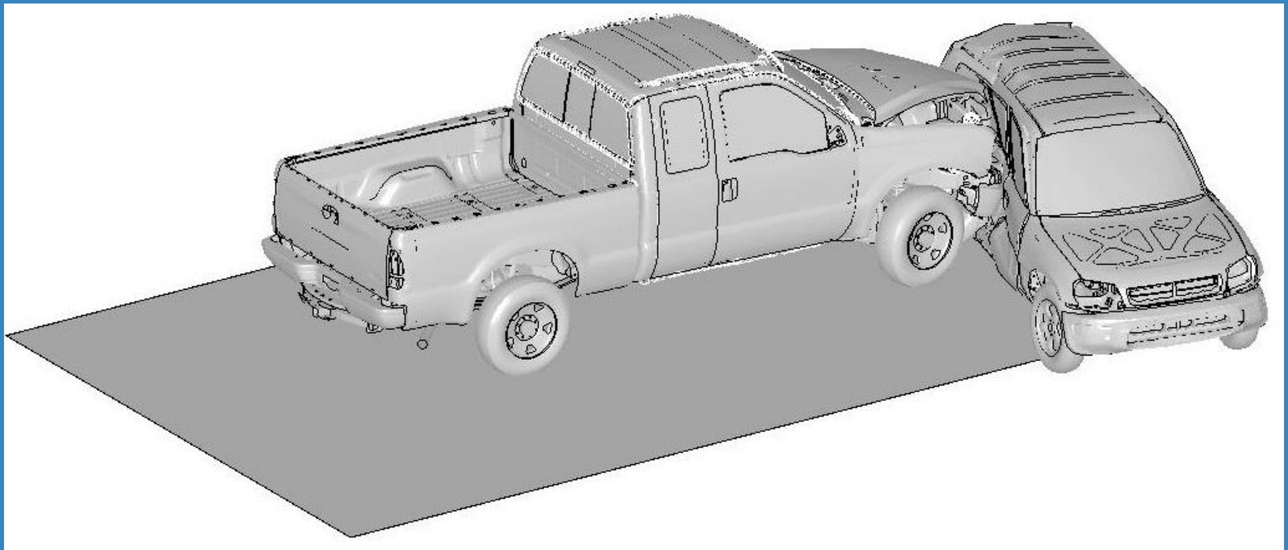


Case 3: DAB NPROC=16, PAB NPROC=48, FRSTP=16

Case 1: DAB & PAB 64cpu, NPROC=0







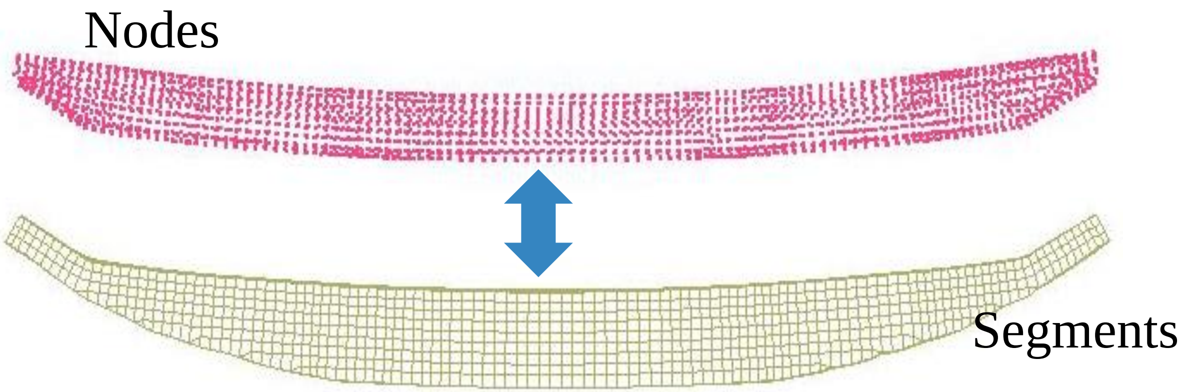
Contacts

Allows unmerged Lagrangian elements to interact with each other

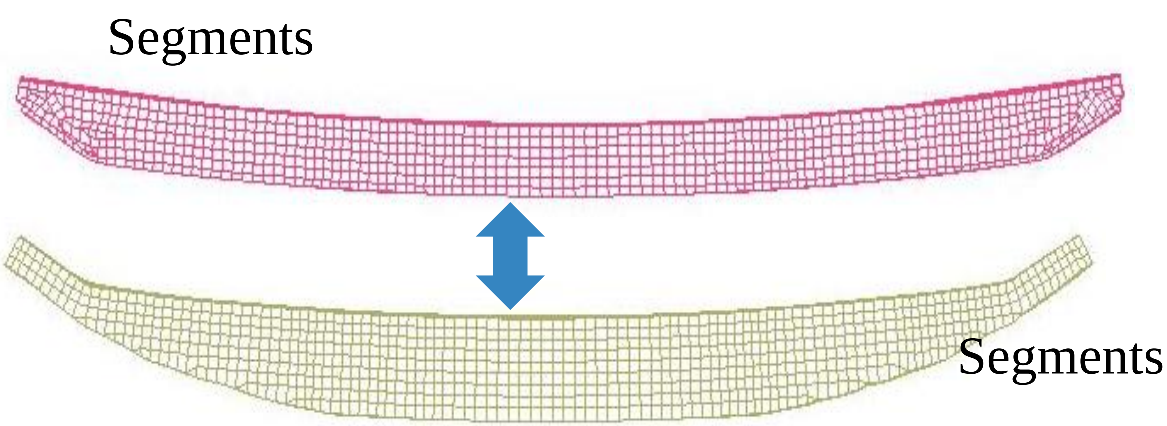
- Parts that impact/push/slide/rub against each other
- Parts that should be tied together

Contacts

– Nodes/Segments based, Soft=0/1

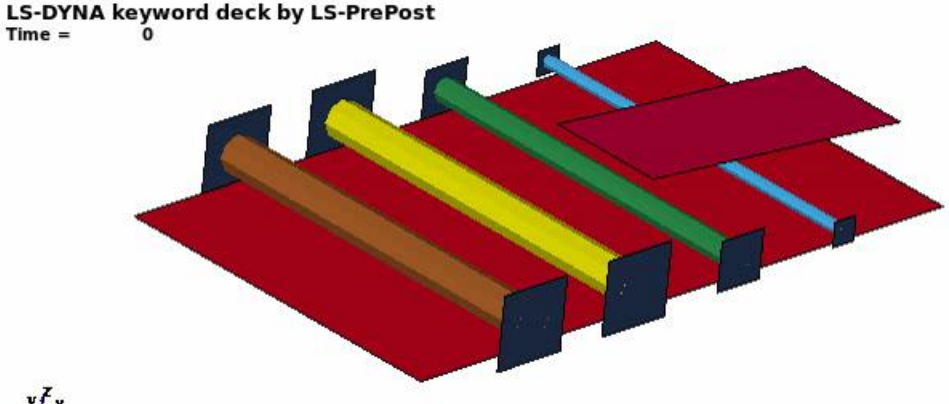


– Segments/Segments based, Soft=2, Mortar

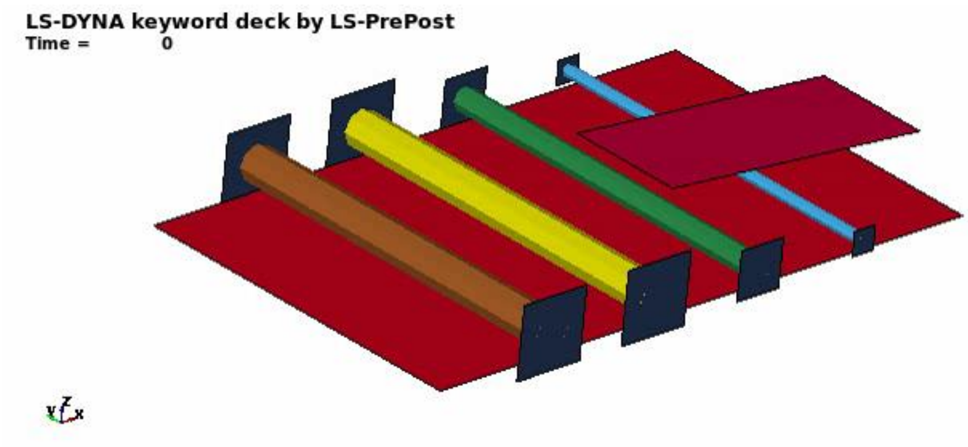


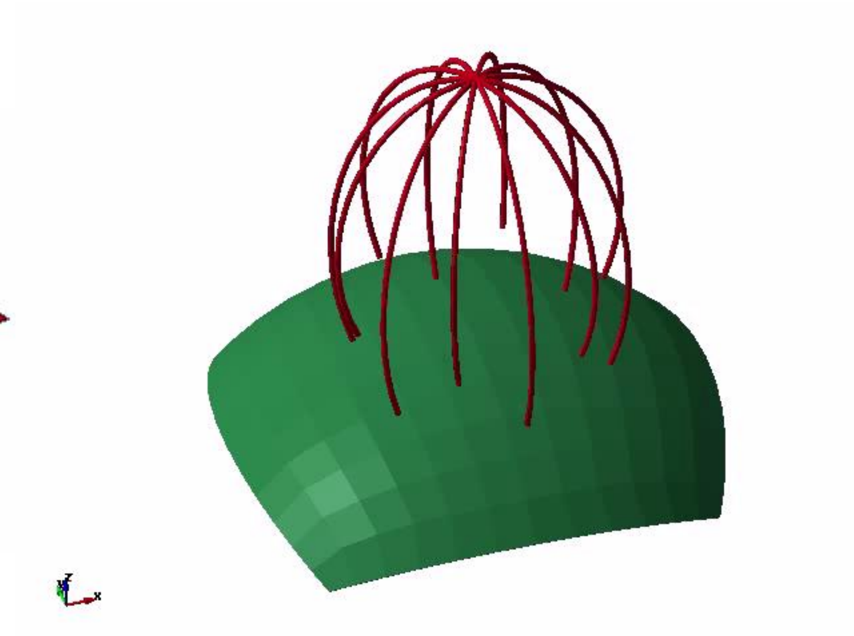
Mortar Contact for Lagrangian/Classical FEM

