Novinky LS-Dyna R17

SVS FEM

Ansys part of Synopsys

Recent Developments in Ansys LS-DYNA

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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
- NVH/Acoustics
- Thermal
- Chemistry

Ansys LS-DYNA

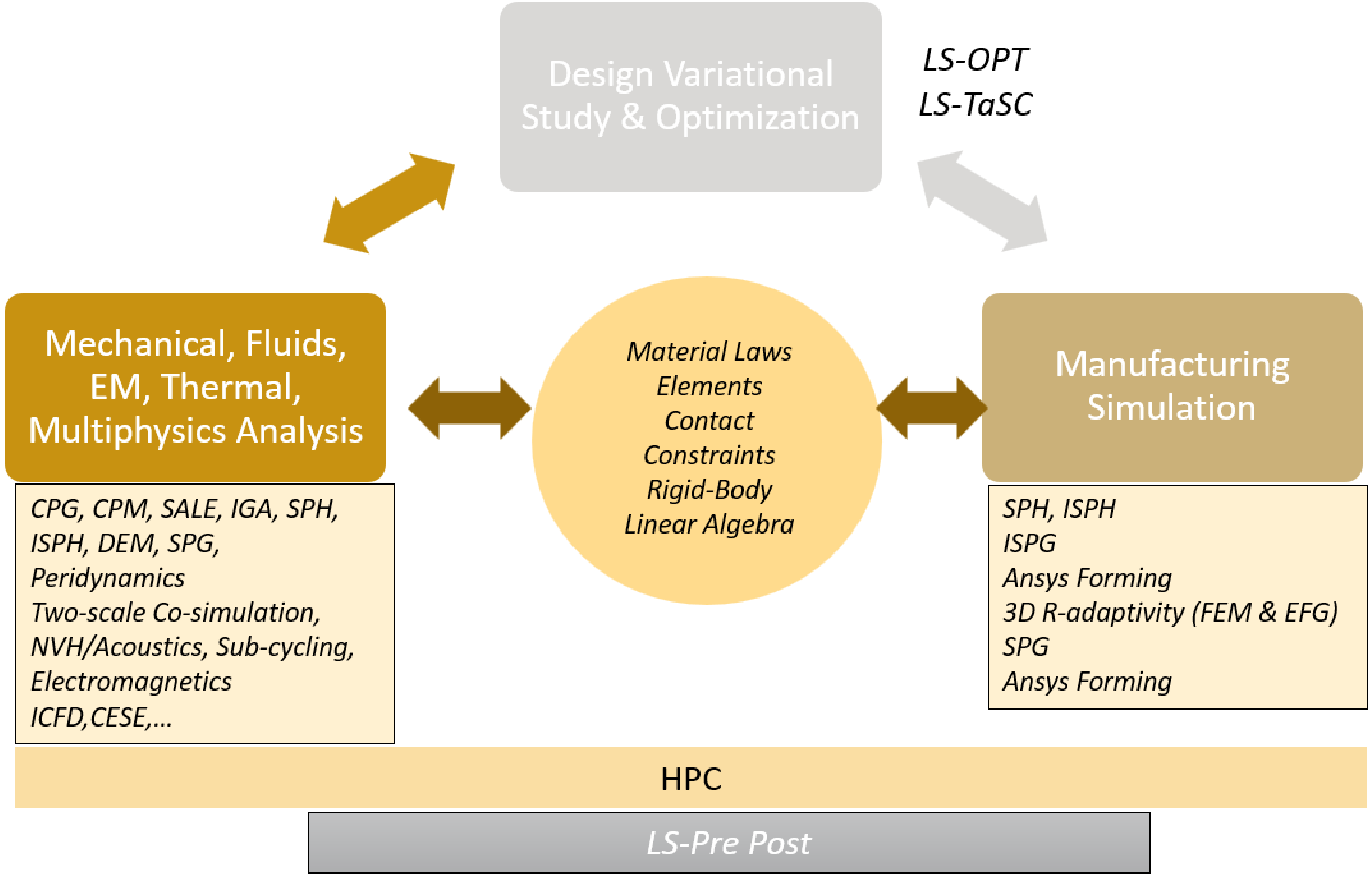
HPC / Cloud

- Crash
- Aerospace
- Biomedical
- Electronics
- Defense

LS-PrePost	LS-OPT	LS-TaSC	Mechanical	Ansys Forming	Dummies, HBM & Barriers	pyDYNA

SVS FEM

Model-based Simulation Workflow for Virtual Product Development



Manufacturing Simulation

Ansys Forming, ISPG, SPG

Ansys Forming

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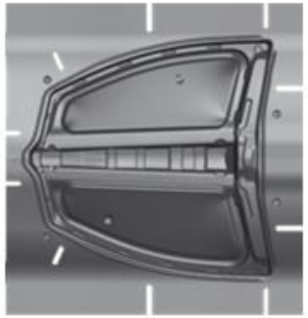
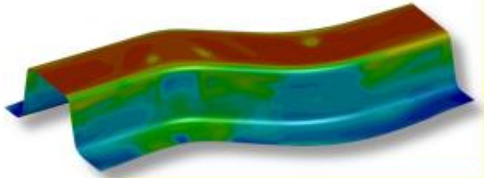
Cold/Hot Forming

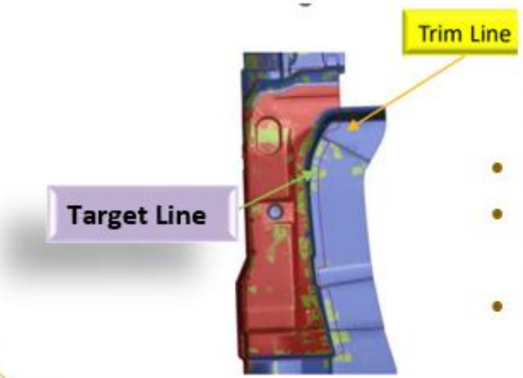
- Blanking
- Drawing
- Gravity Loading
- Trimming
- Springback
- Lancing
- Clamping
- Flanging/Restriking





Trim Curve

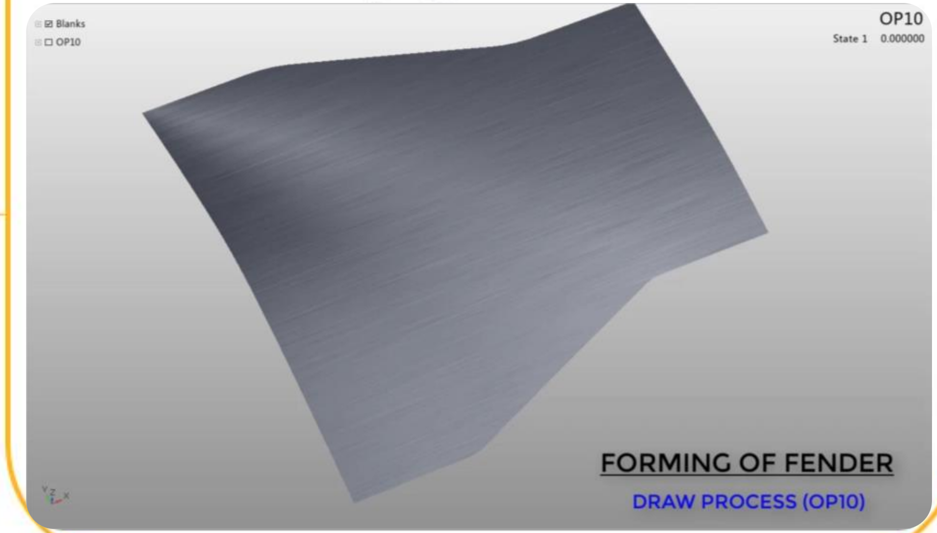
- Easy Geometric error validation
- Easy Trim line development

