Recent Innovations in LS-DYNA R17 (2026R1)

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LS-DYNA: Tightly Coupled, Scalable Multiphysics Solver

Finite Elements

Meshless

IGA

Multiscale

DEM/SPH

One Code, One Model, Multiphysics

Solid Mechanics

Electro-Magnetism

Fluids

Ansys LS-DYNA

NVH/Acoustics

Thermal

Chemistry

HPC / Cloud

LS-PrePost

LS-OPT

LS-TaSC

Mechanical

Ansys Forming

Dummies, HBM & Barriers

pyDYNA

Industries

Crash

Aerospace

Biomedical

Electronics

Defense

...

Model-based Simulation Workflow for Virtual Product Development

Certification By Analysis

Design Variational Study & Optimization

LS-OPT
LS-TaSC

Mechanical, Fluids, EM, Thermal, Multi-Physics Analysis

CPG, CPM, SALE,IGA,SPH,
ISPH, DEM, SPG,
Peridynamics
Two-scale Co-simulation,
NVH/Acoustics, Sub-cycling,
Electromagnetics
ICFD,CESE,…

Material Laws
Elements
Contact Constraints
Rigid-Body
Linear Algebra

Manufacturing Simulation

SPH, ISPH
ISPG
Ansys Forming
3D R-adaptivity (FEM & EFG)
SPG
Ansys Forming

HPC

LS-PrePost

Presentation Outline

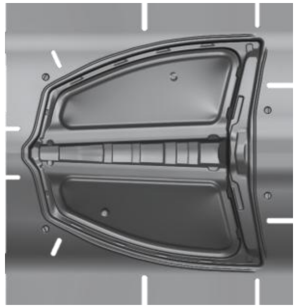
- Manufacturing Simulation
- Core Technologies - Material models, contact, elements, etc.
- Physics enhancements
- HPC
- Pre & Post Enhancements in LS-PrePost
- Optimization – LS-Opt/LS-TaSC
- Conclusion

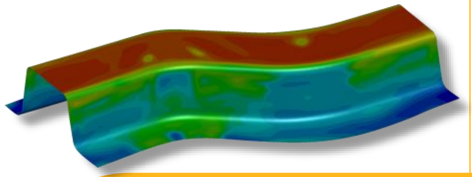
Manufacturing Simulation

Ansys Forming

Cold/Hot Forming

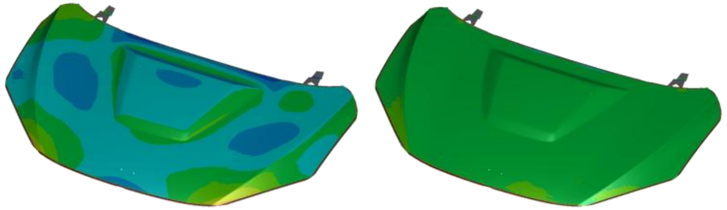
- Blanking
- Drawing
- Gravity Loading
- Trimming
- Springback
- Lancing
- Clamping
- Flanging/Restriking



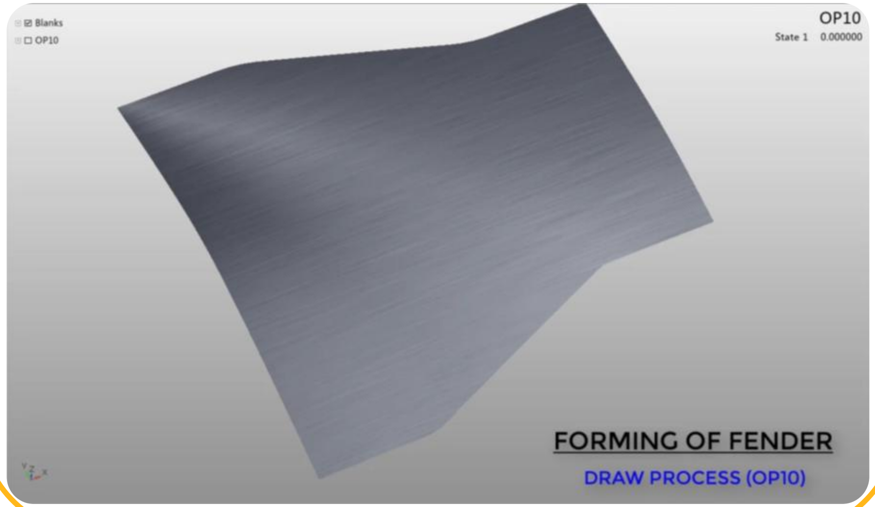


*Springback Compensation

- Automatic Iteration
- Automatic Compensation for Draw Die
- Separate Coordinate Systems for Springback & Draw

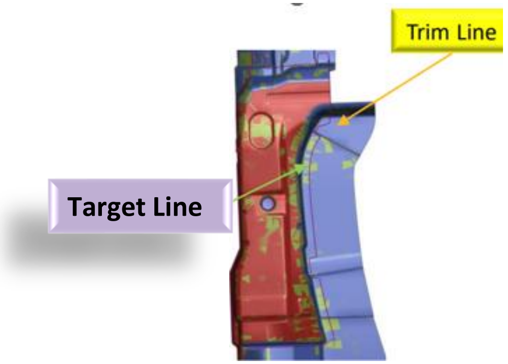


Dedicated Platform for Multi-Stage Stamping Simulations



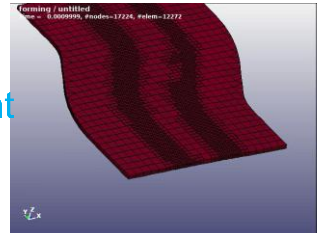
Trim Curve

- Easy Geometric error validation
- Easy Trim line development



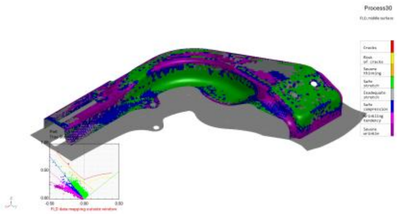
*Solid Elements

- Auto mesh refinement
- Easy pre/post



*One-Step

- Unfold flat blank
- Rough formability prediction
- Allow binder definition



*Dedicated Material Editor & Library

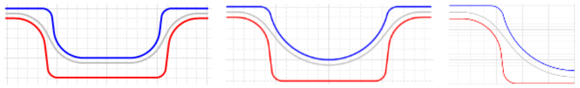
- Yield Locus
- Hardening Curve
- FLD Curve
- Support Most Stamping Related Materials

* New Capabilities

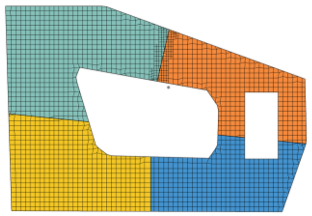
Ansys Forming

Drawbead Design & Modeling

- *** Bead Force Estimation**
- Drawbead Profile Design

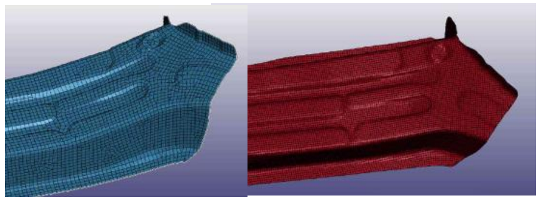


*** Tailor Welded Blank**

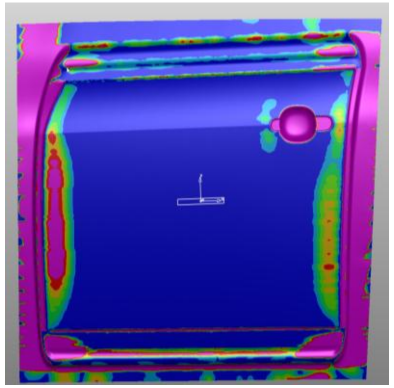


Innovative Specialized Features

- Mesh Check & Repair
- Surface Defect Analysis
- In-Core Mesh Adaptivity
- Mesh Regeneration with adaptivity
- Variable Friction



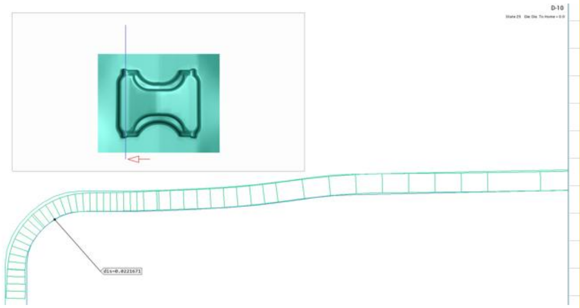
Bad Mesh Auto Fix



Surface Defect Evaluation

***Non-Linear Contact**

- Variable contact stiffness based on the profile



***Universal Material Model**

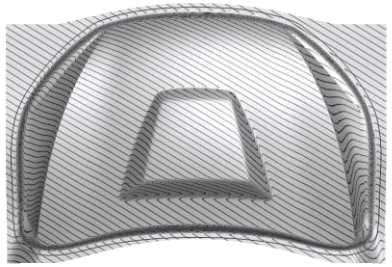
- Can represent any arbitrary yield surface
- Solution Performance Gain - 14%-22%

***Variable Friction Coefficient**

- Define via table or curve

***Reflection (Zebra) Lines**

- User can control light source



Coming Next

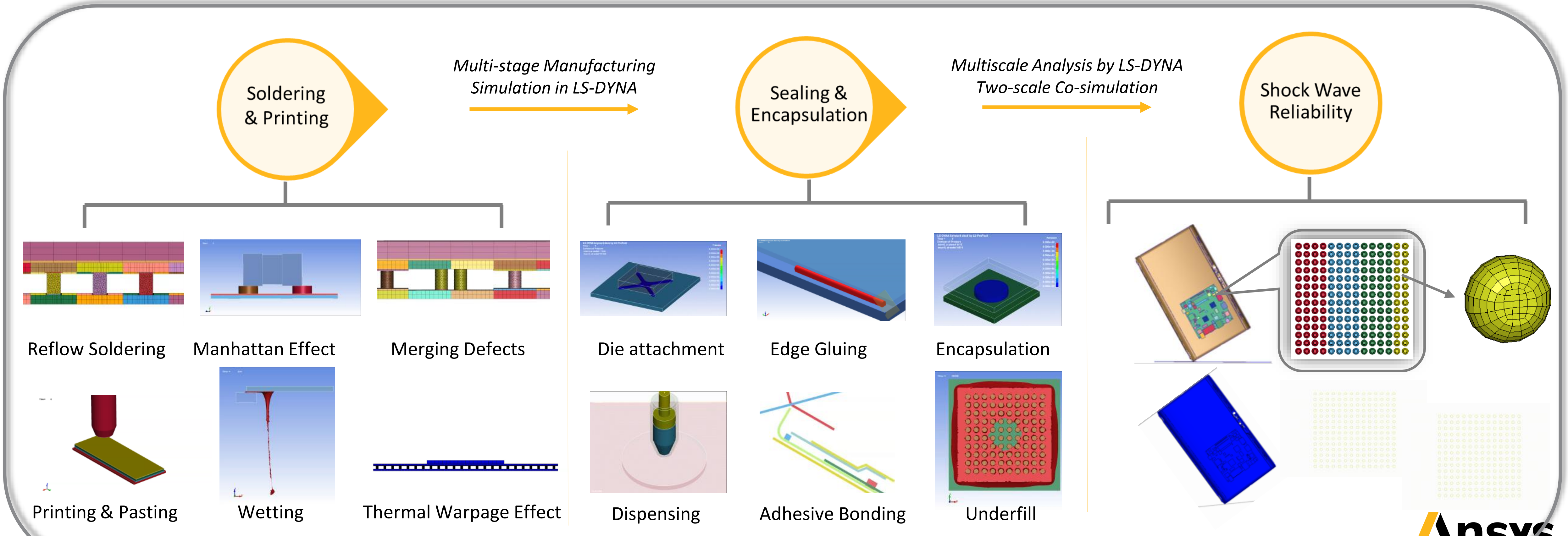
- Springback Compensation for line dies
- Table Hemming (first step for assembly)
- Improved Binder model
- Auto/Semi-auto Reporting
- Die Face Design (and CAD Handling)

*** New Capabilities**

Ansys part of Synopsys

ISPG: Implicit Adhesive Fluid Solver

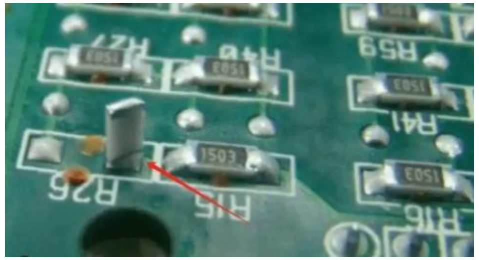
- A particle-based Navier-Stokes equation solver.
- Enables Free-surface fluid flow simulation with surface tension and adhesive force effects.
- ISPG in LS-DYNA has full-implicit MPP versions equipped with particle adaptivity capability.
- Support large-scale Newtonian and Non-Newtonian fluid modeling.

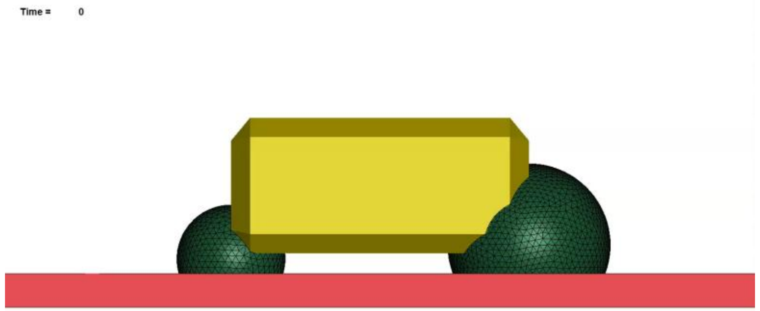


ISPG: Monolithic Fluid-Rigid Structure Coupling*

For IC Manufacturing Simulation

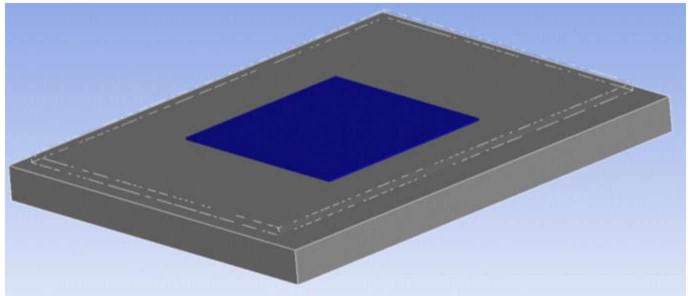
Can implicitly model the dynamic behavior of Fluid-Structure Coupling system with strong surface tension and force-driven actions showing in many IC manufacturing processes.





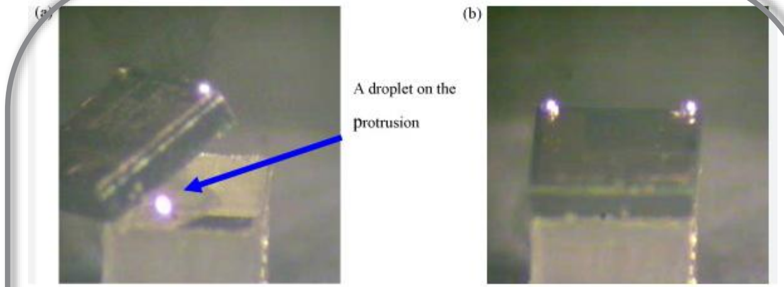
LS-DYNA ISPG 2 hours with 1 CPU core vs weeks of CFD methods.

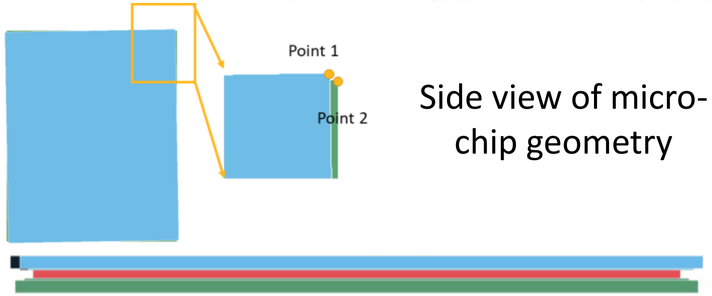
Simulation of Tombstoning Defect in Surface Mounting



ISPG simulation captures the discontinuous pressure field due to partial die contact. Challenging in CFD methods.

Simulation of Force-driven Die Attach (Mount) Process





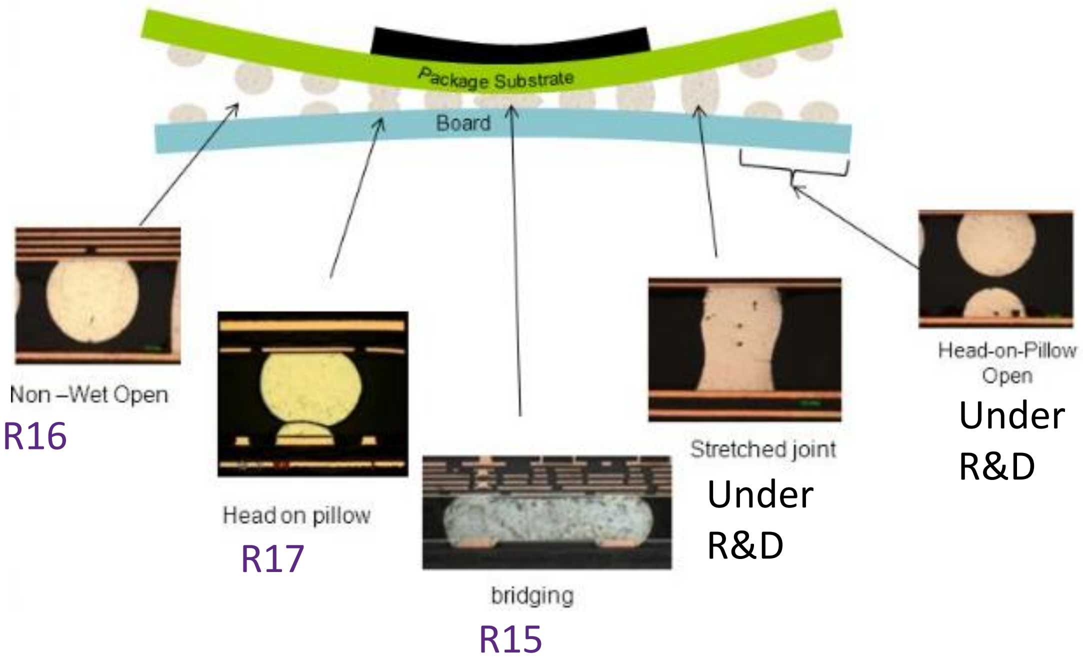
Side view of micro-chip geometry

LS-DYNA ISPG 1 hours 43 minutes with 1 CPU core. Unavailable in current CFD methods.

Simulation of Micro-chip Capillary Self-Alignment Process

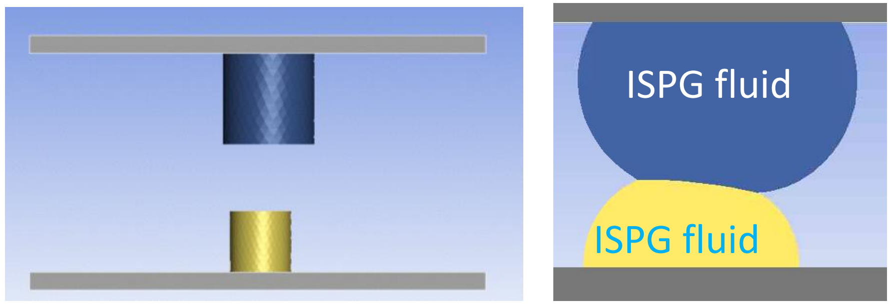
ISPG: Fluid-to-Fluid Contact Algorithm*

During the reflow soldering process, the oxidized surface of fluid can prevent the fusion of solder fluid causing the so-called "Head-on-Pillow" defect. This defect can now be simulated with the **ISPG Fluid-to-Fluid Contact Algorithm**.

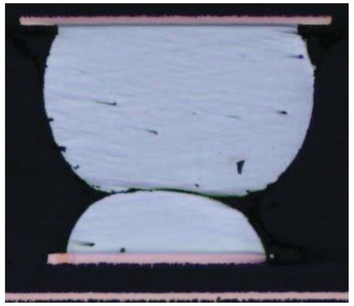


Five major manufacturing defects in reflow soldering process

ISPG simulation of Head-on-Pillow defect

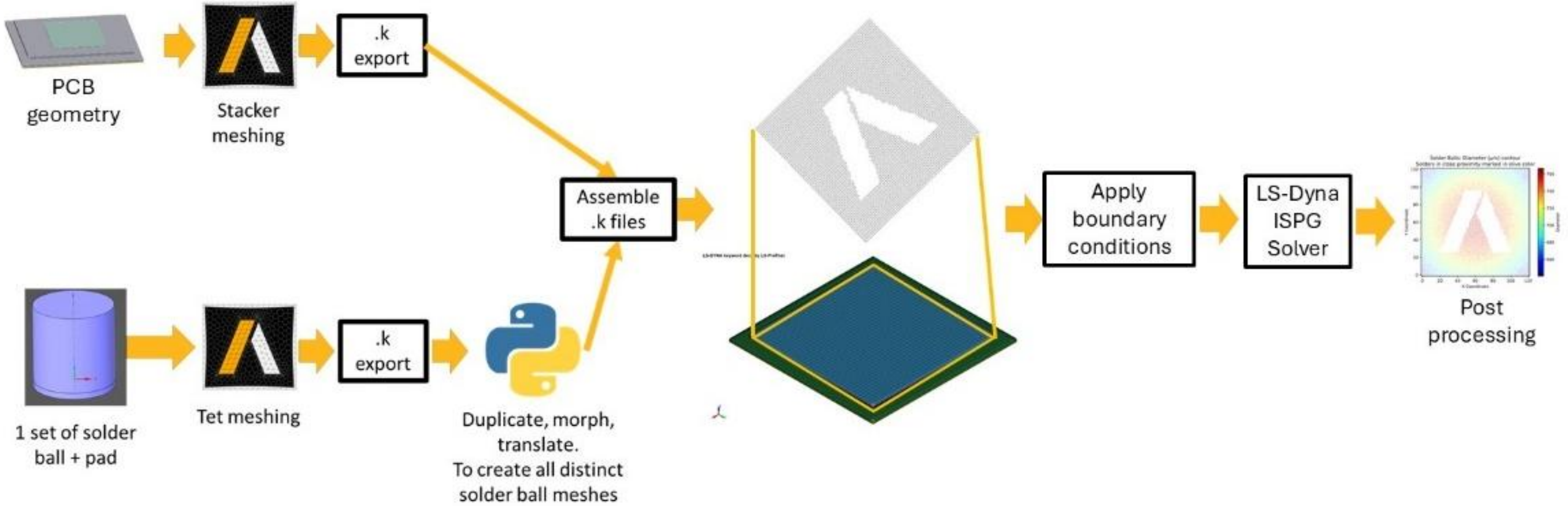


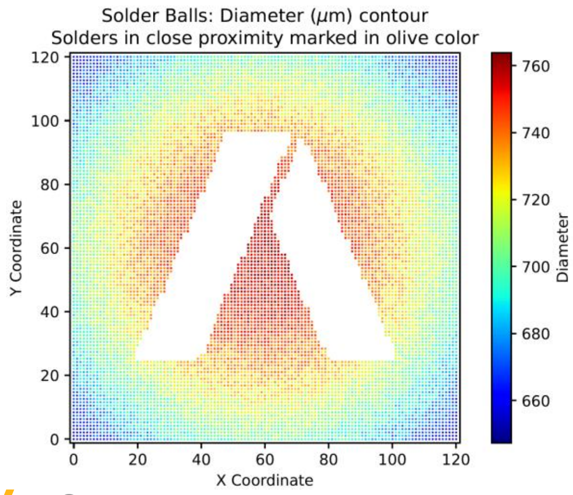
Experiments

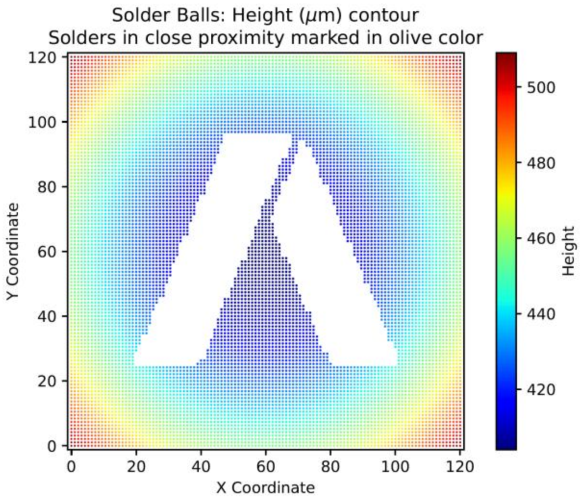


Ansys part of Synopsys

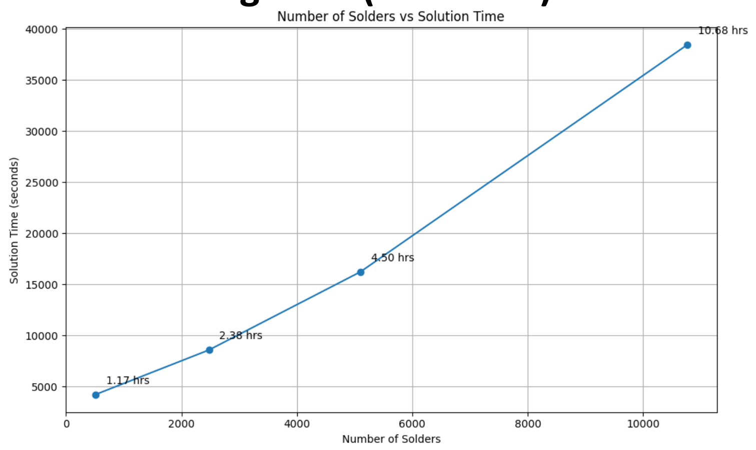
ISPG - Automation of ISPG Solder Reflow Simulation Workflow*







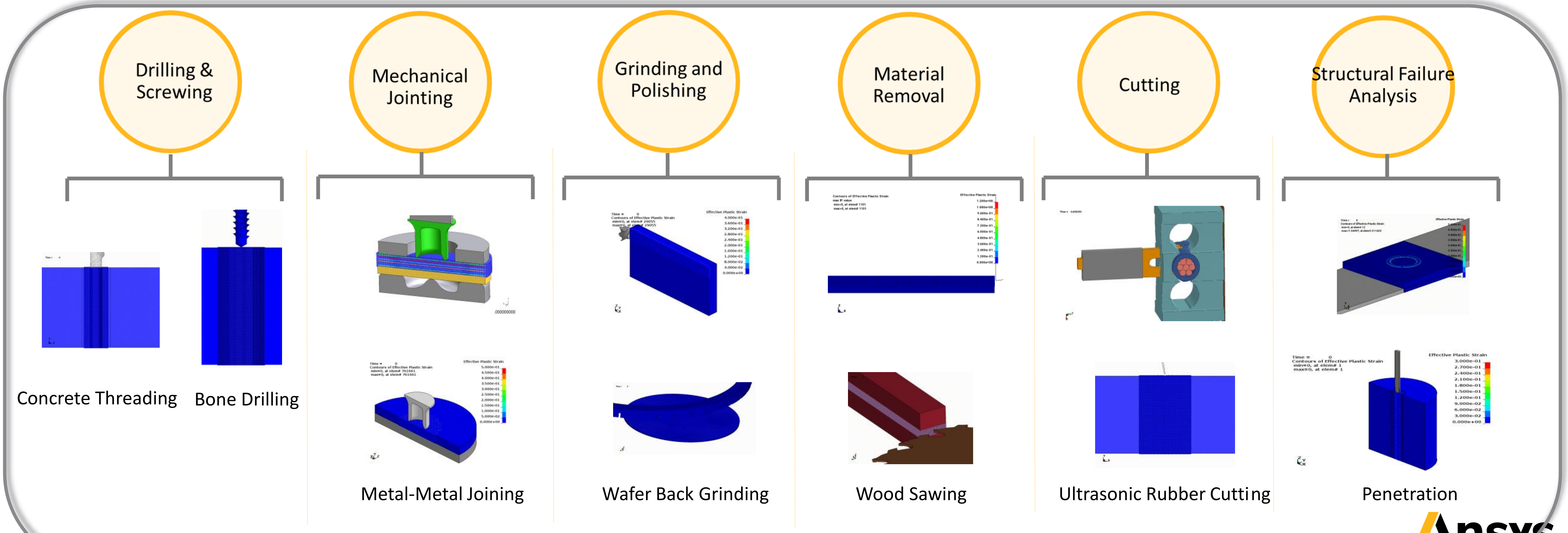
Running time (128 CPUs)



128 CPU, 11 hours << Established numerical methods estimated in months ~ years

Smoothed Particle Galerkin (SPG) Solver

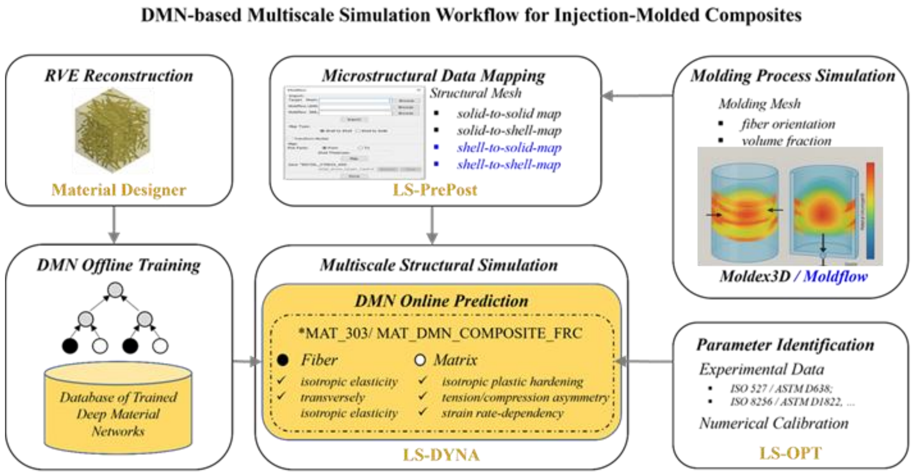
- A Solid Mechanics Solver for general Manufacturing Simulation
- Approximates the dynamics equation of motion with a novel particle approach.
- Can effectively simulate severe deformation & material removal during various manufacturing processes.
- Explicit MPP versions coupled with thermal and several other LS-DYNA solvers such as FEM, ALE and SPH.



Ansys part of Synopsys

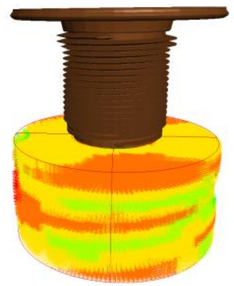
SPG: Workflow to Map Location-Dependent Materials*

- The workflow in ***LSPP*** transfers SFRC material data of Moldex3D/Moldflow (mesh-based) to SPG particles via ****INITIAL_STRESS_SPG***
- Supports both material nonlinear behavior and failure criteria homogenized from microstructures by ****MAT_DMN_COMPOSITE_FRC***

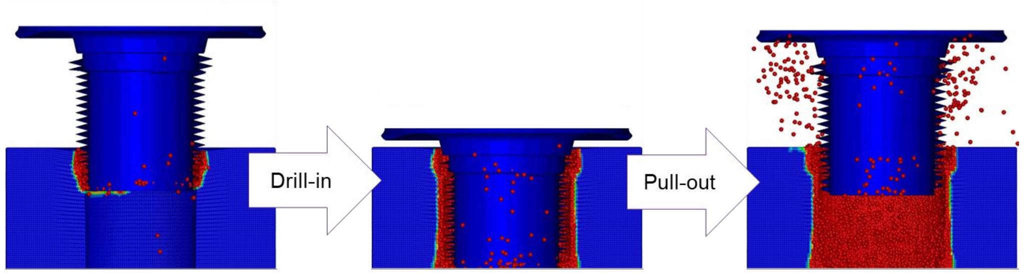


Workflow from injection molding results to SPG material input (fiber orientation & volume fraction), where DMN is pre-trained to predict material behavior based on location-dependent SFRC microstructures

DMN model



Location-dependent material parameters

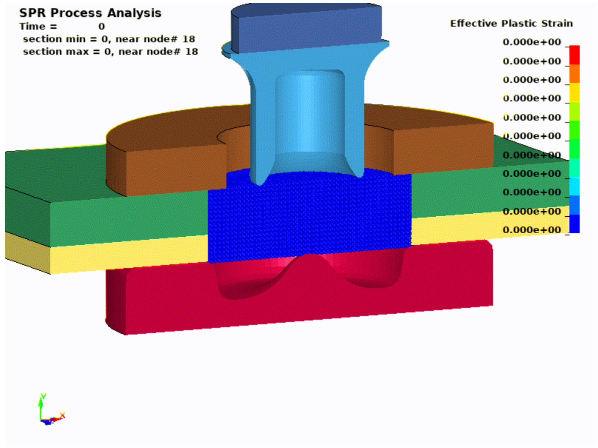


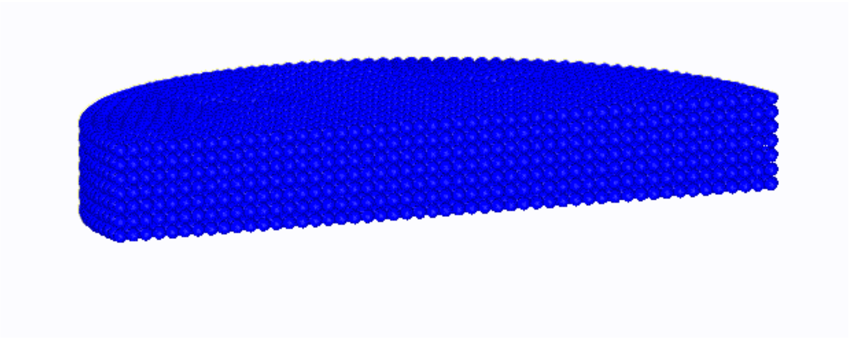
SPG multi-stage analysis: (1) drilling simulation to form threads; (2) pulling-out simulation to test the joint strength

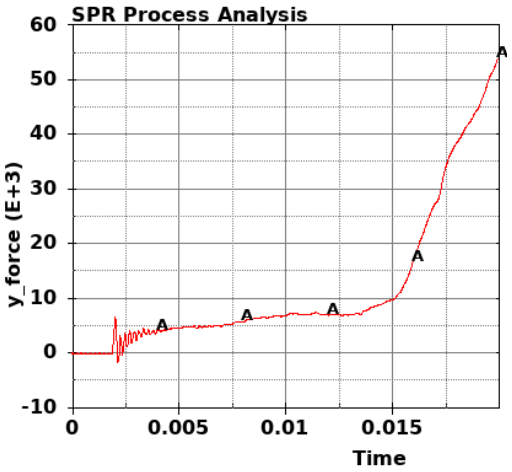
Ansys part of Synopsys

SPG: SPG to SPG Contact*

- The phantom particle algorithm is developed to extend ****DEFINE_SPG_SURFACE_COUPLING*** for the surface with failed particles.
- New keyword ****DEFINE_SPG_SPG_COUPLING*** to simplify definition of the new SPG-SPG contact



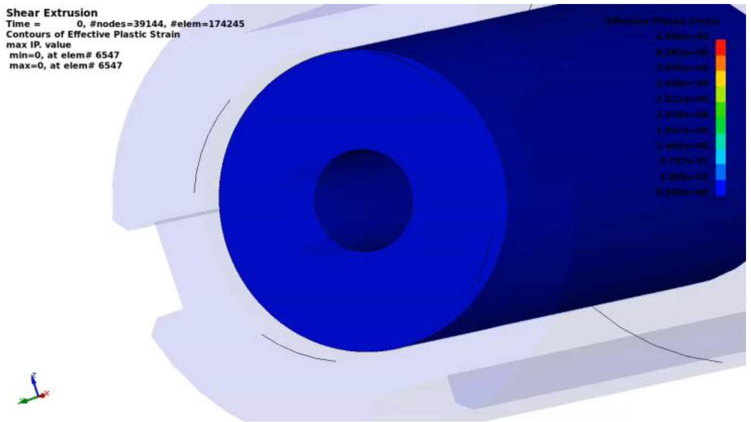




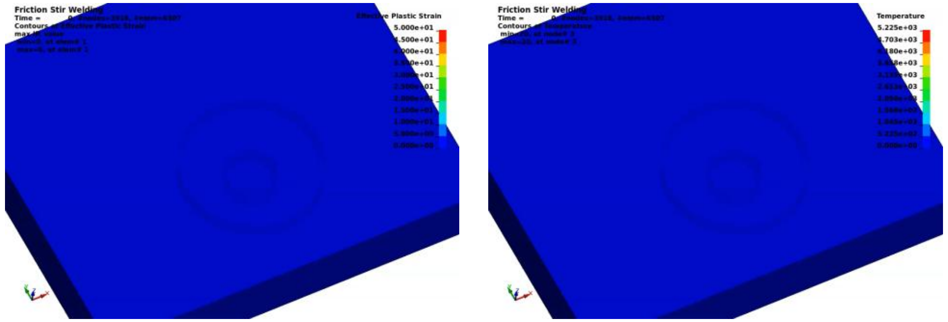
Self-piercing rivet (SPR) simulation to join two solid plates modeled by SPG particles

3D Adaptivity: Tetrahedron Re-mesher*

- Introduce a powerful TET re-mesher, TETGEN, with more controls on mesh quality.
- Remeshing based on Surface mesh and Point set.