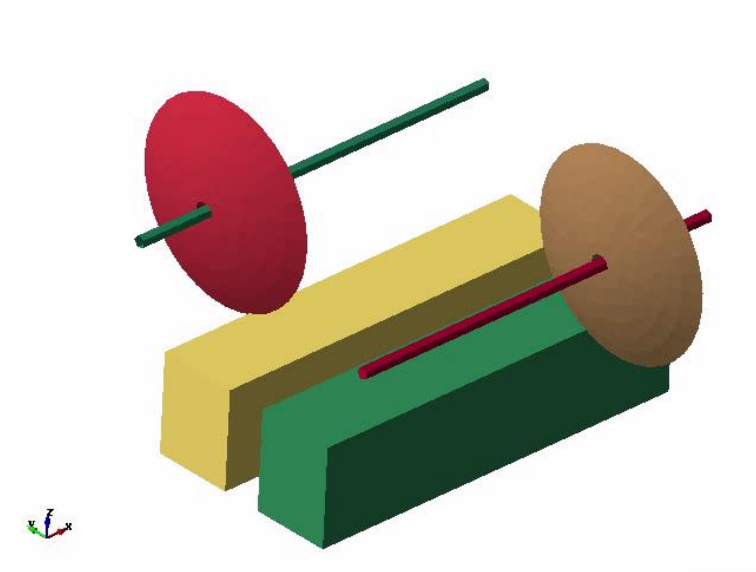
- M.A.Puso and T.A.Laursen, A mortar segment-to-segment contact method for large deformation solid mechanics, Comput. Methods Appl. Mech. Engrg. 193 (2004)
- Goal to make it simple and universal with minimal options
  - Additional CPU time for increased accuracy
- Features
  - Segment to Segment with Accurate Contact Stress Integration
  - Physical Geometry Contact
    - Flat edges on shells
    - Beams are cylinders with flat ends
    - Couples to rotations for beams to exert moments
    - Contact with sharp edges on solids and thick shells
  - Friction
    - Table, part and dynamic friction
    - Wear prediction
- Ongoing improvements
  - High Order Element support
  - Bucket sort frequency

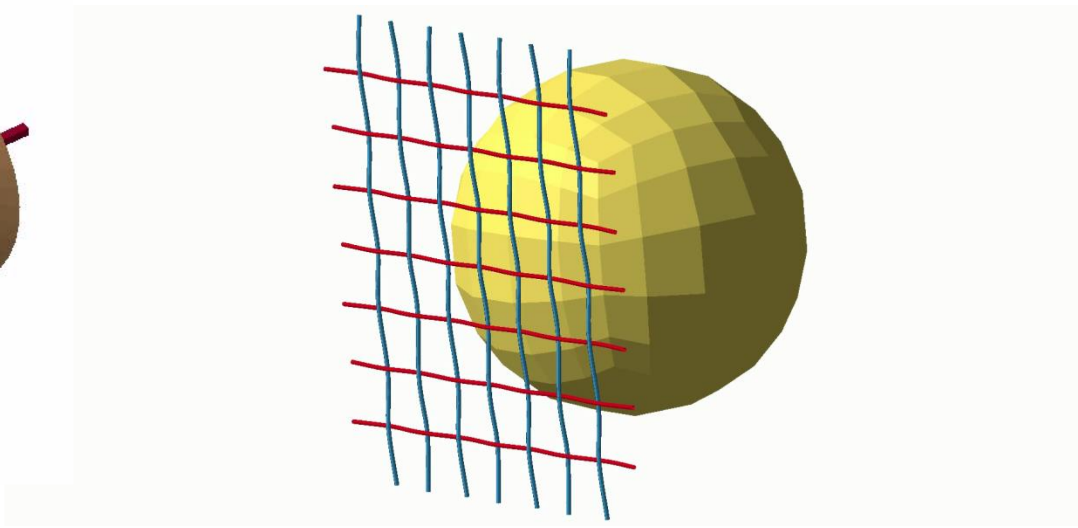


Implicit Examples

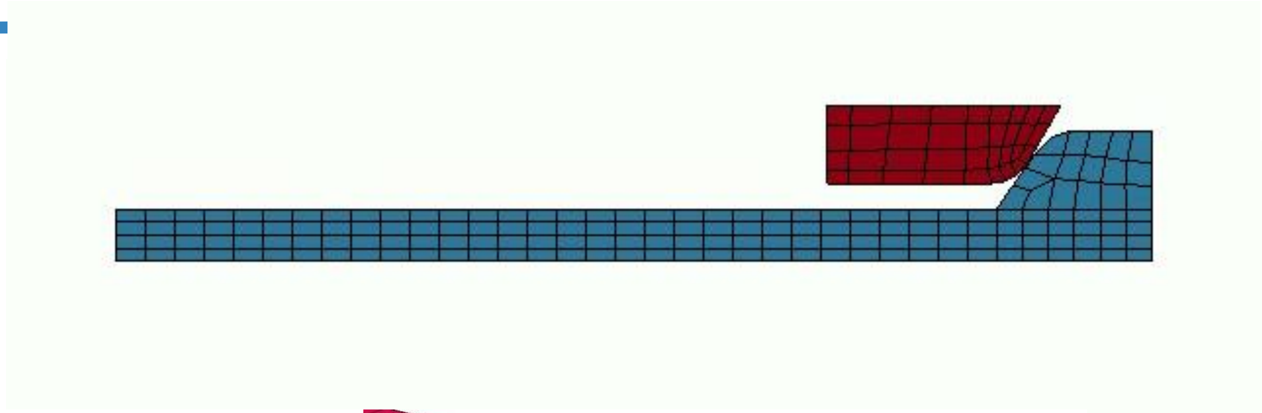


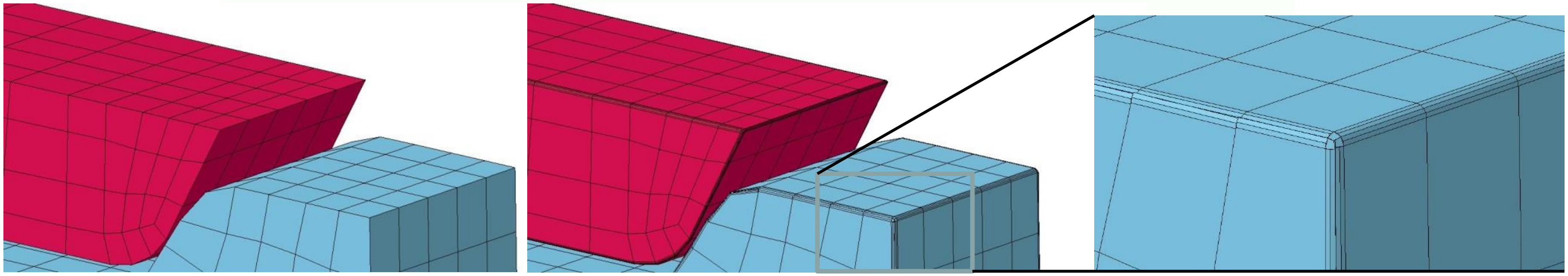




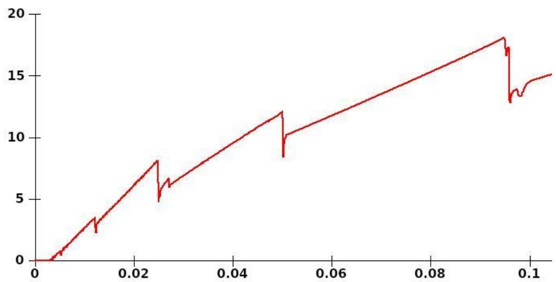


Mortar Contact - Solids

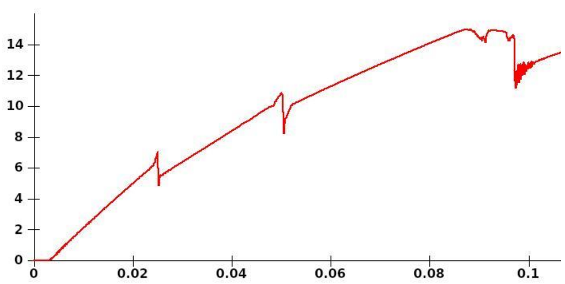




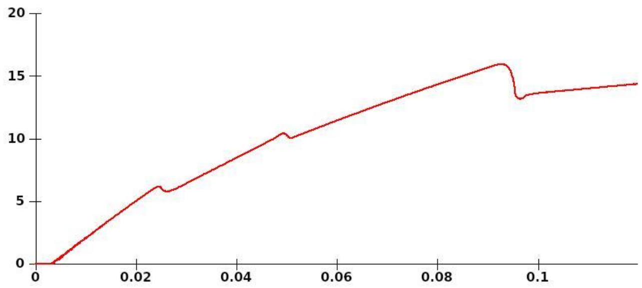
Mortar contact creates internal contact segments to deal with edges



SOFT=0 /1



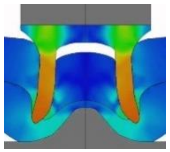
SOFT=2



MORTAR

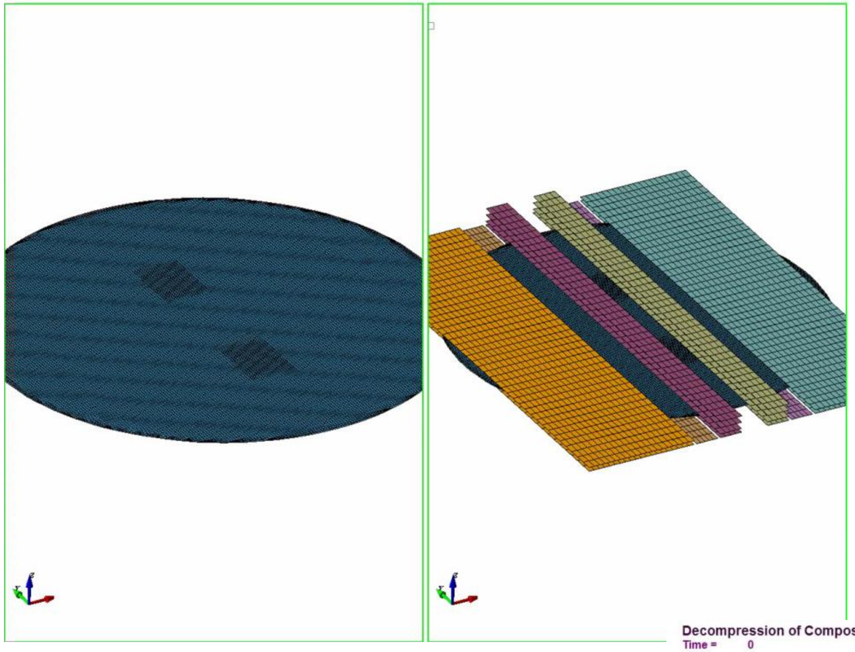
Current State for Explicit Analysis

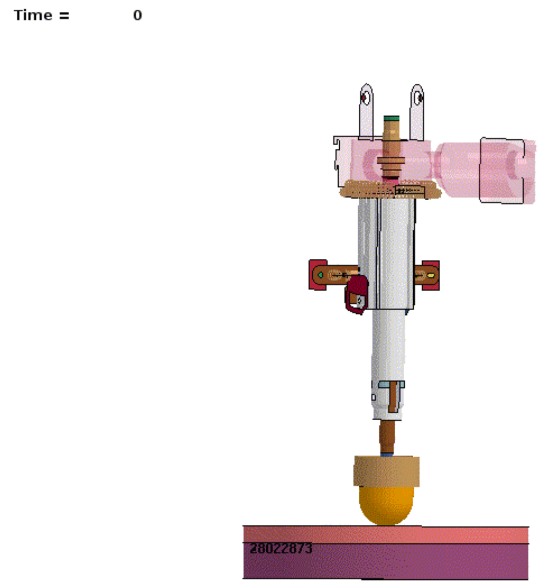
- The same contact regardless of analysis type or version
  - SMP and MPP the same
  - Implicit and Explicit the same
  - Excellent for Implicit/Explicit switch
- Explicit is supported by means of providing an alternative to well established contacts when
  - Contact results are of importance
    - Pressure distribution and friction response
  - Other contacts go unstable