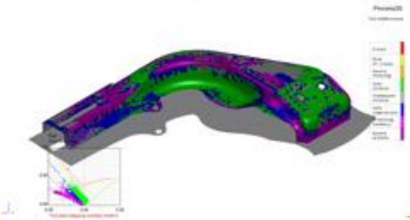


*One-Step

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

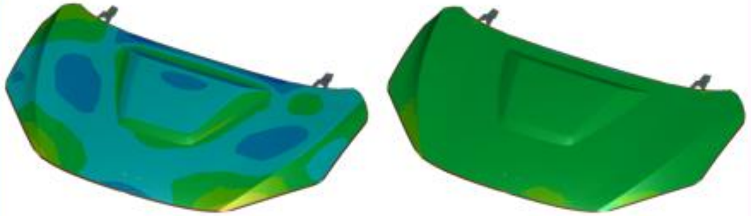
Dedicated Platform for Multi-Stage Stamping Simulations





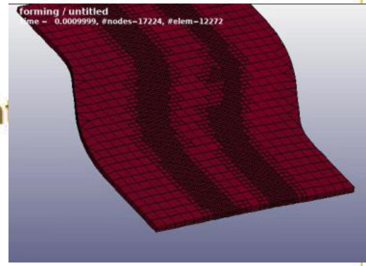
*Springback Compensation

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



*Solid Elements

- Auto mesh refinement
- Easy pre/post



*Dedicated Material Editor & Library

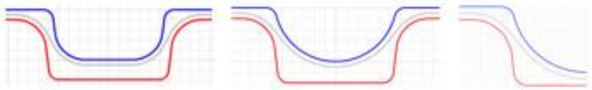
- Yield Locus
- Hardening Curve
- FLD Curve
- Support Most Stamping Related Materials

SVS FEM

Ansys Forming

Drawbead Design & Modeling

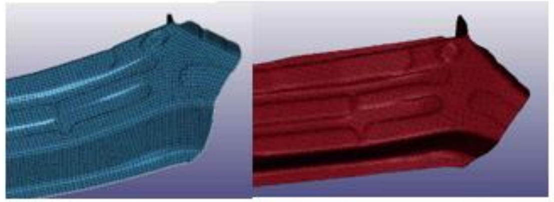
- *** Bead Force Estimation**
- Drawbead Profile Design



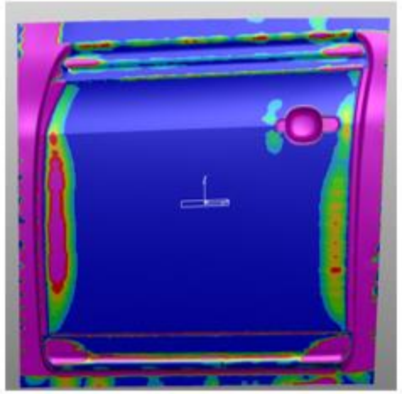
* Tailor Welded Blank

Innovative Specialized Features

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



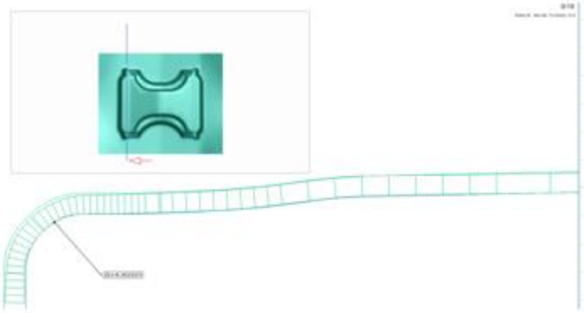
Bad Mesh Auto Fix



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

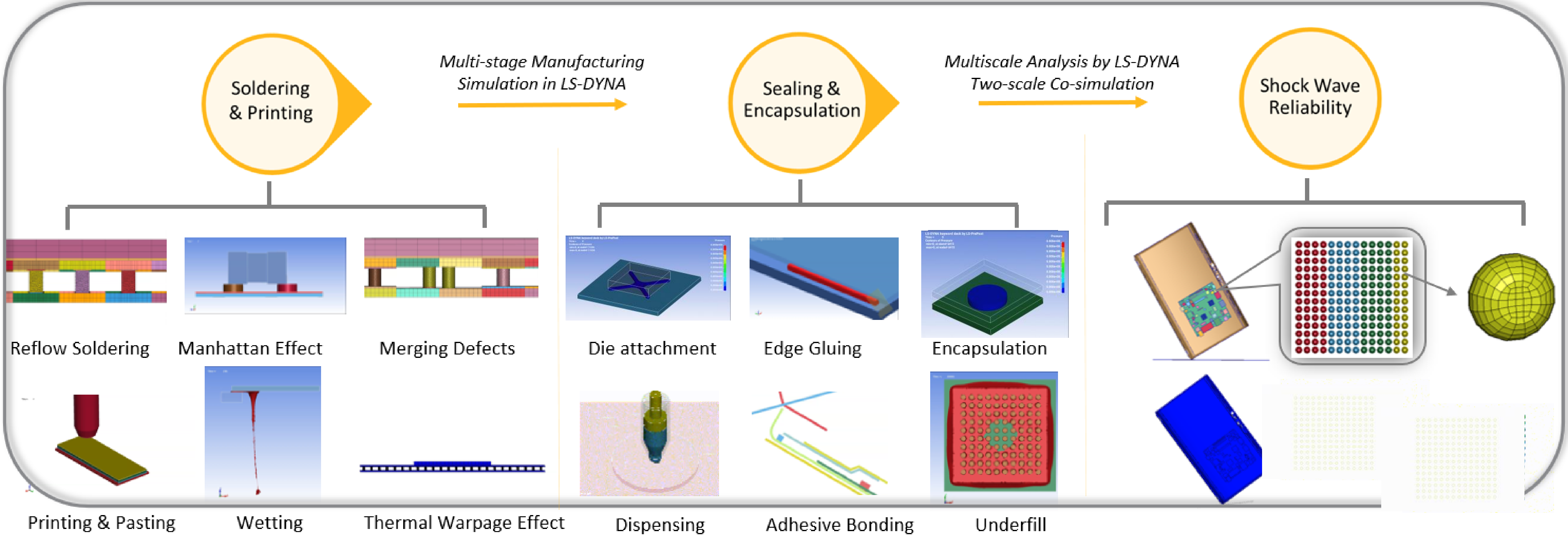
- User can control light source

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)