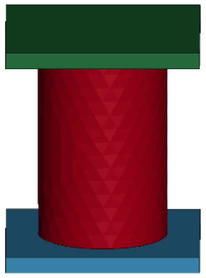
Shear Extrusion

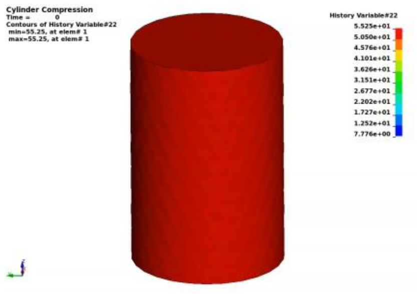


Friction Stir Welding

3D Adaptivity: Microstructure Evolution in Hot Forging*

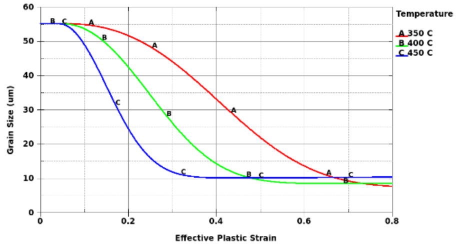
Polycrystalline microstructure evolution (dynamic recrystallization) is calculated as post-processing of forging analysis





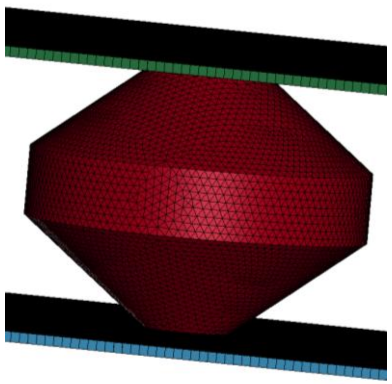
Average Grain Size

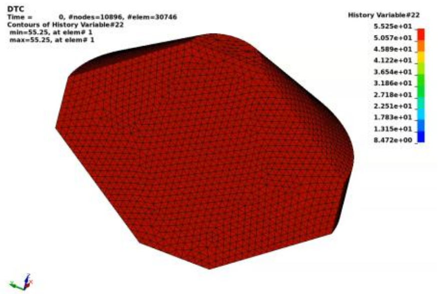
Grain Size Evolution at 0.05 s^{-1}



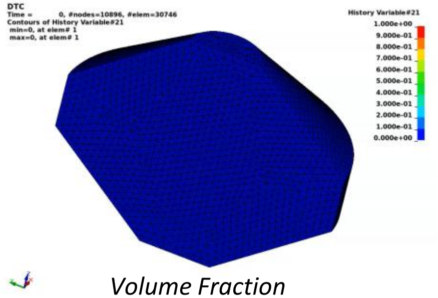
Volume Fraction
400 °C at 0.05 s^{-1}

Cylinder Upsetting
(Aluminum alloy 7050)





Average Grain Size

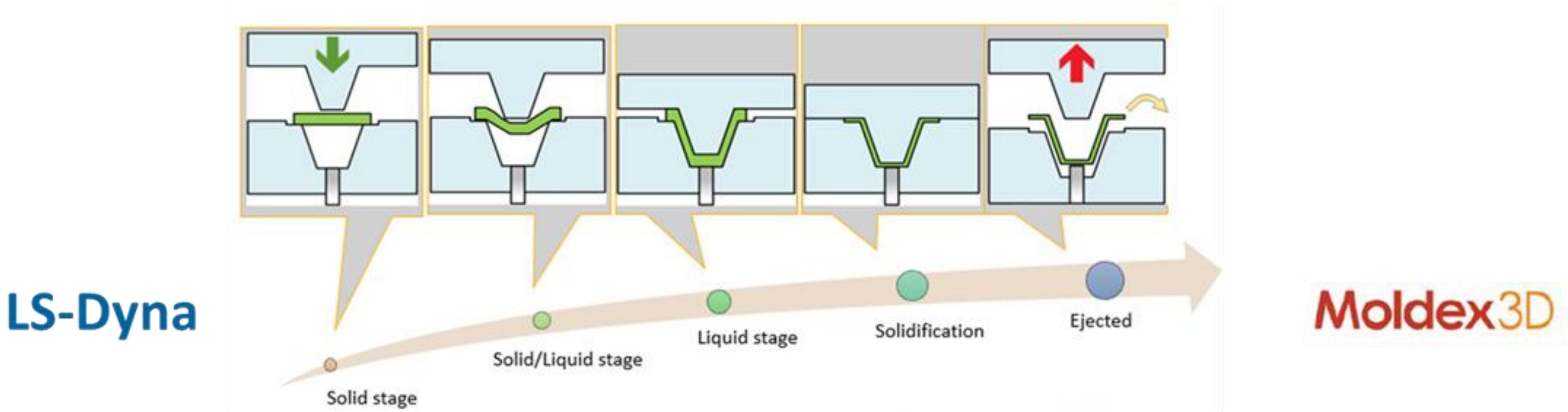


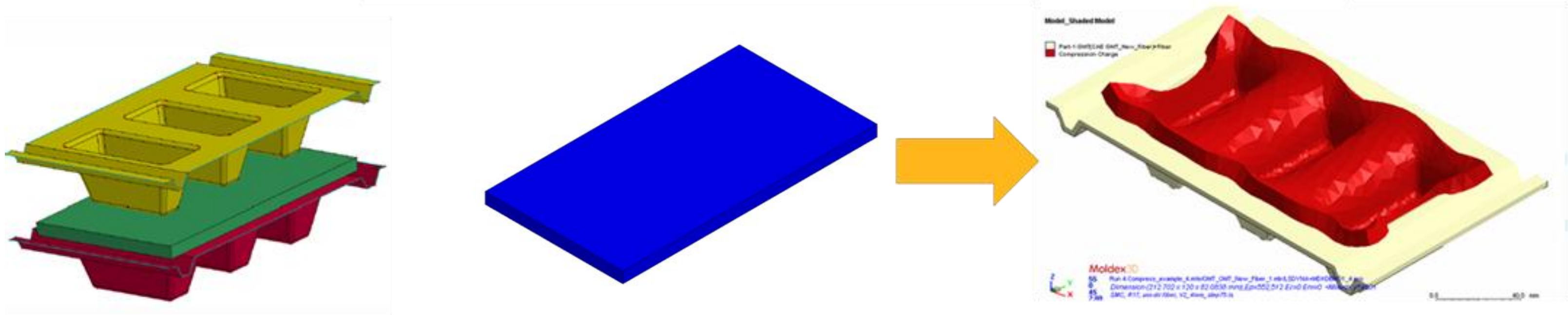
Volume Fraction
450 °C at 0.5 s^{-1}

Double Truncated Cone
Screw Press
(Aluminum alloy 7050)

Multiscale: AI Based Workflow for Compression Molding*

- Can simulate the full compression molding process.
- Automatic initialization of local planar random orientation state for chopped fiber composite charges.
- Export LS-DYNA simulation results to Moldex3D as the initial condition for subsequent liquid filling stage analysis.

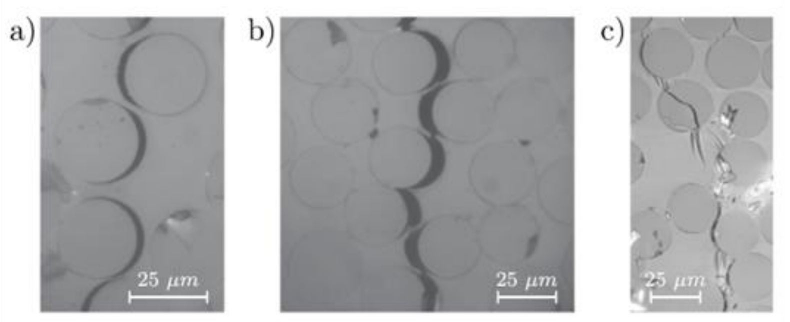




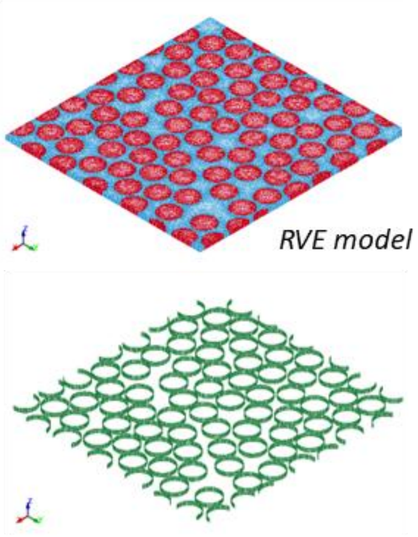
Courtesy of CoreTech System / Moldex3D

Implicit Analysis with Interface Debonding in Composites*

✓ Support RVE homogenization with cohesive interfaces defined through ***RVE_ANALYSIS_FEM***

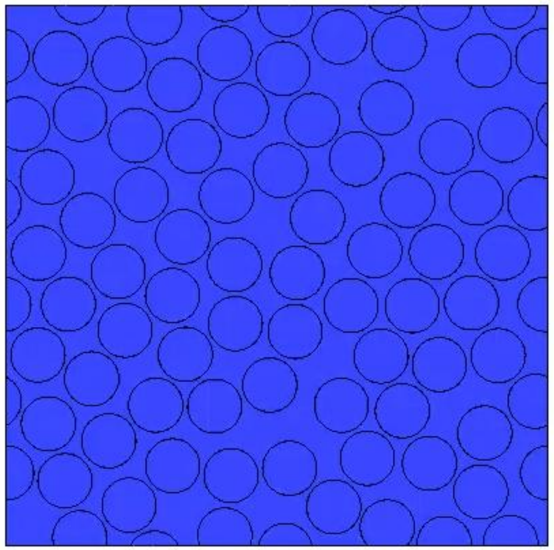


R. Czichos et al. Composites Part C: Open Access 10 (2023) 100341



RVE model

Cohesive Interface Elements



Composites with Interface Debonding

Courtesy of University of Stuttgart & Andrea Erhart (Ansys ACE)

Core Technologies

Elements, Contacts, Boundary Conditions, Material Models, Connections & More

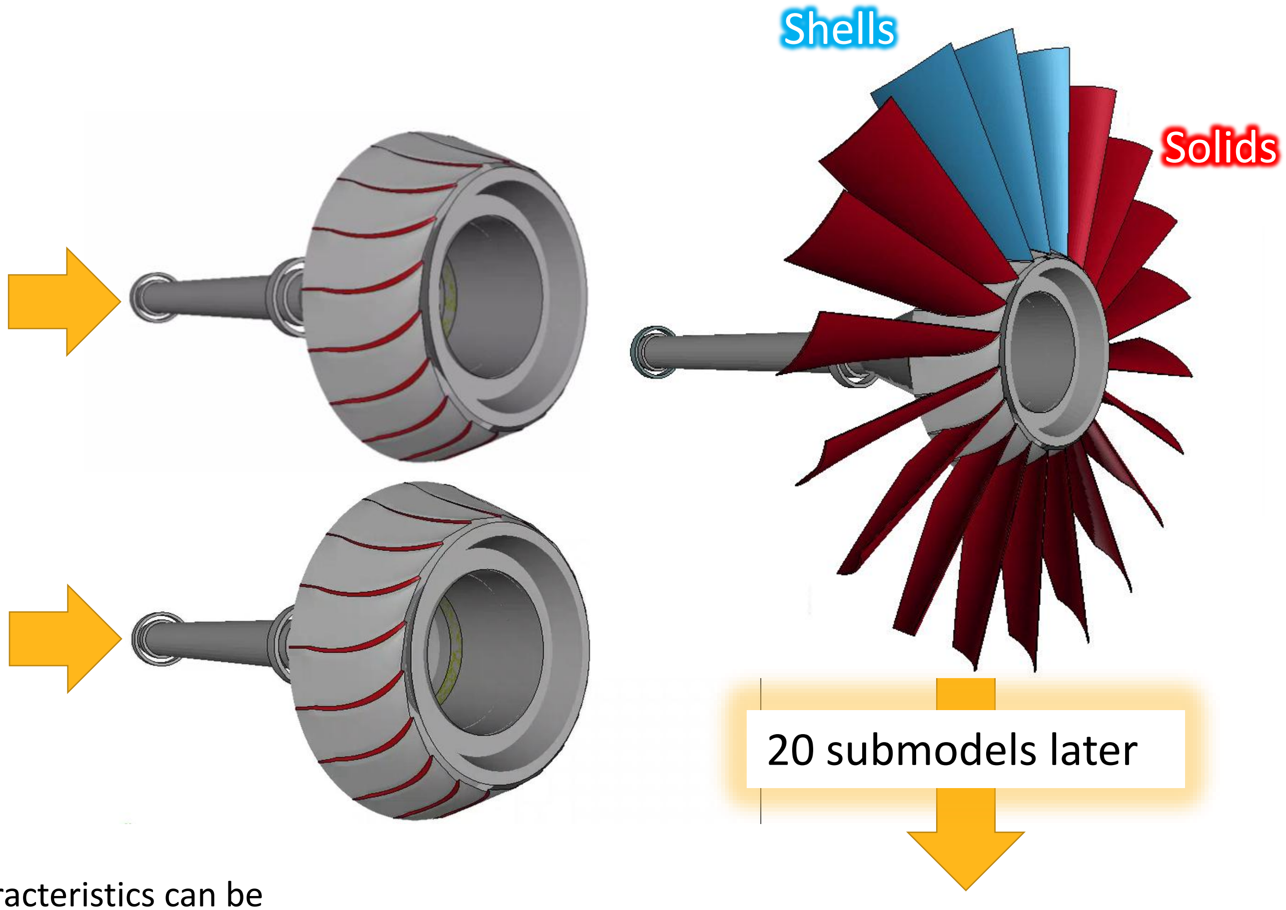
Superelements

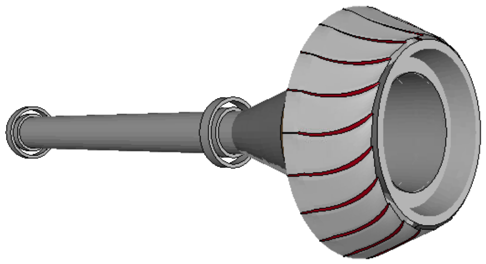
Past

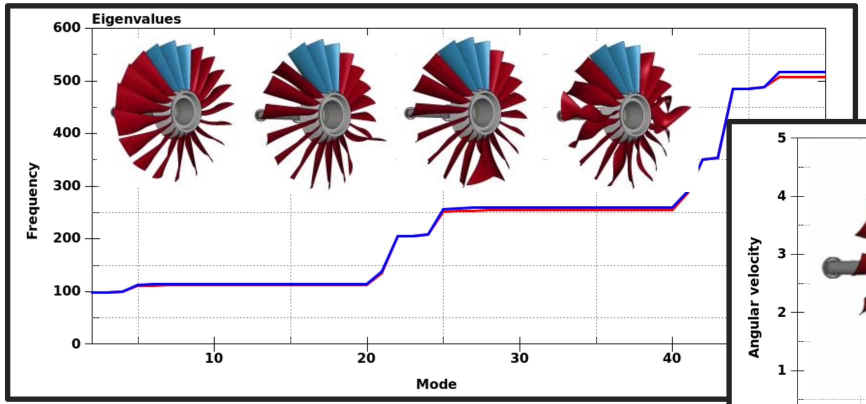
- Supported small displacements and small rotations
- One superelement per processor: Affect load balance in MPP

Present

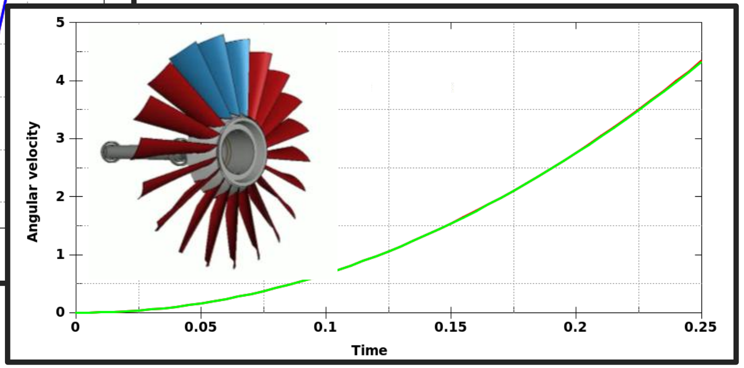
- Properly support attachment nodes/modes
    - Constraint node sets used for the interface to other parts
    - Attachment node sets should be used for external loadings
- Formulation generalized to small displacement & large rotations
    - Each superelement is equipped with an orientation matrix
    - Equivalent to flexible rigid bodies
    - Models with superelements are now objective





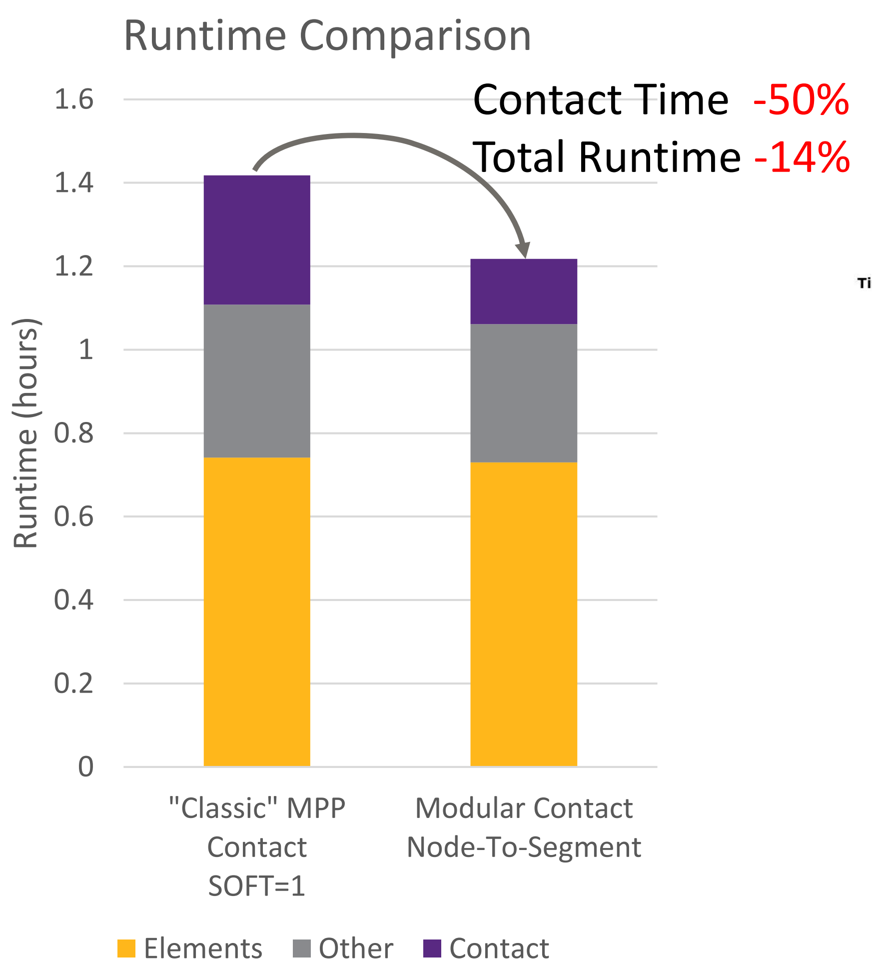


The dynamic characteristics can be verified with an eigenvalue analysis as well as transient load analysis



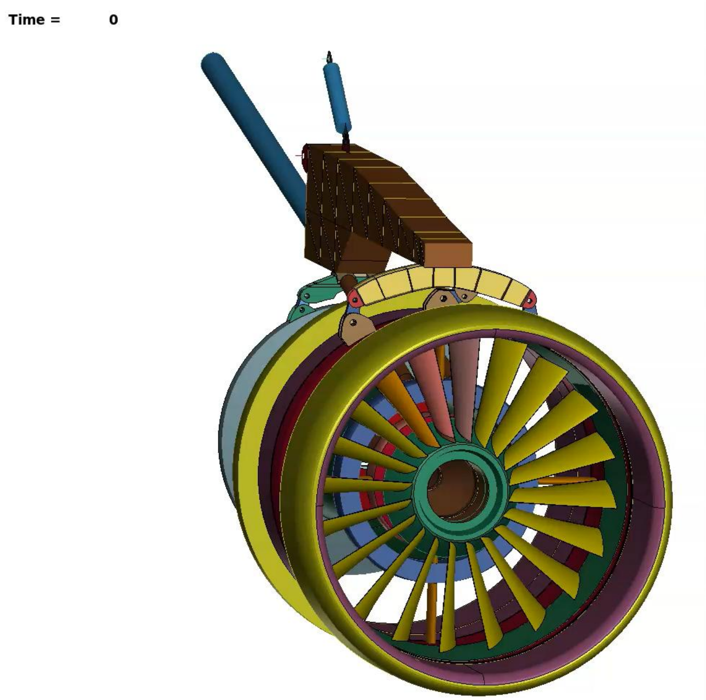
Mass Scaling supported

Modular Contact: Fan Rig Blade-Off Test*

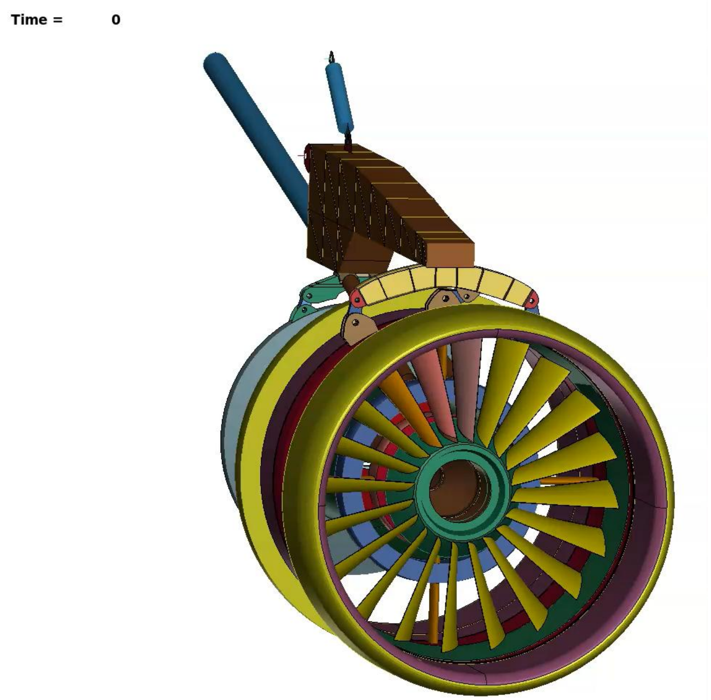


Total Number of Elements: 1.3M
Elements per Blade: 10K (0.8%)
Cycles with Erosion: 0.9%

"Classic" (SOFT=1) Contact:

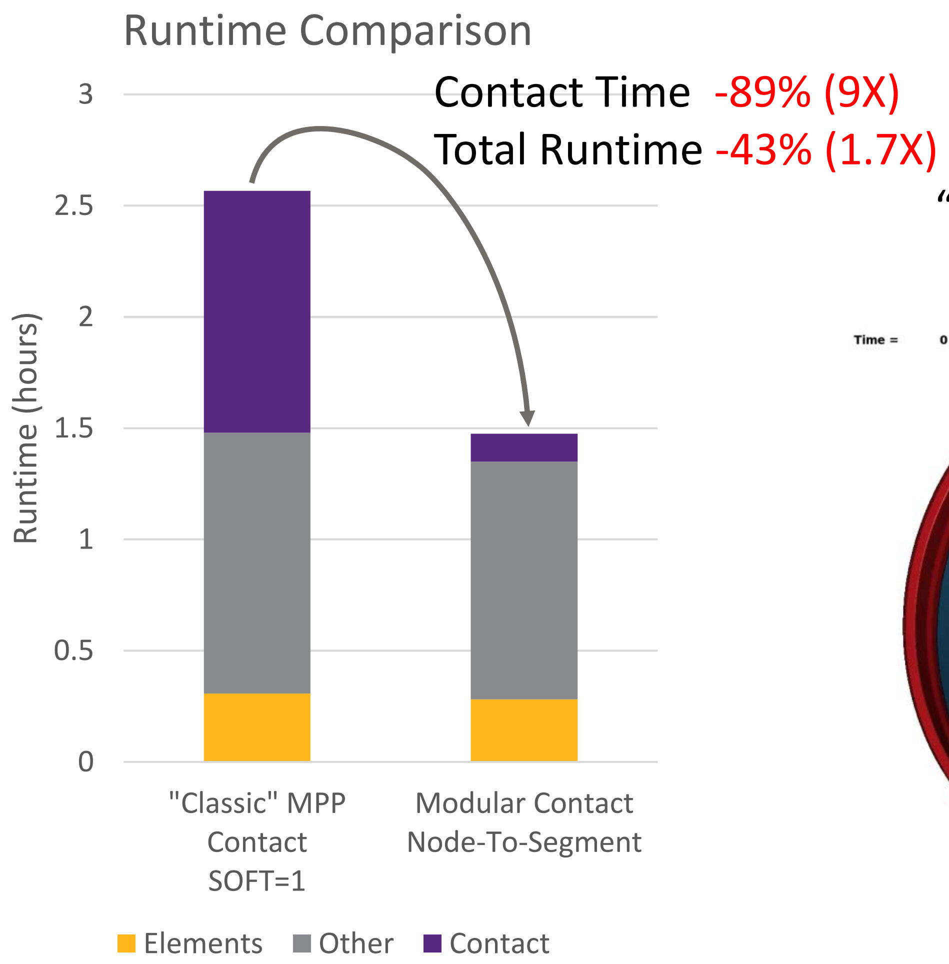


Modular Contact:



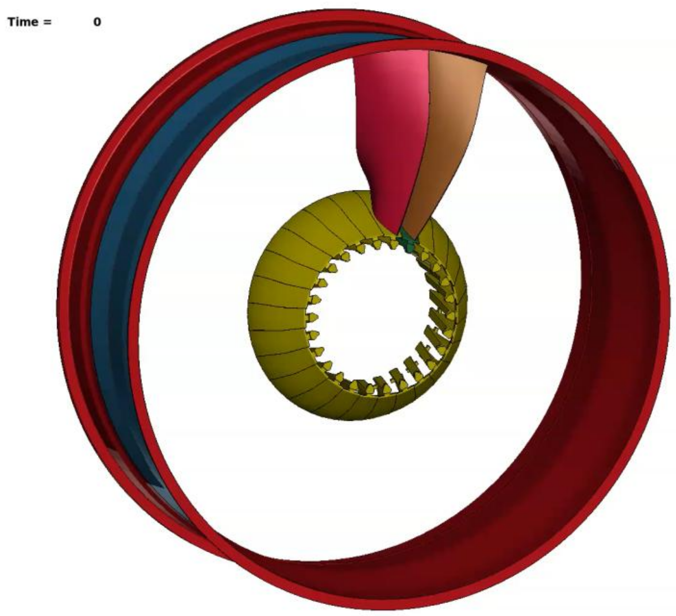
AWG ERIF Test Case 2.1 https://awg.ansys.com/QA+Test+Example+2.1

Modular Contact: Fan Blade-Off Containment Test*

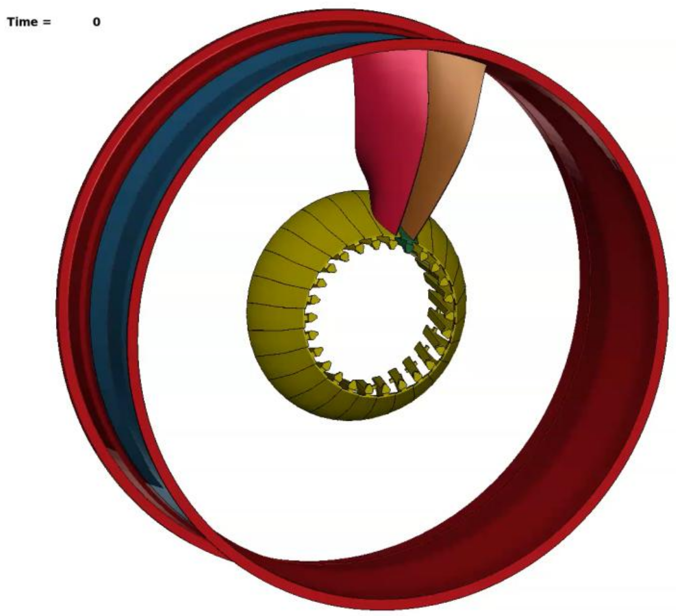


Total Number of Elements:	1M
Elements per Blade:	200K (20%)
Cycles with Erosion:	6%

"Classic" (SOFT=1) Contact:



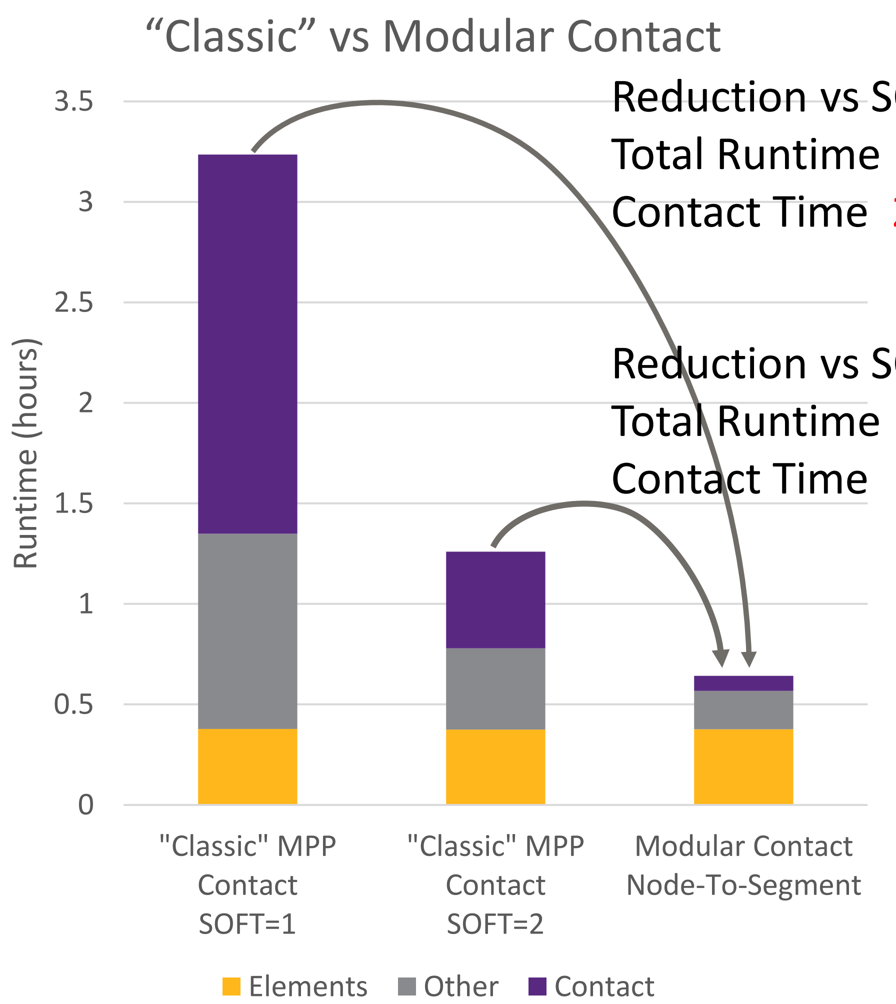
Modular Contact:



AWG ERIF Test Case 2.2 https://awg.ansys.com/QA+Test+Example+2.2
(uniformly refined model)