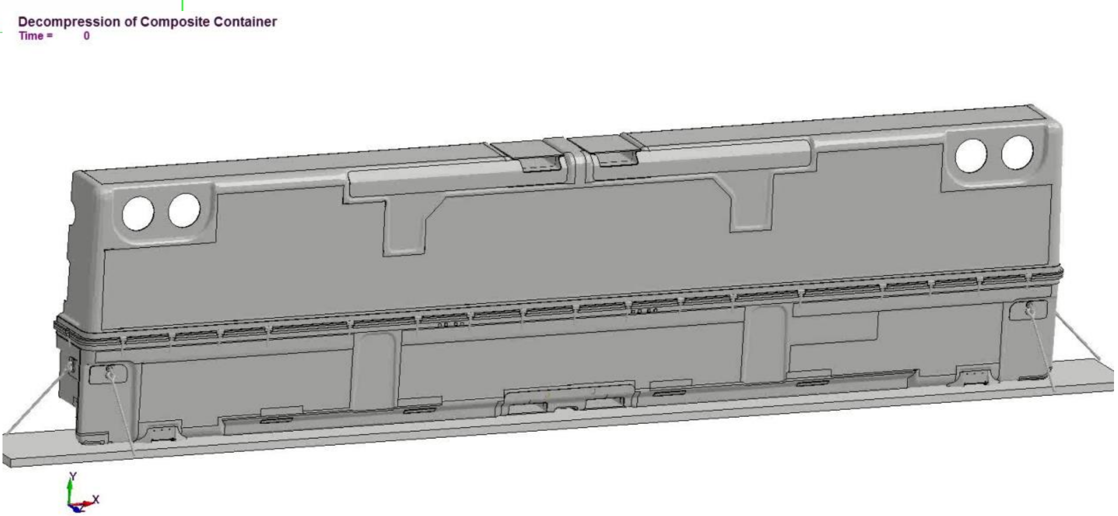


Problem	SOFT=0/1	SOFT=2	MORTAR
SPR detachment (24 cores, MPP single)	1.13	1.00	1.89
B-pillar bend (8 cores, MPP single)	1.13	1.00	2.32

Explicit Examples





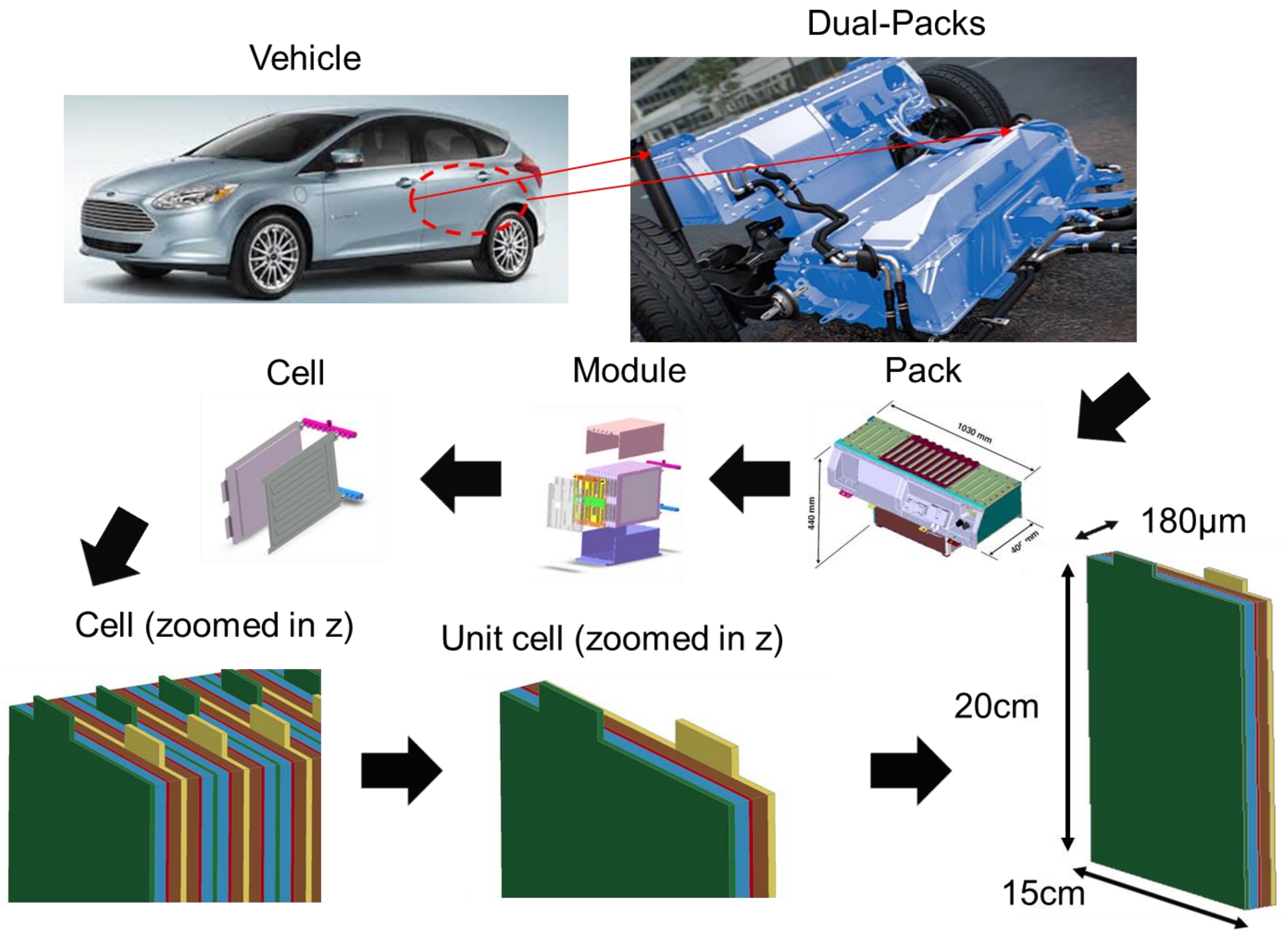


Jensen et al,
"Broad-Spectrum Stress and Vibration Analysis of Large Composite Container"

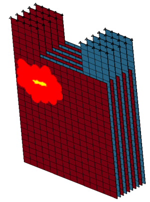
Electromagnetics

Pierre L'Eplattenier, Iñaki Çaldichoury, Sarah Bateau-Meyer

Battery - Introduction

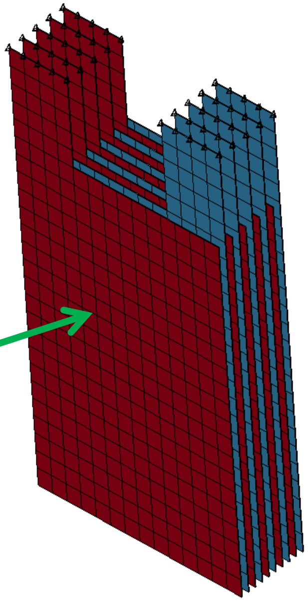


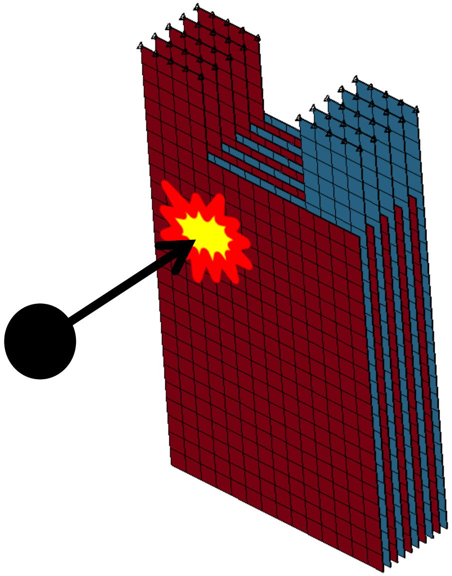
New battery module :

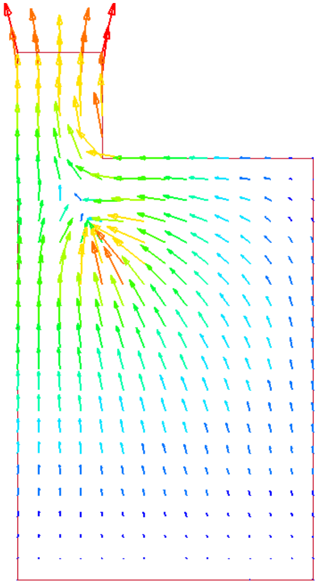


New capabilities are being developed within the EM module in order to simulate short circuits in batteries. The final objective is to be able to predict the combined structural, electrical, electrochemical, and thermal (EET) responses of automotive batteries to crash-induced crush and short circuit, overcharge, and thermal ramp, and validate it for conditions relevant to automotive crash.