ISPG: Incompressible Smoothed Particle Galerkin

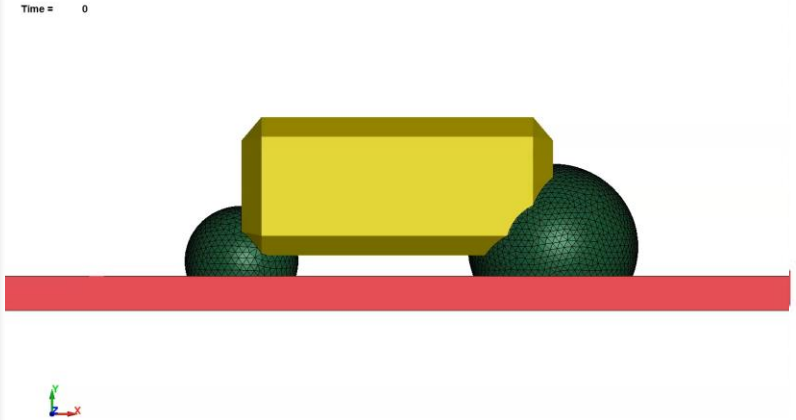
- A particle-based Navier-Stokes equation solver.
- Enables Free-surface fluid flow simulation with surface tension and adhesive force effects.
- ISPG in LS-DYNA has full-implicit MPP versions equipped with particle adaptivity capability.
- Support large-scale Newtonian and Non-Newtonian fluid modeling.



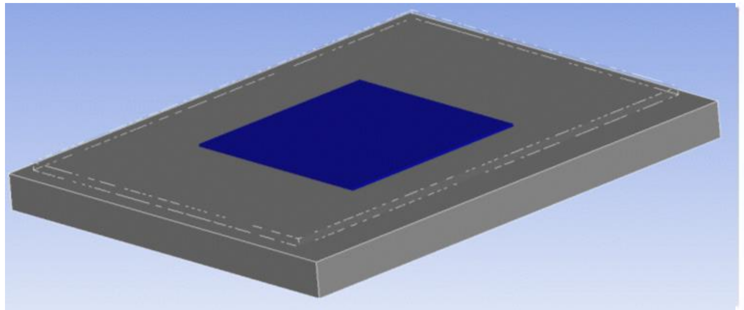
ISPG: Monolithic Fluid-Rigid Structure Coupling

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.

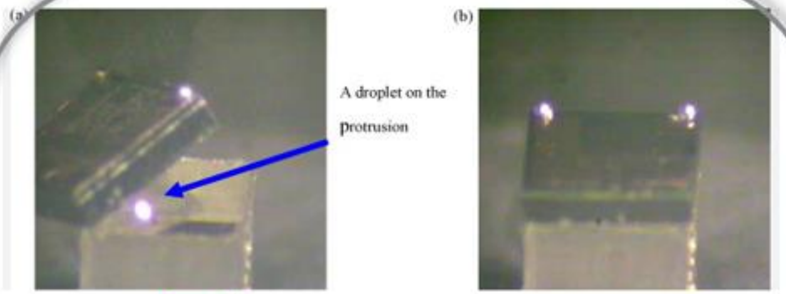


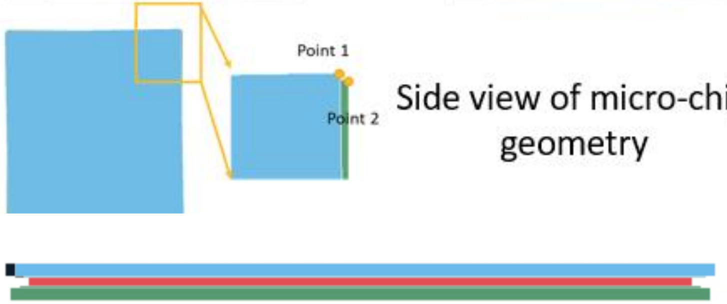
Simulation of Tombstoning Defect in Surface Mounting



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

Simulation of Force-driven Die Attach (Mount) Process





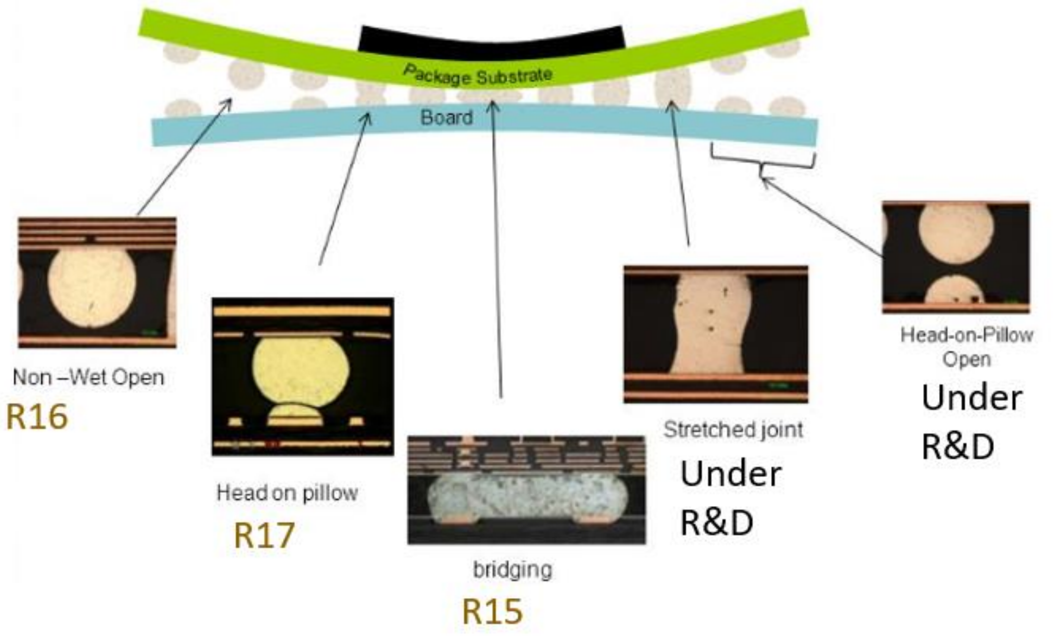
Side view of micro-chip geometry

core. Unavailable in current CFD methods.

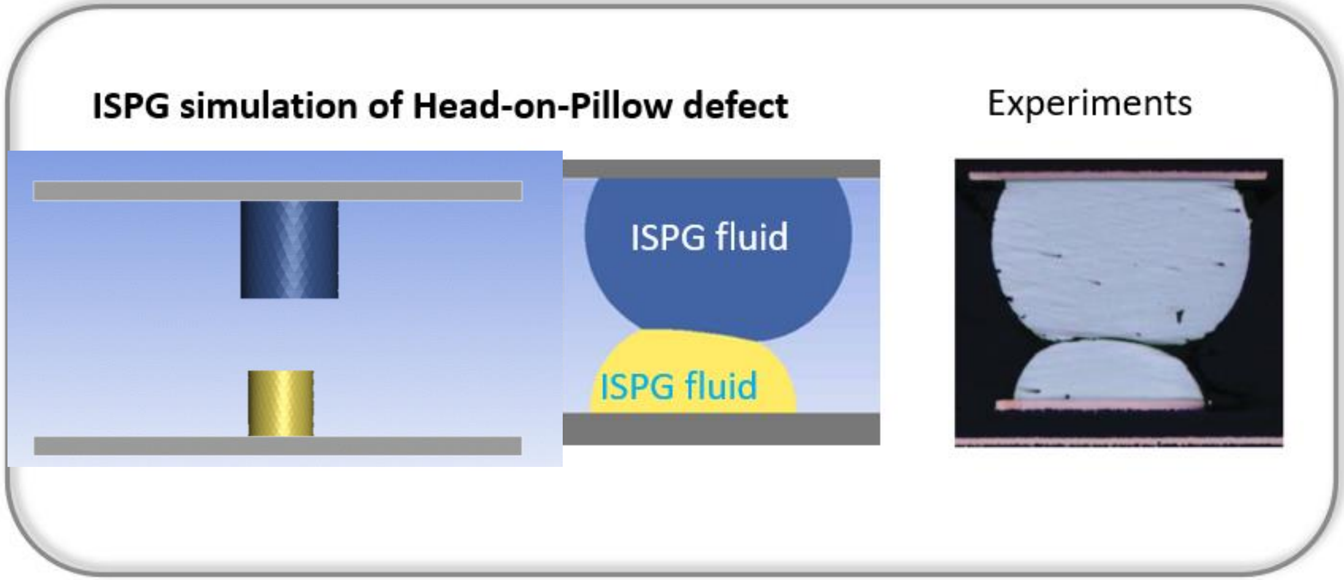
Simulation of Micro-chip Capillary Self-Alignment Process