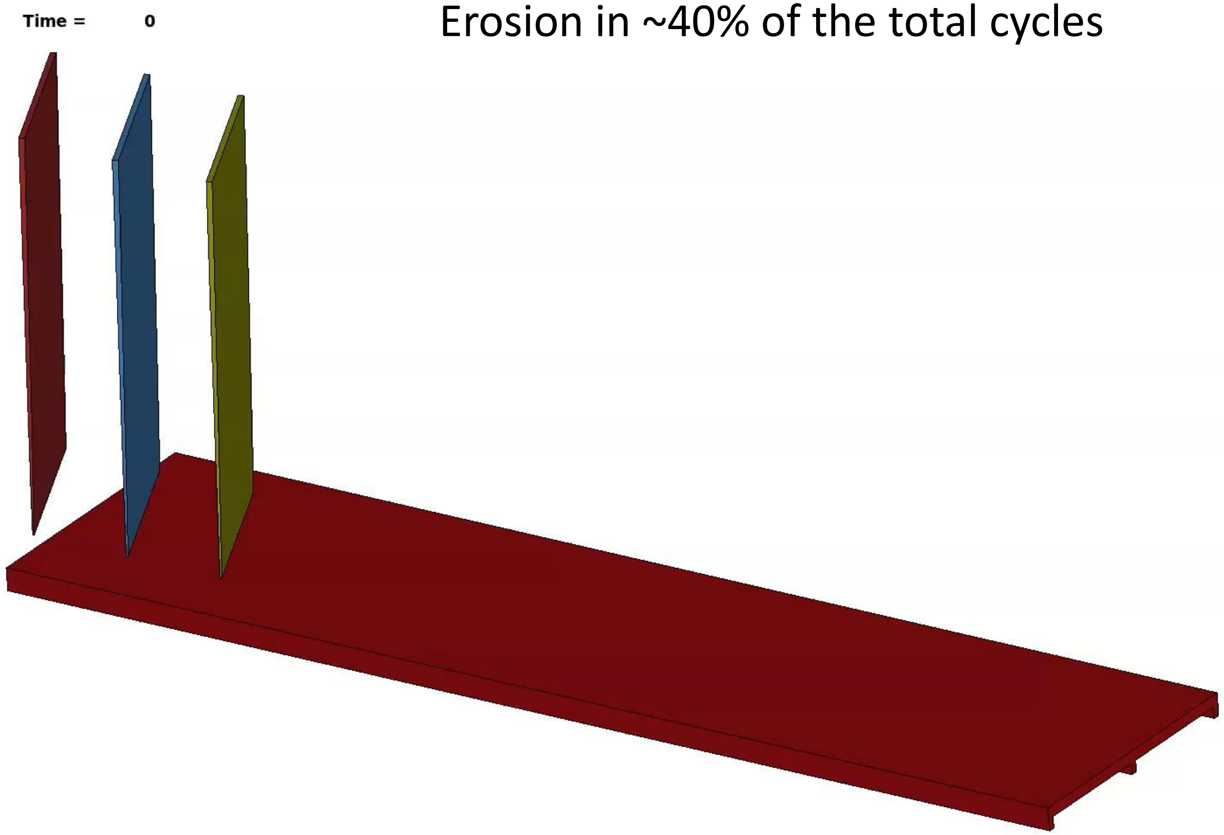
Ansys part of Synopsys

Modular Contact: Simplified & Refined Fan Blade-Off Test*



Reduction vs SOFT=1:
Total Runtime 5X
Contact Time 25X

Reduction vs SOFT=2:
Total Runtime 2X
Contact Time 6X

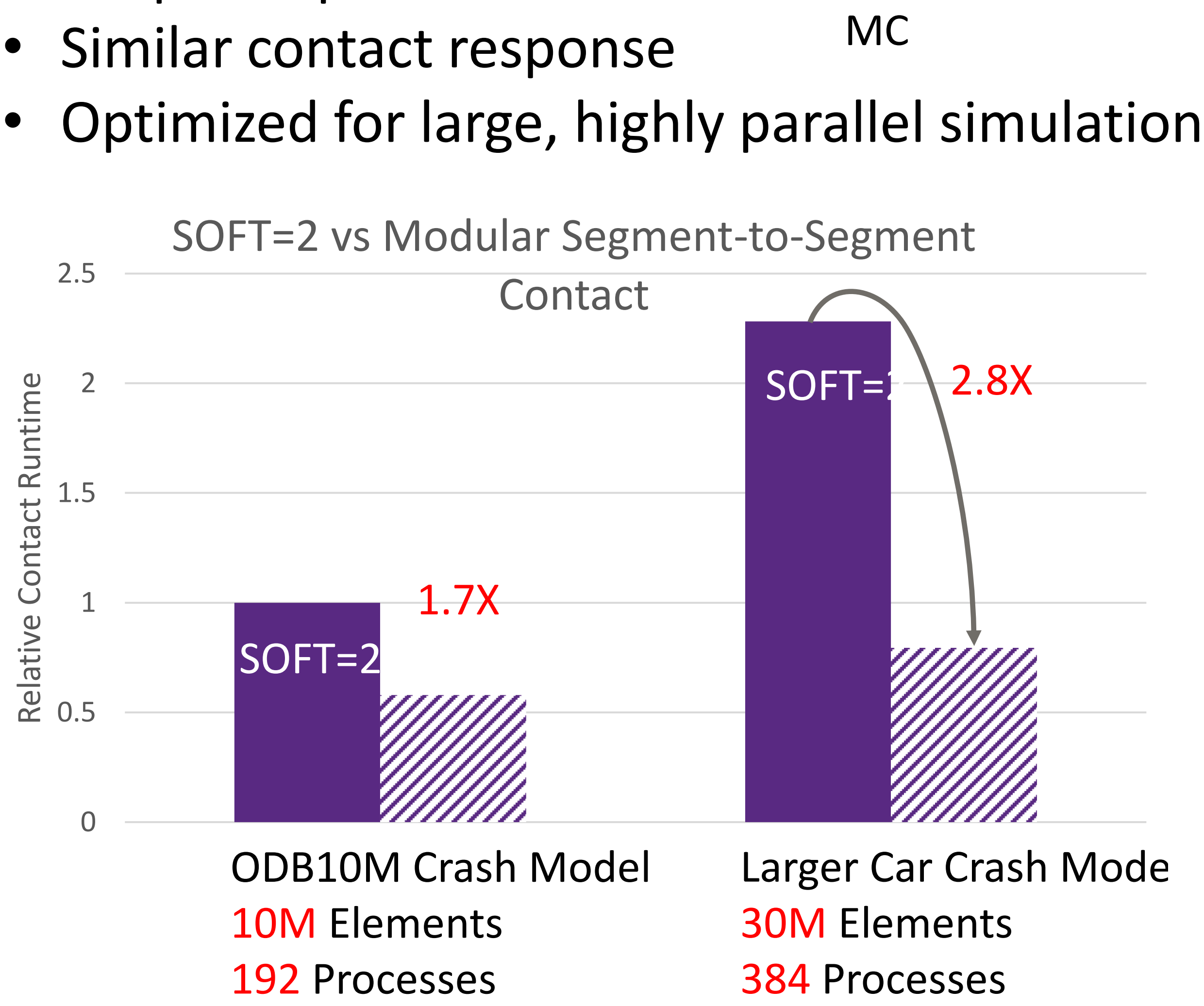


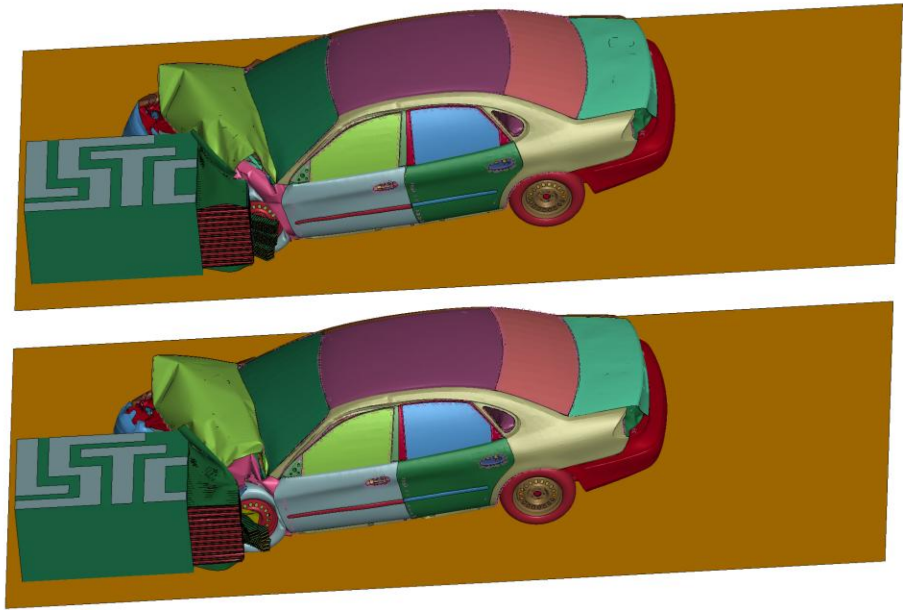
Crushing Blade Example:
Solid Elements: 3M
Erosion in ~40% of the total cycles

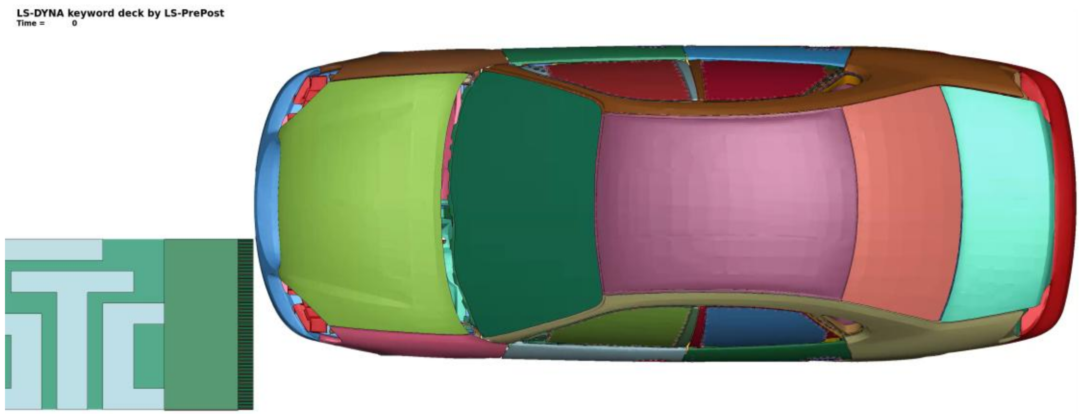
Ansys part of Synopsys

Modular Contact: Segment-to-Segment Contact*

- Drop-in replacement for SOFT=2 contact
- Similar contact response
- Optimized for large, highly parallel simulations

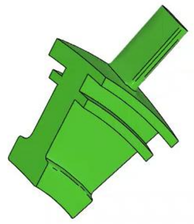




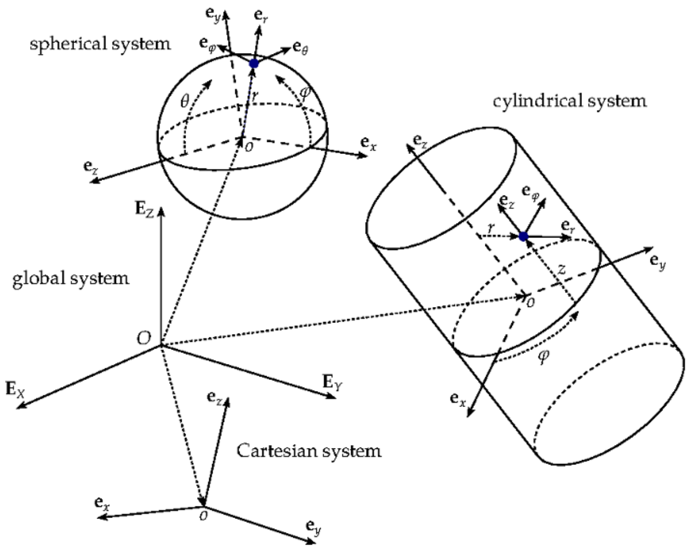


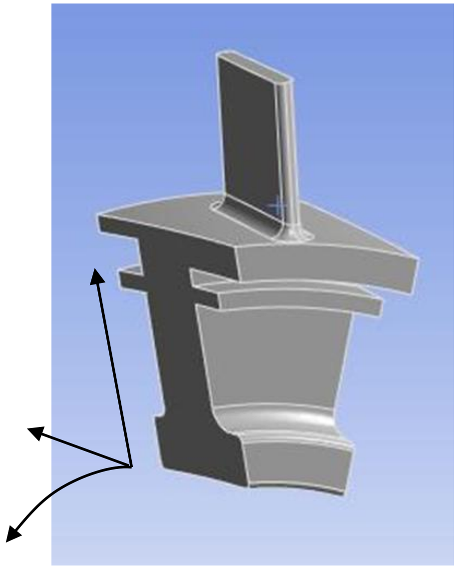
Ansys part of synopsys

Cylindrical* and Spherical Coordinate Systems



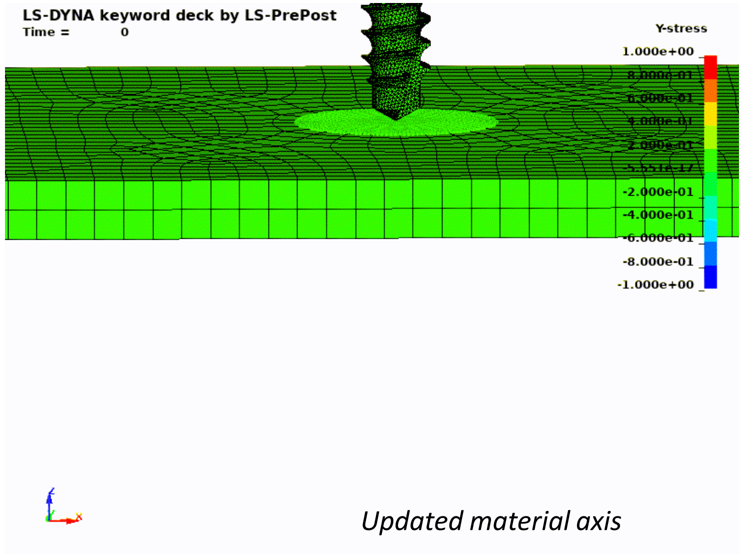
- Facilitates the input of boundary conditions in problems with circular or spherical symmetry
  - Set flag TYPE = 1(cylindrical) or TYPE =2 (Spherical) on:
    - *DEFINE_COORDINATE_NODES
    - *DEFINE_COORDINATE_SYSTEM.
  - Local system option on nodes will honor TYPE flag for the following keywords:
    - *LOAD_NODE_POINT/SET
    - *BOUNDARY_SPC_NODE/SET
    - *BOUNDARY_PRESCRIBED_MOTION_NODE/SET



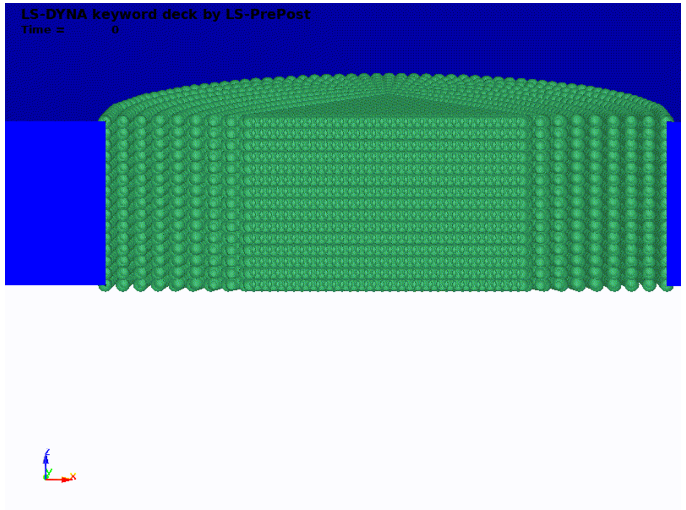


Material Models: Support for Orthogonal Material Models*

- Support ***AOPT*** in orthogonal material models to define material axis at SPG particles and update it as material deforms.
- Supported material models:
  - *_**MAT_COMPOSITE_DAMAGE**_(22), *_**MAT_HONEYCOMB**_(26), _***MAT_BARLAT_ANISOTROPIC_PLASTICITY**_(33), _***MAT_ENHANCED_COMPOSITE_DAMAGE**_(54-55), _***MAT_LAMINATED_COMPOSITE_FABRIC**_(58), _***MAT_MODIFIED_HONEYCOMB**_(126), _***MAT_ANISOTROPIC_HYPERELASTIC**_(295)



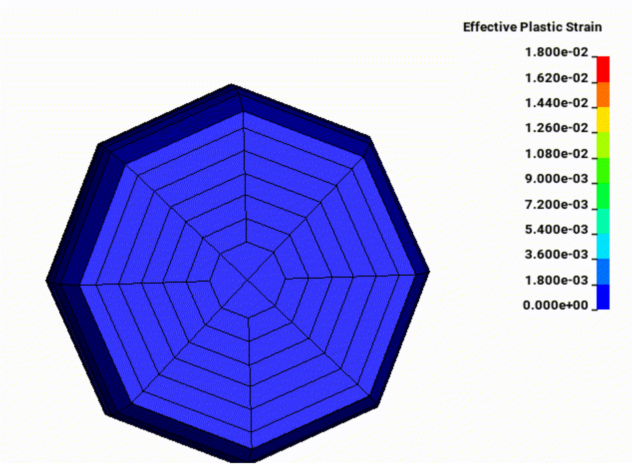
Updated material axis



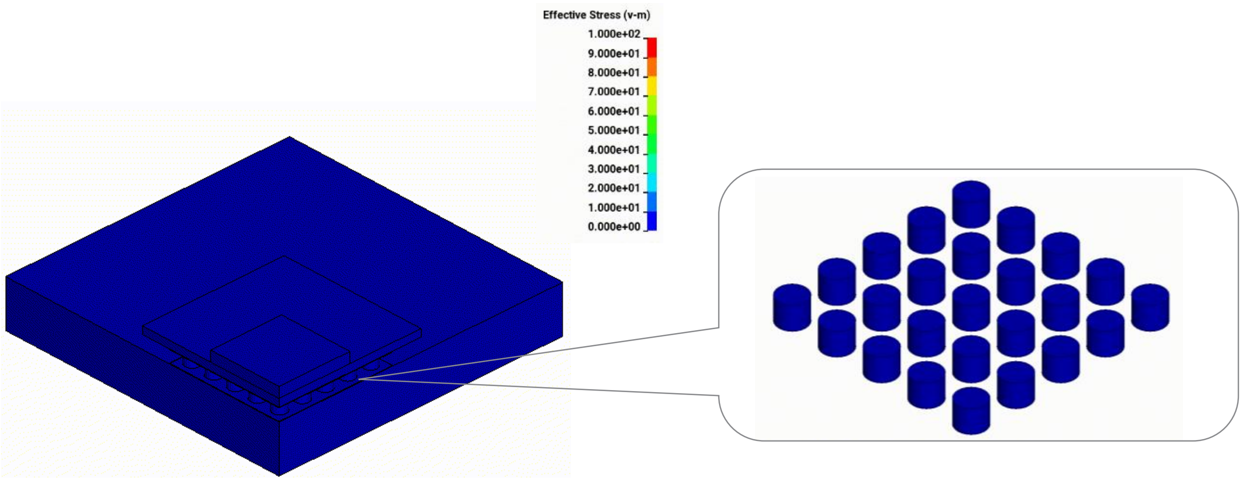
*Drilling process simulation using material model *MAT_COMPOSITE_DAMAGE*

Material Models: Anand Visco-Plasticity Material Model for Solders*

Supports temperature dependent material parameters including Young's modulus and Poisson's ratio



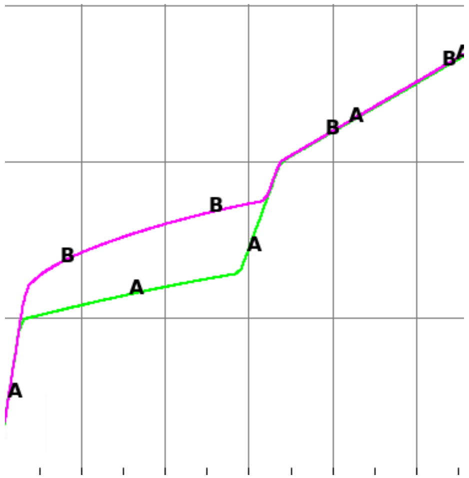
Single solder ball under uniform thermal loading



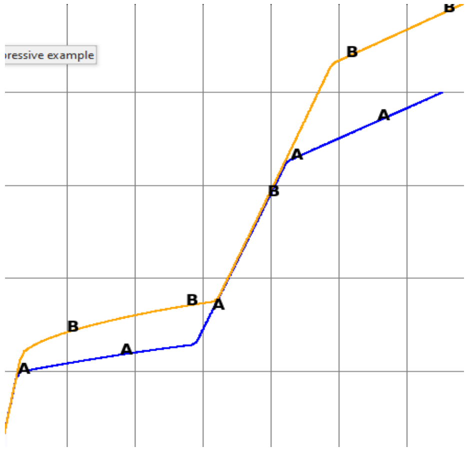
Multiple solder balls under thermal loading

Material Models: New in *MAT_SHAPE_MEMORY (*MAT_030)

- Supports experimental (total) strain-stress curves LCSS and LCSSC.
  - Activated if first datapoint is in origin (0.,0.).
- Compressive hardening curve LCSSC.
  - GT.0: LCSSC instead of LCSS in compression.
  - LT.0: scales LCSSC with ALPHA tension/compression asymmetry parameter.
- Drucker-Prager plasticity IDPP.
  - *MAT_030 uses Drucker-Prager phase transition criterion and J2 (von Mises) plasticity.
  - DP plasticity pressure dependent and consistent with phase transitions.



Phase transitions and J2 plasticity for different pressures



Phase transitions and DP plasticity for different pressures

Ansys part of Synopsys

Material Models: User-Defined Failure

- Users can define their own failure option **FFUNC** via *DEFINE_FUNCTION. (*MAT_ADD_EROSION)
  - Stresses, strains, strain rate tensor, temperature etc. can be provided as arguments.

- The user can add own failure criteria
  - Return value < 1: no failure
  - Return value >= 1: failure

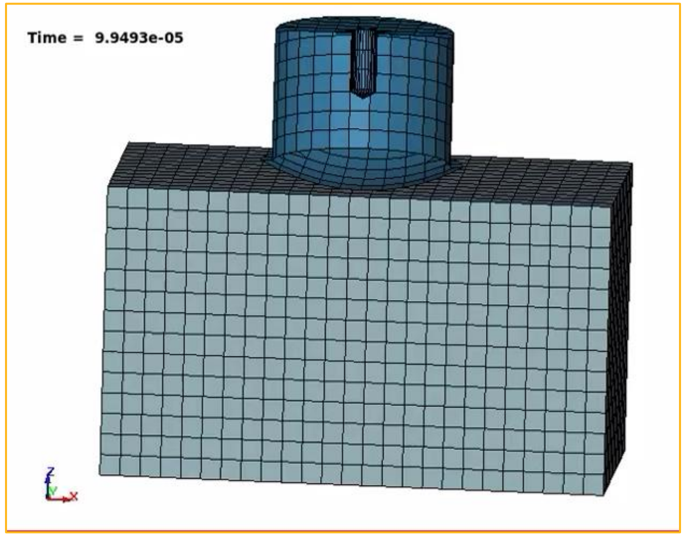
- C style computations

- Printf writes to screen, mes0xxx, d3hs

Example: Max. volumetric strain same as "VOLEPS=0.001"

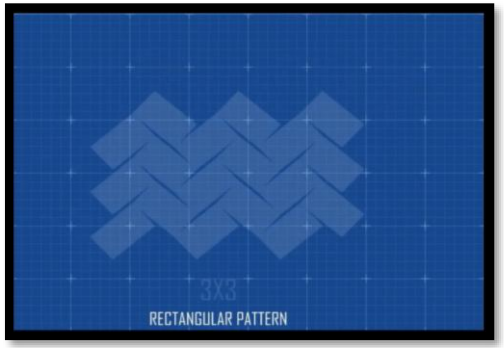
```
*DEFINE_FUNCTION
      1234
float func(float s1,float s2,...,
           float e1,float e2,...,
           float r1,float r2,...,
           float time, float eqp,
           float effrate, float temp,
           float eid, float ipt) {
$ DECLARATIONS
  float dmg,evol,evolcrit;
$ CRITIVAL VALUE
  evolcrit=0.001;
$ VOLUMETRIC STRAIN
  evol=e1+e2+e3;
$ FAILURE CRITERION
  dmg=evol/evolcrit;
$ DEBUG OUTPUT
  if (dmg>=1.0) {
    printf("ELEMENT %d (IP=%d) FAILED AT
T=%.7e\n",int(eid),int(ipt),time);
  }
$ RETURN VALUE
  return dmg;
}
```

Example: Special Failure Criterion for Foam

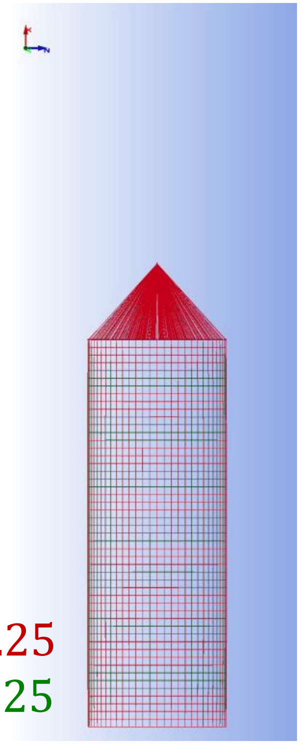


Material Models: Support For Auxetic Foams*

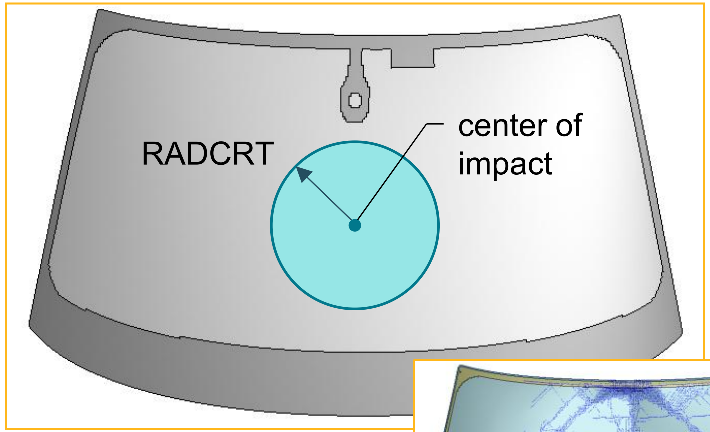
- Counter-intuitively expand (shrink) under stretching (compression)
  - Negative Poisson‘s ratio due to folded microstructure
- Available as a new option on *MAT_038 (Blatz-Ko foam)

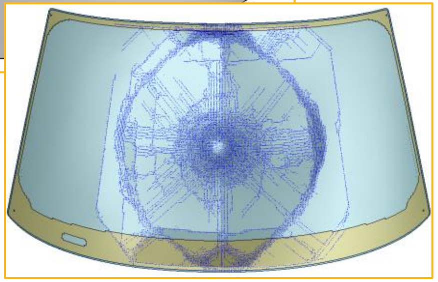


$$\nu = \begin{cases} -0.25 \\ 0.25 \end{cases}$$



Material Models: Windshield (Head) Impact





- Keyword *MAT_GLASS
- ENGCRT/RADCRT: nonlocal failure model
  - Initially deactivates failure/cracks
  - 1st element with σ_{max}>"FT"×"FTSCL" defines center of impact
  - Internal energy of part within radius RADCRT is monitored
  - When internal energy reaches ENGCRT, failure is activated
- NEW: critical energy depends on edge distance
  - ENGCRT<0 refers to *DEFINE_FUNCTION, e.g.,

```
*DEFINE_FUNCTION
       100
float func(float distx) {
  float engx;
  engx=min(0.03*distx,7.3);
$ printf("DISTANCE=%.7e, ENERGY=%.7e\n",distx,engx);
  return engx;
}
```

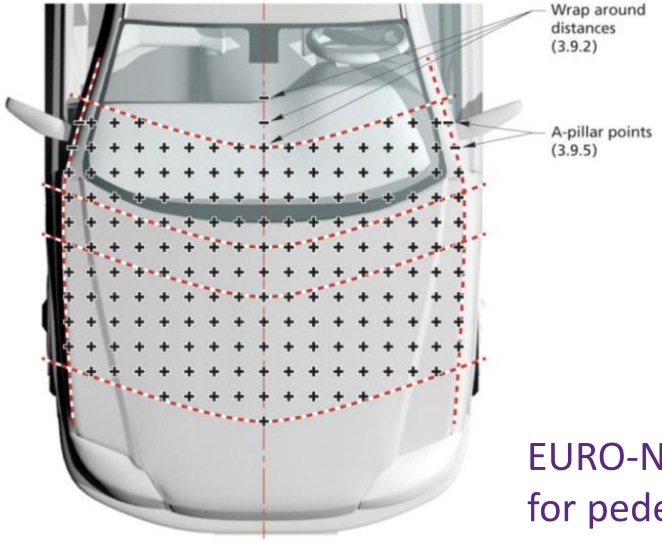
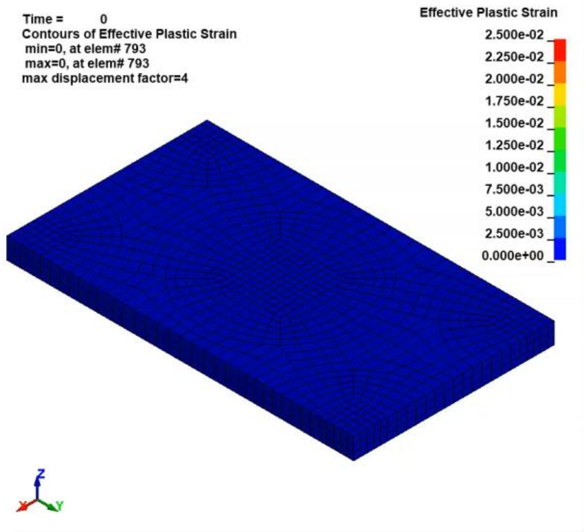


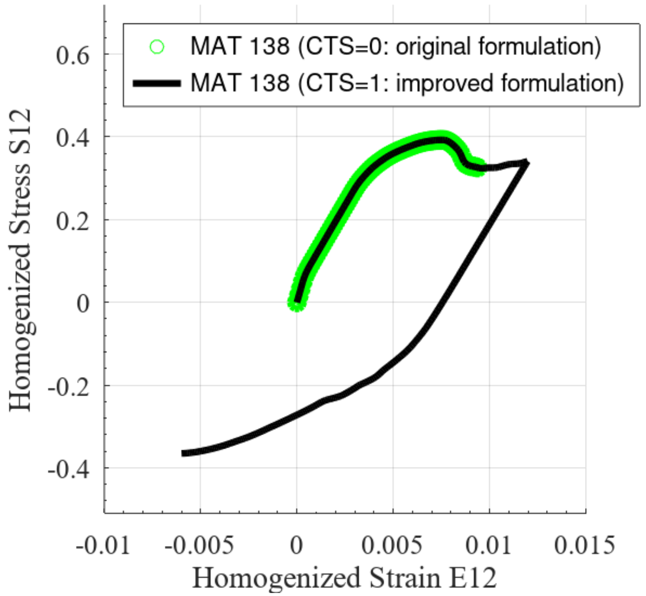
Figure 17: Grid points

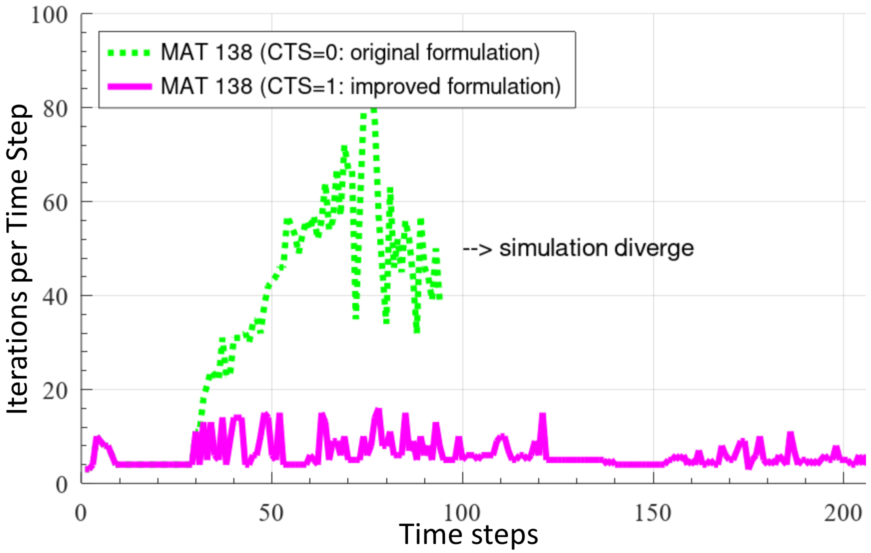
EURO-NCAP testing protocol for pedestrian protection

Material Model: Cohesive Material Interface Failure Simulation

- ***MAT_COHESIVE_MIXED_MODE**
  - Widely used to model interface debonding, delamination and fatigue in composite failure analysis
- **New feature in R17 (2026R1)**
  - Introduce new algorithm to improve its stability and convergence in implicit analysis