Lithium-Ion cell



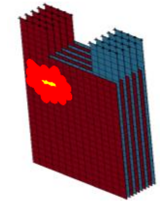


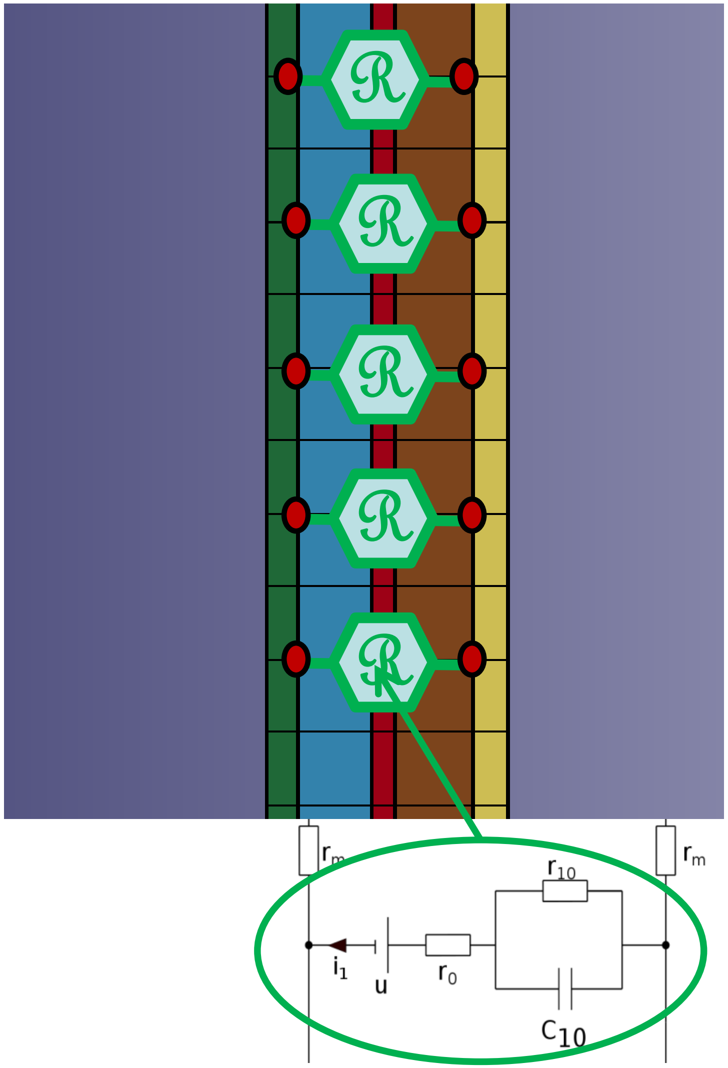


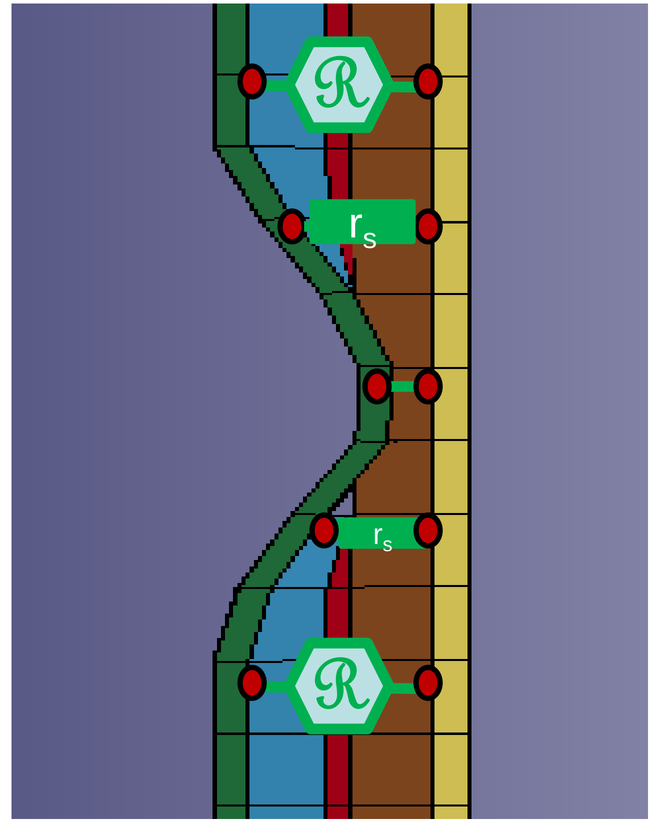
In collaboration with
J. Marcicki et al,
Ford Research and Innovation Center, Dearborn, MI

ONE FORD
ONE TEAM • ONE PLAN • ONE GOAL

Short-circuit simulation :







Replace Randle circuit by resistance Rs

$Rs \times i^2$ added to thermal

ONE FORD
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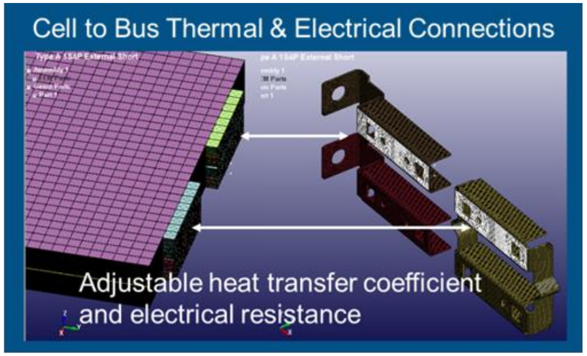
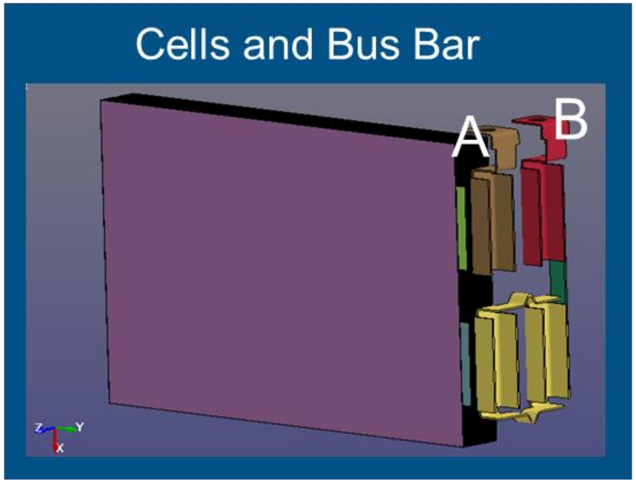
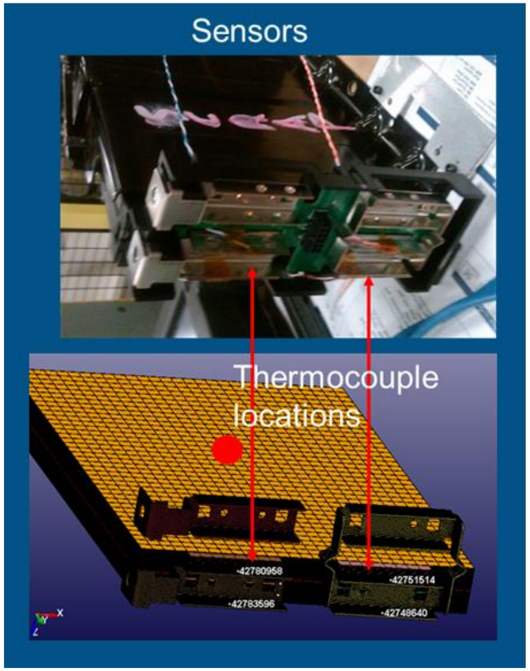
Battery – External short (1)

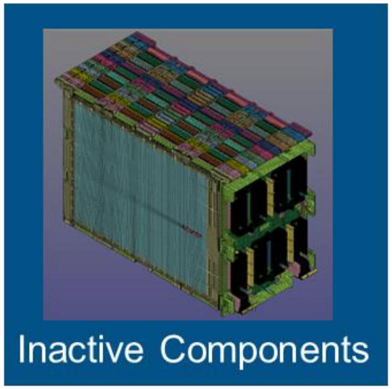
External short on a cell module





Short circuit resistance applied between A and B creates current pathway





In collaboration with J. Marcicki et al
Ford Research and Innovation Center,
Dearborn, MI, USA

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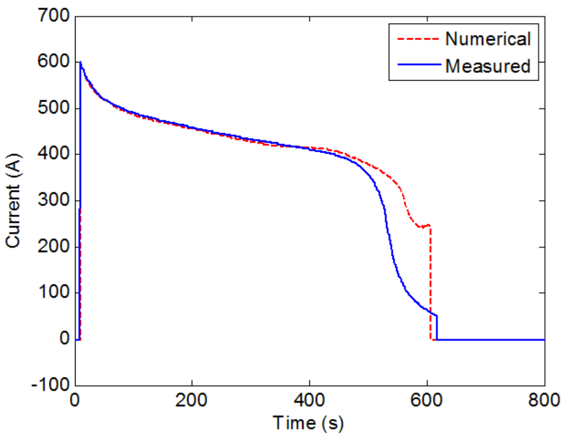
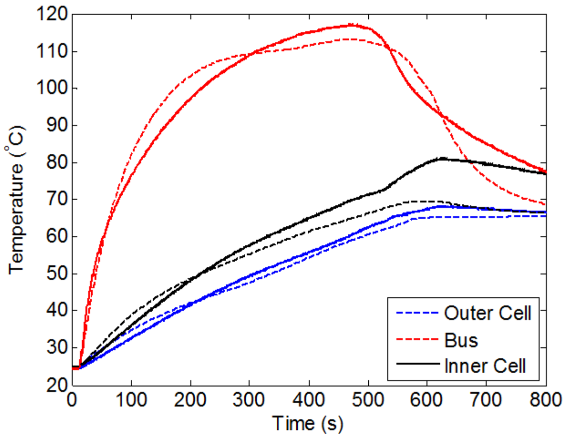
Battery – Exp. vs Num. temperature elevation at different locations

Model Predicted Current versus Experiment



Model Predicted (Dashed) Temperatures versus Experiment (Solid)



In collaboration with J. Marcicki et al
Ford Research and Innovation Center, Dearborn, MI, USA

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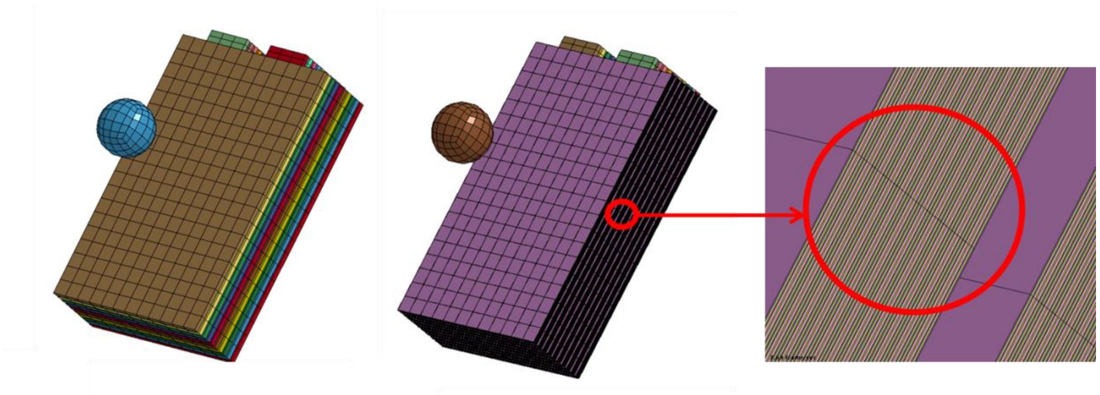
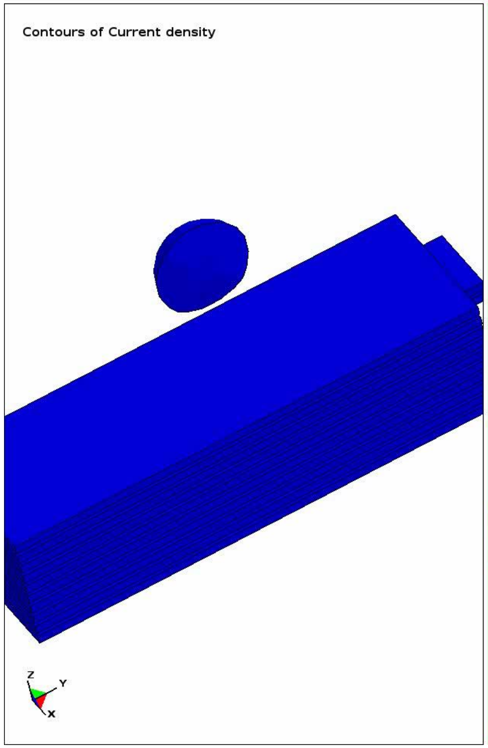
Battery – Internal short (1)