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**.

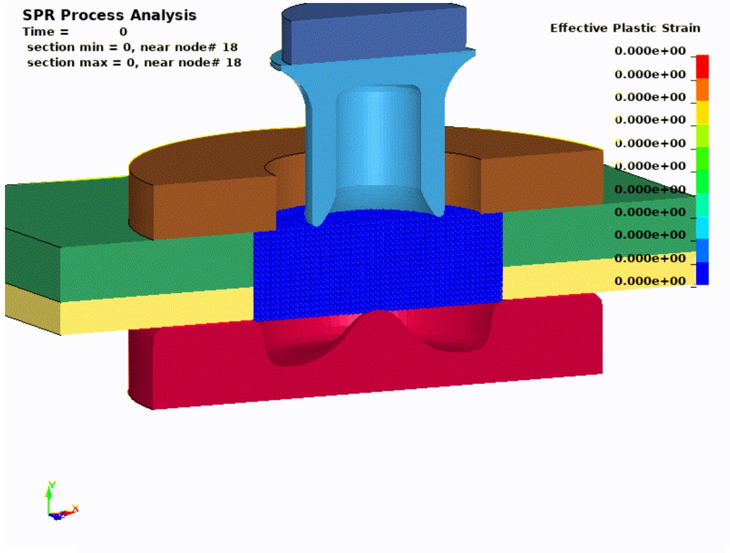


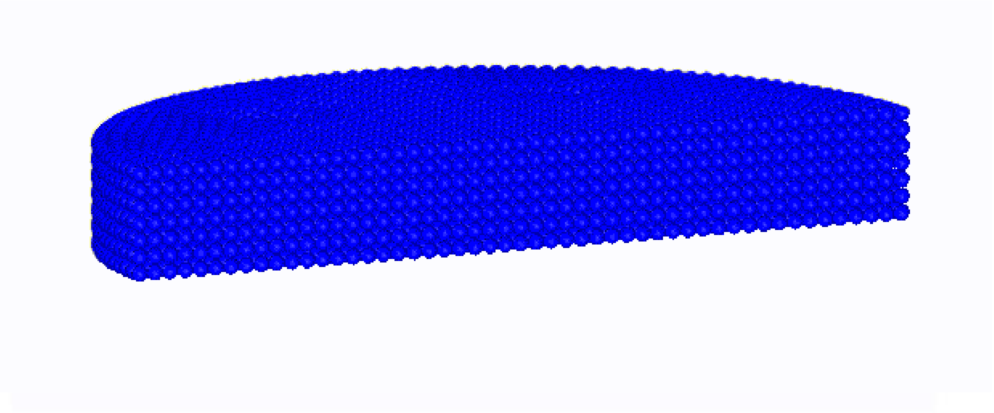
Five major manufacturing defects in reflow soldering process