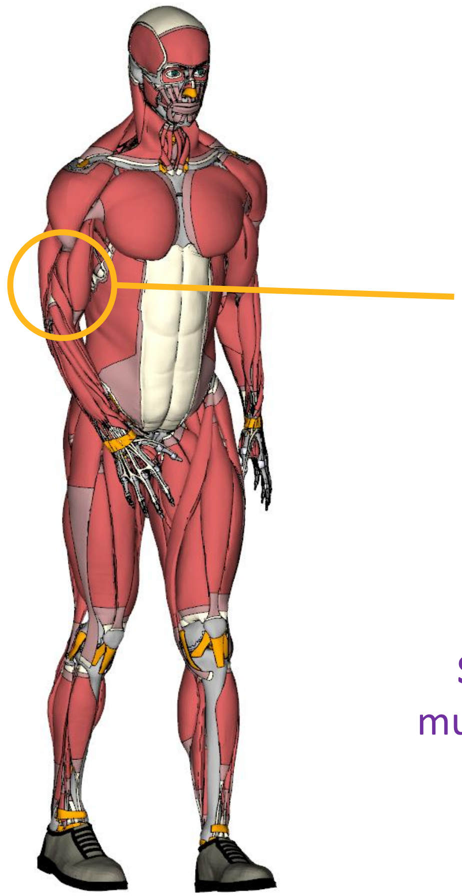


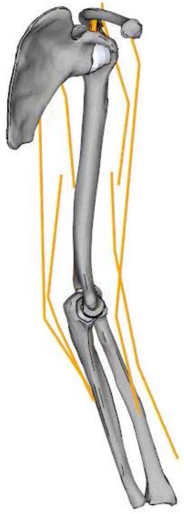
DigiTain

Ansys part of Synopsys

HANS: Active Muscles

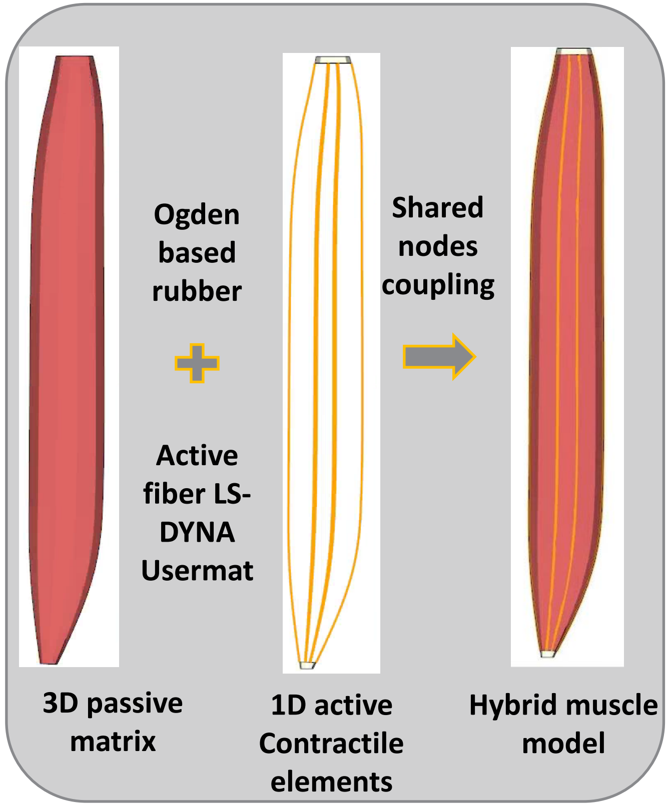
HANS
Our human body model

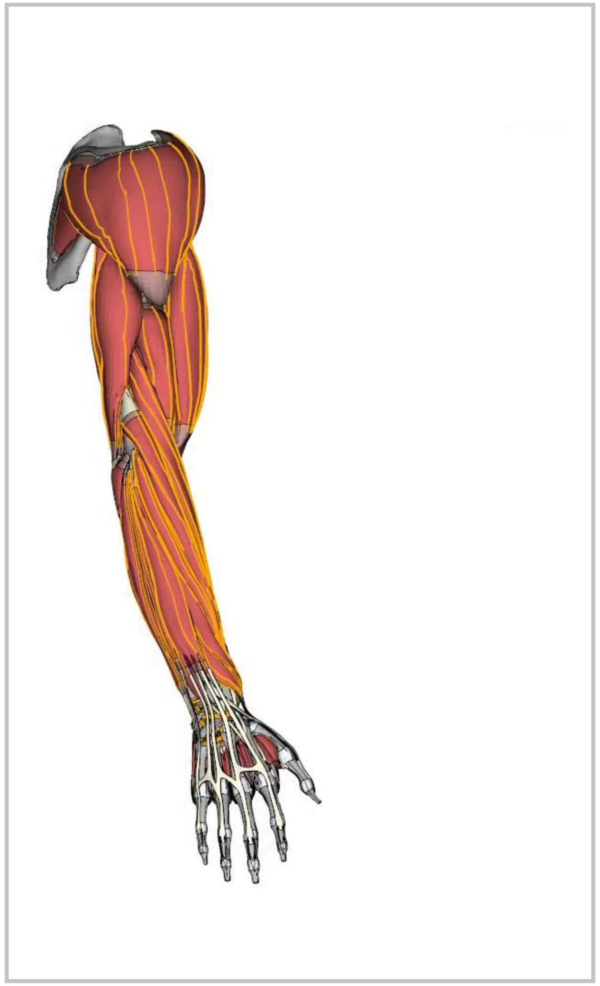




State of the art:
muscles represented by 1D beams

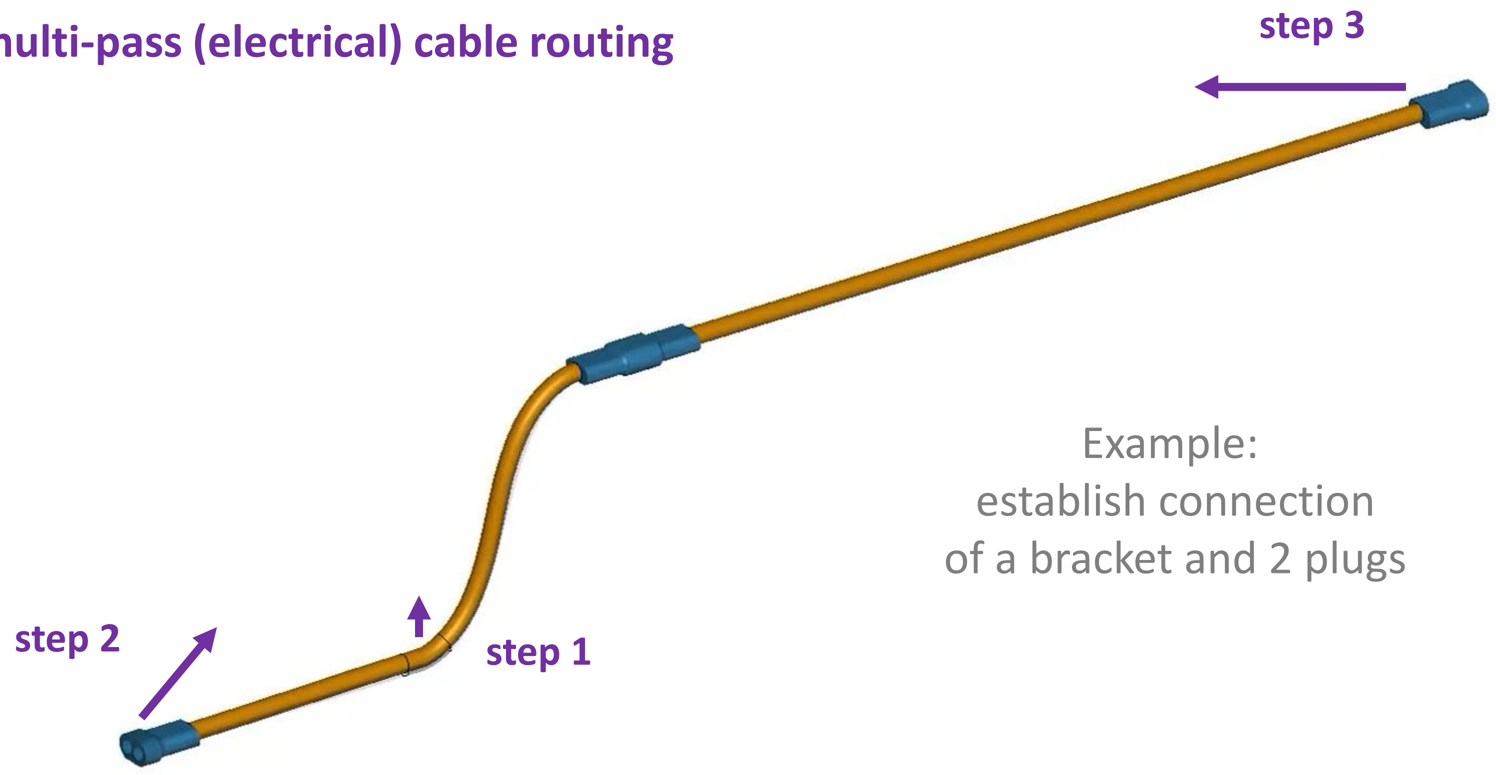
New concept:
Hybrid solids-beams model





Multi-step Motion in Single Run

- New feature within keyword *BOUNDARY_PRESCRIBED_FINAL_GEOMETRY
  - Step-by-step specification of different start/end positions via birth and death times
  - Faster setup and calculation (compared to dynain approach)
  - Possible application: **multi-pass (electrical) cable routing**



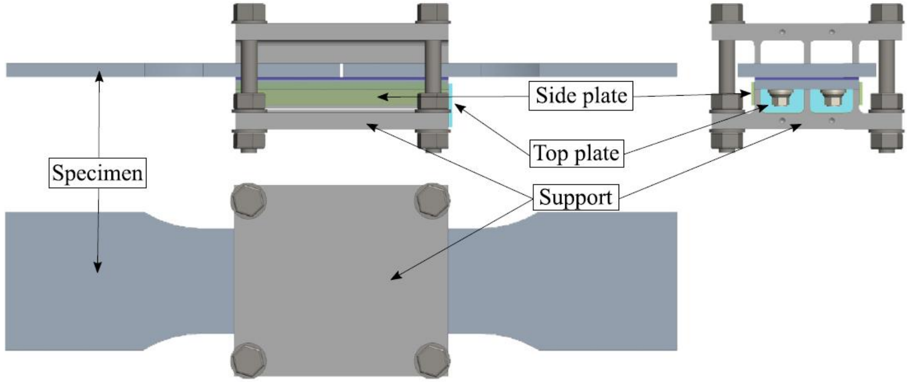
Example:
establish connection
of a bracket and 2 plugs

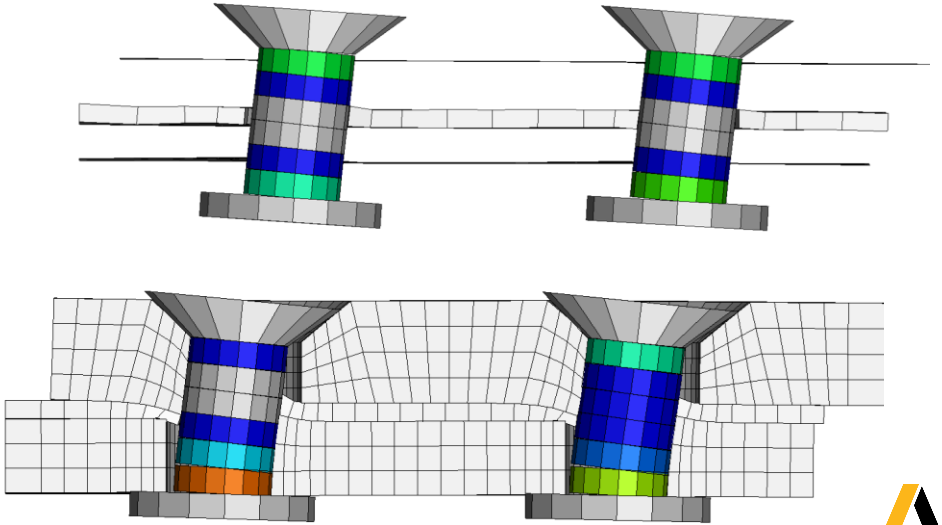
Courtesy: Srikanth Adya, Ansys ACE

Ansys part of Synopsys

Connectors: Simplified Modelling of Bolted Joints*

- A new keyword *DEFINE_BOLTED_JOINTS for simplified modelling of structures containing a large number of bolts, e.g., airframes.
- Each bolt is modelled using beam elements, interacting with hole nodes through a penalty contact. The head and nut can be countersunk and are modelled as analytical contact surfaces.
- The bolt beams can be pretensioned using already existing functionality.

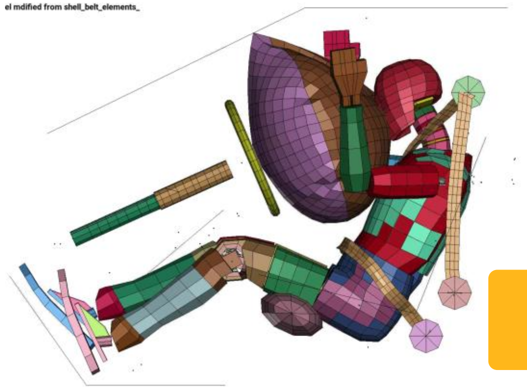




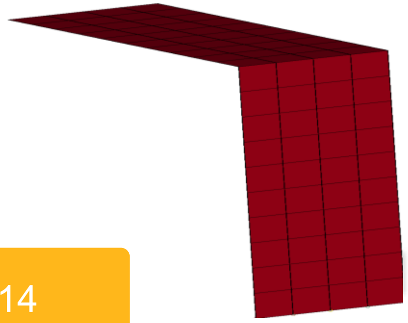
Ansys part of Synopsys

CNRB, MAT_126, SENSOR & SEATBELT

- An option to skip internal force calculation of nodal rigid body, node set constrained by *CONSTRAINED_NODAL_RIGID PART.
- MAT_126: Improved robustness of table-type strain-rate dependent load curves.
- SENSOR_DEFINE:
  - Option to trace pulley's slippage, wrappage angle forces & added mass.
  - Significant speed up in processing of DEFINE_CURVE_FUNCTION commands that utilize SENSOR or SENSORD.
- Improve the robustness when the formulation of 2D seatbelt 's fabric material is 12 or 14, mostly for double-precision.



FORM=-14



FORM=12

Physics Enhancements

Thermal, Mechanical, Acoustics/NVH, Particles, Fluids, EM, Multi-Physics Analysis

Thermal Solver: Heat generation from Laser Absorption*

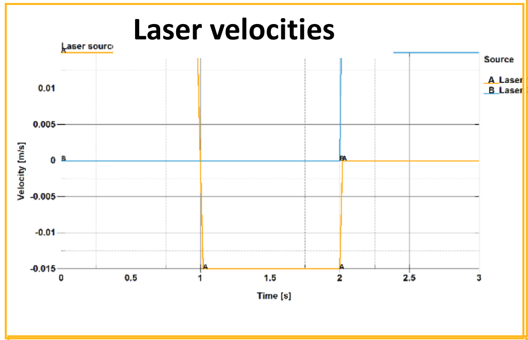
- Volumetric heat source with a trajectory-based approach for the laser motion

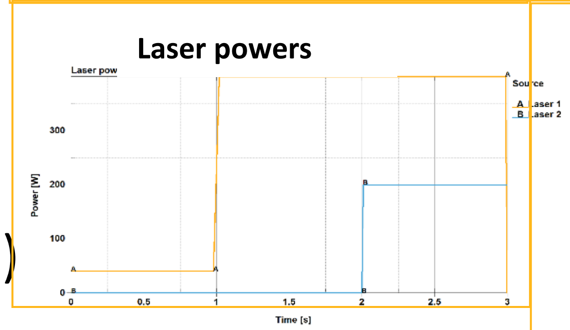
- Based on physical input data
(laser power and surface distribution, absorption coefficient lay-up of the structure)

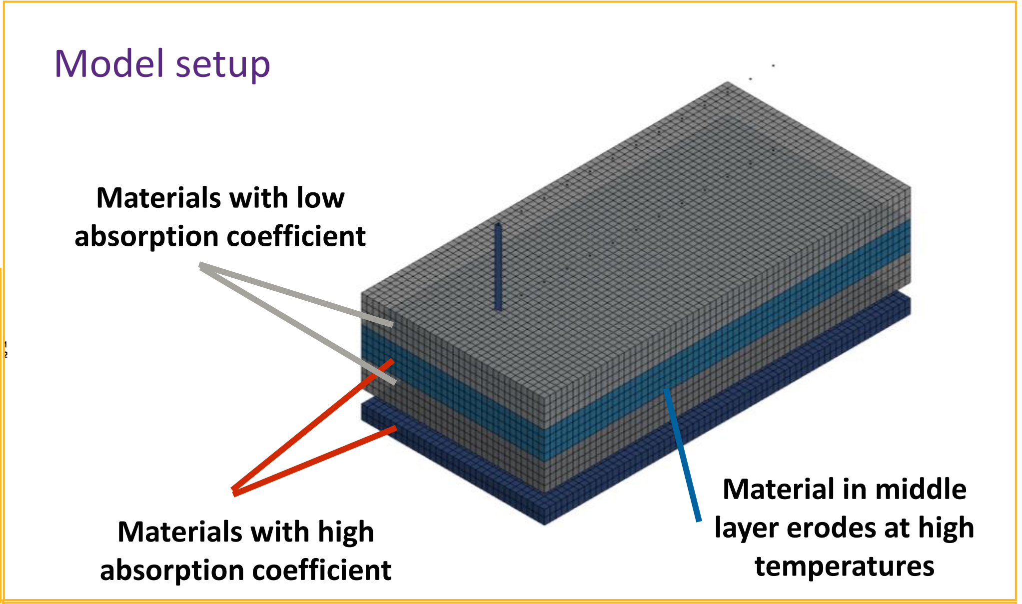
- Heat input algorithm across the material thickness is second-order accurate
(analytical solution: Beer–Lambert law)

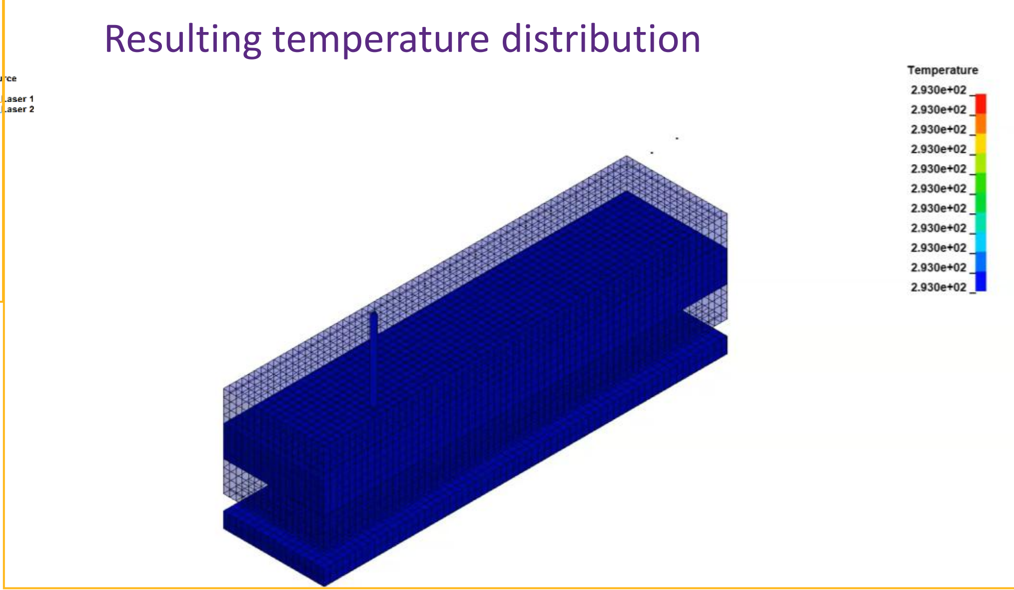
Keyword: *LOAD_HEAT_LASER_ABSORPTION

Show case example: 3 passes of 2 laser sources on heterogenous block







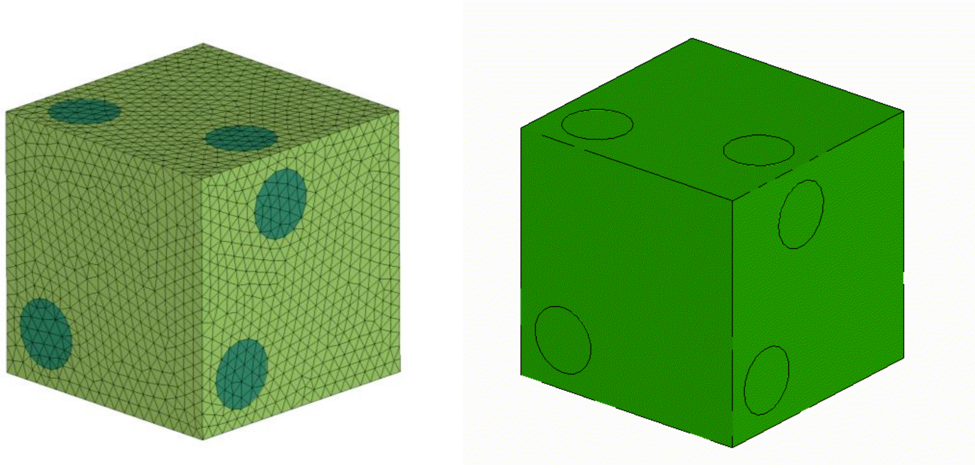


Explicit Analysis: RVE Module

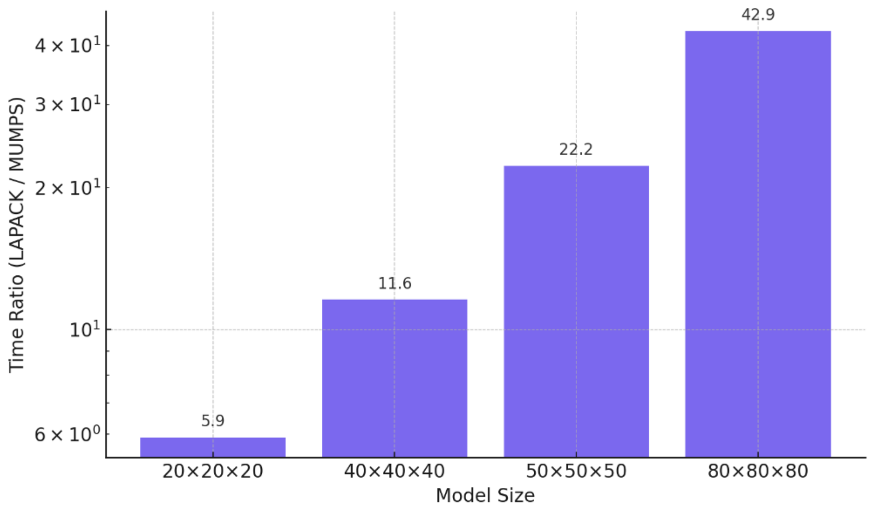
- RVE implicit analysis has convergence issue when dealing with excessive deformations, hard contact or material failure.
- RVE explicit analysis requires to solve an inverse problem for imposing periodic boundary conditions during initialization.
- **Keyword: *RVE_ANALYSIS_FEM**

New feature in R17 (2026R1)

- Introduce MUMPS sparse solver to greatly improve its performance for large-scale explicit RVE simulation.



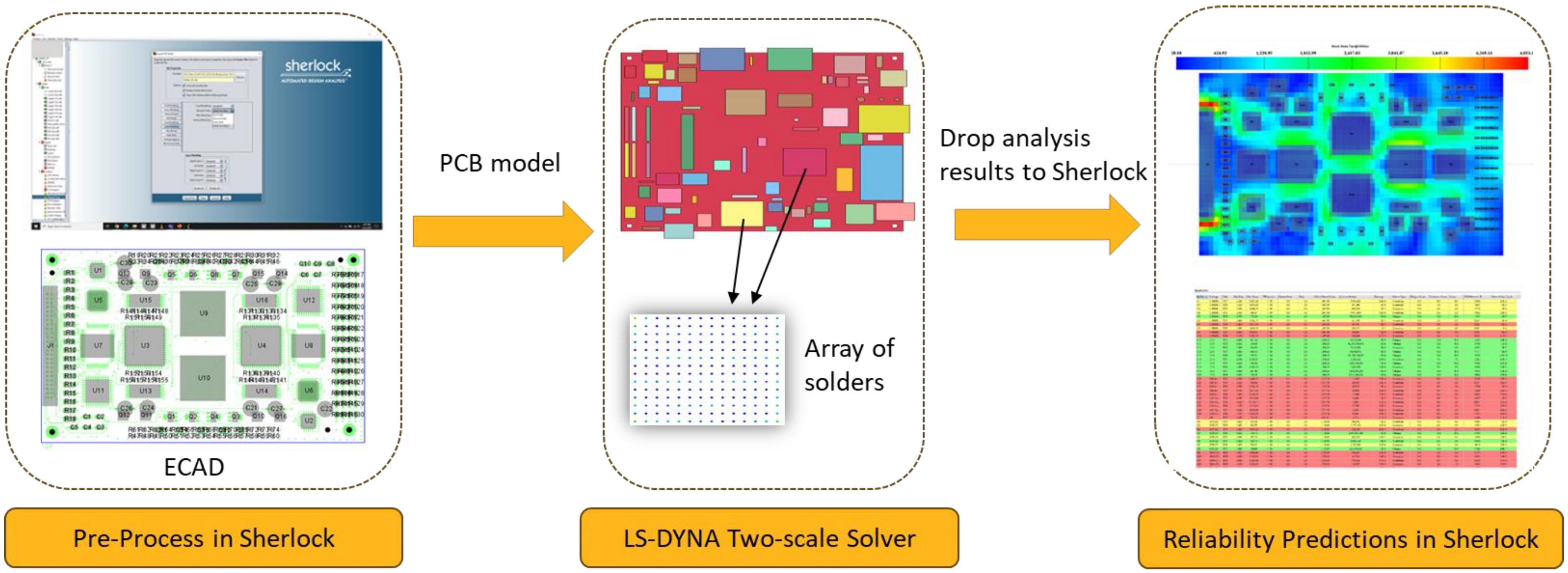
RVE explicit analysis of Nano-particle reinforced rubber



Performance speed-up using new MUMPS solver compared to old LAPACK solver

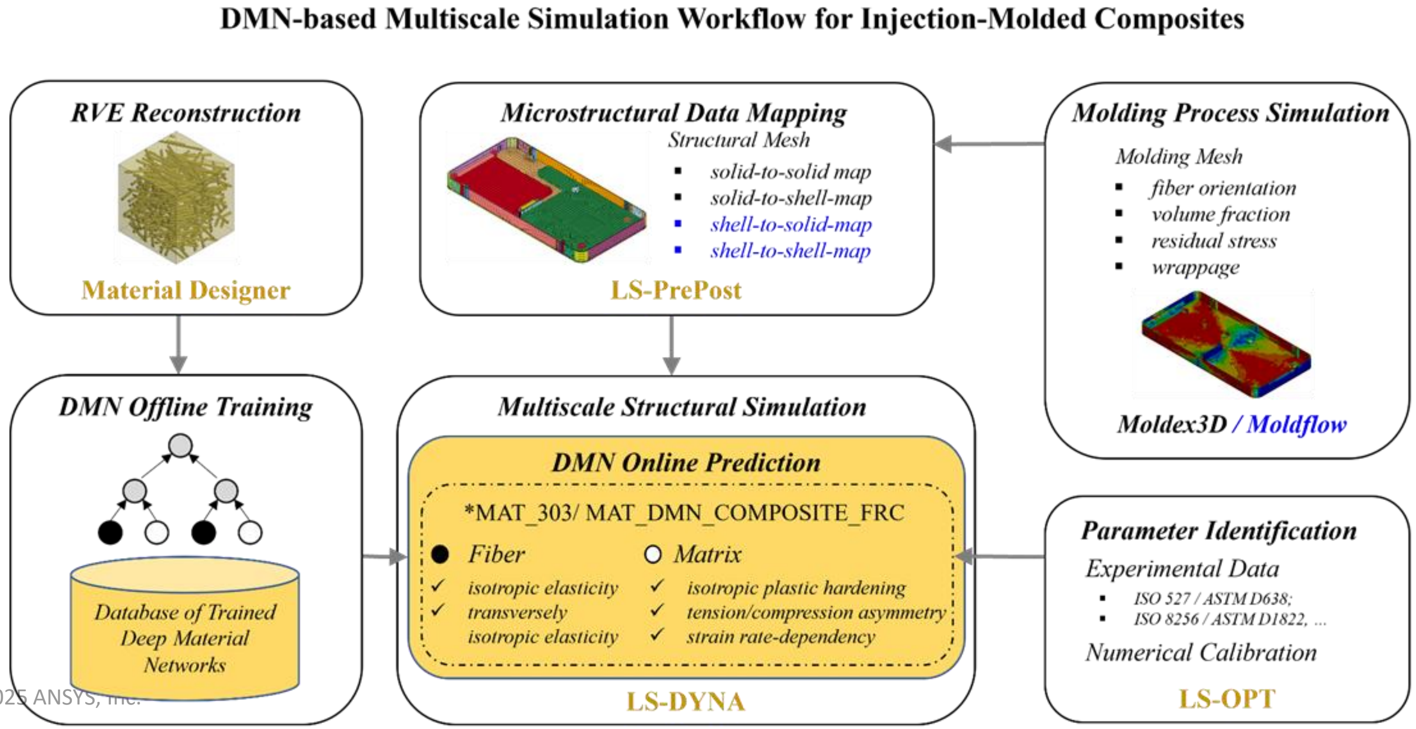
Workflow of Sherlock and LS-DYNA for Drop Test Analysis

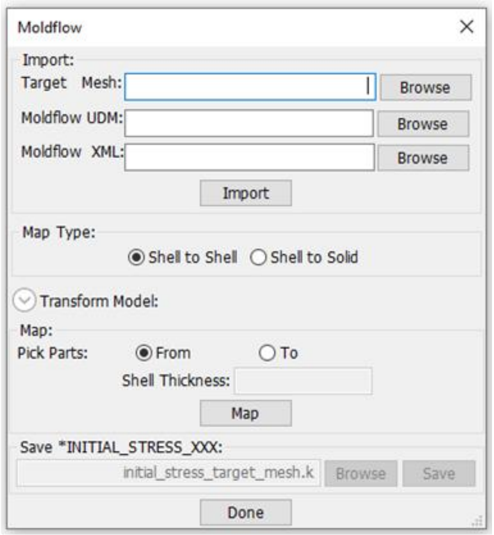
- Two-scale Co-simulation
  - Two-way concurrent analysis ***INCLUDE_COSIM** to speed up explicit analysis, such as electronics drop test.
  - Reliability analysis requires detailed stress information in areas of interest (such as solder joints in electronics).
- **New feature in R17 (2026R1)**
  - Integrating high-fidelity results from LS-DYNA two-scale method to Sherlock for accurate reliability predictions.



AI-based Multiscale Simulation Workflow

- DMN (Deep Material Network)
  - A machine learning method for multiscale nonlinear simulation of composite materials.
- **New feature in R17 (2026R1)**
  - Moldflow & LS-Dyna simulation workflow in ***LSPP*** for manufacturing process-informed multiscale structural simulation.
  - Shell-to-Shell and Shell-to-Solid fiber orientation data mapping for injection-molded plastics and composites.





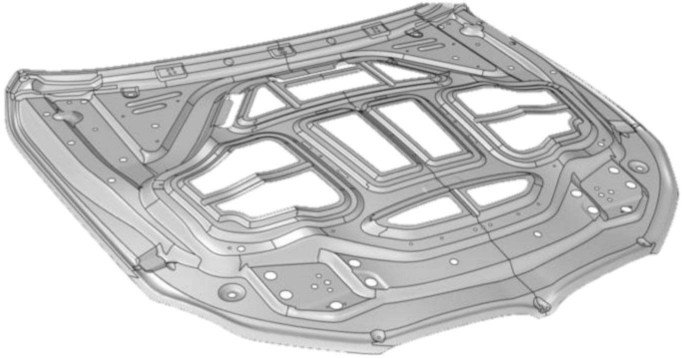
Data mapping in LS-PrePost

IGA: Geometric versatility – B-reps & Beyond

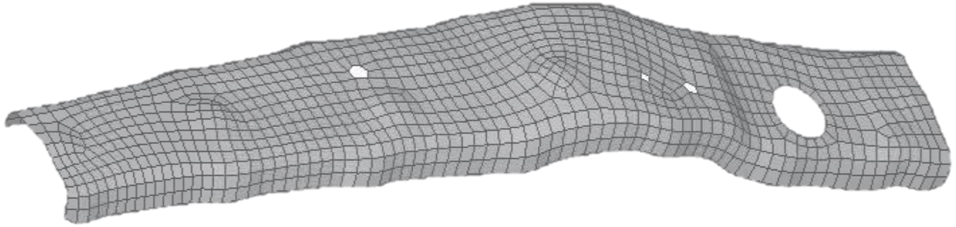
NON-BOUNDARY FITTED, (TRIMMED) STRUCTURED

BOUNDARY FITTED, UNSTRUCTURED

SHELL

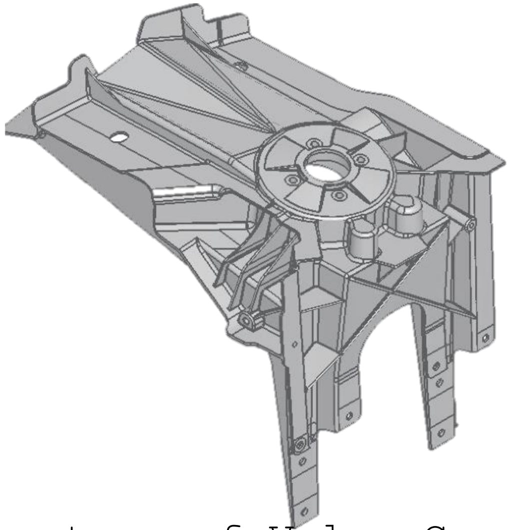


courtesy of BMW

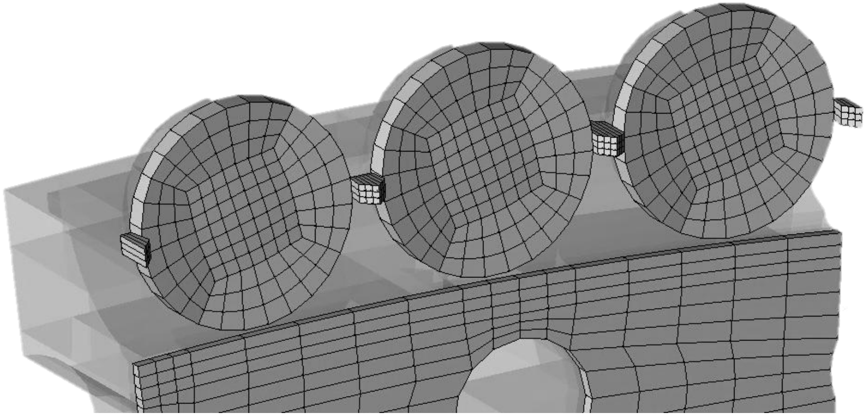


courtesy of Honda Motors

SOLID



courtesy of Volvo Cars



courtesy of General Electric

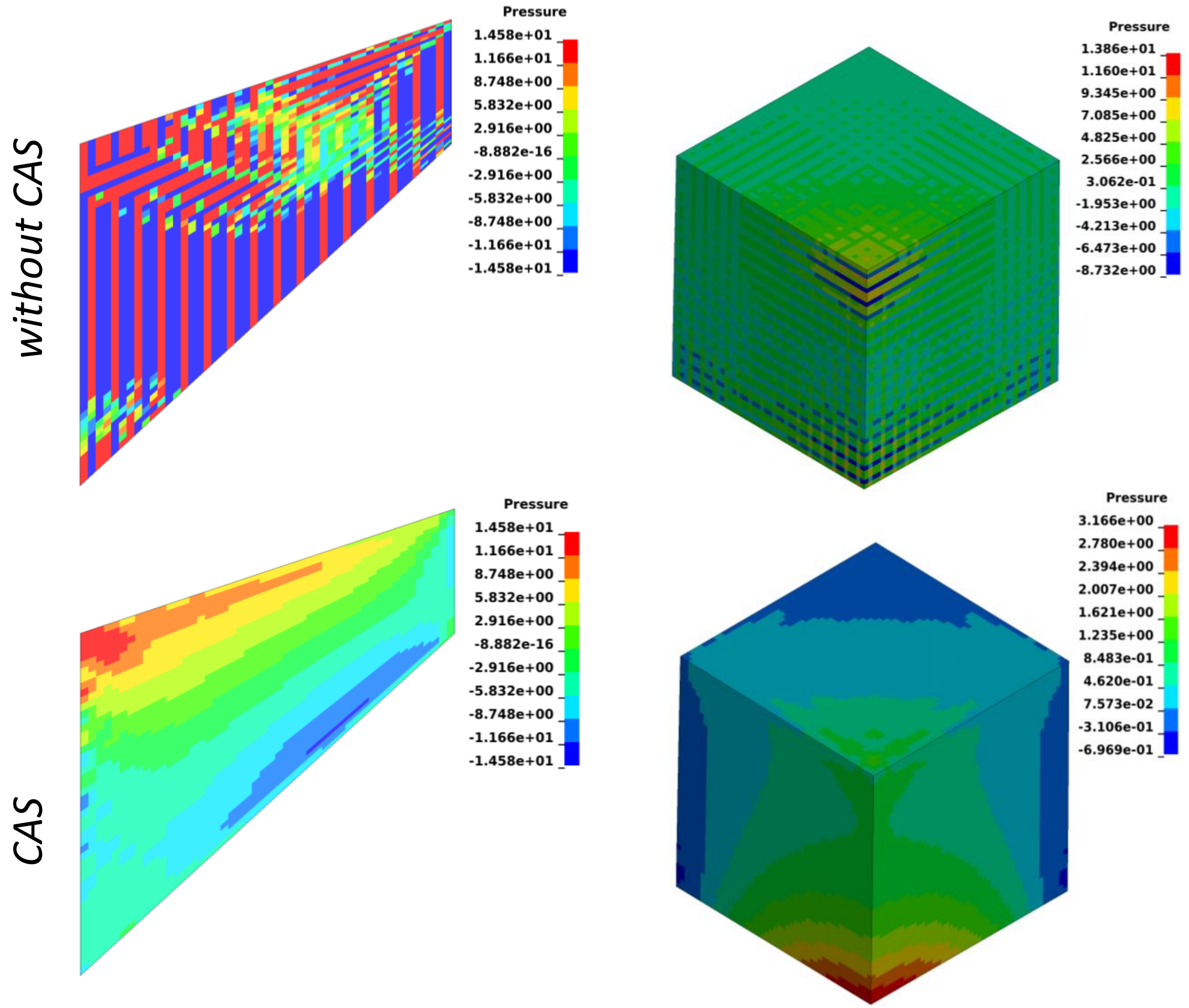
Ansys part of Synopsys

IGA: Alleviating Volumetric Locking

- Continuous Assumed Strain (CAS) formulation specifically designed for C^1-quadratic discretization.
  Casquero and Golestanian, CMAME 73:1241-1252, 2024.