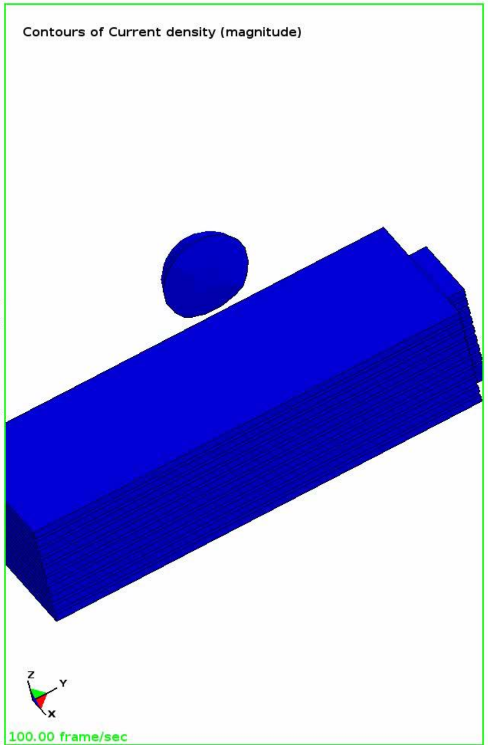
10 cells module crushed by a sphere using Composite Tshells

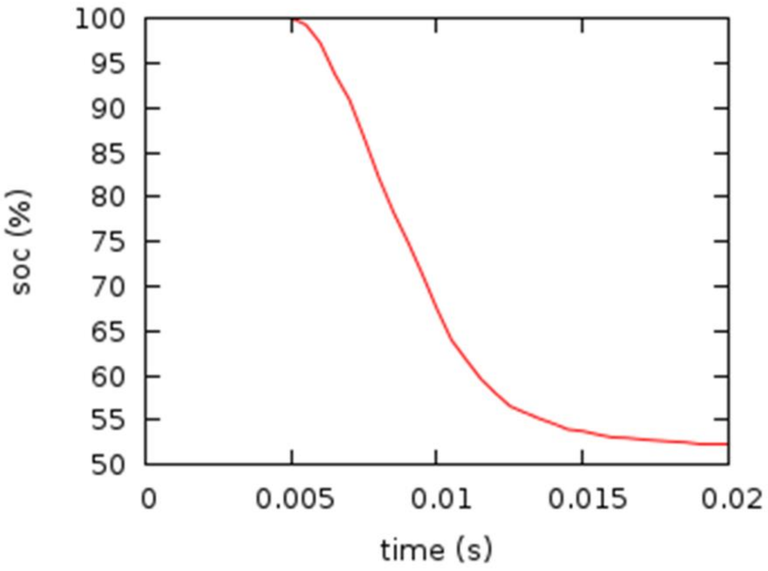


Potential

Current density



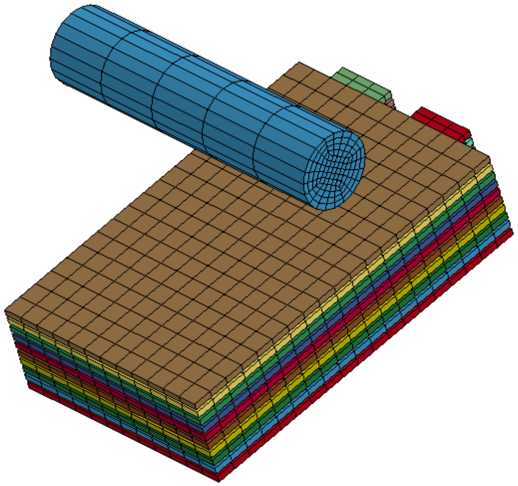




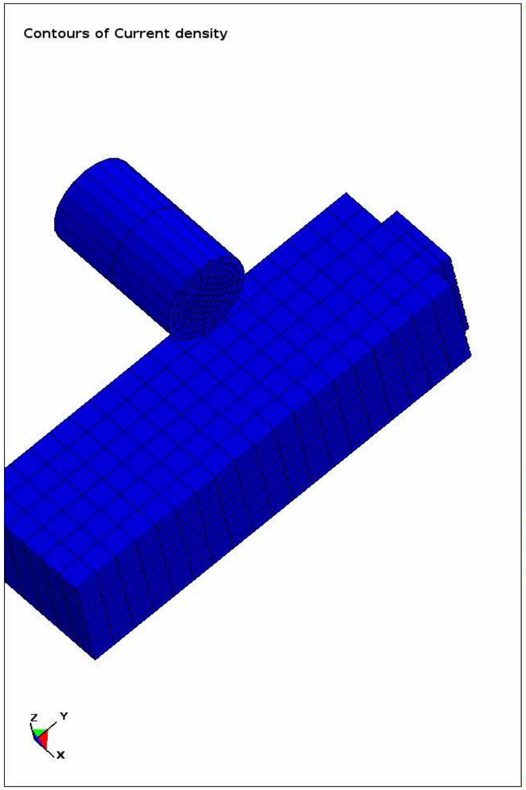
State Of Charge vs time

Battery – Internal short (2)

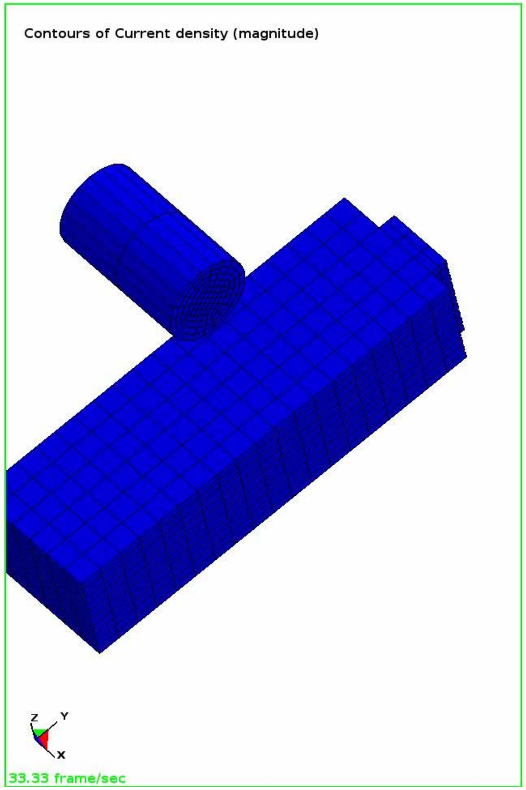
10 cells module crushed by a cylinder using Composite Tshells

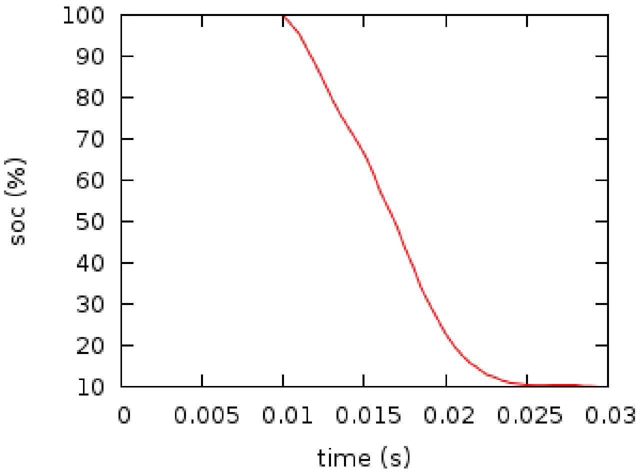


Potential



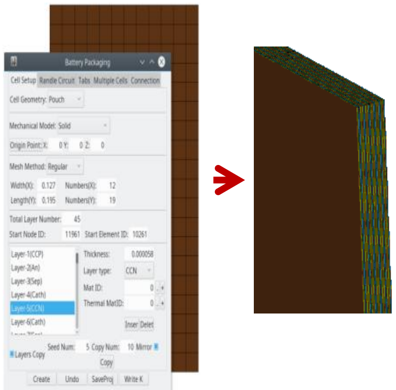
Current density



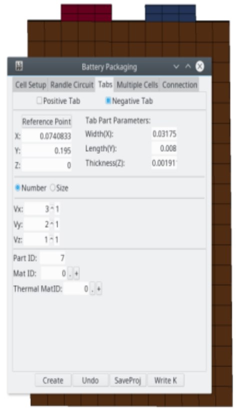


State Of Charge vs time

LS-PREPOST Battery Packaging Application

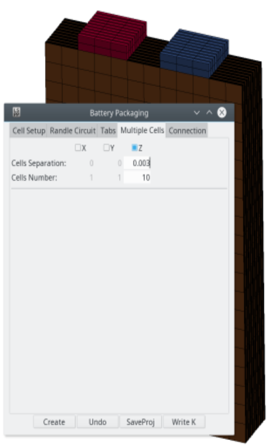


a

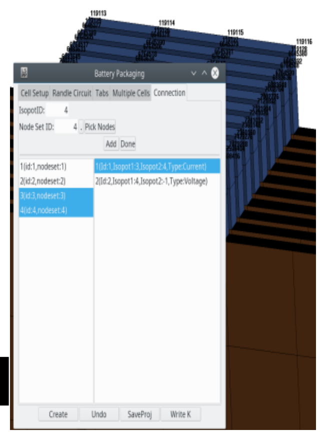


b

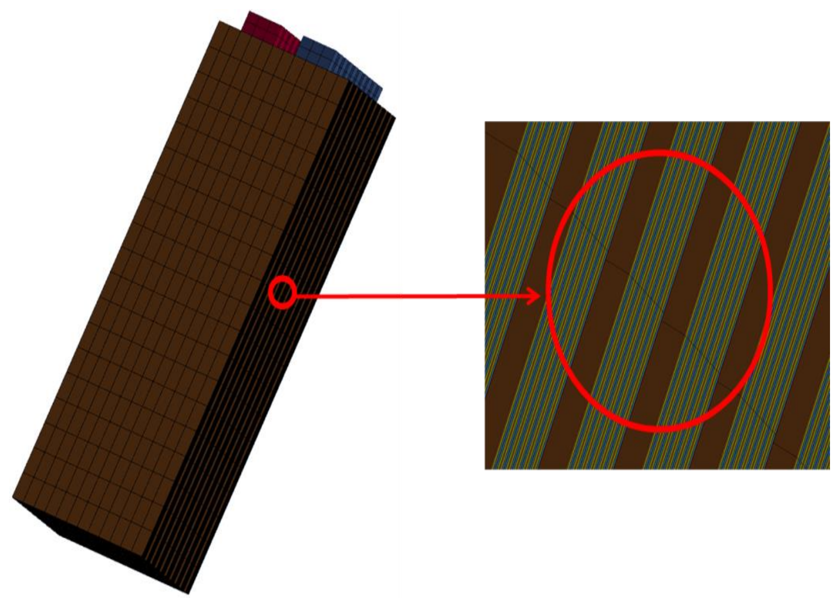
- Easy design of the layers of a single cell
- Addition of connecting tabs
- Multiplication of cells to create modules
- Electrical connections