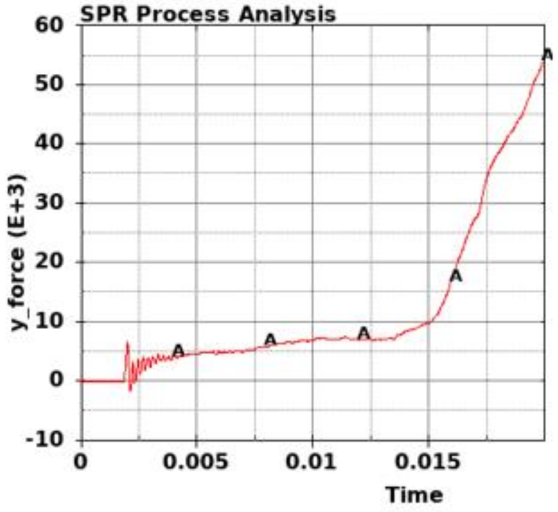


SPG: SPG to SPG Contact

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



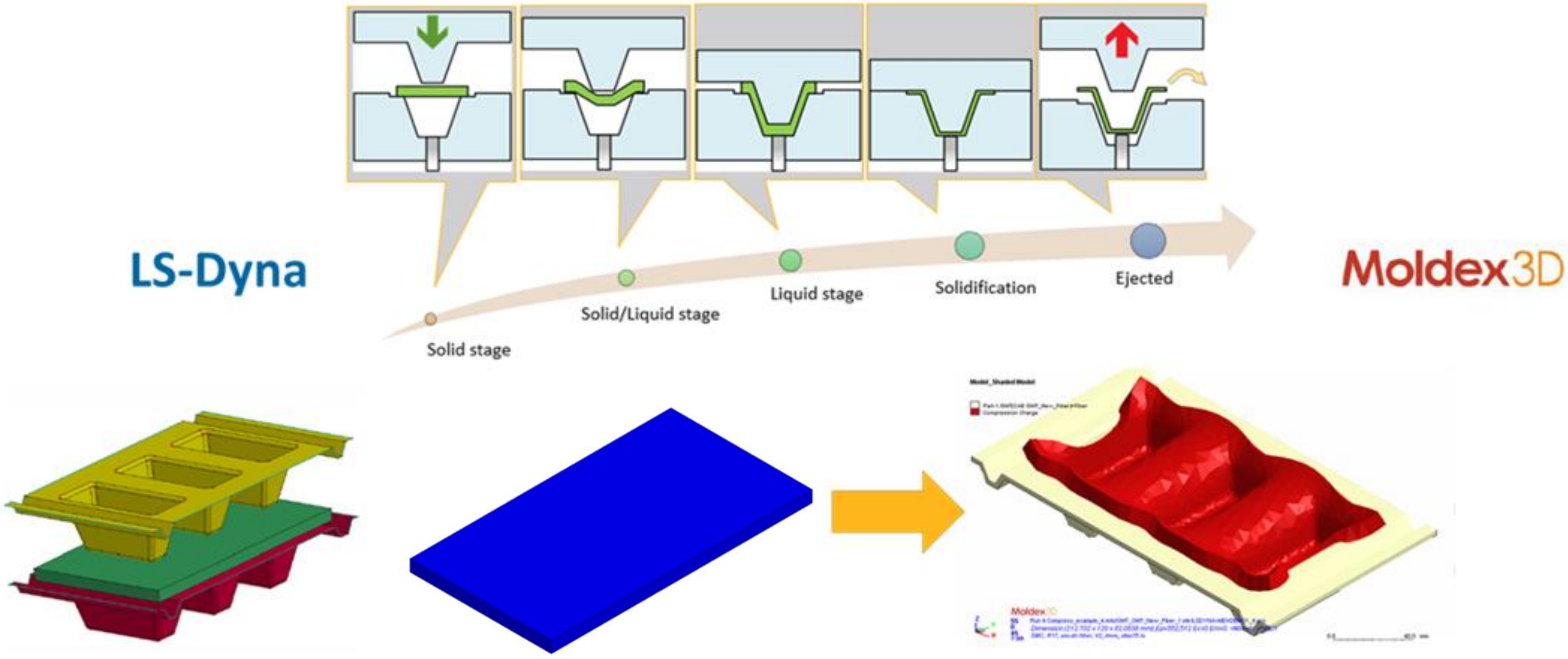




Self-piercing rivet (SPR) simulation to join two solid plates modeled by SPG particles

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 melting and solidification process.



Courtesy of CoreTech System / Moldex3D

Core Technologies

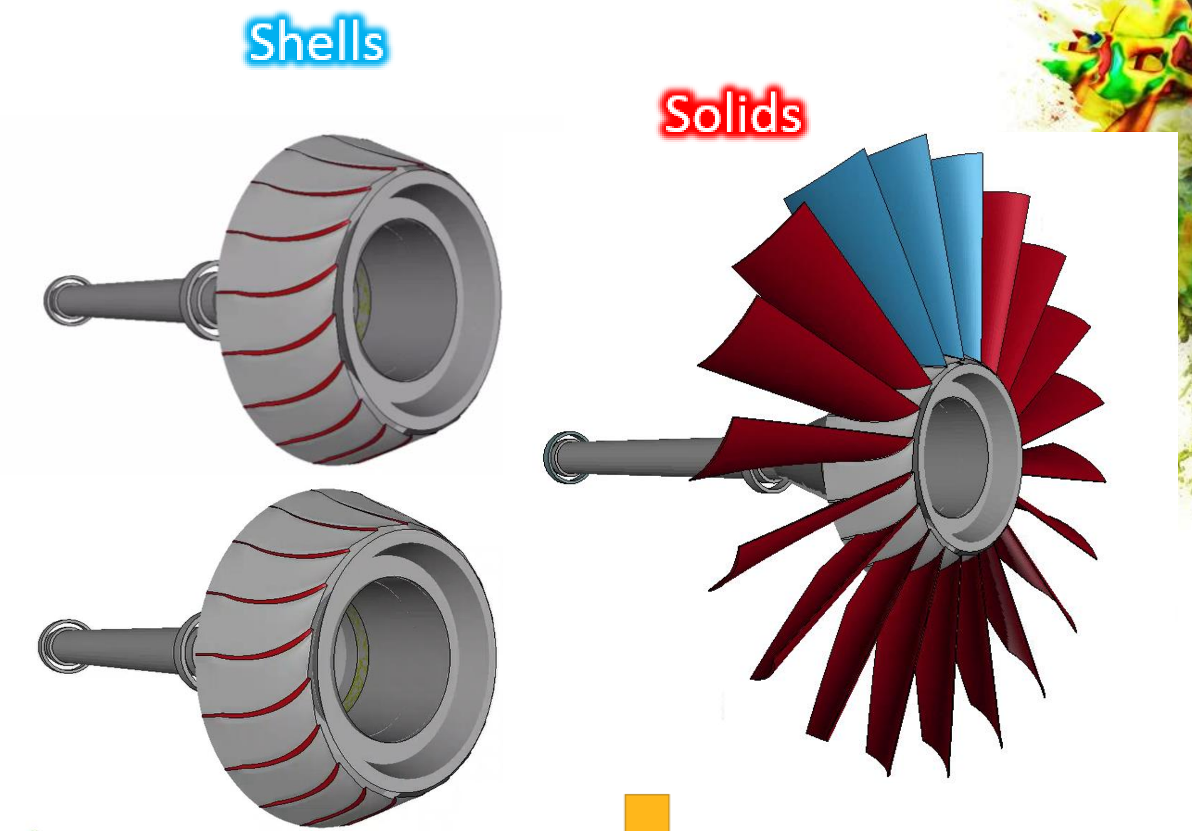
Superelements, IGA, Modular contact, Material models

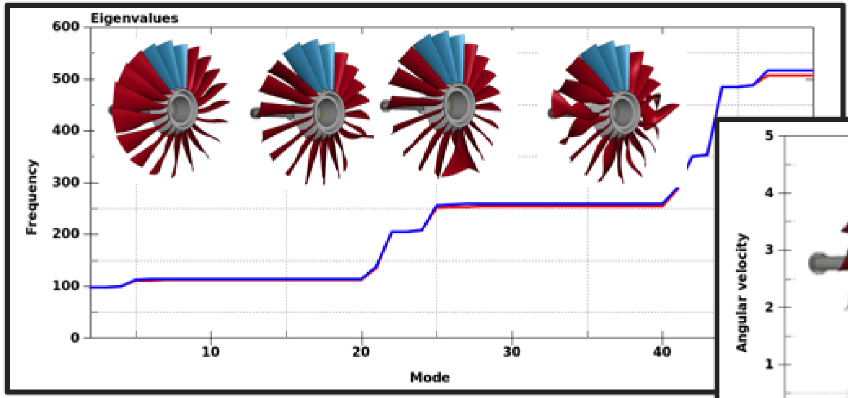
Superelements

… a powerful technique to condense a large group of finite elements into a single, matrix-based representation, drastically reducing model size and computational cost for complex assemblies.

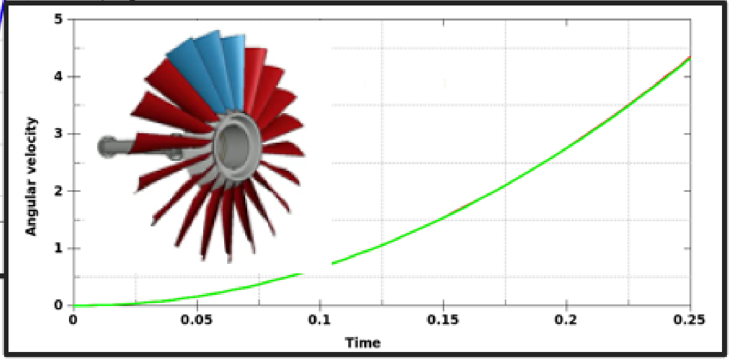
Recent Enhancements

- Better MPP performance
- Now handles large rotations (objective formulation)
- Supports mass scaling
- Improved output and visualization
- Higher robustness

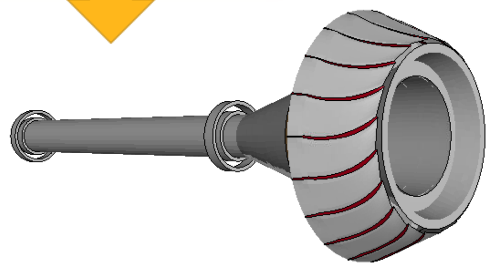




The dynamic characteristic: verified with an eigenvalue analysis as well as transient load analysis