- Accurate approximation of the pressure field is imperative for triaxiality-driven failure models, e.g., `*MAT_224`, `*MAT_251`, etc.

- Explicit dynamics only for now.

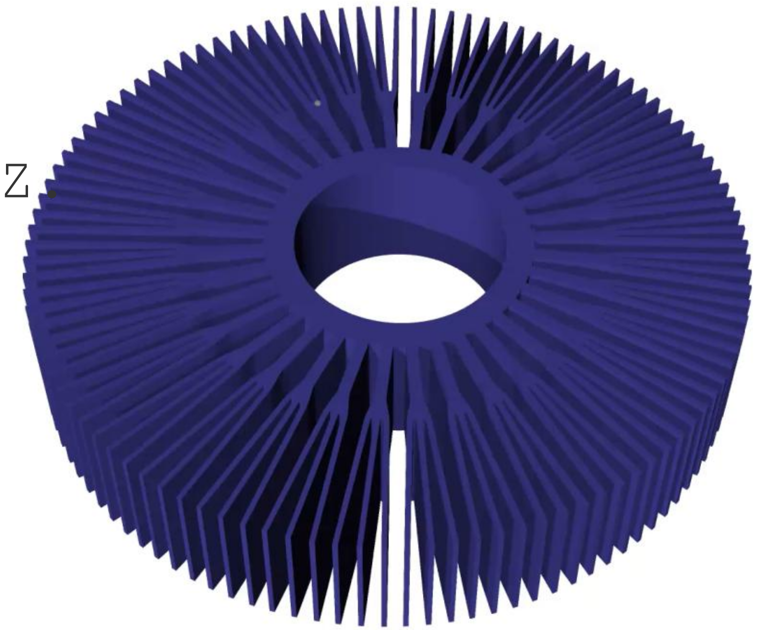


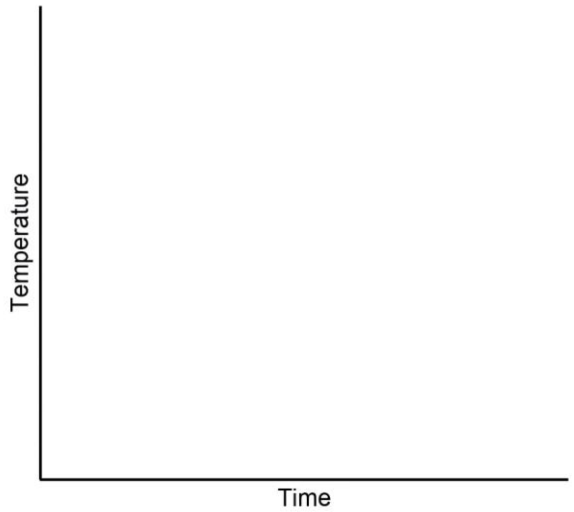
Cook's membrane (single layer of solid elements)

Cube under volumetric load

IGA: Thermal Analysis

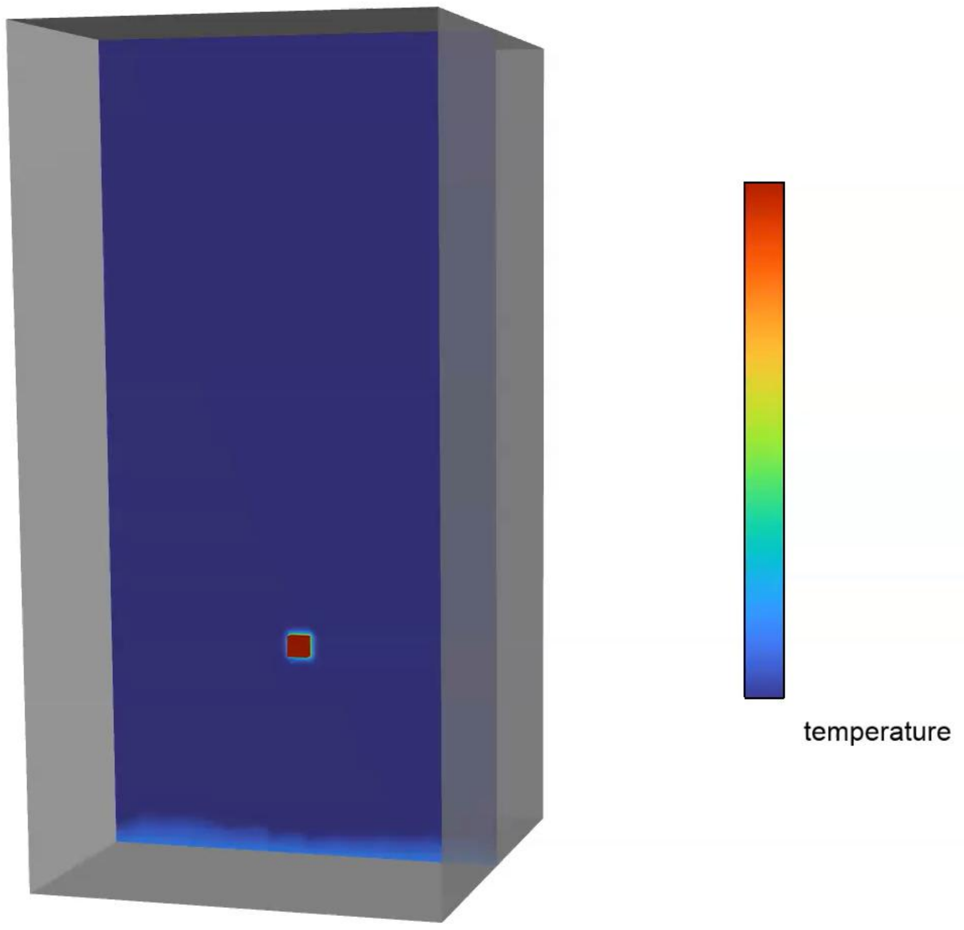
- Steady State and Transient Thermal Conduction Analysis.
- Isogeometric solids
  - Boundary fitted/untrimmed structured splines.
    `*IGA_3D_NURBS_XYZ`
  - Unstructured splines
    `*IGA_3D_BASIS_TRANSFORM_XYZ.`





IGA: Conjugate Heat Transfer

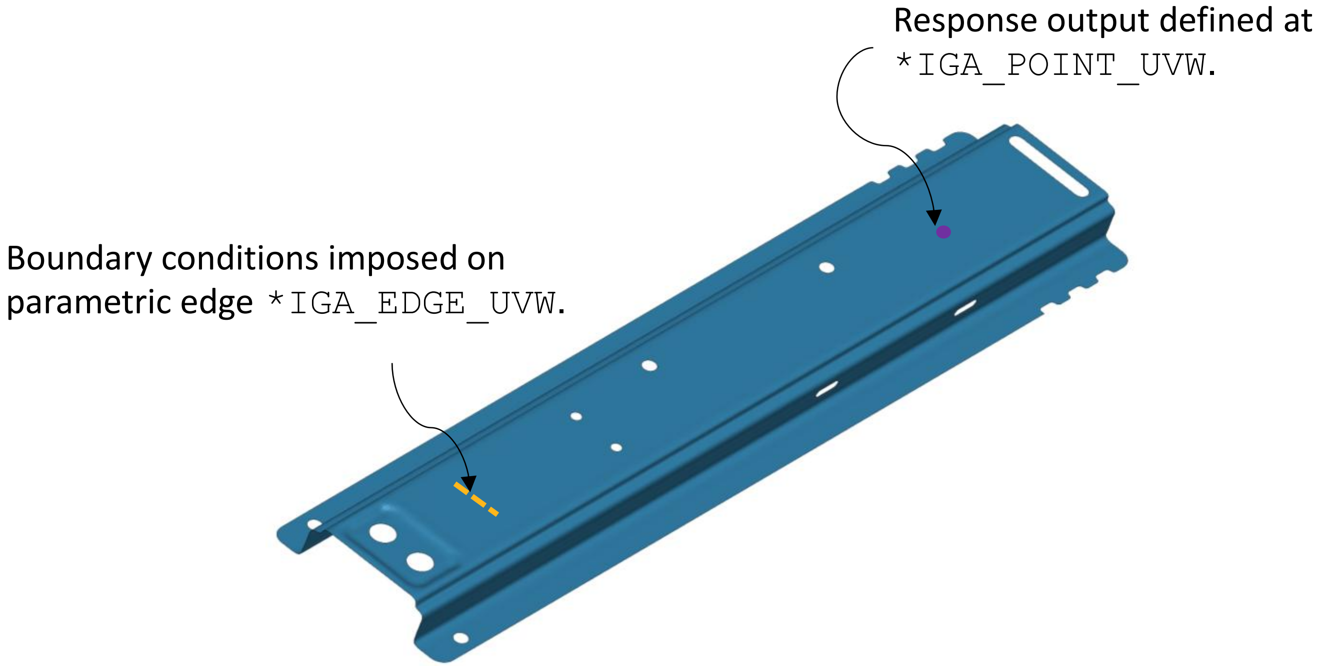
- Coupling IGA and ICFD solvers.
  - SMP only for now.
- Isogeometric solids
  - Boundary fitted/untrimmed structured splines.
    *IGA_3D_NURBS_XYZ
  - Unstructured splines
    *IGA_3D_BASIS_TRANSFORM_XYZ

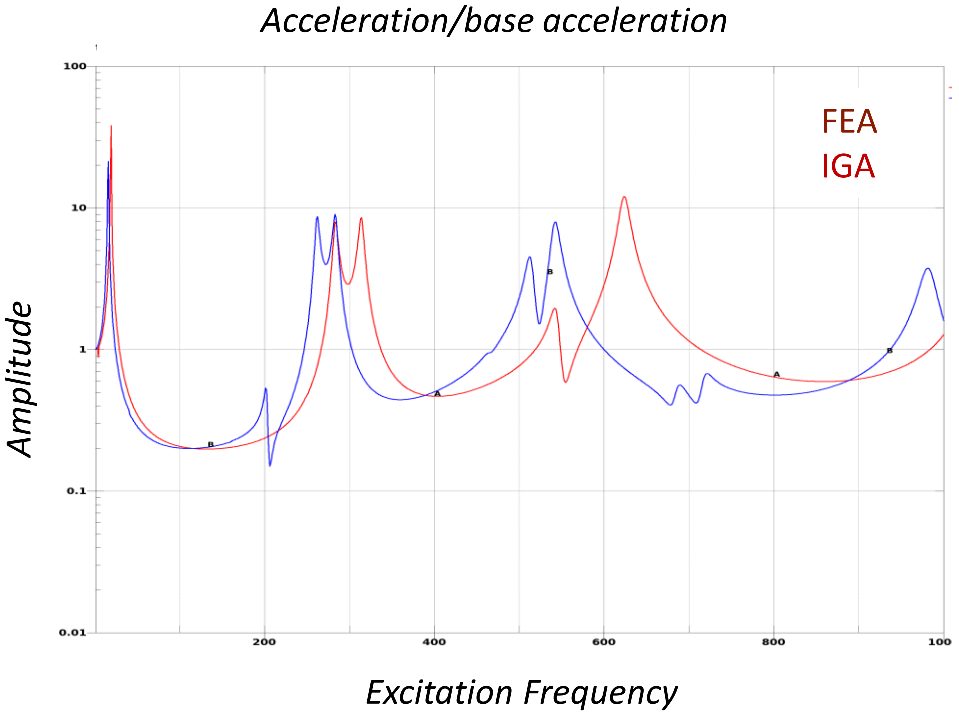


Cooling of a simple cube in a fluid domain

IGA: Frequency Response Function Analysis

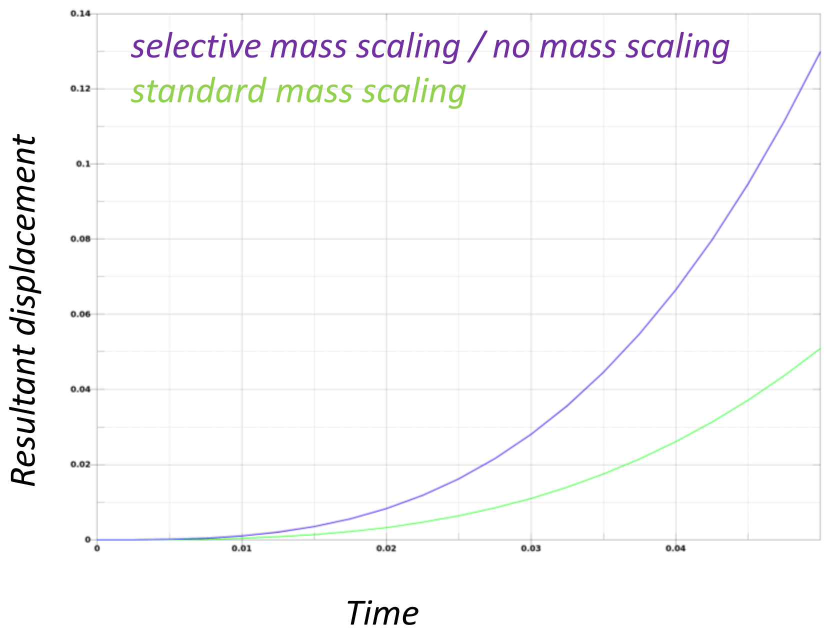
- Velocity, acceleration, or displacement can be imposed on geometric entities, e.g. points, edges, faces, using large mass method.
- Added mass is defined by `*IGA_MASS`.





IGA: Miscellaneous

- Selective Mass Scaling for Isogeometric Solids
  `*CONTROL_TIMESTEP` with `IMSCL=1`
- Constrained Tied Contact for Isogeometric Solids
  Adhesives, welds, etc.
- Spatial Variation of Selected Material Parameters (ongoing work)
  `*DEFINE_FIELD, *DEFINE_POINT_CLOUD, *PART_FIELD`
- Codebase Modernization (ongoing work)
  - Utilize full vector length with element erosion
  - GPU



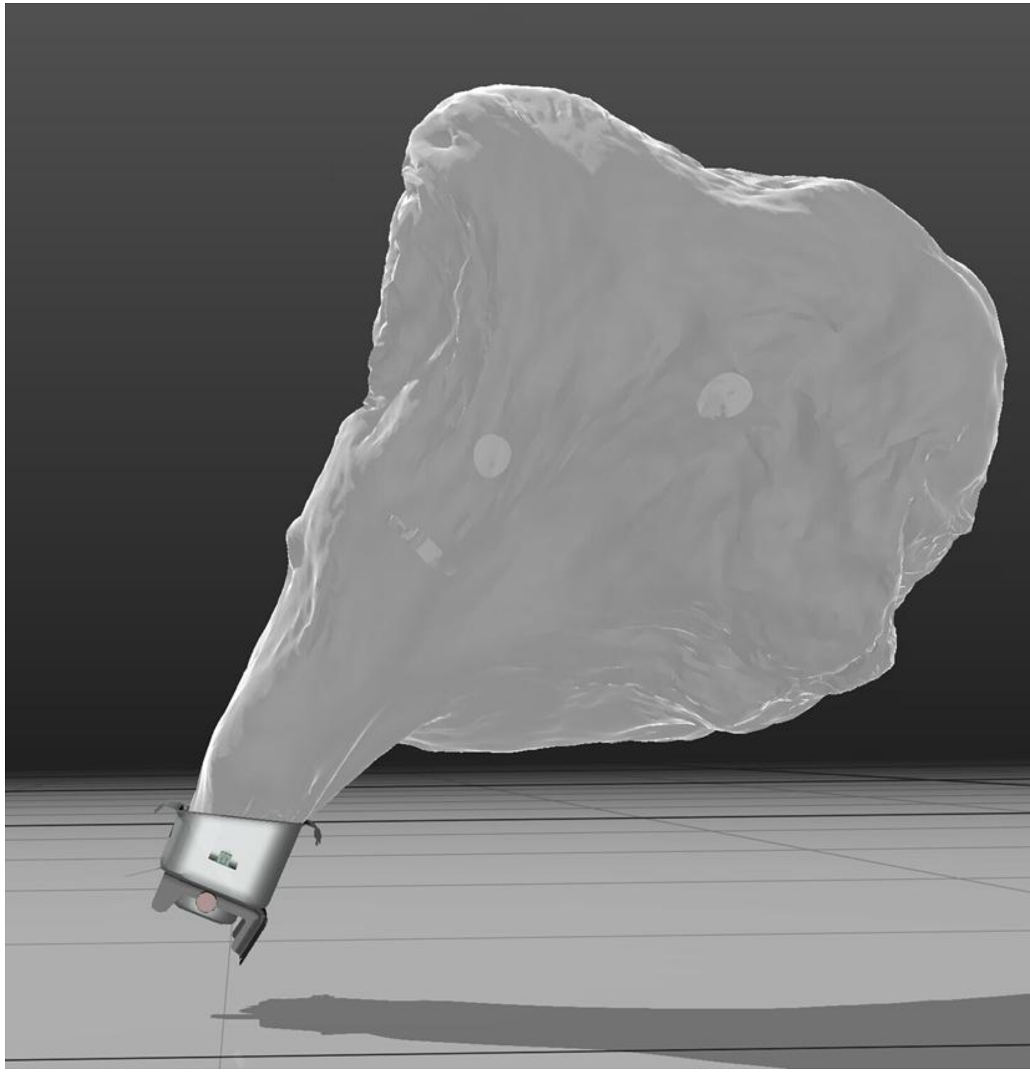
CPG: Continuum Particle Gas - New Features & Improvements

New Features

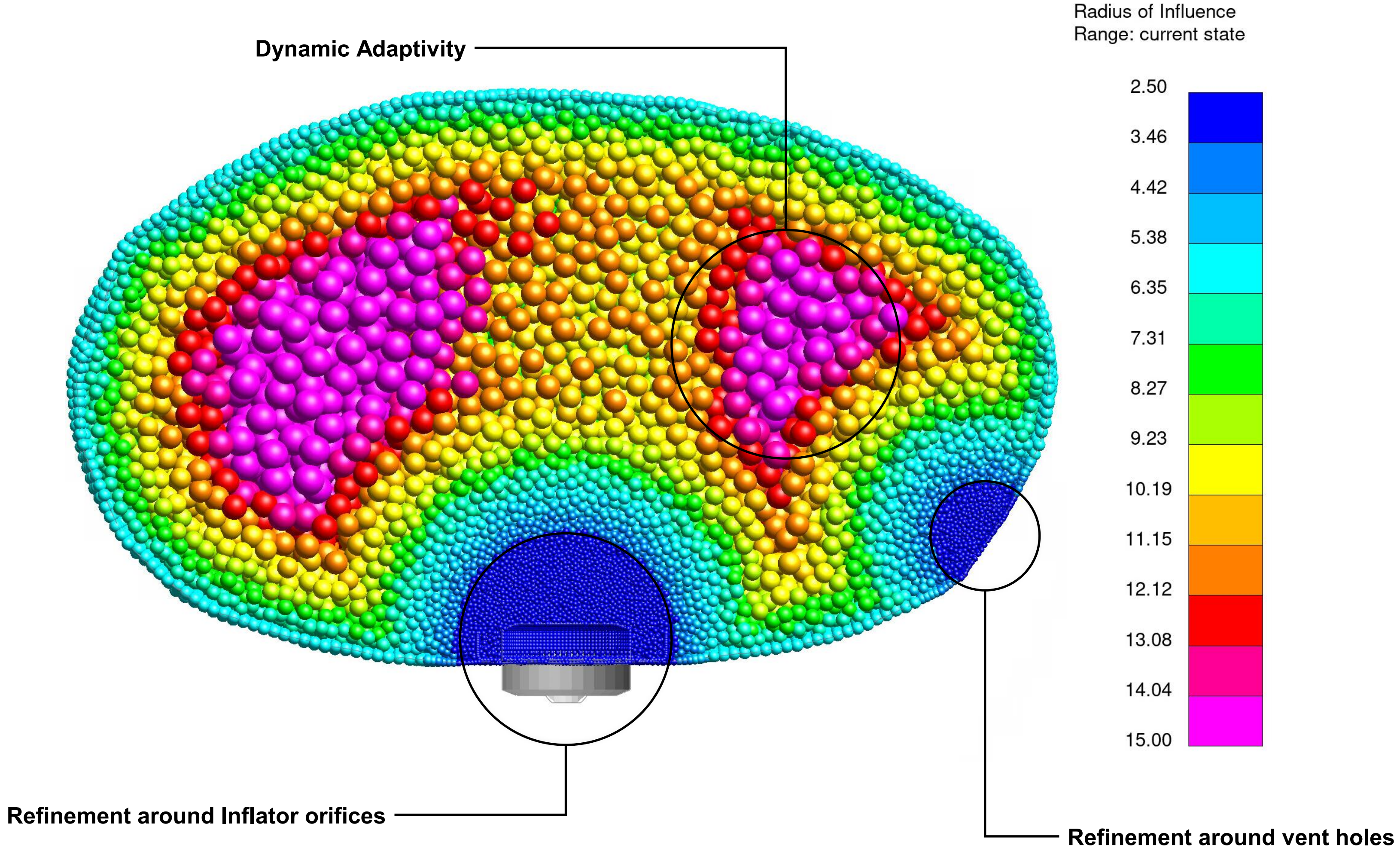
- New options to locally refine point-cloud around inlets (inflators) and/or outlets (vents).
- Adaptivity option to dynamically refine/coarsen the point cloud based on distance to walls.
- Add optional standard k-epsilon turbulence model.
- 2-way thermal coupling with shell parts through LS-DYNA's thermal solver.
- Vents can open once given pressure is reached (PPOP)
- Add bag geometry integrity checks.
- 1-way and 2-way coupling with Discrete Element particles (mechanical and thermal coupling available).
- Add start-time, and time-switch to terminate CPG and switch to uniform-pressure calculation.

Improvements

- Support multiple *AIRBAG_CPG keywords.
- Stability and robustness improvements.
- Various input checking improvements.
- More complete outlet (vent) treatment.
- Update inflator orifice area during time-integration for deformable inlets.
- Additional part-specific information in ABSTAT data.

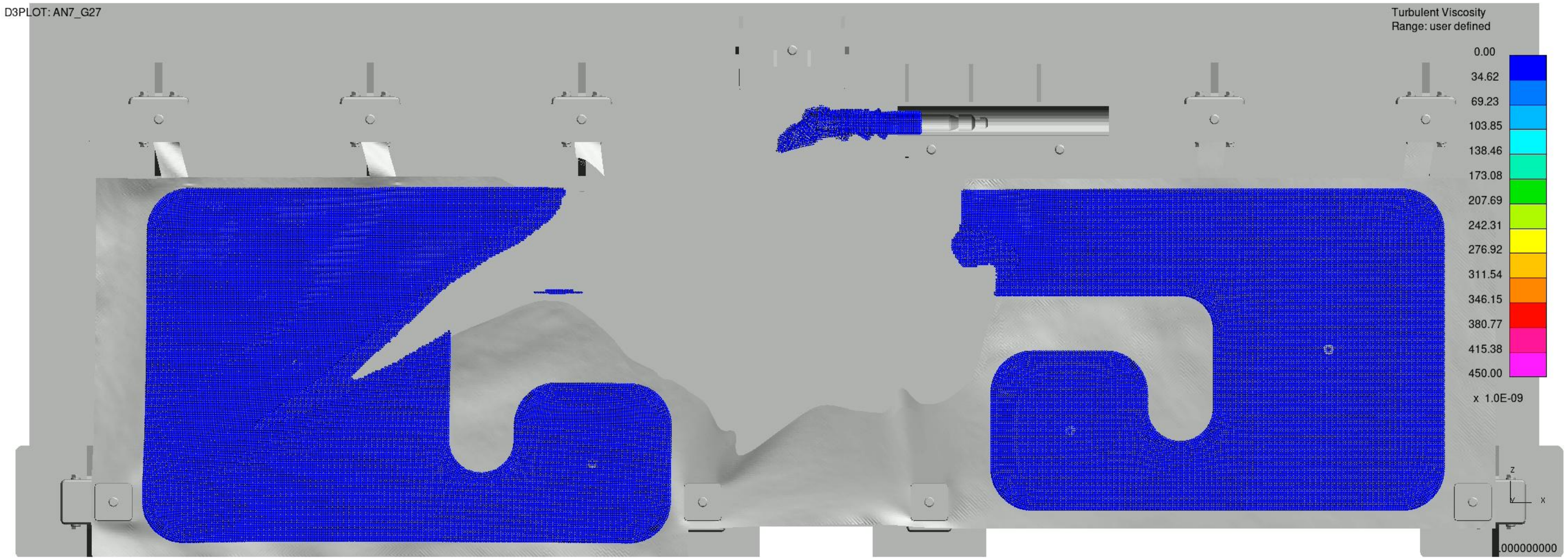


CPG: Dynamic Point Cloud Adaptivity

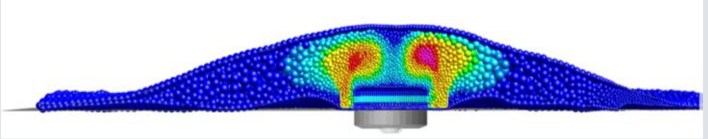


- Various controls over particle size.
- Balance between accuracy and computational cost.

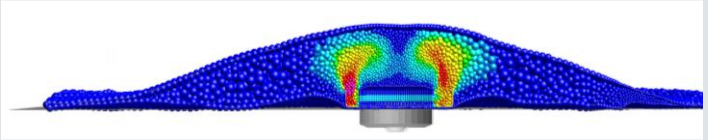
CPG: Standard k-eps Turbulence Model



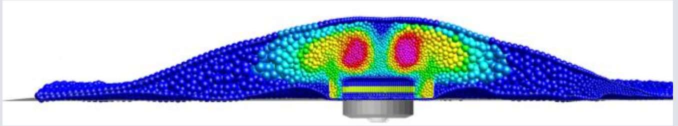
Numerical model courtesy of JSOL Corporation. Experimental data courtesy of Toyoda Gosei Co., Ltd.



k –Turbulence kinetic energy



ε – Rate of dissipation of turbulence kinetic energy



μ_T – Turbulent viscosity

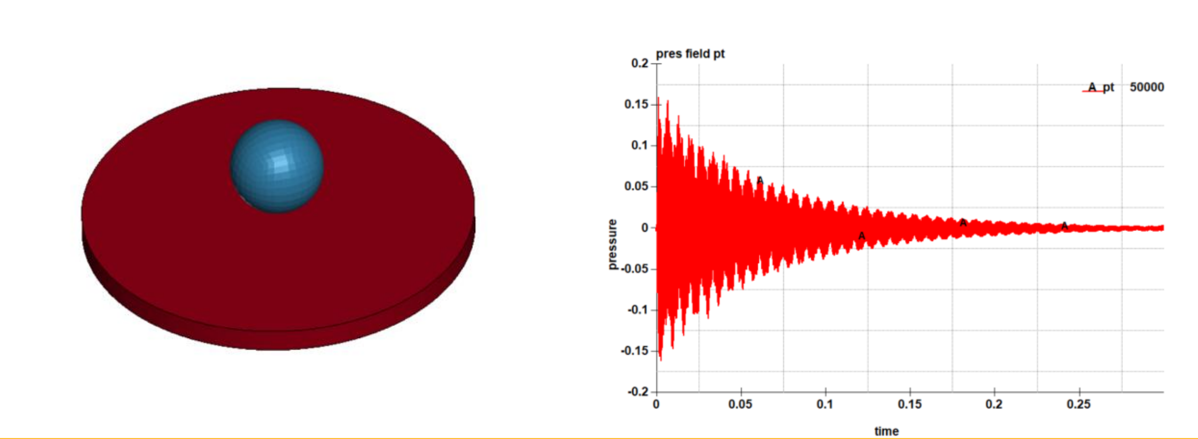
CPG: Coupling with Discrete-Element

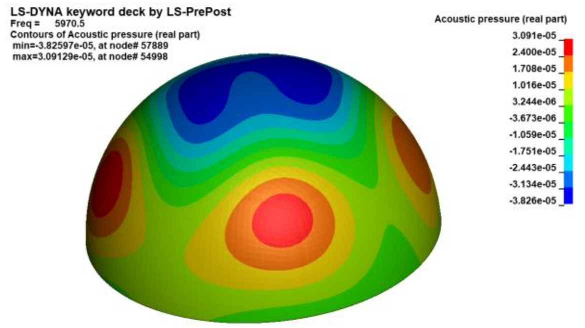
- 1-way or 2-way coupling
- Heat transfer between particles, gas and structure
- Developed for battery thermal runaway simulations.

Acoustics Solver Enhancements

Quick restart option

- Capture acoustic pressure at new microphone locations in a faster way (restart=2)



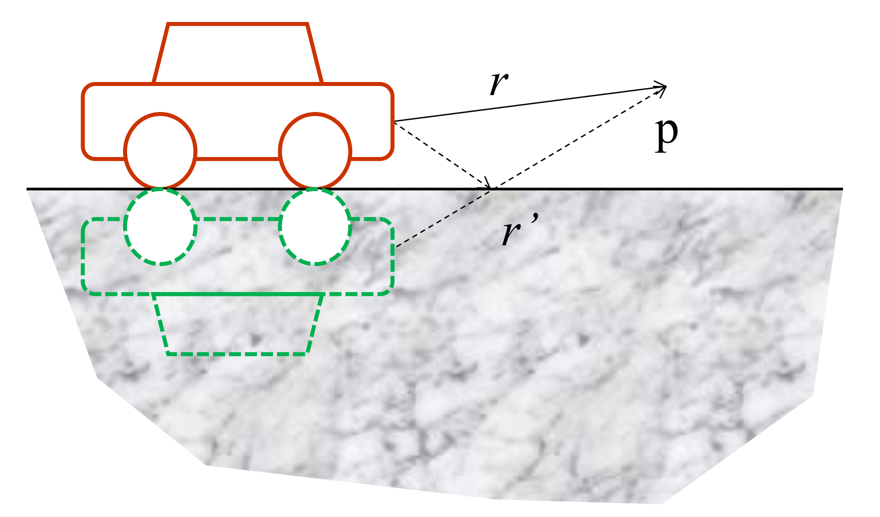


D3ACP at 5970.5 Hz

Runs (MPP with 48 cores)	Total CPU time
1st run	3 hours 48 minutes
Restart 2 (with d3acp)	**3 minutes 58 seconds**
Restart 2 (no d3acp)	**6 seconds**

User Defined Reflecting Coefficient for BEM

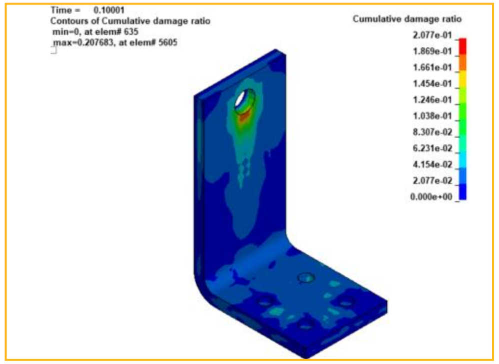
- New parameter “RC”
  - Helps in modeling different reflection planes.
- Works for both SMP and MPP
- Currently Rayleigh method is supported



Fatigue Solver Enhancements

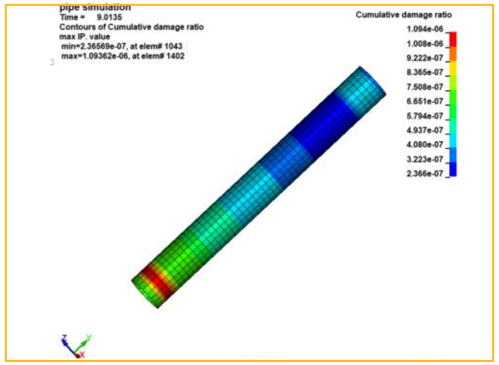
D3Part

- Run fatigue analysis on selected part(s) from a big model.
- Can Restart from existing d3part database.



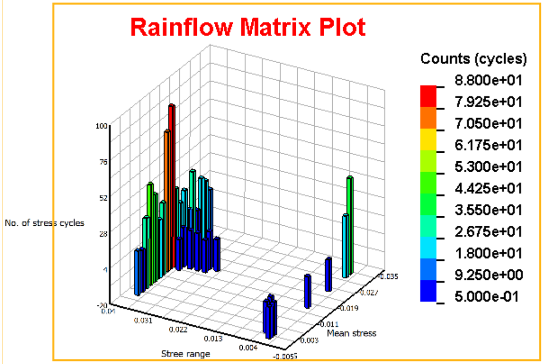
Early Termination due to Fatigue damage

- Can be applied to a single part, or to the whole model.
- Saves run time.

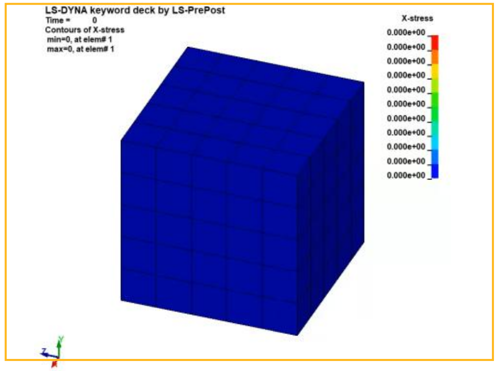


Rainflow Matrix Plot

- Activates fatigue.rainflow lsda file output & define the set of elements for the output.
- Can be post processed in LS-PrePost to show the rainflow bins.



- A new flag NFAIL to keep or remove failed elements in d3max

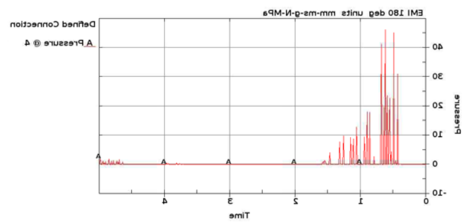


SALE Solver Enhancements

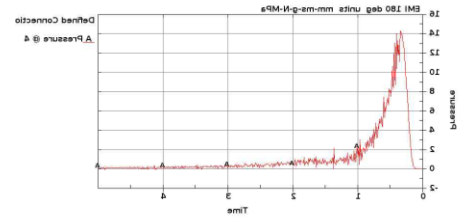
Novel method to resolve Pressure Oscillations

- Widely used to model soil under explosive loading
- Pressure oscillations, stemming from the advection process.

Oscillating pressure Before



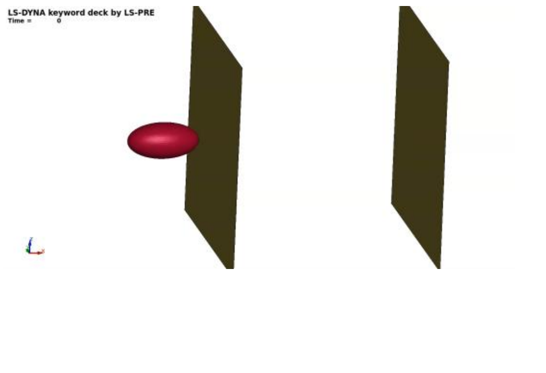
Oscillating pressure Cured



Apply FSI loading on the structure

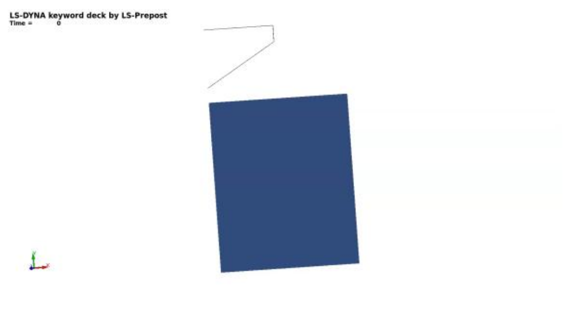
- Before: Only pressure applied
- **Now:** Can apply the force & pressure on the Lagrange structure from previous run.