c



d

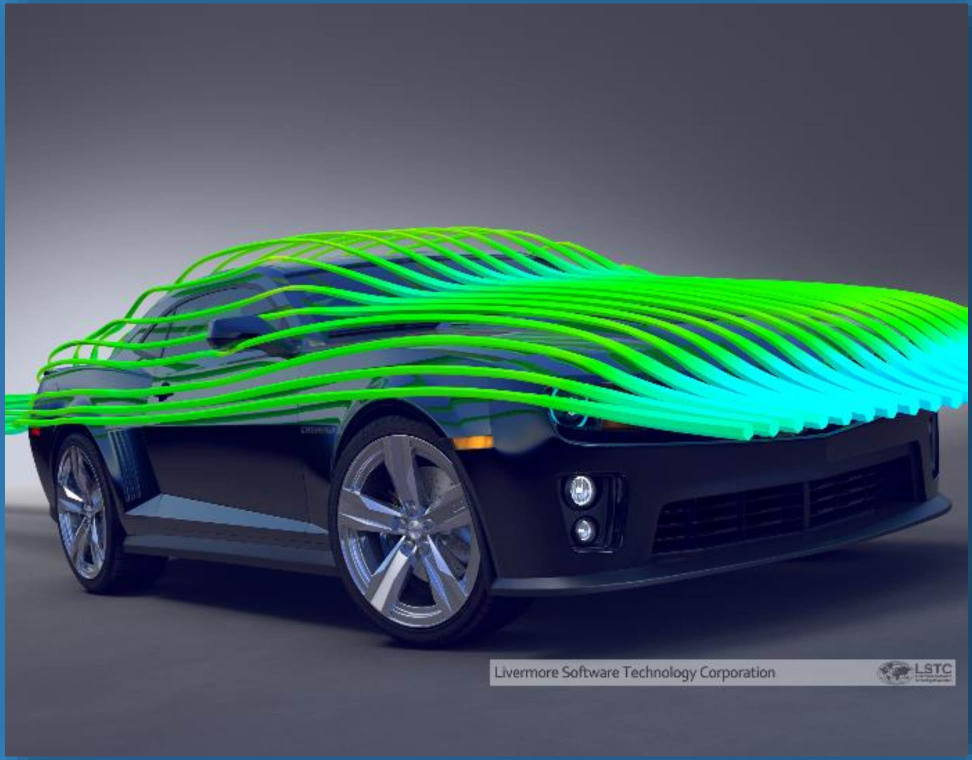


Battery – Plans for the future

- Collaborations with Ford Research and Innovation Center and Oak Ridge National Labs to improve:
  - Mechanical simulations of layered cells
  - Criteria for onset of internal short circuits
  - Setting of internal short resistance

- Development of more macroscopic models for modules and packs

- Addition of new features in LS-PREPOST battery packaging application



Incompressible CFD (ICFD)

Facundo Del Pin

ICFD

CFD solver through revisions

R7

R10

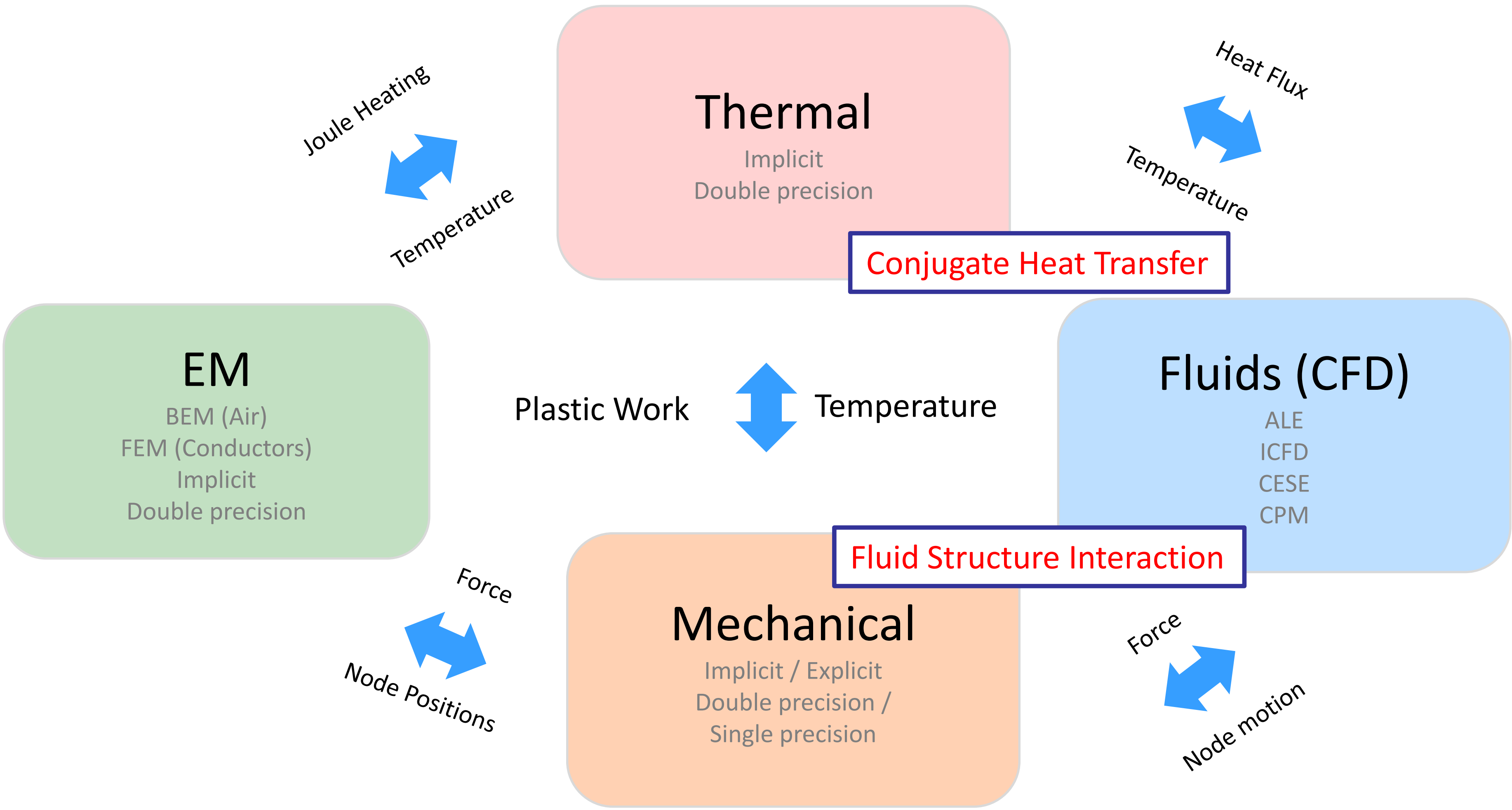
New turbulence models including k-e, k-w, relizable k-e, Spalart-

fi

- Steady state analysis coupled to thermal and FSI.
- Generalized flow in porous media on fabric material for parachute simulation and deformable structures.
- Improvements in RANS turbulence models and addition of new models.
- User control over automatic boundary layer mesh generation.
- Improvements on FSI accuracy and stability.
- LSPP new pre processing GUI.

- Several new control and database options.
- Non-inertial reference frames

ICFD



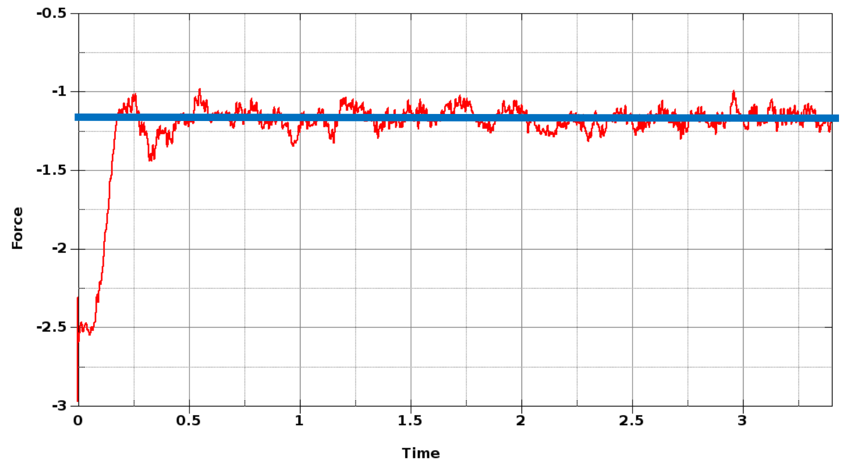
CAE consolidation without co-simulation

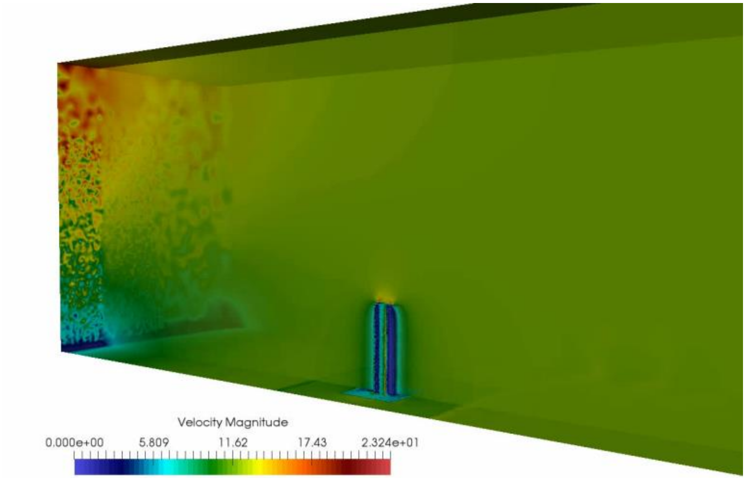
ICFD R10

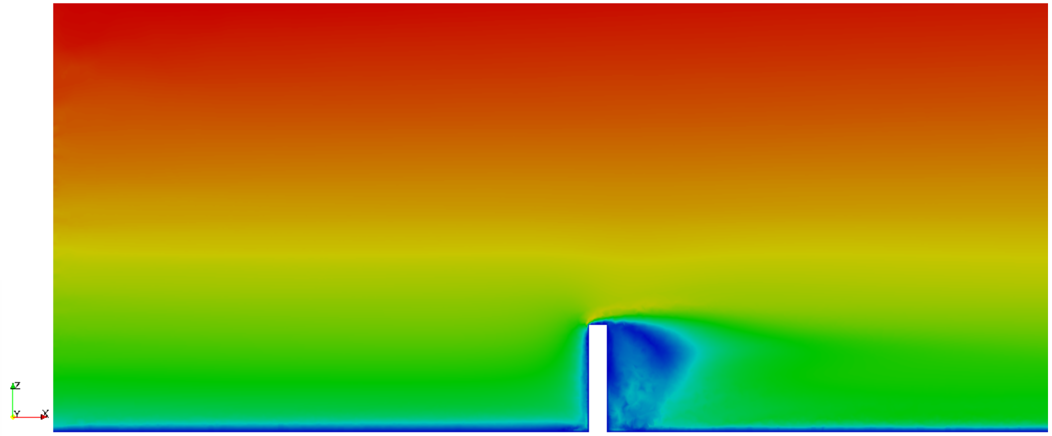
Steady state analysis

Most engineering applications are transient.

Some times engineers do not need the instantaneous transient fluctuations of the force but a time average value.







Steady state analysis allows engineers to study physical problems in a time average fashion.

ICFD

RANS turbulence models

Most commonly encountered RANS Turbulence models are present :

- Turbulent models with High Re number wall treatment : Standard K-Epsilon, Realizable K-Epsilon, Wilcox K-Omega
- Turbulent models with Low Re wall treatment : Menter SST, Spalart-Allmaras

These models can be either used in conjunction with the transient solver or the steady state solver.