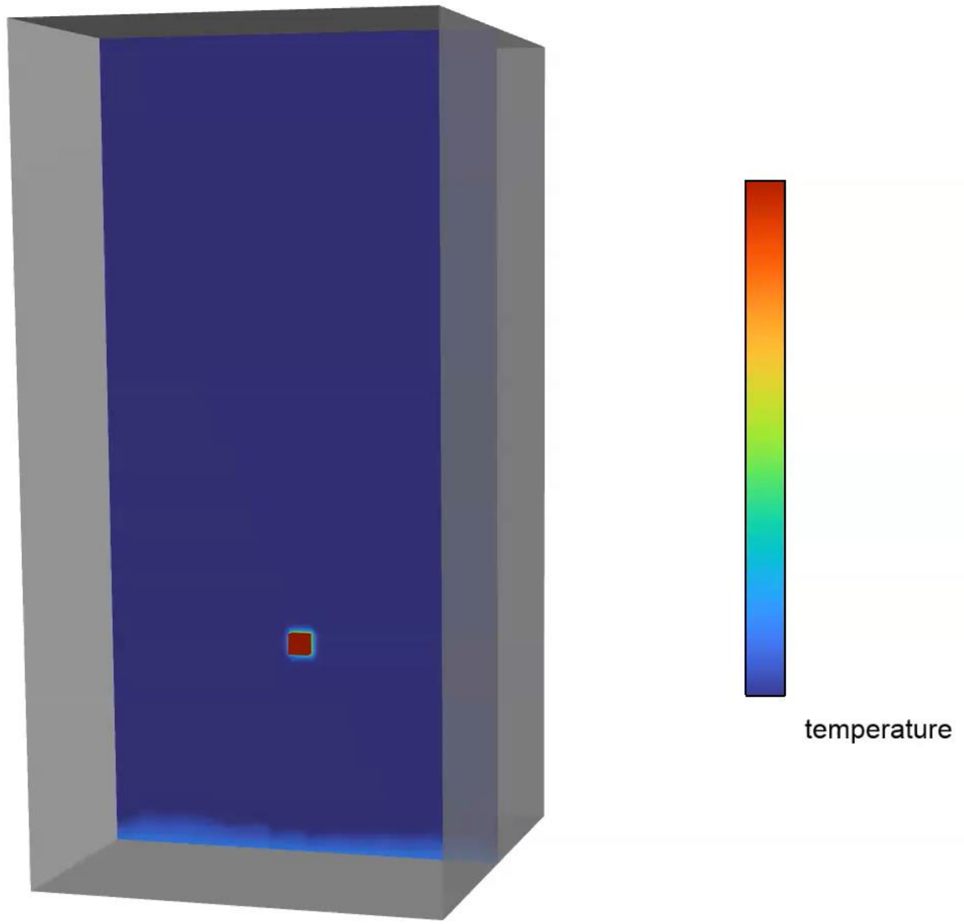
20 submodels later



Mass Scaling supported

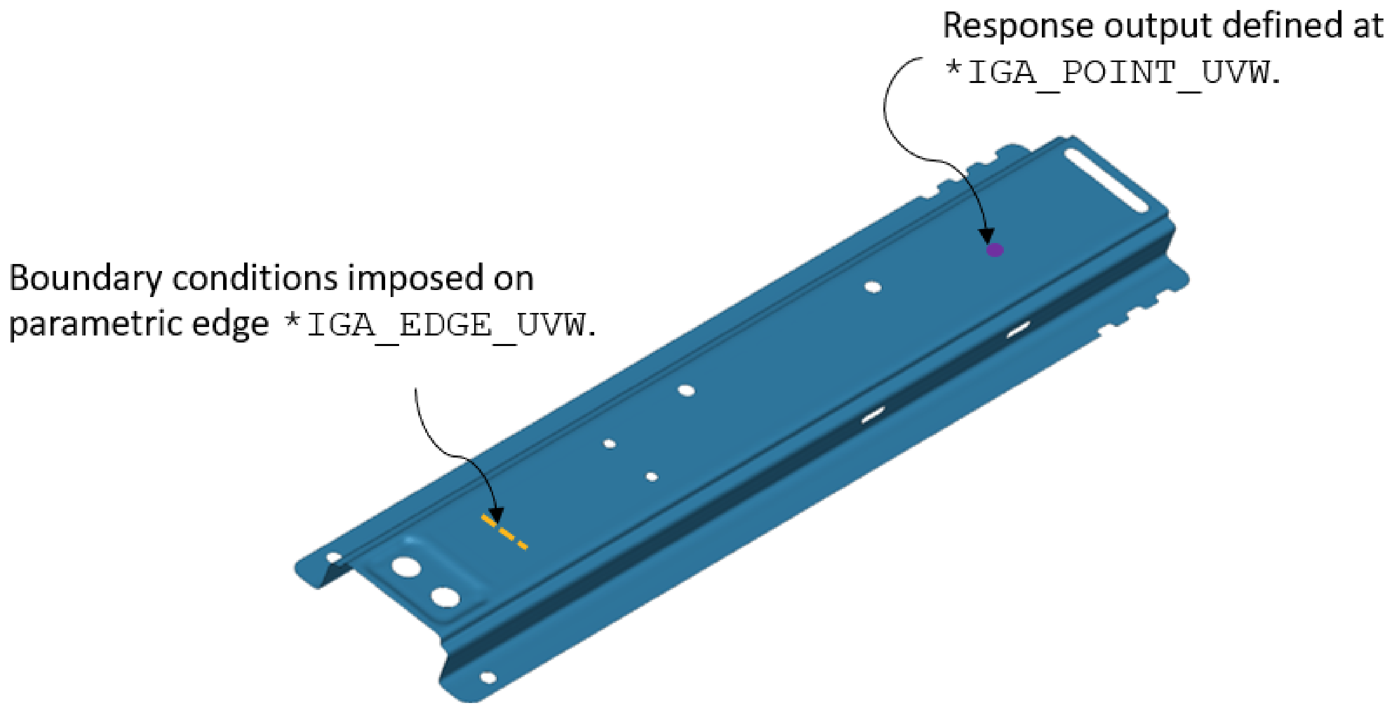
IGA: Conjugate Heat Transfer

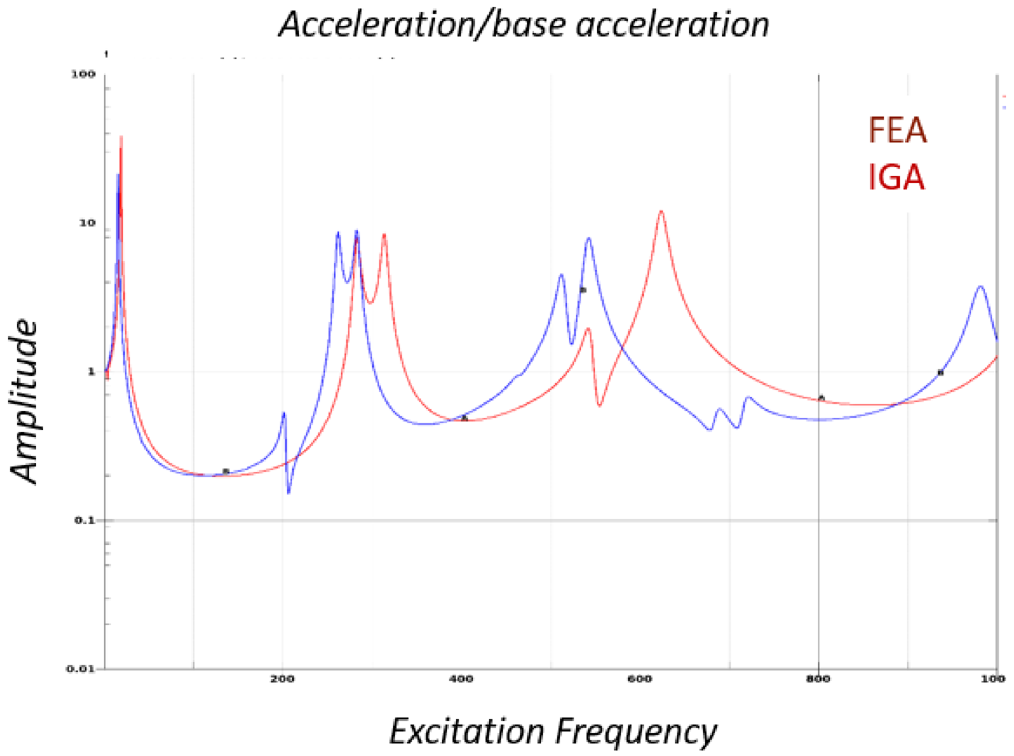
- Coupling IGA and ICFD solvers.
  - SMP only for now.
- Isogeometric solids
  - Boundary fitted/untrimmed structured splines.
    *IGA_3D_NURBS_XYZ
  - Unstructured splines