Validation example : Capacitor study



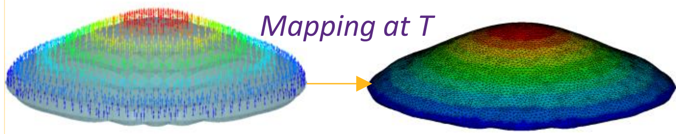
Barotropic Cavitation Modeling

- A stable and low-cost method for simulating phase changes between water and air.
- Water is modeled as a homogeneous air–water mixture, with pressure depending only on the compression ratio (barotropic).



Flexible mapping between ALE & Lagrangian body

- ALE-> FEM

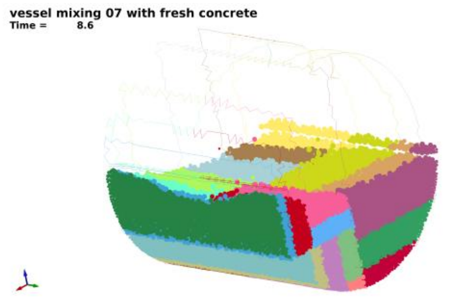


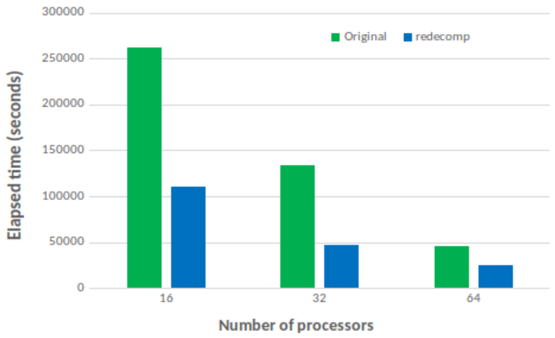
- FEM->ALE

DEM Solver Enhancements - 1

2X Speed up

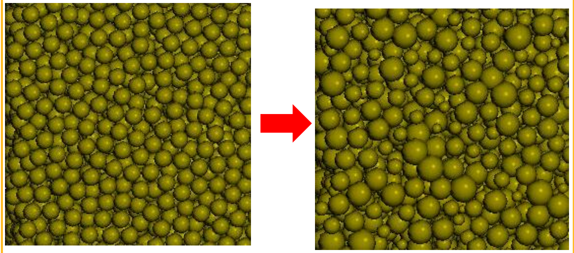
- Improved decomposition based on current geometry





Improved distribution of Mass, Volume, Inertia, and Radii input parameters

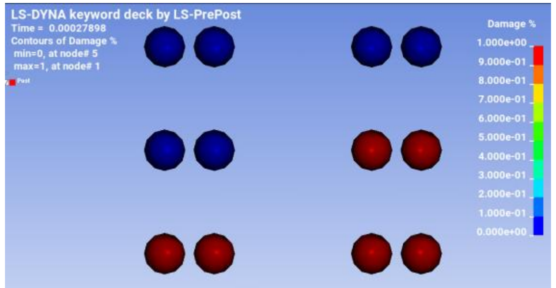
- Statistically distribute using normal or Weibull distribution.

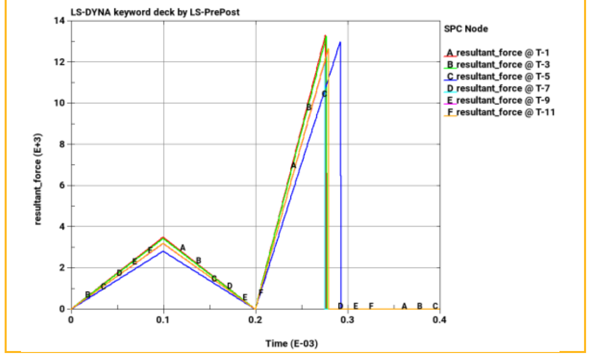


Distribution of DEM Particles

Improved distribution of bond input parameters

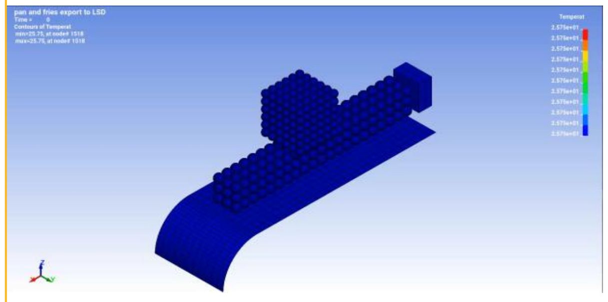
- Statistically distribute with a normal or Weibull distribution.





Temperature effect on the particles of DEM is introduced.

- DEM particles radius are increased or decreased with the change in the temperature.
- The stiffness between the bond can be adjusted to simulate desired materials such as intumescent materials.



Temperature effect on DEM

DEM Solver Enhancements - 2

Thermal transfer between Solids & DEM particles.

- The change in temperature in DEM particles is taken into account to change the radius of the particle.
- DEM captures thermal transfer and expansion of the particle

Several new ASCII outputs are available during Dynamic Relaxation phase

- GLSTAT_DR: Global statistics and energies
- MATSUM_DR: Part energies
- RCFORC_DR: Resultant contact interface forces.
- SLEOUT_DR: Contact interface energies

Temperature effect on DEM

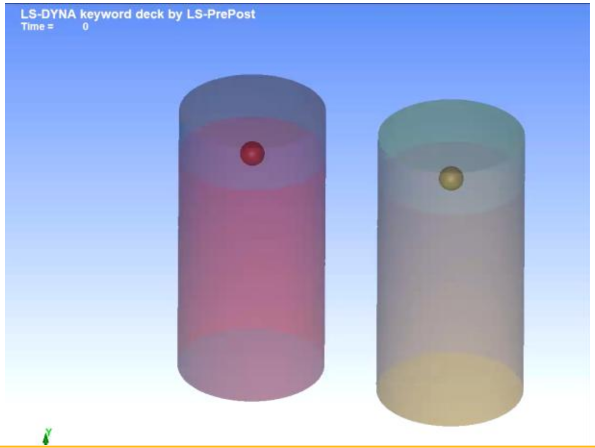
Ansys part of Synopsys

CFD: ICFD Solver Enhancements - 1

Free Surface and Bi-phasic flows

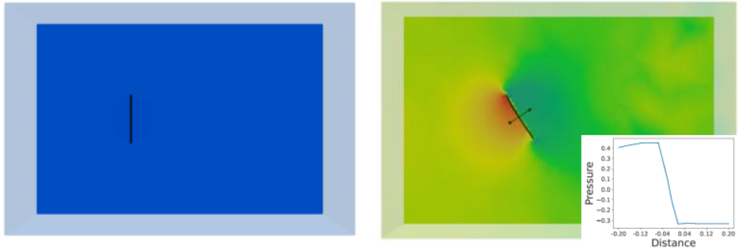
- Narrow-band levelset
- WENO levelset
- Load curve or function initialization of levelset
- Use two material per volume for levelset with multiple volumes

Two fluid domains in the same model using different materials.



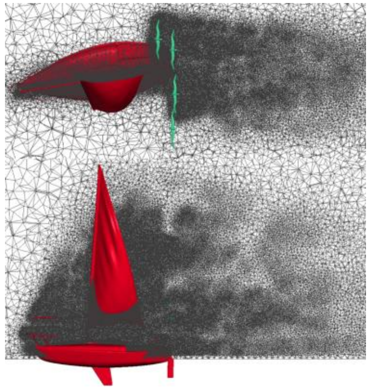
Immersed FSI

- New immersed finite element formulation for fluid-structure interaction based on Finite Element enrichment.
- Simplified UI for Resistive Immerse Implicit Surface (RIIS) method.
- Improved adaptive meshing capability. Improved interface recognition accuracy.



Sharp pressure discontinuities across the interface

Old interface *New Interface*



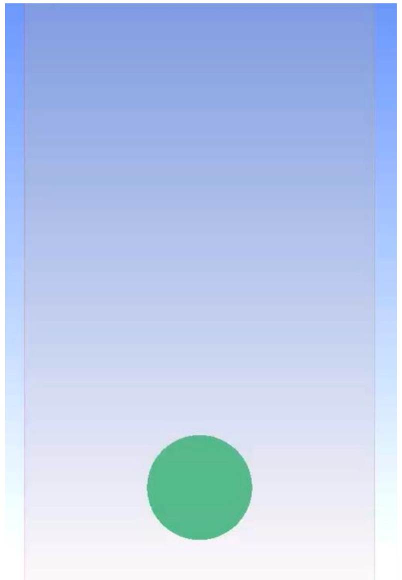
Improved adaptive meshing

Ansys part of Synopsys

CFD: ICFD Solver Enhancements - 2

Visco-elastic model

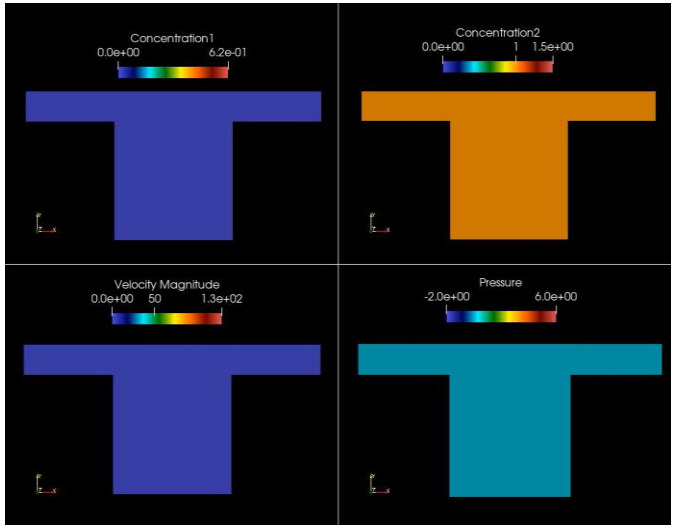
- New: Giesekus model added (alongside Oldroyd-B)
- Enables more accurate polymer flow simulations

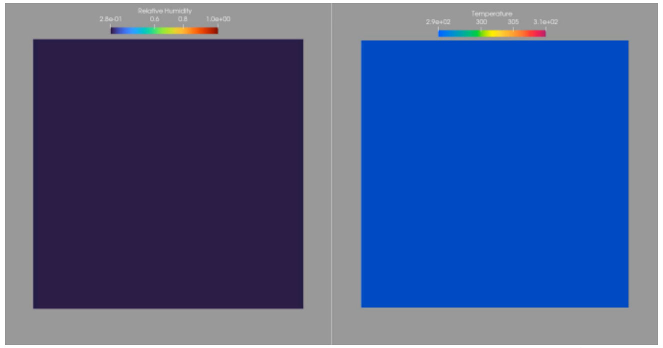


Rising bubble test using the Giesekus model

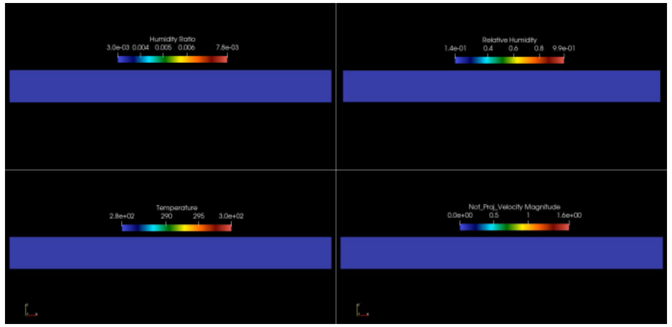
Multi-species Solver

- Chemical Reactions and Fluid Density Change with Species Concentrations and FSI.
- Mesh Adaptivity with Species Concentrations.
- Heating, Ventilation and Air Conditioning (HVAC) Solver: Moist Air Mixture (Dry Air + Water Vapor psychrometry).





Cold wall reaching condensation conditions (colors: Relative Humidity and Room Temperature).

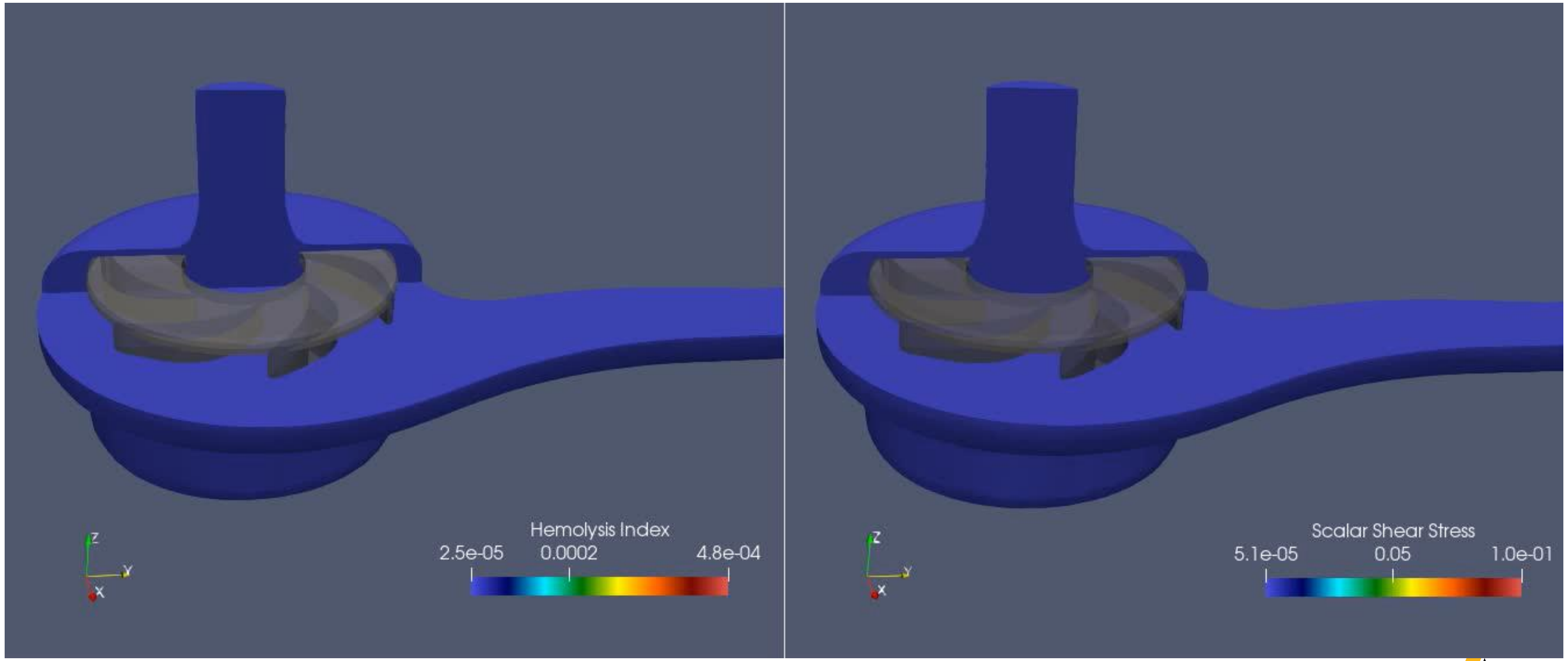


Hot jet of moist air entering an HVAC duct (colors: Relative Humidity, Room Temperature, Air Speed).

CFD: ICFD Solver Enhancements - 3

Cardiovascular Flow

- Transport and Tracking of the Hemolysis Index and the Scalar Shear Stresses.
- Extension of the User Interface for Residence Time transport (more complex source zones definition).

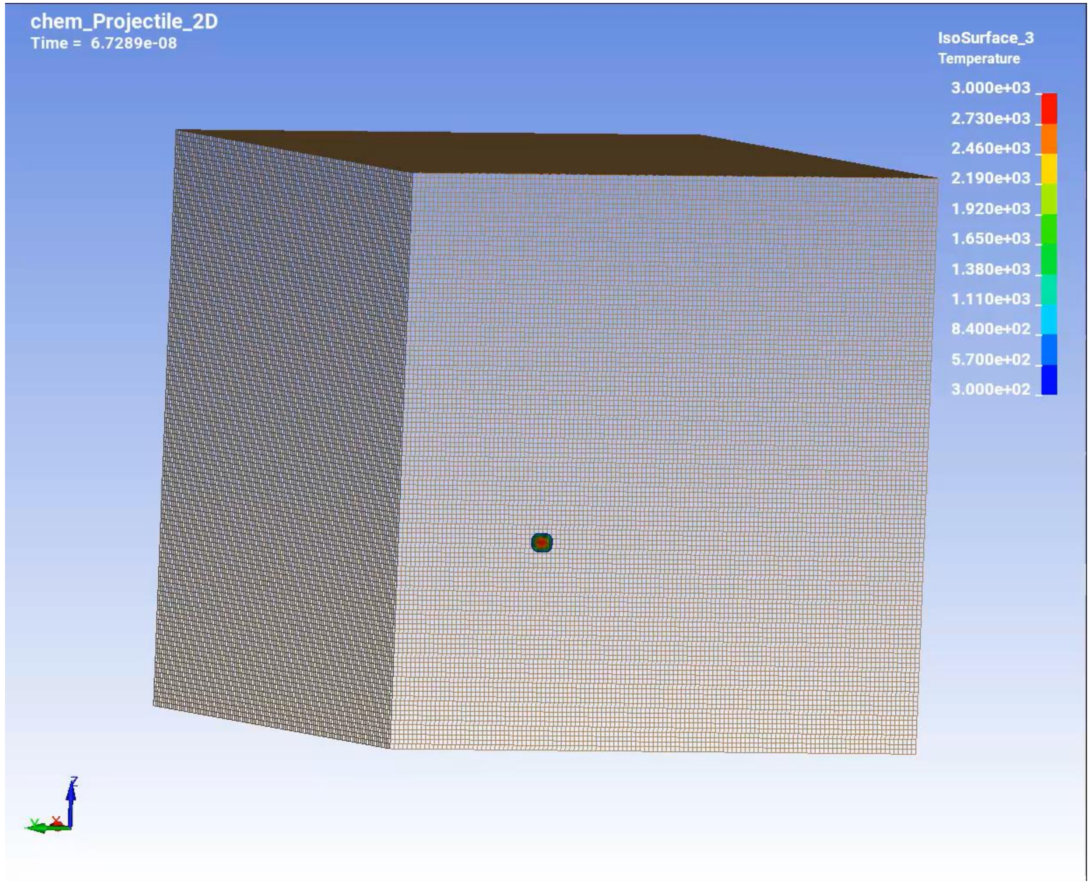


LVAD pump results in collaboration with Dr. Cestari and Dr. Oliveira INCOR/HC/Univ. San Pablo/UNICAMP.

[2] K.H. Fraser, T. Zhang, M. Ertan Taskin, B.P. Griffith, Z.J. Wu.A Quantitative Comparison of Mechanical Blood Damage Parameters in Rotary Ventricular Assist Devices: Shear Stress, Exposure Time and Hemolysis Index. Journal of Biomechanical Engineering, 2012, Vol. 134 / 081002-1.

CFD: Chemically Reacting Dual CESE Solver* - 4

- 3D, 2D, and 2D axisymmetric versions.
- Binout time-history output.
- Full d3plot support.
- Couples with point sources included by user.
- Couples with porous media modeling.
- Solution initialization via geometric regions.



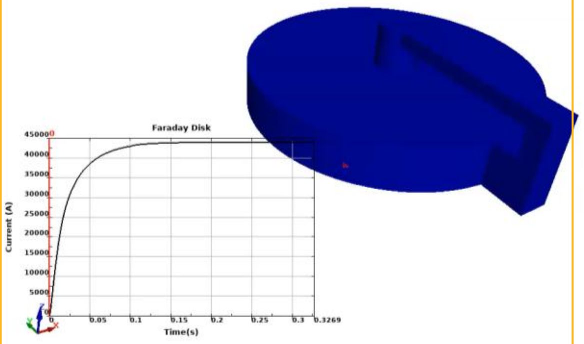
Temperature contours during detonation wave expansion

EM Solver Enhancements -1

DC Electric Generator

- Uses Eddy current solver
- Typically involves rotating parts to generate current
- Users can now directly include rotating velocity Eddy current effects without moving mesh.

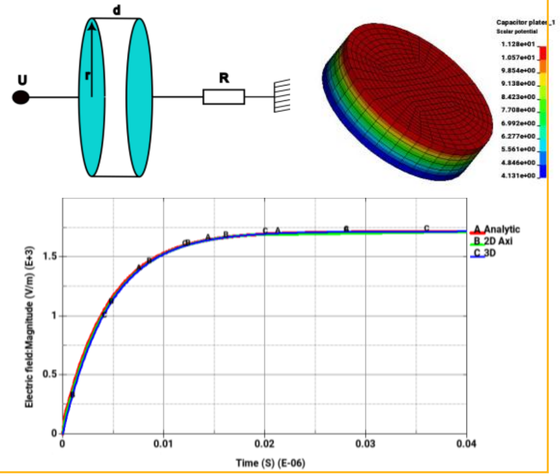
Validation example : Faraday Disk



Dielectric Heating

- Suited for dielectric breakage, capacitor analysis, RF ablation.
- Add-on to Resistive heat solver.
- Available for quasi static electric analysis

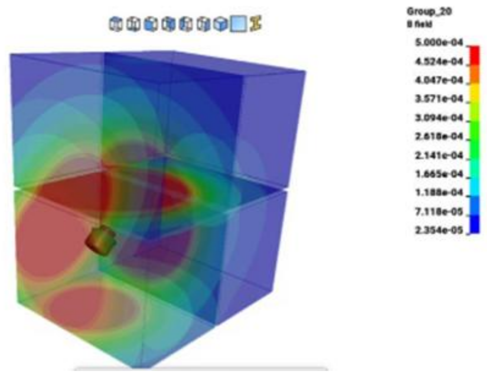
Validation example : Capacitor study



Biot Savart two step solve

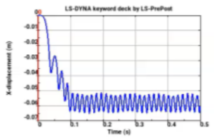
- Results from a previous magnetostatic analysis can be reused in a subsequent analysis to map magnetic fields on non-magnetic parts.

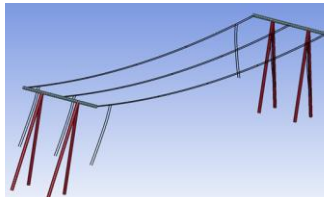
An example of a magnetic field study far away from a set of magnets



Lorentz Force in beams

- Users can now ask for a Lorentz force calculation in beam elements using the Resistive heating solver (based on Biot Savart integration – no diffusive effects).





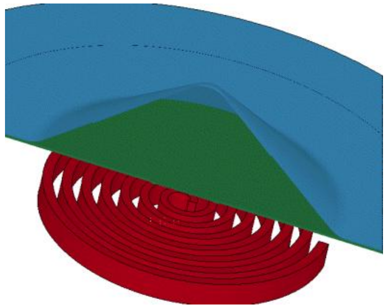
Attraction of two parallel wires due to electromagnetic forces

EM Solver Enhancements - 2

Analysis Speedup

- Applications: Electromagnetic metal forming, magnet snapping simulations.
- BEM matrix assembly routines have been optimized for calculation gains.
- Users can avoid recomputation of parts of BEM matrices on non deforming bodies.

Testing example on 4 CPUs. Classic electromagnetic forming

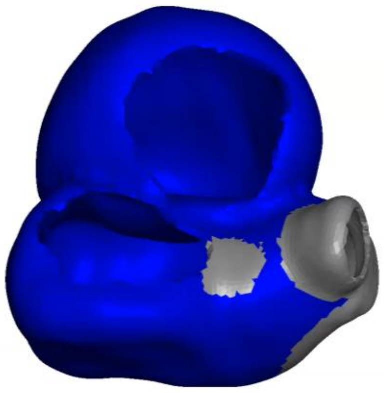


R16	R17+*EM_SOLVER_BEM_REASSEMBLY applied on coil
27min	13min

ElectroPhysiology

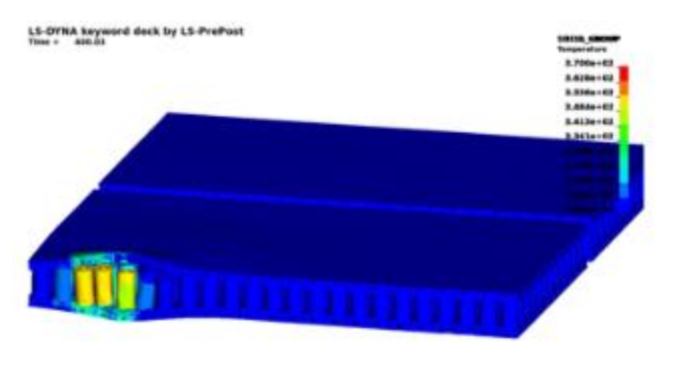
- Helps study the effects of drugs on Cardiac behavior, mechano-electric feed-back.
- Improved robustness of EP-Eikonal solver.
- Added TO-ORD, Trovato EP, Margara Coupled EP Mechanical model

VT-inducing isthmus refractory period
Unidirectional Block at isthmus -> VT

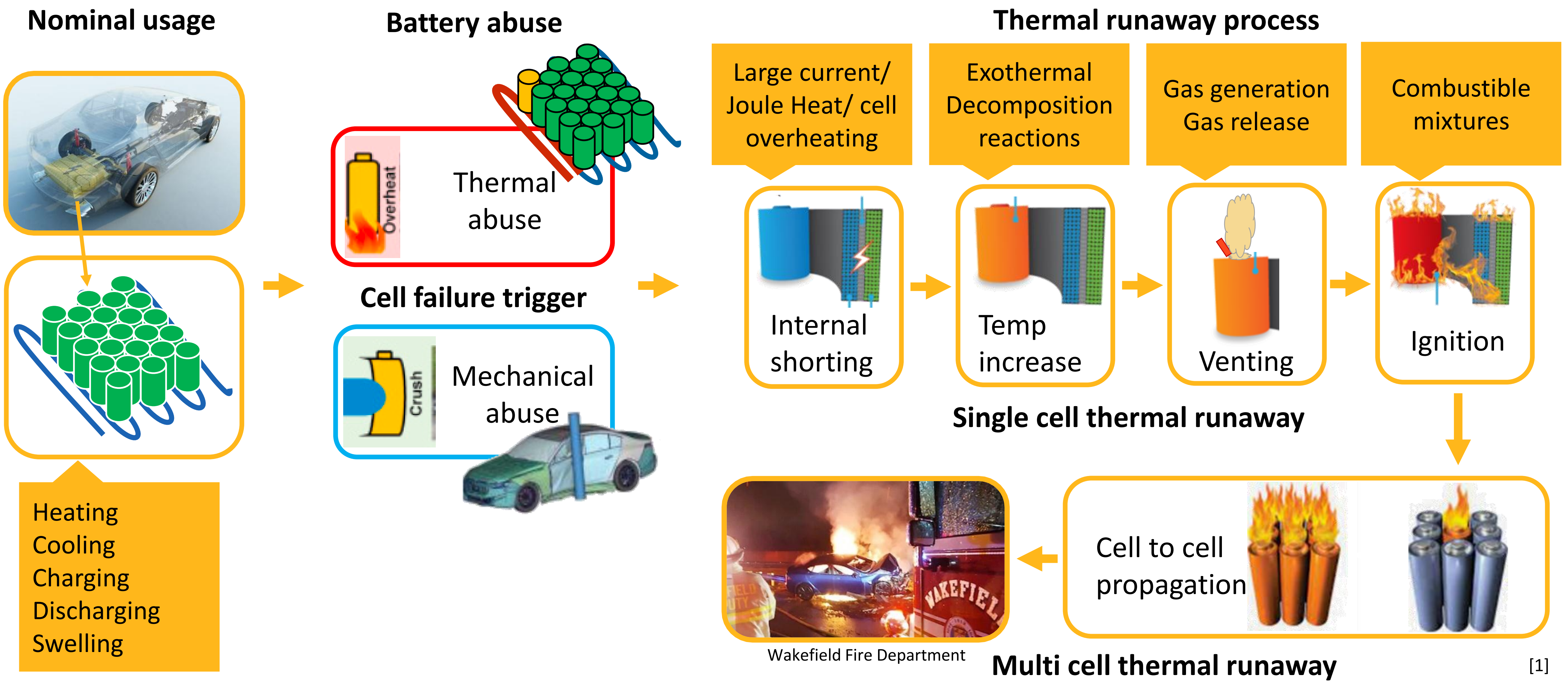


Batteries

- A new hybrid direct-iterative solver approach for speed ups in large Electrothermal battery models (that use BatMac).



Multiphysics Battery Framework



Evolution of Battery Modeling Development

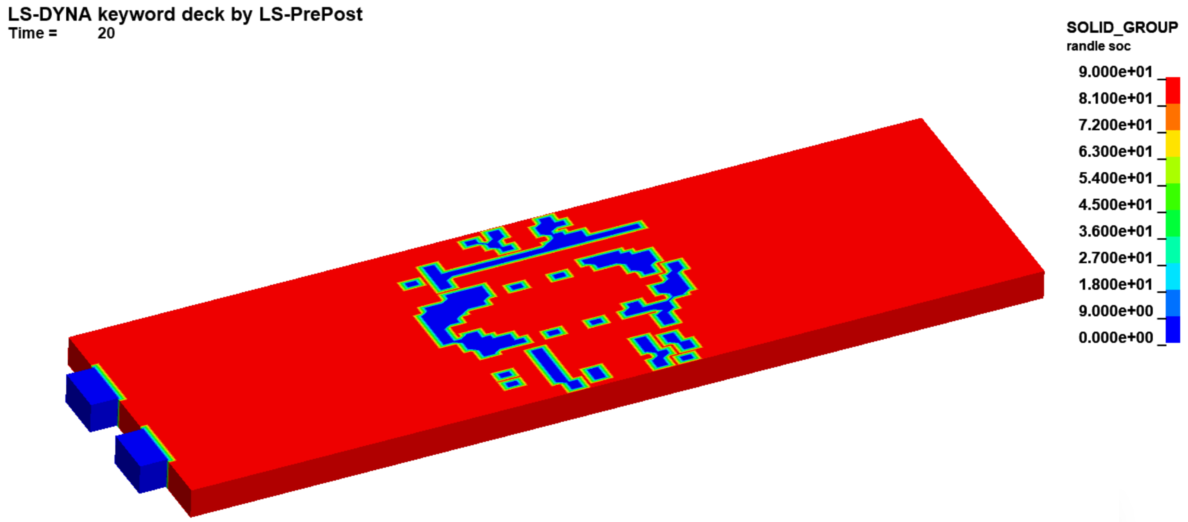
Version	EM resistive heating solver	Structural solver	Thermal solver	Fluid CPG solver	Fluid ICFD solver
R17/Dev	**New short criteria for Randles circuits based on external variable, Improved EM solver performance, Binary output for some EM results**	**Additional expansion term based on external variable**		**Improved thermal coupling CPG-Structure, CPG-DEM coupling**	**Load/Map results from a previous steady state analysis**
R16	Improved EM contact, temperature dependent OCV	`MAT_126` Sahraei failure criterion, add an externally defined variable to nodes	Thermal option for automatic single surface contacts	First release of CPG for airbags	
R15	Better erosion criteria in solid model, improvements on the exothermal reaction model, conductive shells	`MAT_126` strain-rate dependency			
R14	Exothermic reaction model				
R13	Erosion, second order Randles		Exothermic reaction model		
R12	First release of BatMac and other Equivalent Circuit Models (ECM)				

Courtesy: Raphael Heiniger, Ansys ACE

Battery Abuse Simulations – Trigger Short Circuit

- External variables can be used to trigger short circuits in battery cells
  - Use *LOAD_EXTERNAL_VARIABLES to define a temporally varying spatial distribution of an external field, obtained for example from a previous simulation.
  - Reference the external variable in *DEFINE_FUNCTION for short circuit criterion used by *EM_RANDLES_SHORT

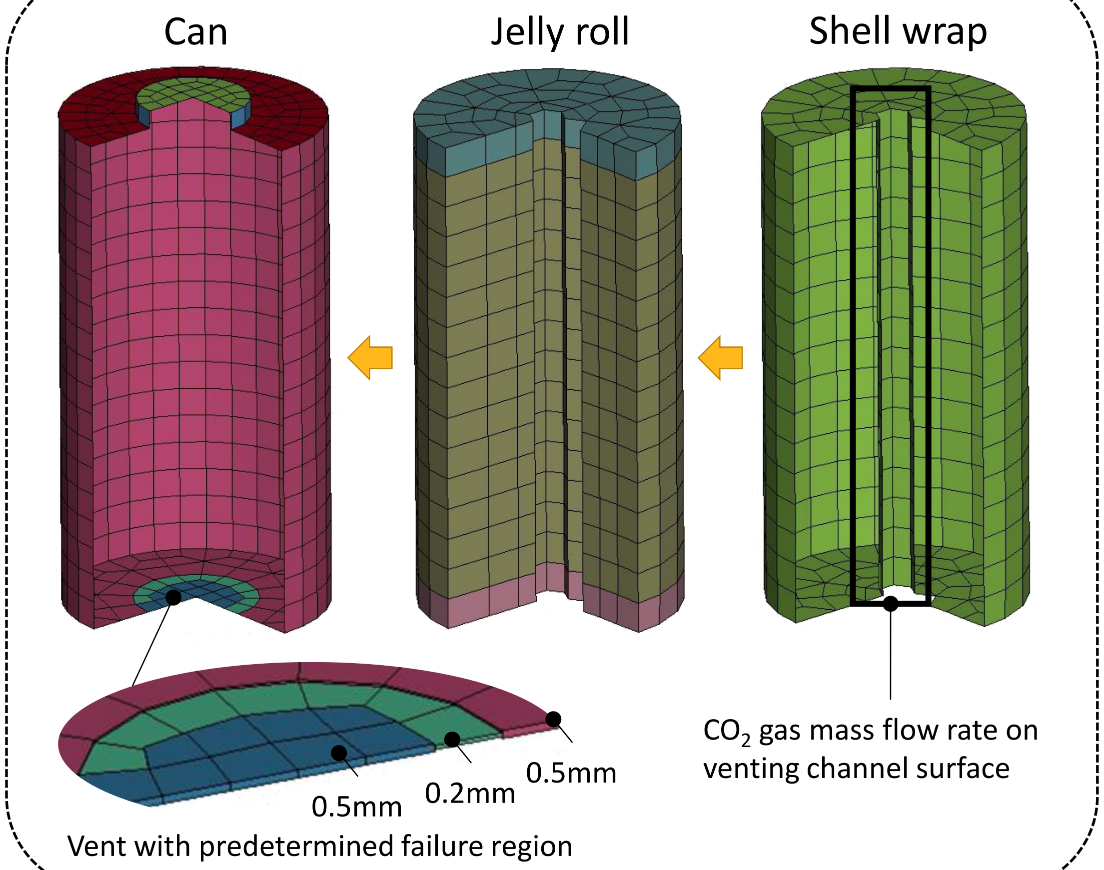
```
*EM_RANDLES_SHORT
$#areaType    functId
         2        501
*DEFINE_FUNCTION
$#      fid      defintion
        501      short circuit criteria
float resistance_short_randle1(float temp,
float time, float extvar)
{
  float T_melt;
  float shortres;
  T_melt=1;
  shortres=1.0;
  if ((extvar > T_melt)) {
     return shortres;
  } else {
     return -shortres;
  }
}
```