Backward facing step problem :

Velocity

Turbulent Kinetic energy

ICFD

Generalized Anisotropic Flow Through Deforming Porous Media and Deforming Solids

ICFD-LSDYNA User Interface:

New Anisotropic Porous Media flow model (PM model ID=9): The model reads the solid mesh and the state field and maps elemental permeability tensors and solid displacements to the fluid mesh

Deforming Solid Problem Definition:

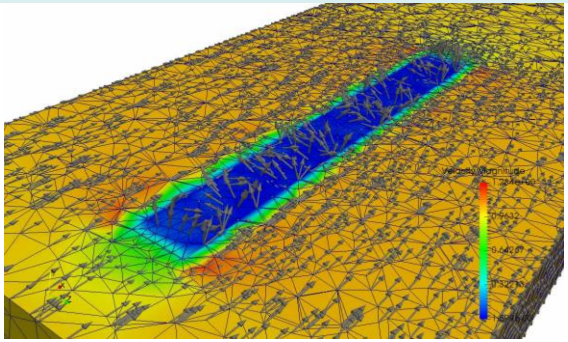
- Structural solver computes permeability tensor and stores it in a file
- The LSDYNA file format loaded by the ICFD solver is:

```
*ICFD_MODEL_POROUS
$ material ID=2, porous media model ID=9
2,9
$porosity, Forchheimer factor, nstepsolid, solidts, file-
basename
1.,0.1,8,0.02,solidst_

where:
nstepsolid: number of time steps for the solidproblem
           (number of files with solid state data),
solidts: time step for the solid problem (fluid time
step<=solidts),
file basename: filename pattern for solid state.
```

```
*NODE
1 0.0 0.0 0.0
2 0.0 0.0 0.5
...
*ELEMENT_SOLID
1 1 6 96 98 33 53 99 179 119
...
*INITIAL_STRESS_SOLID
$for each solid/hexa element (we only used Kij)
1 1 9 1 0 0 0
0.0 0.0 0.0 0.0 0.0
0.0 0.0 K11 K12 K13
K21 K22 K23 K31 K32
K33
...
```

Linear interpolation between time steps for mesh displacements and permeabilities if $\Delta t_{fluid} < \Delta t_{solid}$.

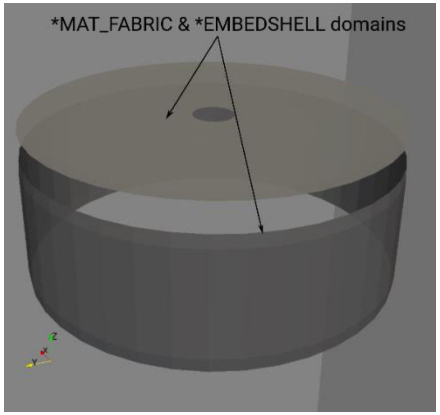


ICFD

Parachute modeling in CFD Porous Media Solver: an FSI approach

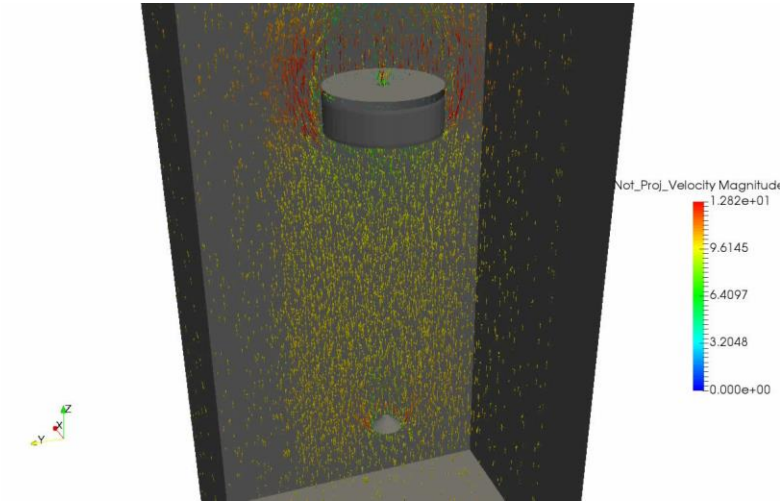
```
*MAT_FABRIC
$    mid          ro          ea        eb        ec      prba     prca     prcb
       4 533.772 4.3090E+8     0.000     0.000  0.140000    0.000    0.000
```

```
*ICFD_MODEL_POROUS
$ material ID=2, PM ID=8
2,8
$ porosity, permeab, frabric thickness
1., 0.001, 0.005
```




```
*ICFD_CONTROL_FSI
$ two-way coupling
0
*ICFD_BOUNDARY_FSI
$PID's
4,5,6
```

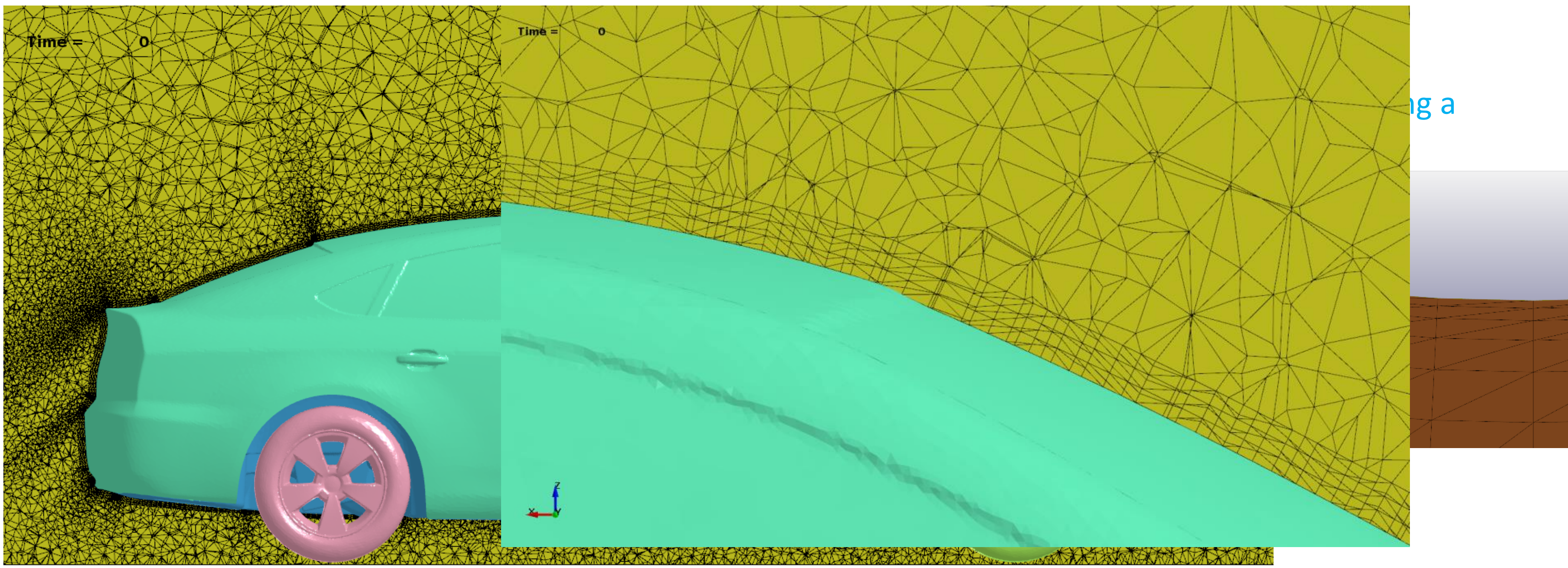
```
*MESH_EMBEDSHELL
1
4, 5, 6
```

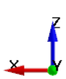


ICFD

User Control over boundary layer mesh

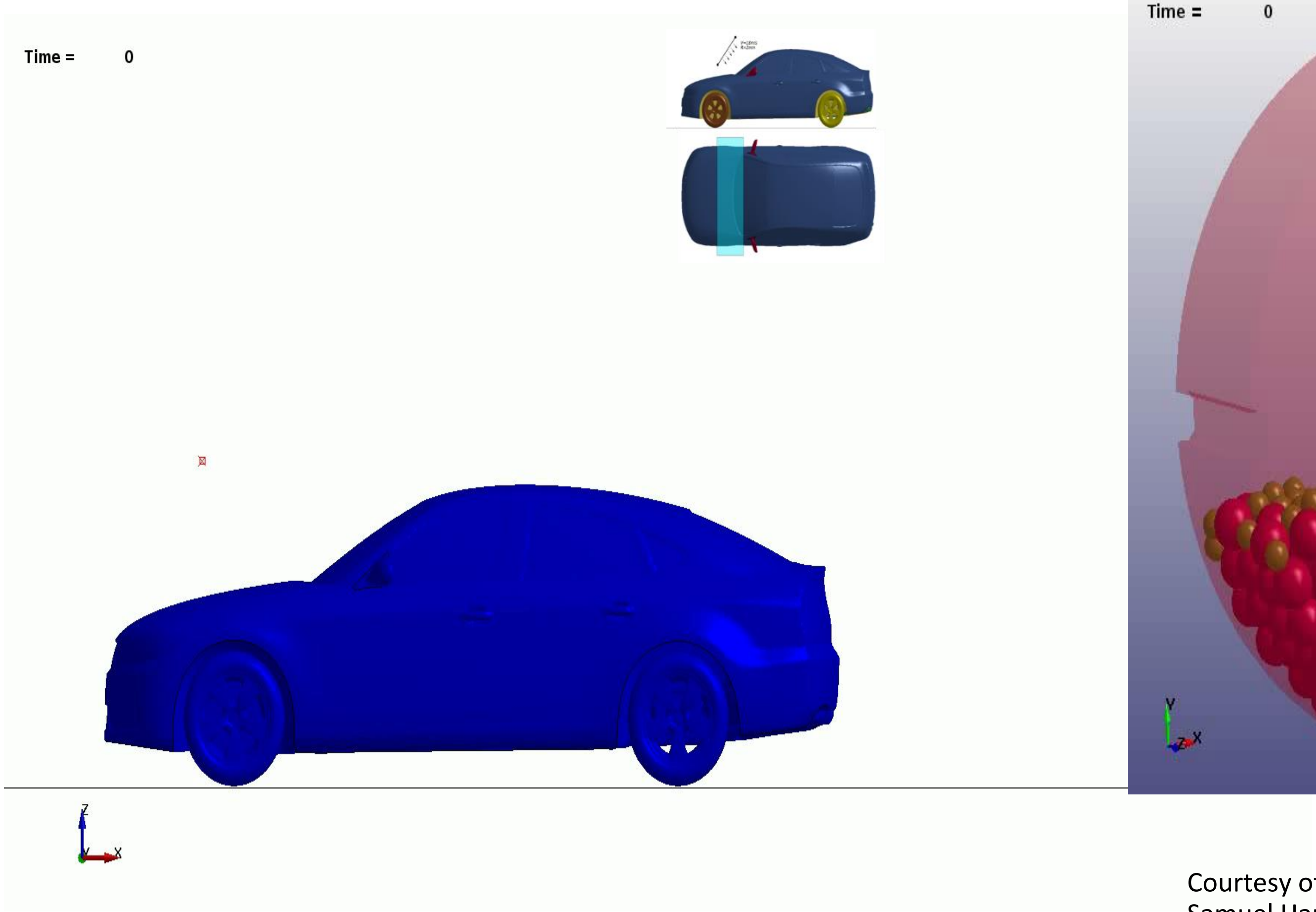
Users can control the size, height and distribution of elements in the boundary layer as well as position of the first volume node for more control of the y+.