    *IGA_3D_BASIS_TRANSFORM_XYZ



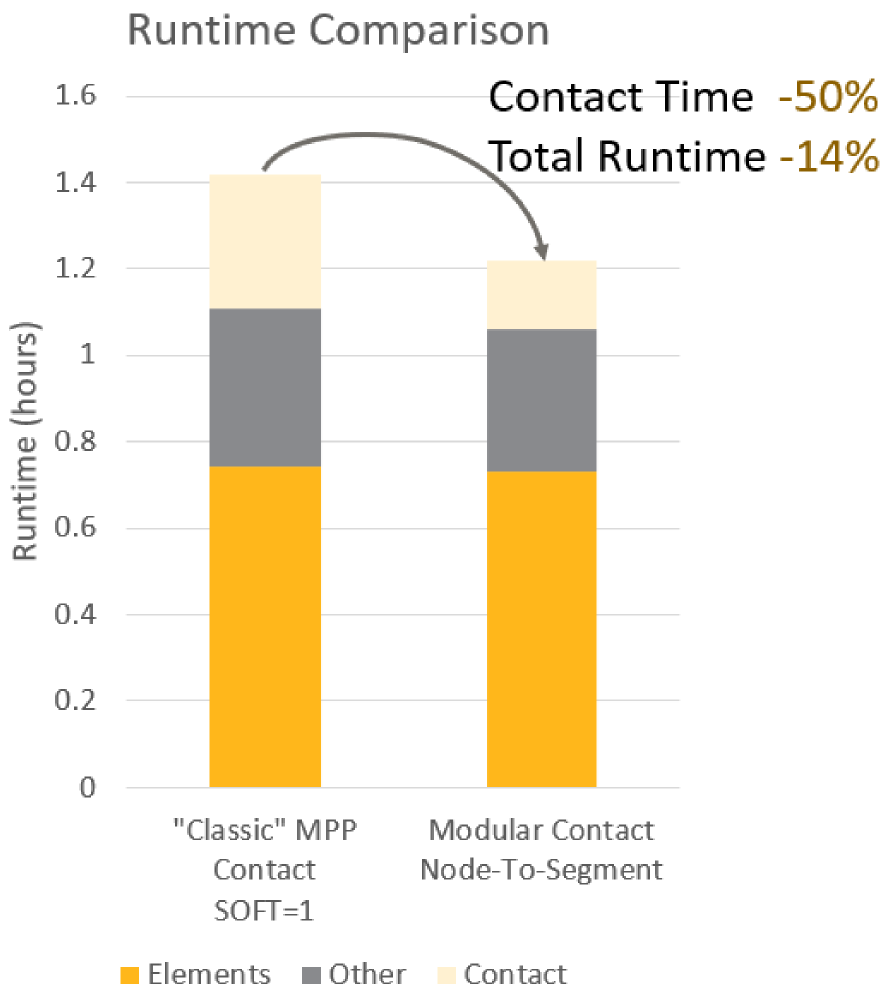
IGA: Frequency Response Function Analysis

- 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.



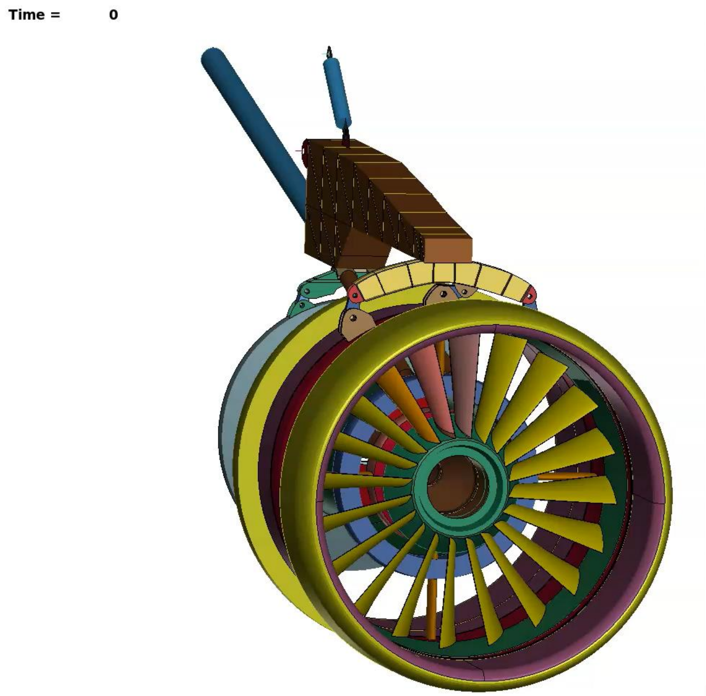


Modular Contact: Fan Rig Blade-Off Test

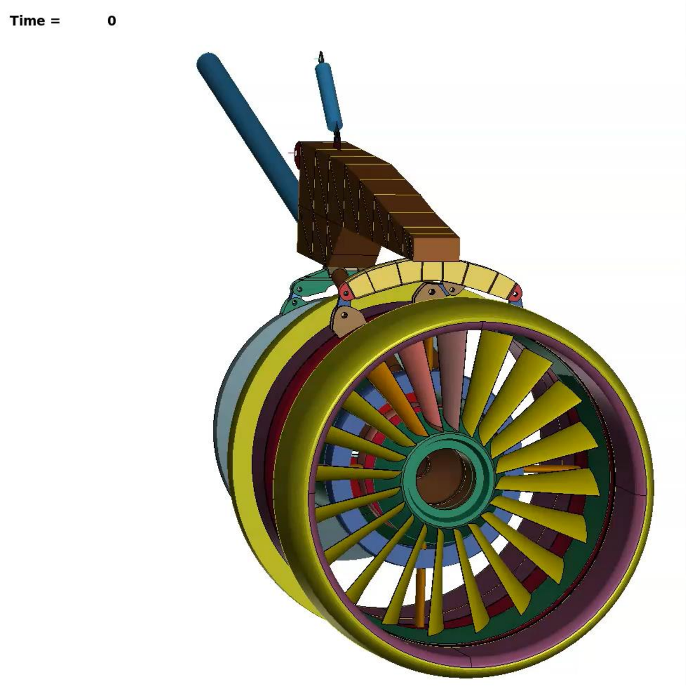


Total Number of Elements: 1.3M
Elements per Blade: 10K (0.8%)
Cycles with Erosion: 0.9%