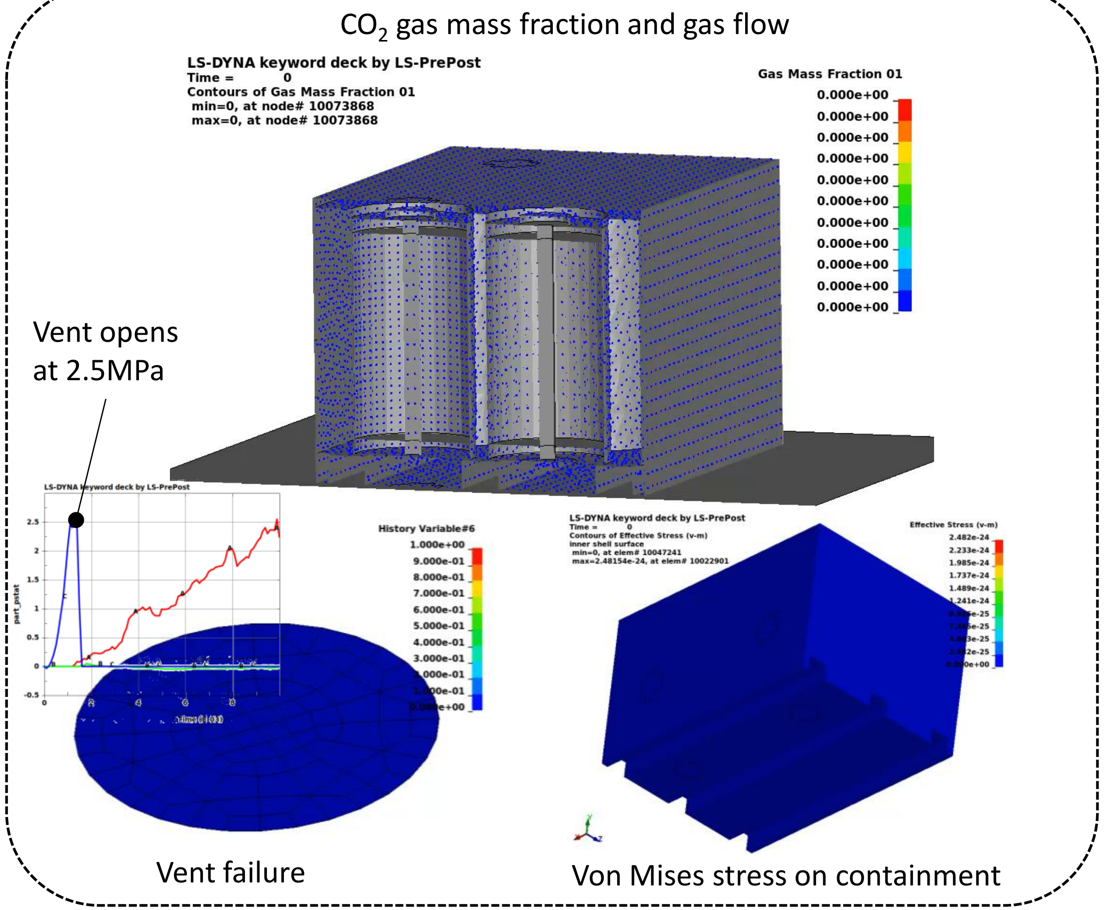
Ansys part of SYNOPSYS

CPG: Battery Venting and Failure Applications

- Cell and CPG setup



- Results

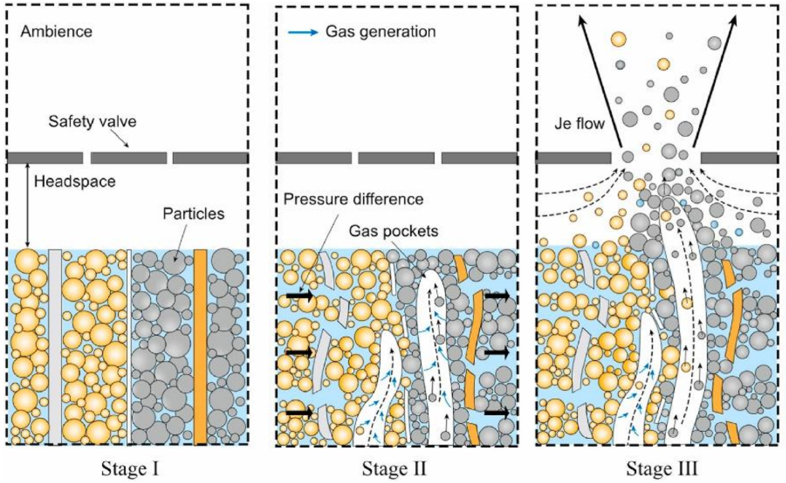


Courtesy: Raphael Heiniger, Lead Application Engineer

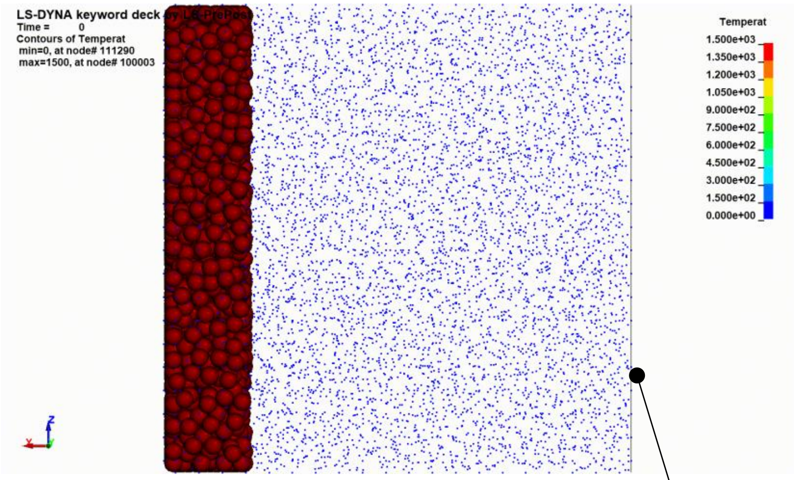
Ansys part of Synopsys

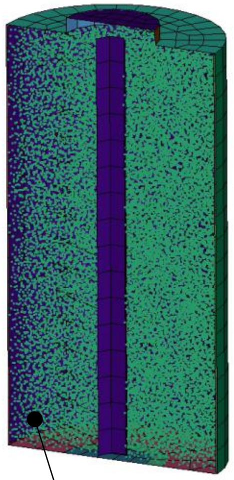
CPG: Ejecta modeling using CPG and DEM

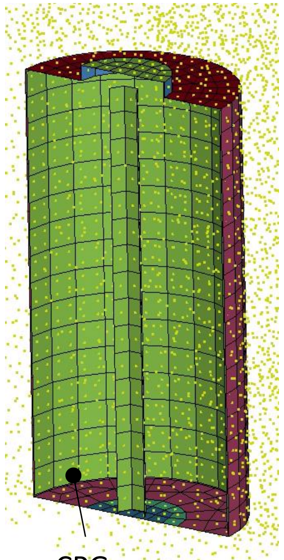
- Demand for solution to perform battery cell venting events and consider ejecta and debris deposition.
- Represent ejecta with discrete sphere particles.
- Introduction of terms to couple CPG and DEM.
  - Coupling force, Thermal coupling.

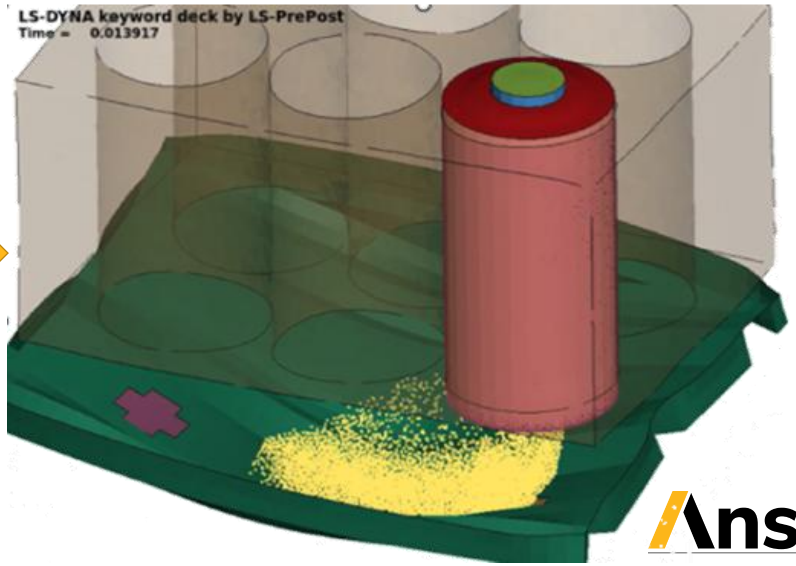


[7]









Hot wall

DEM

CPG

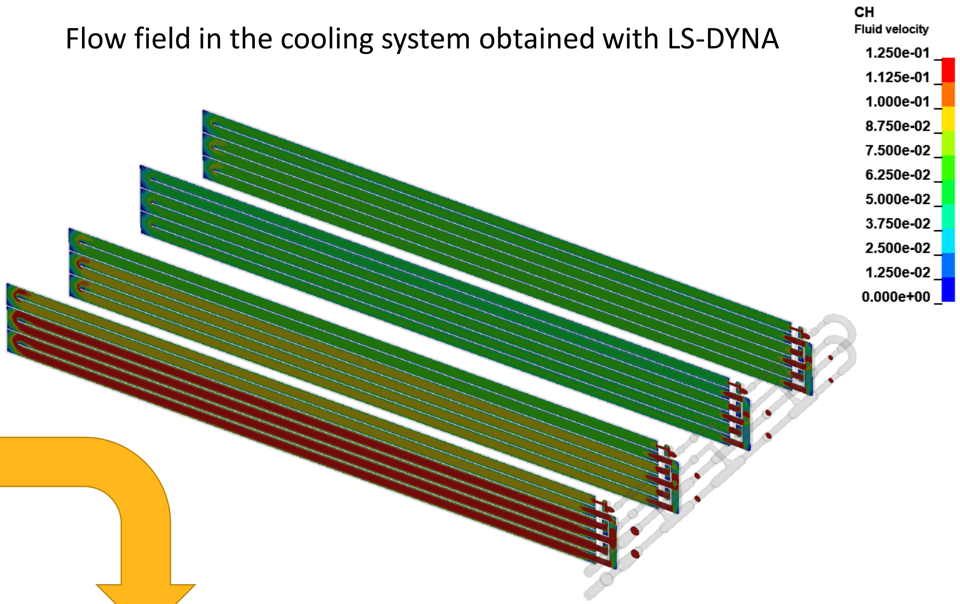
Courtesy: Raphael Heiniger, Lead Application Engineer

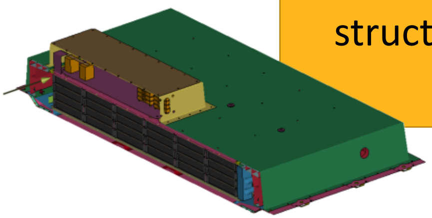
Ansys part of Synopsys

ICFD Enhancement for Thermal Battery Management

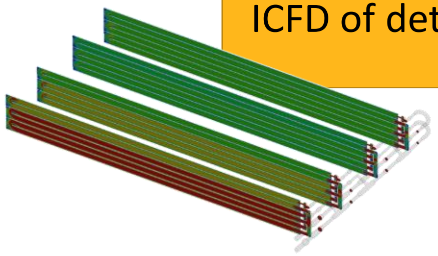
- Introduce the new approach to conjugate heat transfer using the ICFD-solver.
  - Export fluid flow (velocity, pressure) to binary file.
  - Include and automatically map from binary file.
  - Flow field can be obtained in LS-DYNA another code.

Flow field in the cooling system obtained with LS-DYNA





Battery pack thermal, structural model with coarse cooling system



Steady state fluid simulation in ICFD of detailed cooling system

Export the fluid flow as a result file

new

Binary flow-result file (velocity, pressure)

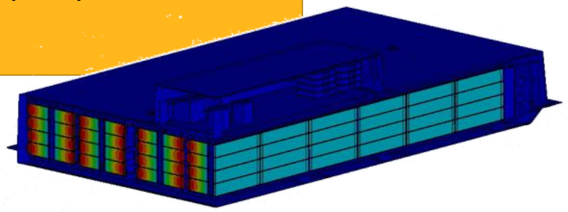
Including and mapping of flow-result file into new run

new

Transient thermal simulation ICFD + thermal + (EM) on crash model

Various thermal loading:

- Initial temperatures
- Heat generation in cells

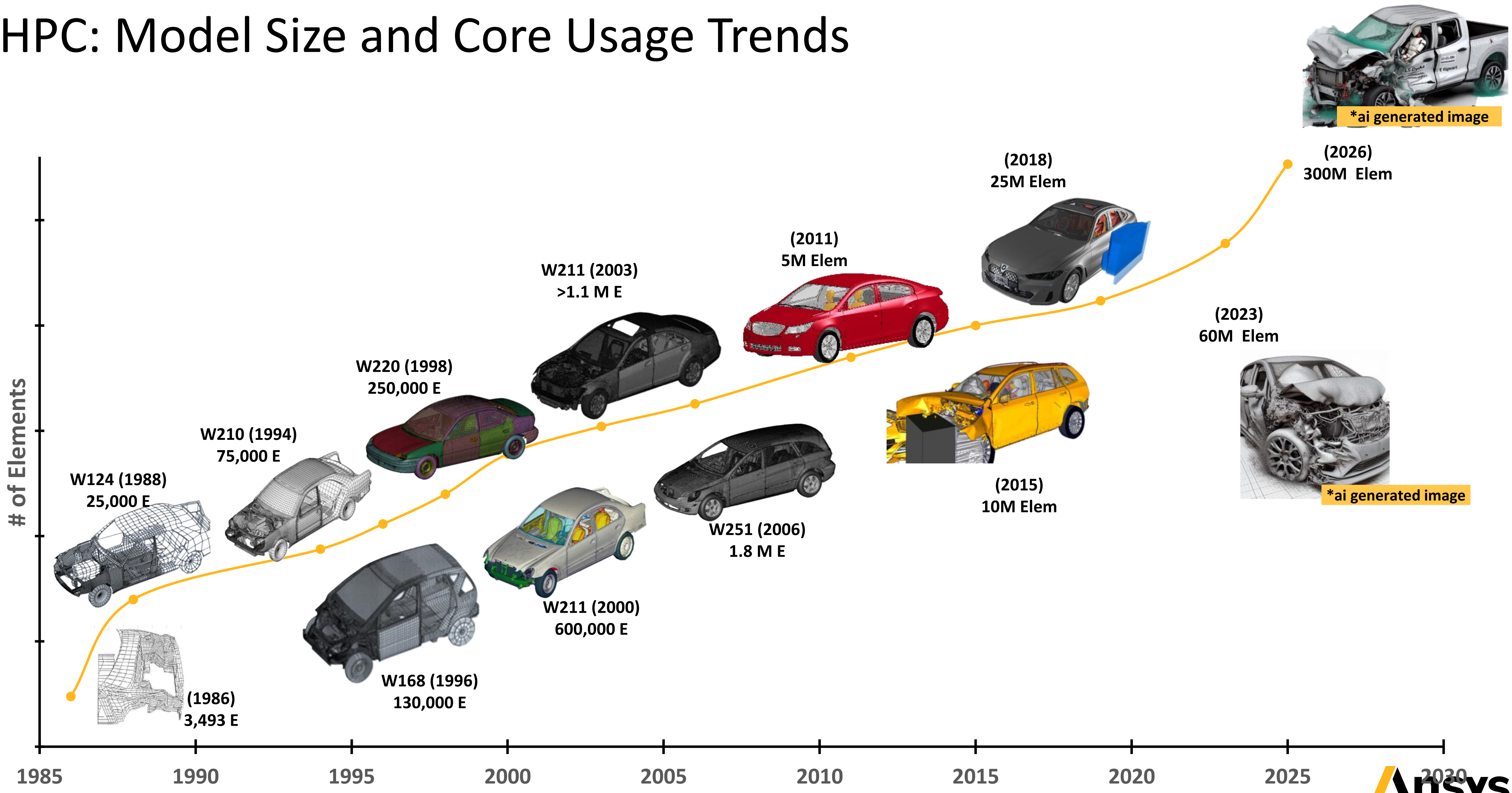


Courtesy: Raphael Heiniger, Ansys ACE

HPC

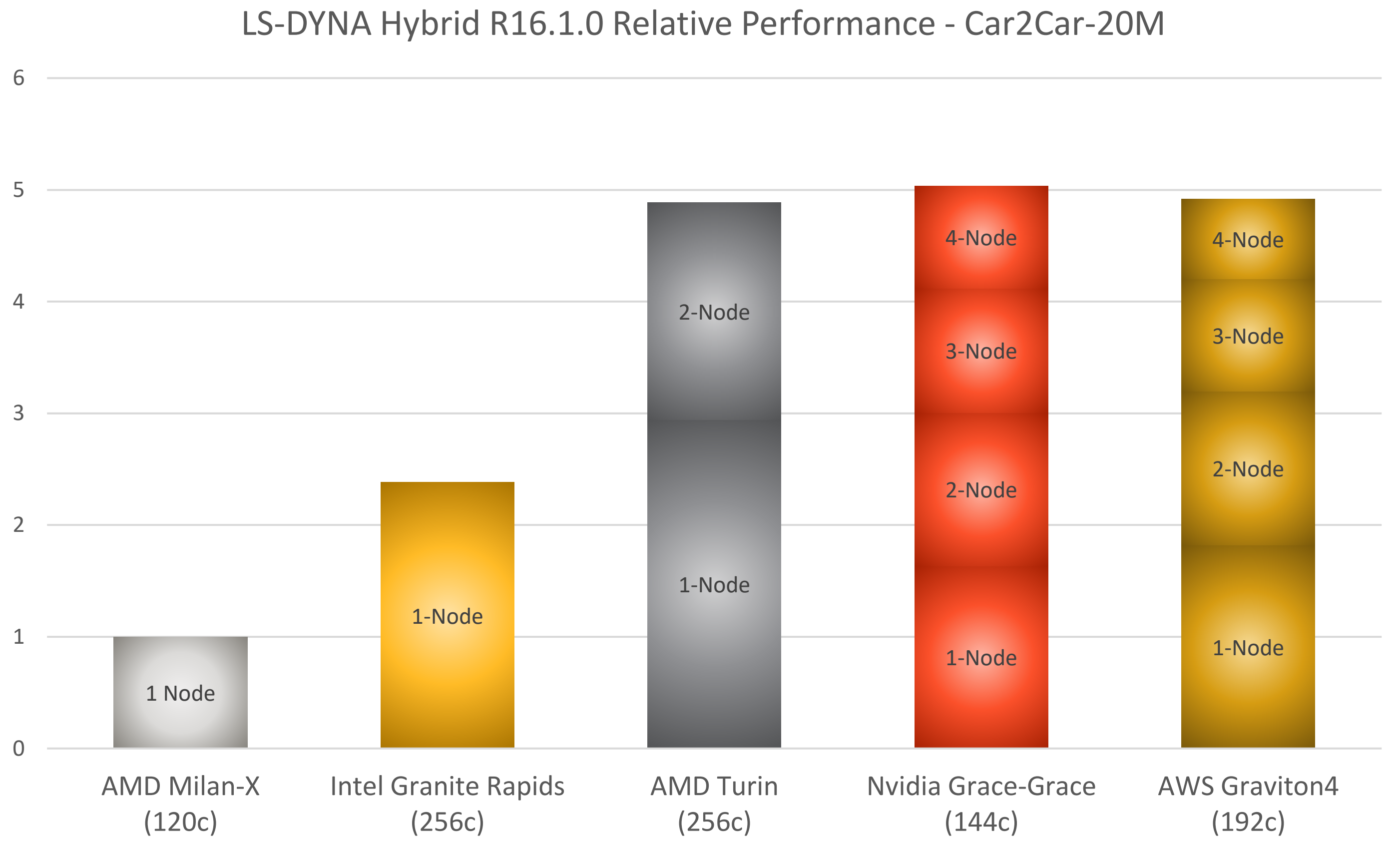
CPU/GPU

HPC: Model Size and Core Usage Trends



Ansys part of Synopsys

Latest CPU Performance: x86 and ARM64

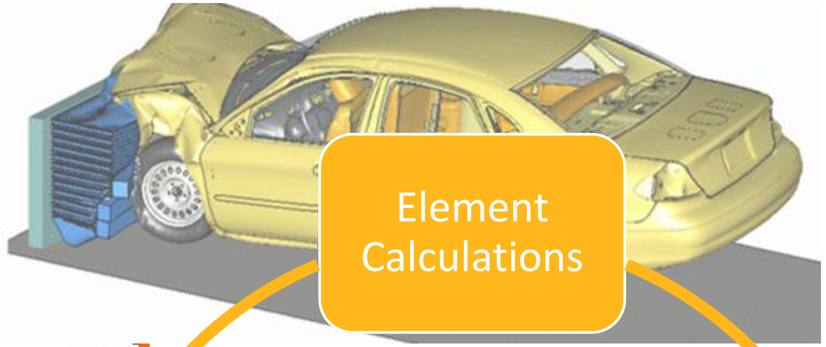


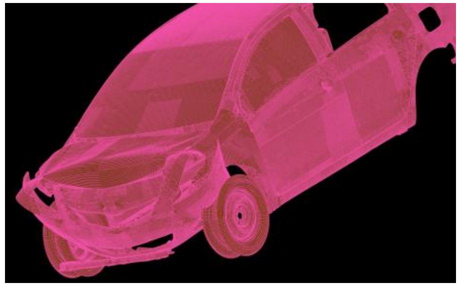
LS-DYNA R16.1.0 Hybrid
x86 AMD – AOCC4.2 avx2
x86 Intel – ifort190 avx2
ARM64 – Armflang23.1 neoverse-v2
Open MPI 5.0
Car2Car-20M

CPU	SKU/Instance	Cores per Node	Interconnect + rate
AMD Milan-X	AMD EPYC 7V73X	120c	
Intel Granite Rapids	Intel Xeon 6980P	256c	
AMD Turin	AMD EPYC 9755	256c	InfiniBand 2xNDR (200Gb/s)
Nvidia Grace-Grace	Grace CPU Super Chip	144c	InfiniBand 4xNDR (400Gb/s)
Amazon Graviton4	m8g.48xlarge	192c	EFA (50Gb/s)

Ansys part of Synopsys

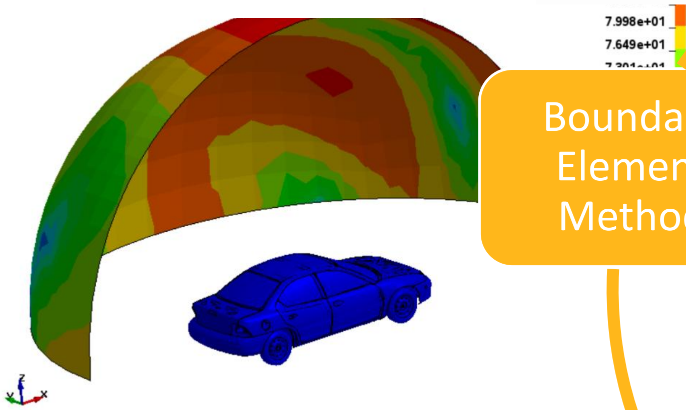
LS-DYNA GPU Solver R&D - Preview





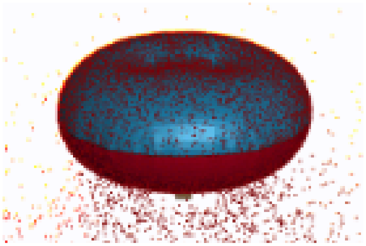
Near-constant search time as number of interactions increases

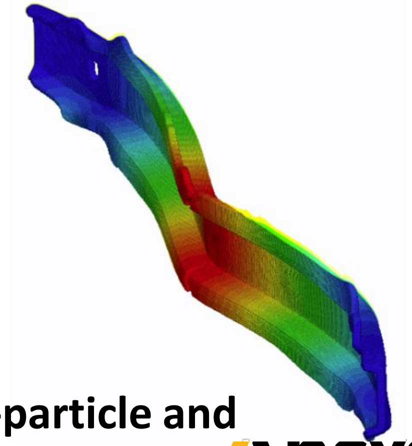
Multi-node / Multi-GPU acoustics simulation



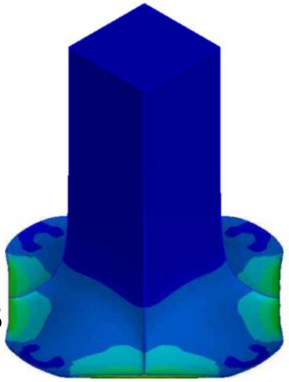
GPU offloading

- Element Calculations
- Contact Algorithms
- Particle Methods
- Isogeometric Analysis
- Boundary Element Method





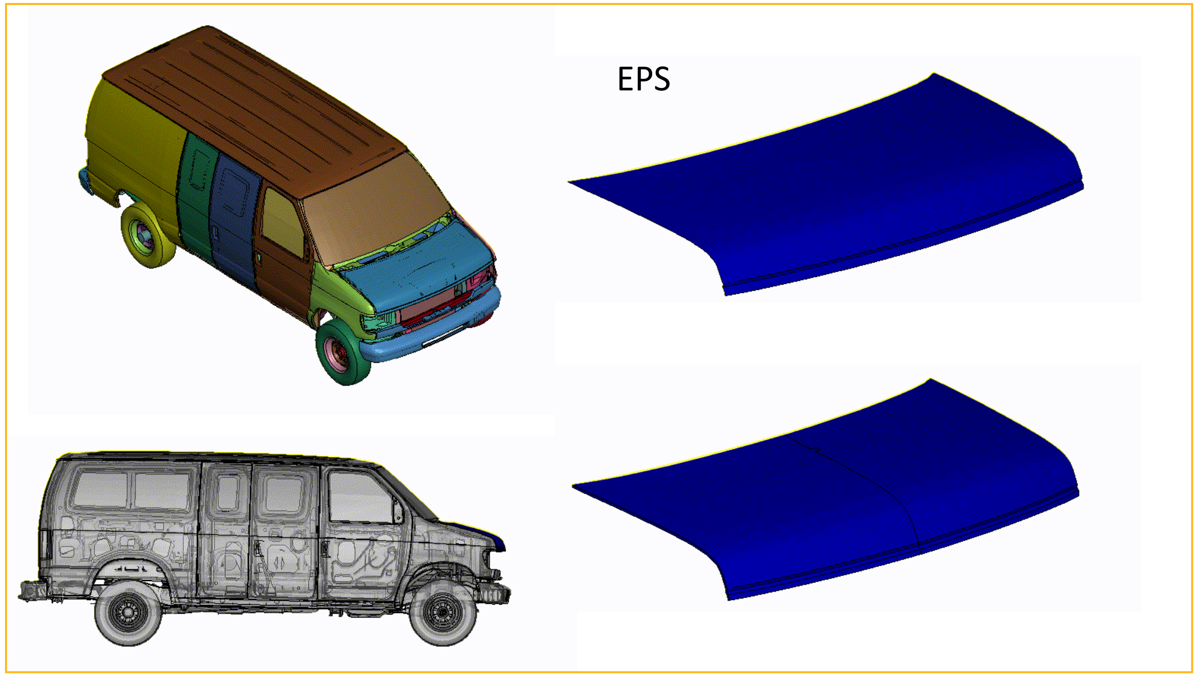
Accelerating particle-to-particle and particle-to-structure interactions

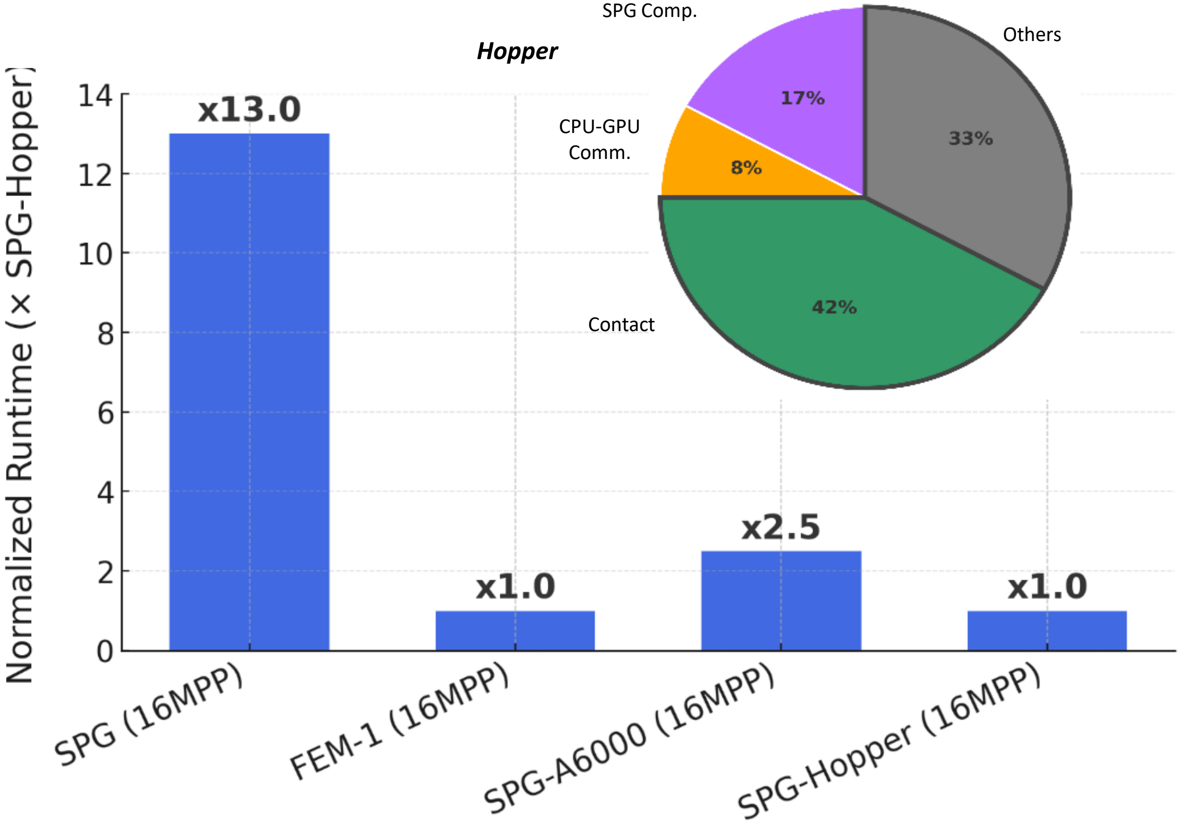


Large deformation analysis of solid bodies

GPU: SPG-GPU coupling with FEM (Early Preview)

- Original car model: ~300k elements
- Hood part (refined with 4-layer solids): 137k HEX elements / 176k SPG particles
- Hardware: Intel Xeon 4210 (CPU), Nvidia RTX A6000 (GPU)





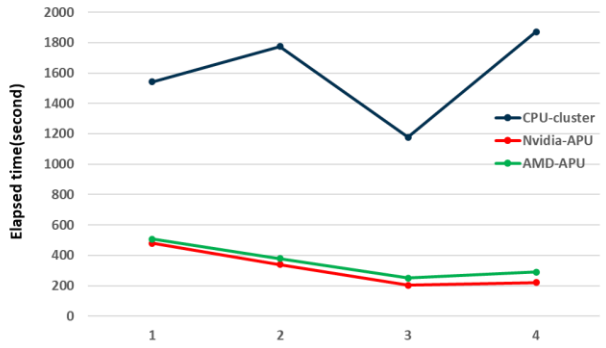
FEM 1: Reduced Integration Finite Element Model

Ansys part of synopsys

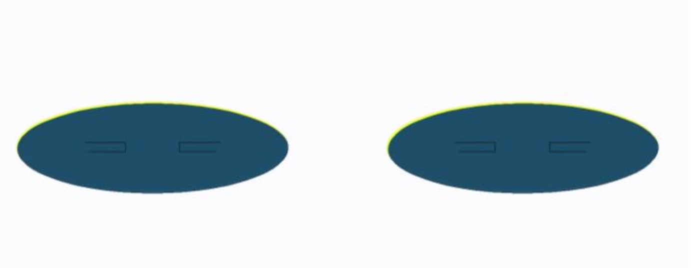
GPU: Particle Solvers in Action (Early Preview)

CPM Flat Air Bag

- 3-million CPM particles
- Most of the computational cost is from CPM

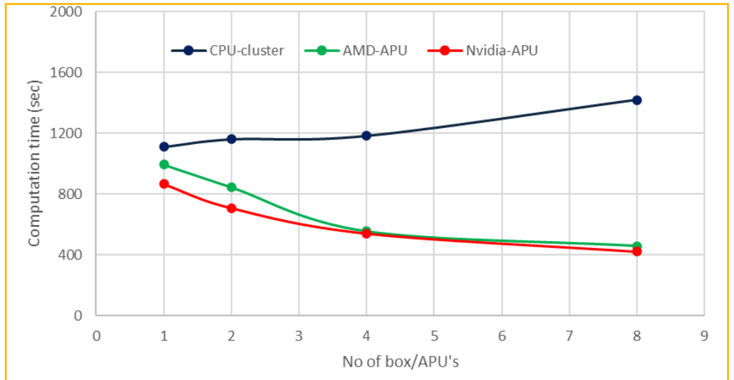


CPU-Cluster: Yx48 *APU*

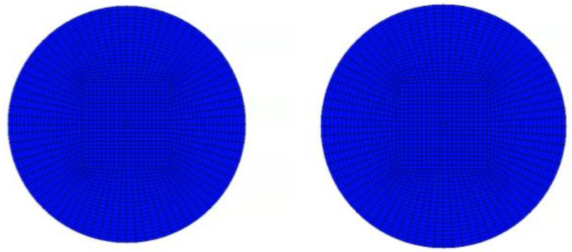


PBM Solver for explosive

- 5-million High explosive and 3-million air particles
- Most of the computational cost is from PBM