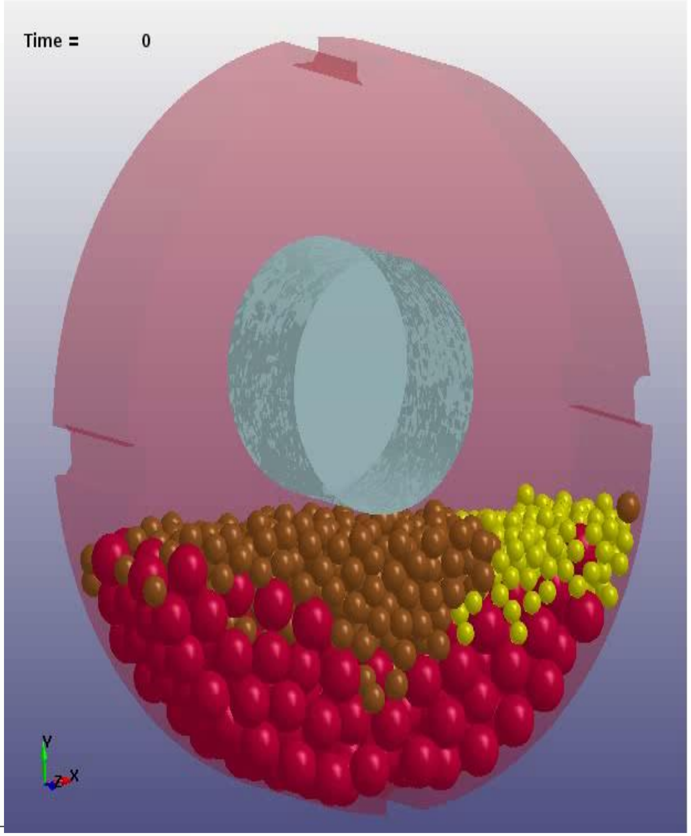




ICFD – New Features for DEM Coupling

Two-way Coupling, Particles affect fluid volume



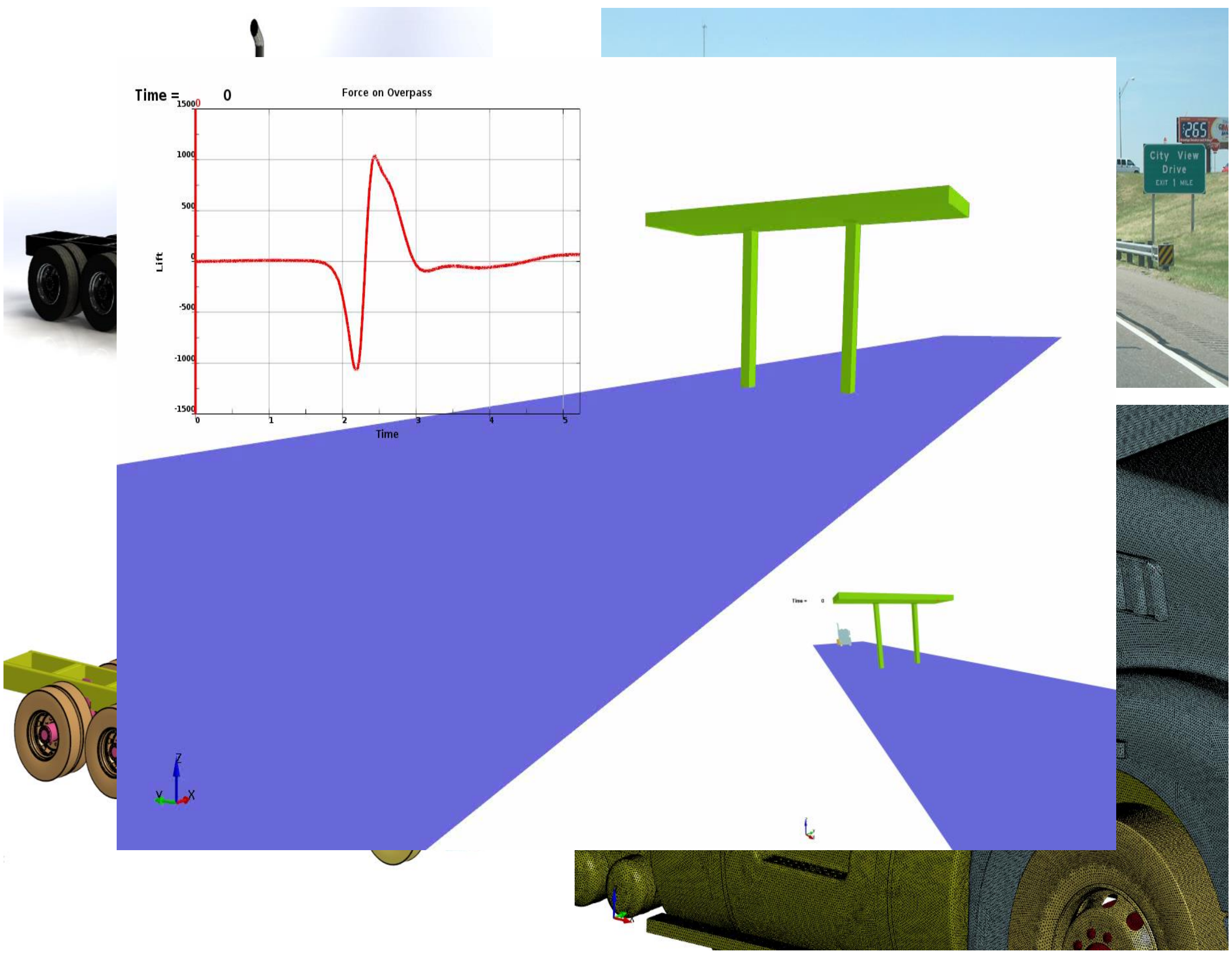


Water management: Rain Simulation

Courtesy of:
Samuel Hammarberg, doktorand.
Pär Jonsén, Professor.
Göran Lindkvist, PhD.

LULEÅ UNIVERSITY OF TECHNOLOGY

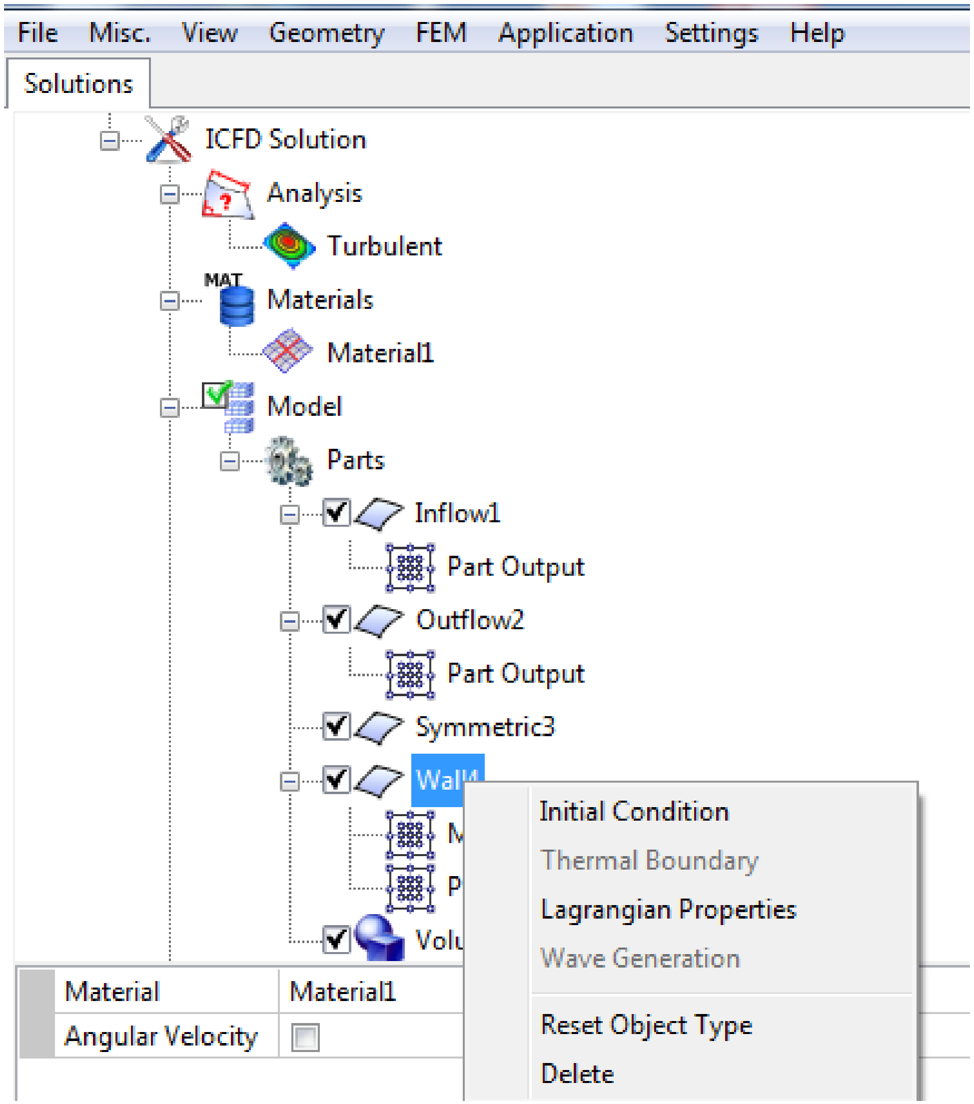
ICFD – DEM for External Load Application



ICFD

LSPrePost 4.5: CFD pre-processing

- New GUI available in LSPP 4.5 for ICFD input deck set up.
- Tree Structure where user defines global analysis properties and part boundary conditions rather than keywords.
- More intuitive to use and offers more guidance to CFD analysts and engineers not familiar with LS-DYNA keyword format
- Could be extended to other LS-DYNA modules in the future (implicit, thermal, electromagnetics etc)



Future

- New features and algorithms will be continuously implemented to handle new challenges and applications
  - Electromagnetics,
  - Acoustics,
  - Compressible and incompressible fluids
  - Isogeometric shell & solid elements, isogeometric contact algorithms
  - Discrete elements
  - Peridynamics
  - Simulation based airbag folding and THUMS dummy positioning
  - Control systems and links to 3rd party control systems software
  - Composite material manufacturing
  - Battery response in crashworthiness simulations
  - Sparse solver developments for scalability to huge # of cores
  - Multi-scale capabilities are under development

Summary

Our ultimate goal is to deliver one highly scalable software to replace the multiplicity of software products currently used for analysis in the engineering design process. ***Only one model is needed and created.***

Capabilities

Multi-physics and Multi-stage

Structure + Fluid + EM + Heat Transfer

Implicit + Explicit ….

Multi-scale

Accurate failure predictions

Multi-formulations

linear + nonlinear + peridynamics + …

Thank You !