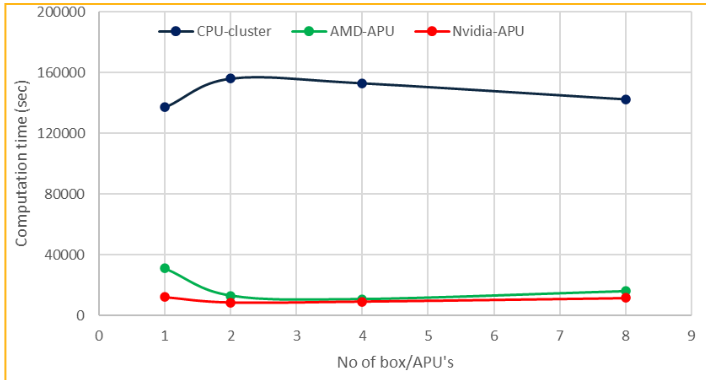


CPU-Cluster: Yx48 *APU*



DEM Solver

- 5-million DEM particles.
- Most of the computational cost is from DEM



Simulation with funnel sieving example

CPU-Cluster: Yx48 *APU*

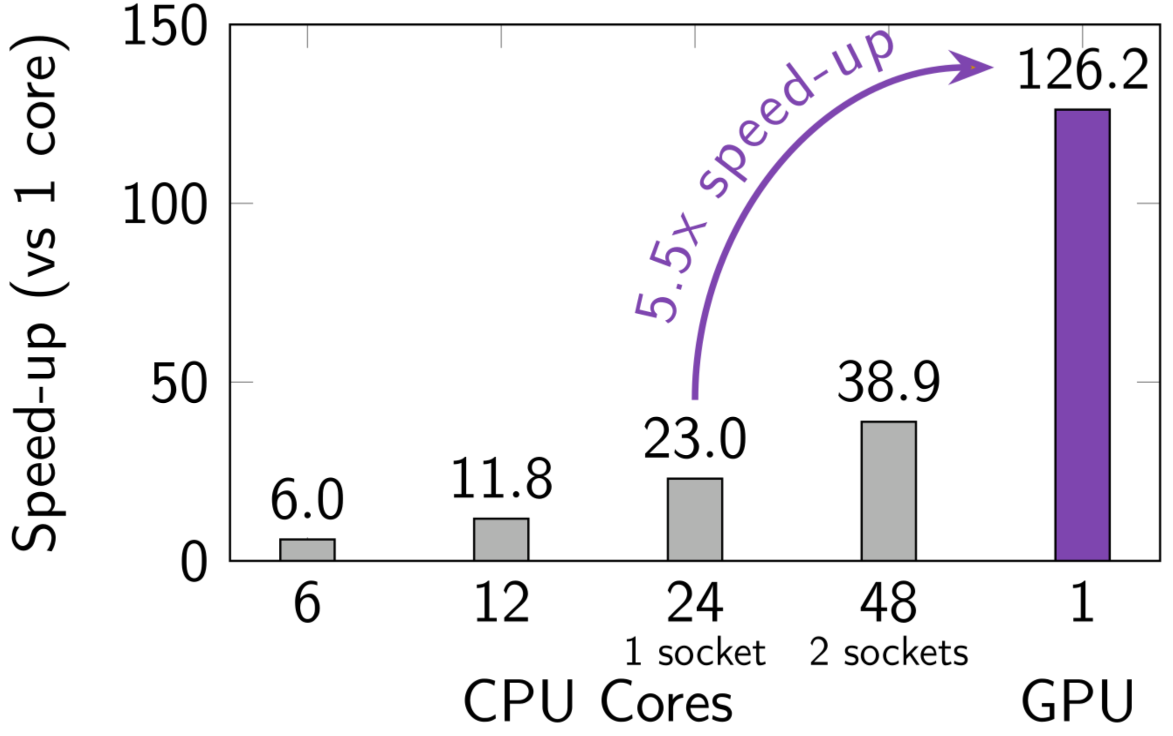
GPU: Sparse Equation Solver for Implicit & Multiphysics (Early Preview)

- We are adding GPU capabilities to our **in-house sparse direct solver**.
- We are considering all types of GPUs, from laptop to datacenter cards and "superchips".
- Comparing CPU (Intel Xeon Gold 6548Y+, 32 cores, Emerald Rapids) and GPU (NVIDIA **H100** NVL, 94GB).
- Four mechanical problems, 5-20M dofs. Factorization time:

Problem	CPU time(s)	GPU time(s)	Note
#1	34.6	7.9	Factorization fits entirely on the GPU.
#2	21.1	8.0	
#3	91.6	58.2	Doesn't fit entirely on the GPU; requires moving data back to the CPU on the fly.
#4	98.9	26.2	

GPU: Acoustics BEM solver (Early Preview)

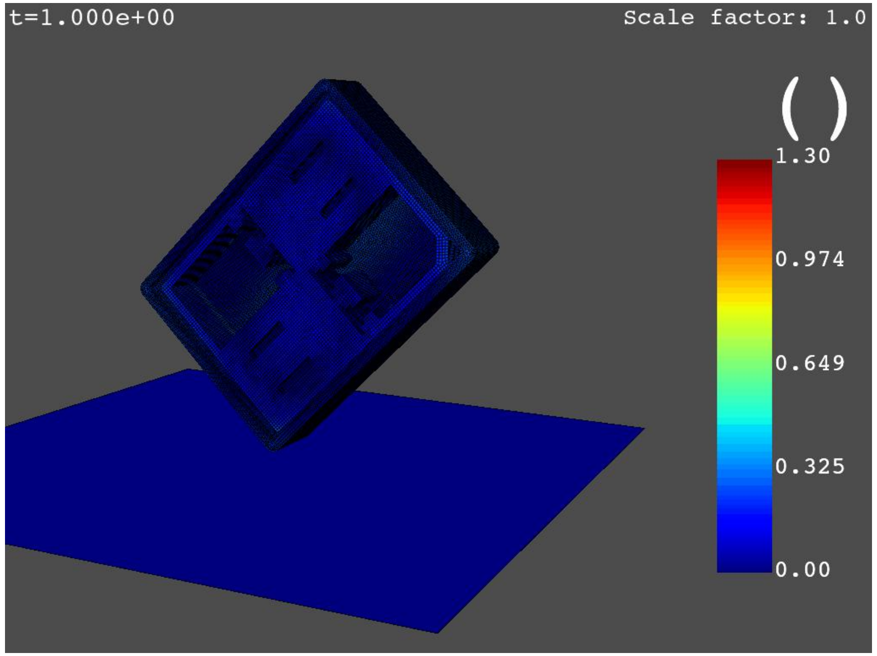
- We are adding GPU support to our **Boundary Element solver for Acoustics**.
- We are considering all types of GPUs, from laptop to datacenter cards and "superchips".
- Example, engine block problem (78k BEM dofs).
  Two 24-core Intel Xeon Gold 6542Y (Emerald Rapids) + 1 NVIDIA **H100** NVL.



Ansys part of Synopsys

PyDyna – Pythonic API for LS-DYNA

Interact with DYNA solver through pythonic functions



What is PyDyna?

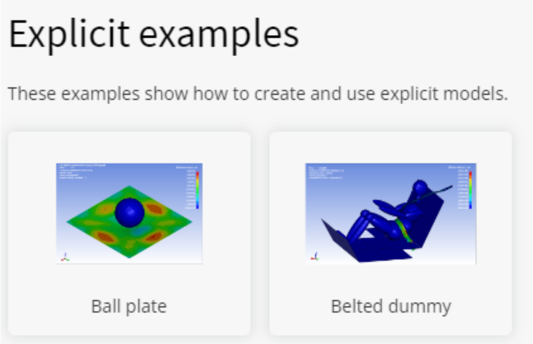
- Curated, well documented, high-level Pythonic APIs for LS-DYNA.
- Covers Pre/Solve and Post processing scenarios.

Why is it used?

- Creating Custom workflows.
- Generate data & models for Machine Learning.
- Building custom applications.

How is it used?

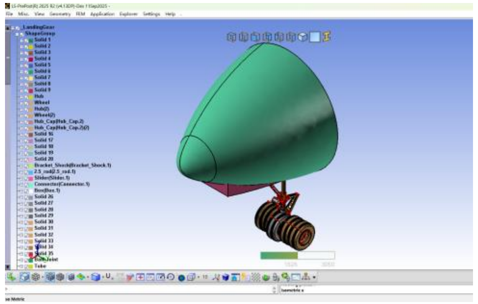
- APIs and documentation on Github: https://dyna.docs.pyansys.com/version/stable/
- Easy to follow examples.
- Also available through Jupyter-notebook.



Pre/Post in LS-PrePost

LS-PrePost New Features

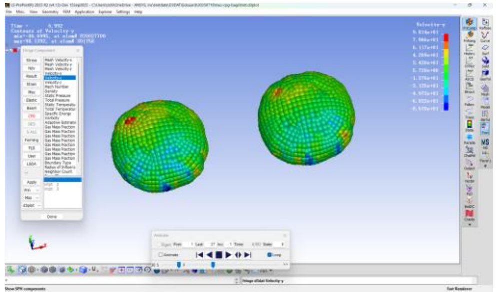
Data exchange for CAD files

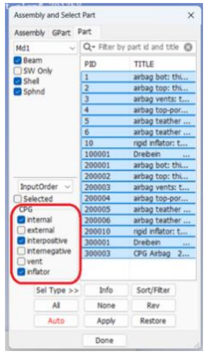


- Parasolid File
- ACIS File
- AutoCAD File
- CATIA v4 File
- CATIA v5 File
- Inventor File
- JT File
- UG File
- SolidEdge File
- SolidWorks File
- Creo-Pro/E File

D3DAT file support for CPG

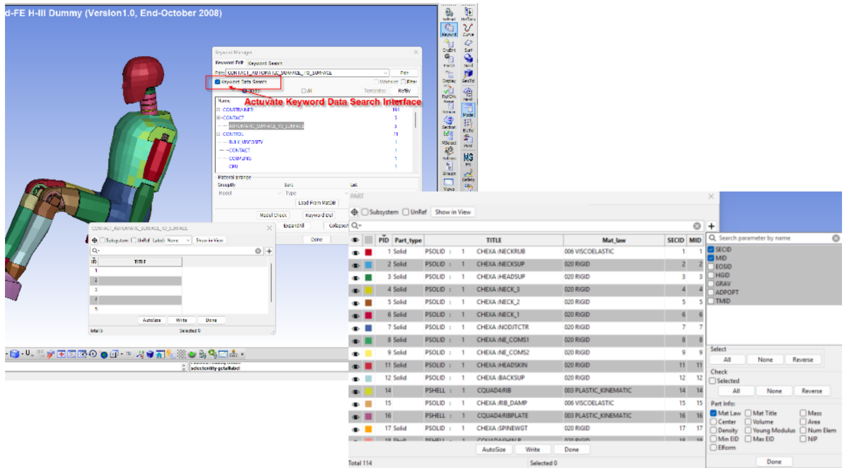
show different types of CPG with different colors



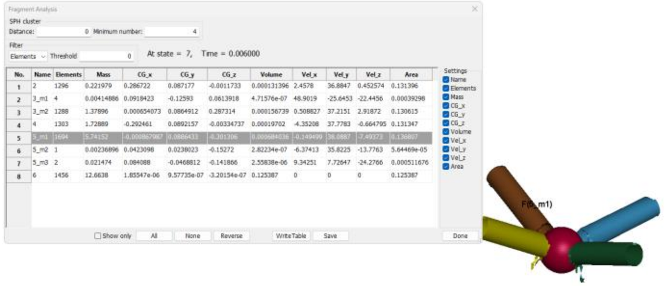


Keyword Data Search

Powerful tool to search keyword data with filtering

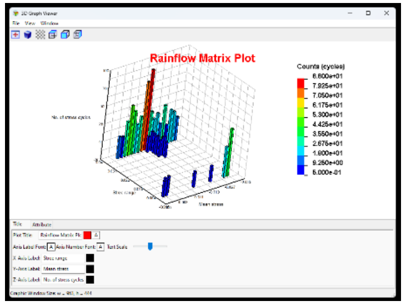


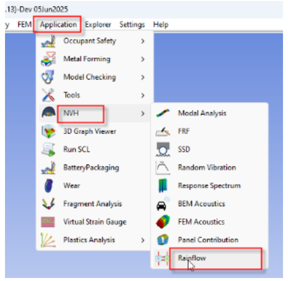
Fragmentation Analysis



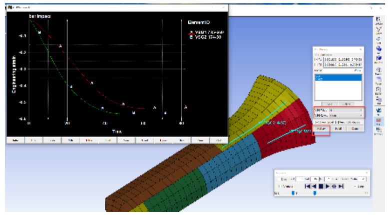
*Rainbow Matrix Plot

Rainflow matrix is a set of 3D data saved by LS-DYNA NVH Fatigue Analysis, it saved the stress range, mean stress and no. of stress cycles (counts)





Virtual Strain Gauge

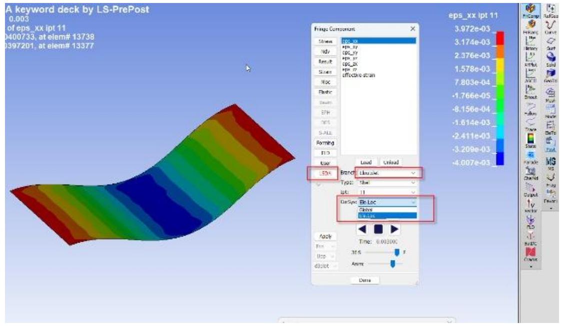


Ansys part of synopsys

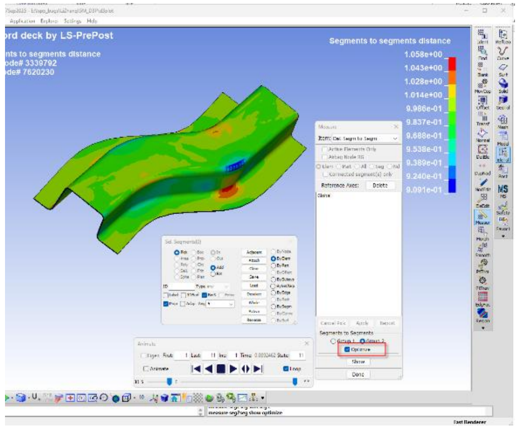
LS-PrePost New Features

Fringe LSDA File

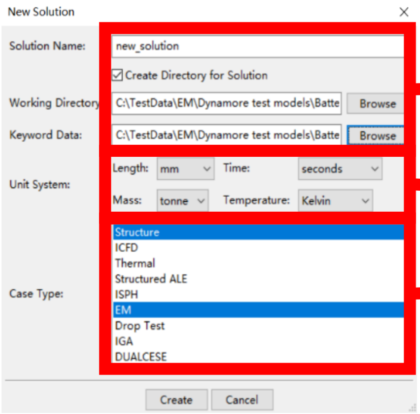
LSDA is a database file format written by LS-DYNA, files that are in LSDA format are binout (time history data), dynain(binary), d3dat, d3ispg, etc.

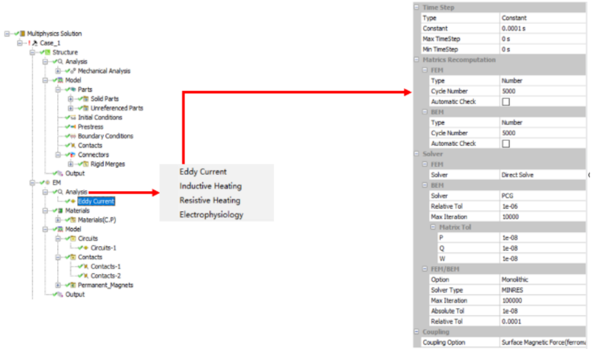


Segment-to-Segment distance Measurement



Solution Explorer - EM





LS-Reader and pyDPF

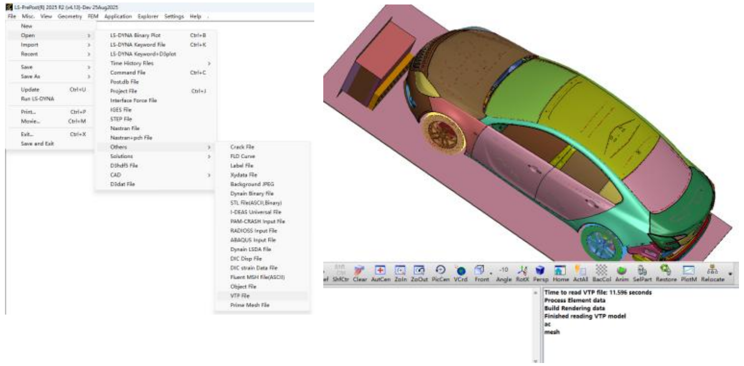
LS-Reader updated to version 0.1.87

- Support latest FEMZIP library version 17.1.901
- Support more LS-DYNA LSDA files such as SPH, DES, CPG, CPM
- Binout files, more branches are being supported (numbers are being increased continuously)
- Python version 3.11

pyDPF Plugin

- Support TSHELL data
- Support shell integration point data for all layers (composite)
- Support LSDA file format
- Support FEMZIP version 17.1.901

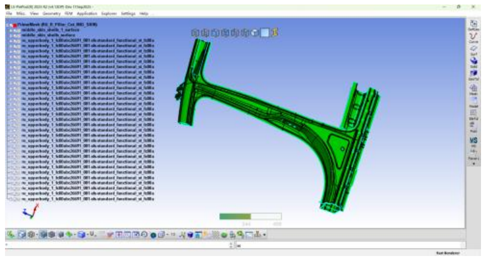
Saving and Reading VTP files



Nastran to LS-DYNA Conversion

- Element Conversion:
  - Shell -> *ELEMENT_SHELL, *ELEMENT_SHELL_OFFSET, *ELEMENT_SHELL_THICKNESS
  - Solid -> *ELEMENT_SOLID
  - 1D ELEMENT -> *ELEMENT_BEAM
    - Use *INTEGRATION_BEAM for T and Channel cross sections
- Material Conversion:
  - MAT1 + MATT1 -> *MAT_106
  - MAT9 -> *MAT_002_ANISO
  - TABLEM1/2/3 -> *DEFINE_CURVE
  - PCOMP -> *PART_COMPOSITE
  - PCOMPG -> *PART_COMPOSITE_LONG
- Coordinate System transformation -> Can handle Multiple levels transformation to Global
- Include file Handling -> Keep all Nastran include file structure and output in LS-DYNA include files
- Use “save keywordbylongfmt 1” to handle long format (double precision) data

PrimeMesh data Support – Read and Display .pmdat file

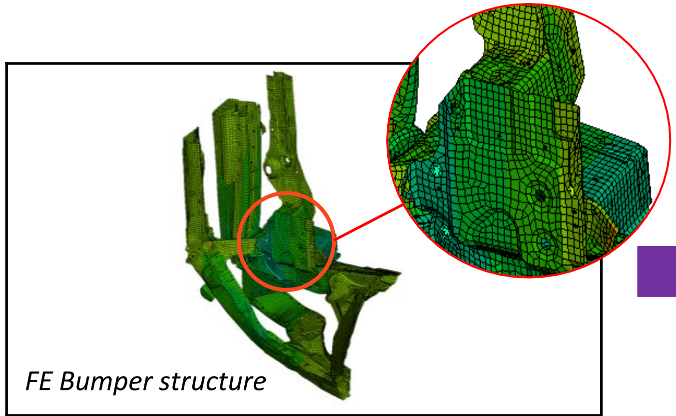


Ansys part of synopsys

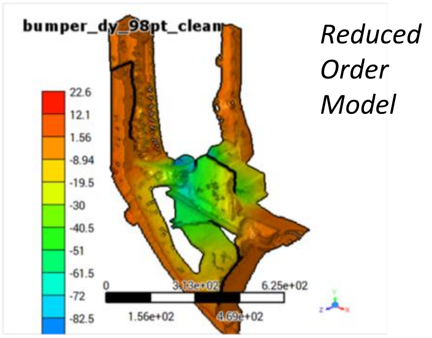
Optimization - LS-OPT & LS-TaSC

Parametric, Topology & Shape Optimization

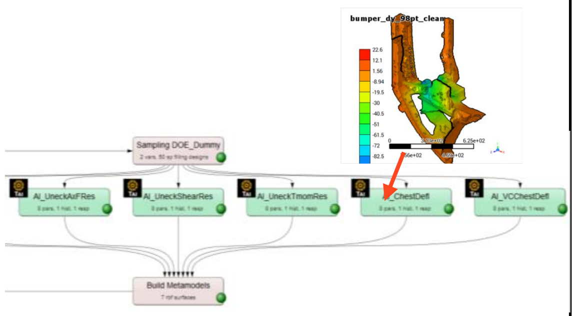
Twin Builder ROM Integrated Workflow



LS-DYNA/LS-OPT



Ansys TB/TwinAI



LS-OPT/LS-DYNA/TB

Training Data Generation

- LS-OPT *DOE* is used to perform multiple LS-DYNA simulations
- LS-OPT *extracts* the full field dynamic output of these simulations, and *exports* in TB format

ROM Creation

- Twin Builder consumes the generated data to create *Dynamic Field ROMs*
- ROM is exported as a `.twin` file

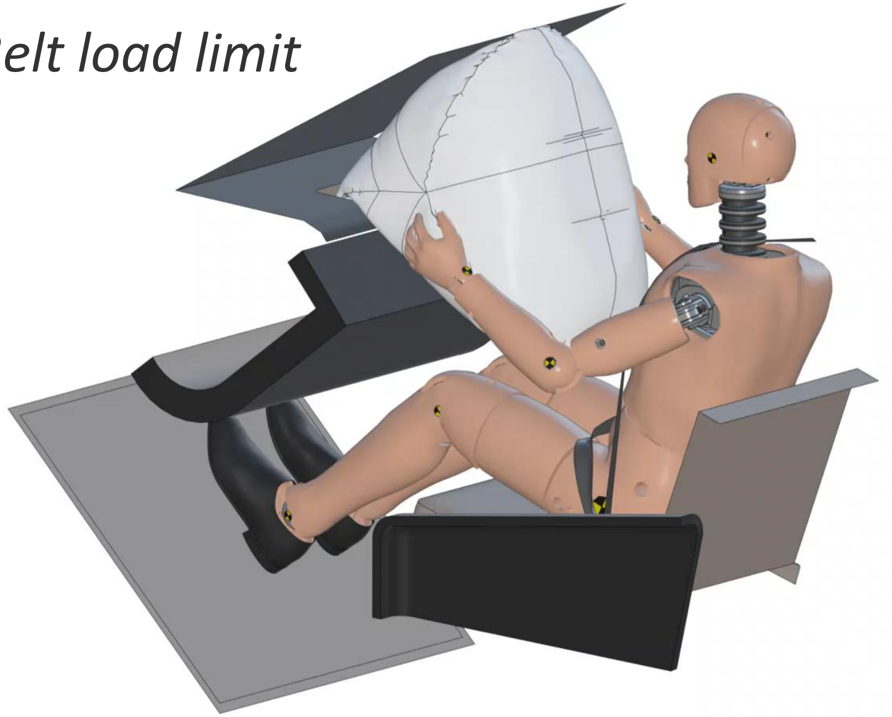
ROM Consumption

- Sensitivity Analysis, Robust Design or Optimization can be performed in LS-OPT
- When *coupled* as a *substructure*, ROM can be used to accelerate 3D simulation in LS-DYNA

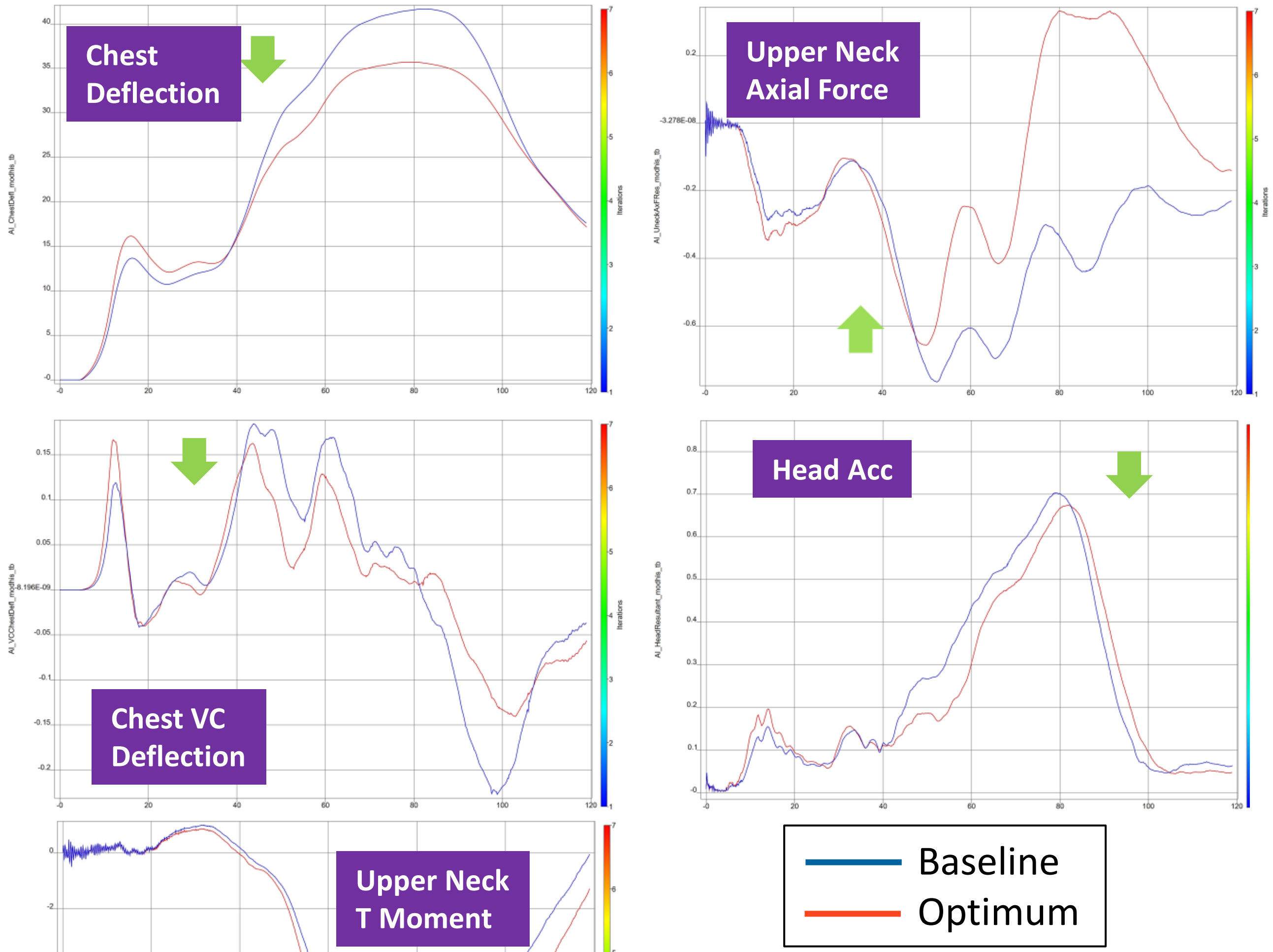
ROM Optimization of Occupant Restraint System

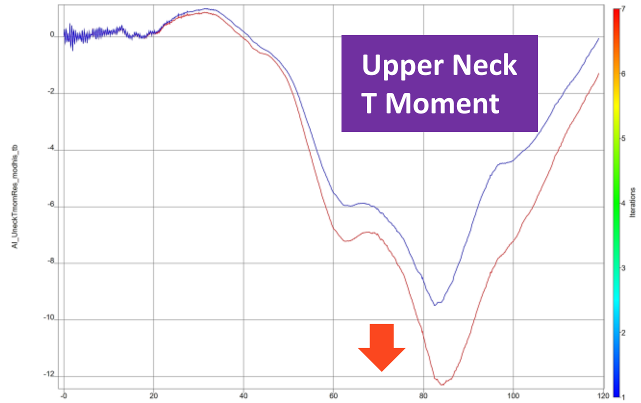
Same ROM as calibration

- *Min. Aggregate peak response* over 7 injury criteria (head, neck, chest)
- Variables
  - *Belt Pull-in length*
  - *Belt load limit*



Courtesy: Humanetics Group



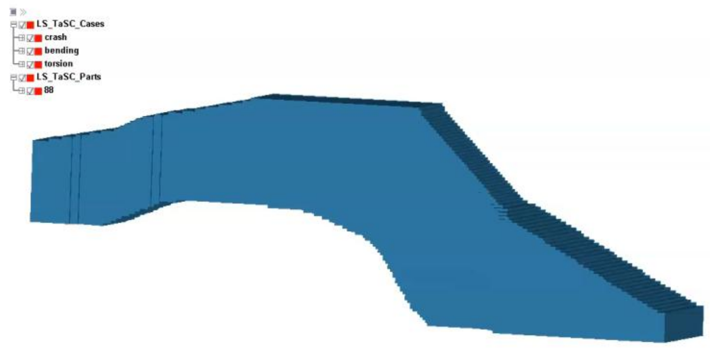


7 injury criteria = 5 improved+2 degraded (only 5 shown)

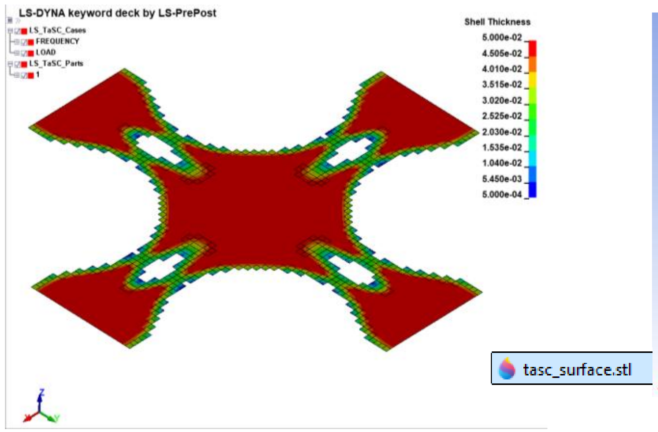
Ansys part of synopsys

LS-TaSC: Enhancing Topo & Shape Optimization

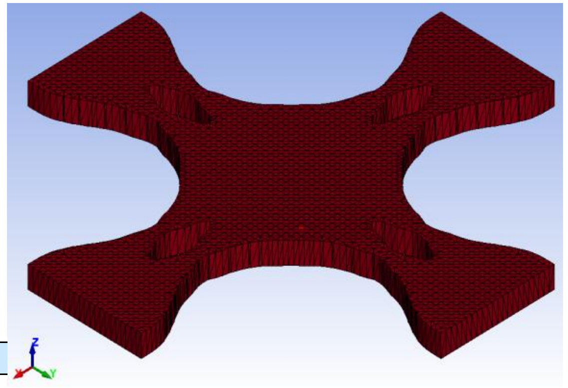
- Minimum/maximum feature size controlling to enable mega-castings integrated with energy absorption.
- Multidisciplinary design optimization of shell thickness, accounting for impact, static, and NVH load cases.
- Visualize and export shell structure thickness design in 3D format.
- Enable user-defined load cases and provide customization options for response editing, FE model modification, and interactive design workflows.



Design evolution of a rear torque box for energy absorption casting together with the minimum & maximum feature size controlling, which prevents the holes from casting.



optimum shell thicknesses (static & NVH)



structure with actual thickness

Conclusion

Release Management

Every **alternative** year LS-DYNA release will get **Long-term support**– E.g. 14, 16, 18…

Existing versions used in production will continue to get LTS support until discontinued. *

We continue to release new version with new features every year.

Hardware

Intel Hardware	AMD Hardware	ARM64 Hardware
Intel IFX 2025.2	Intel IFX 2025.2 or AMD AOCC 5.0	Arm Compiler 23.10

Math Library

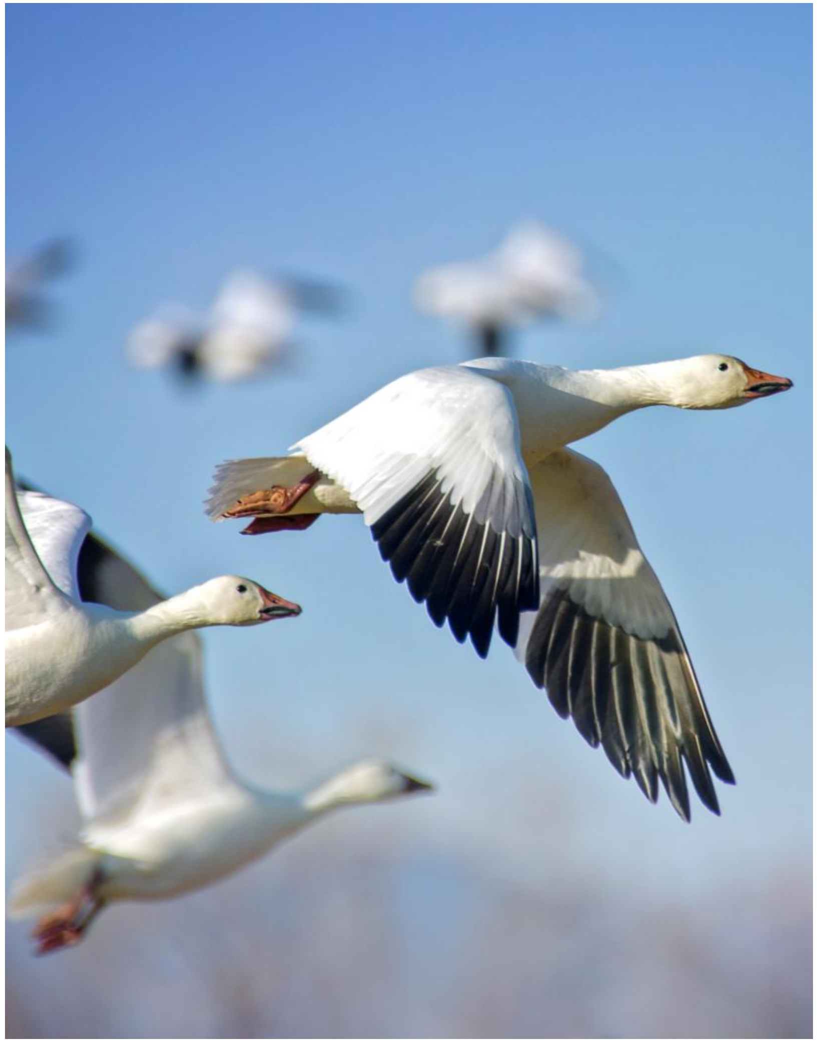
Intel IFX 2025.2	AMD AOCC 5.0	Arm Compiler 23.10
MKL 2025.2	AOCL 5.1	ArmPL 23.10

Upcoming Releases

LS-DYNA 13.2	LTS release	Service Pack	**Q3 2025**
LS-DYNA 14.2	LTS release	Service Pack	**Q3 2025**
LS-DYNA 16.1.1	LTS release	Service pack	**Q4 2025**
LS-DYNA 17.0	New Release	-	**Q1 2026**

Migration to Ansys License Manager

- Migrate ALL LST LS-DYNA licensing from LST LM to Ansys LM Licensing (FlexNet Publisher)
  - STANDARD License key issuing mechanism
  - Full Backward Compatibility Support with solver
    - Customer needs to install a small program (FlexConnector) for older versions and VENDOR support
  - Coming Soon



Key Takeaway

Ansys part of SYNOPSYS®

LS-DYNA

Model-based Simulation Workflow for Virtual Product Development

Design Driven, Model Based Workflows

Bridge Manufacturing & Simulation gap

Support size, scale needs through innovation.

Certification by analysis

Design Variational Study & Optimization

LS-OPT
LS-TaSC

Mechanical, Fluids, EM, Thermal, Multi-Physics Analysis

CPG, CPM, SALE,IGA,SPH,
ISPH, DEM, SPG,
Peridynamics
Two-scale Co-simulation,
NVH/Acoustics, Sub-cycling,
Electromagnetics
ICFD,CESE,...

Material Laws
Elements
Contact Constraints
Rigid-Body
Linear Algebra

Manufacturing Simulation

SPH, ISPH
ISPG
Ansys Forming
3D R-adaptivity (FEM & EFG)
SPG
Ansys Forming

HPC

LS-PrePost

Ansys

part of SYNOPSYS®