"Classic" (SOFT=1) Contact:

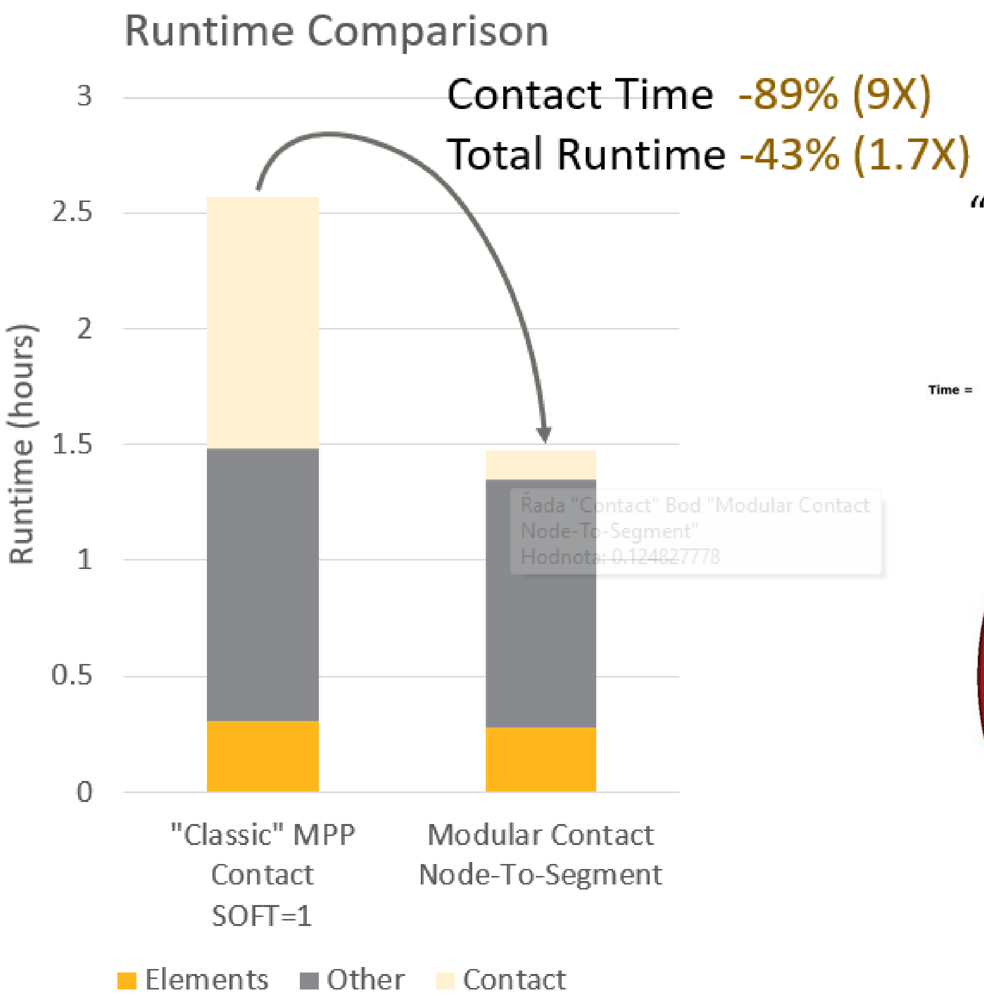


Modular Contact:

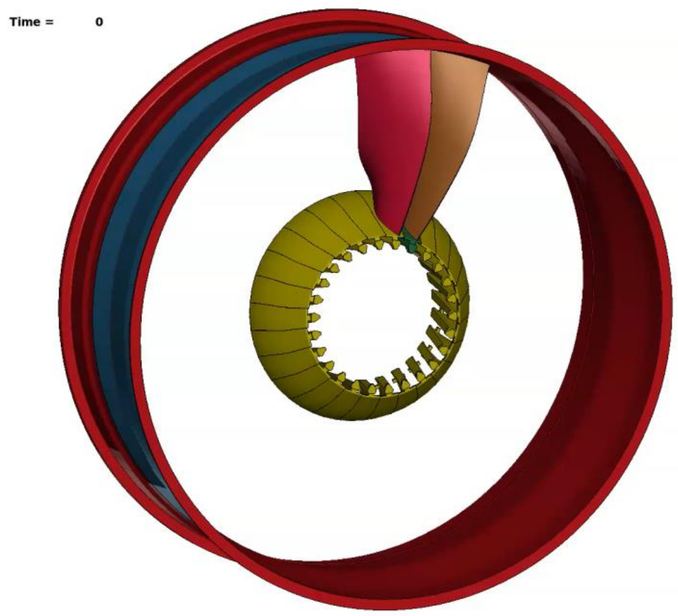


Modular Contact: Fan Blade-Off Containment Test

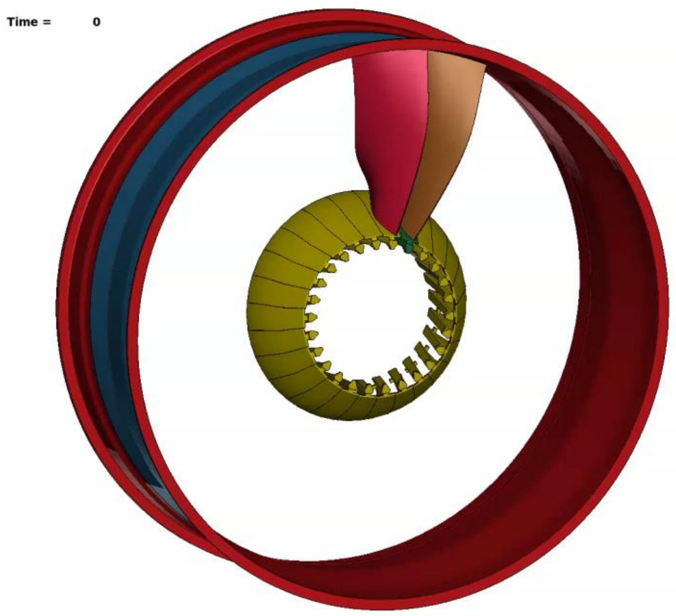
Total Number of Elements: 1M
Elements per Blade: 200K (20%)
Cycles with Erosion: 6%



“Classic” (SOFT=1) Contact:



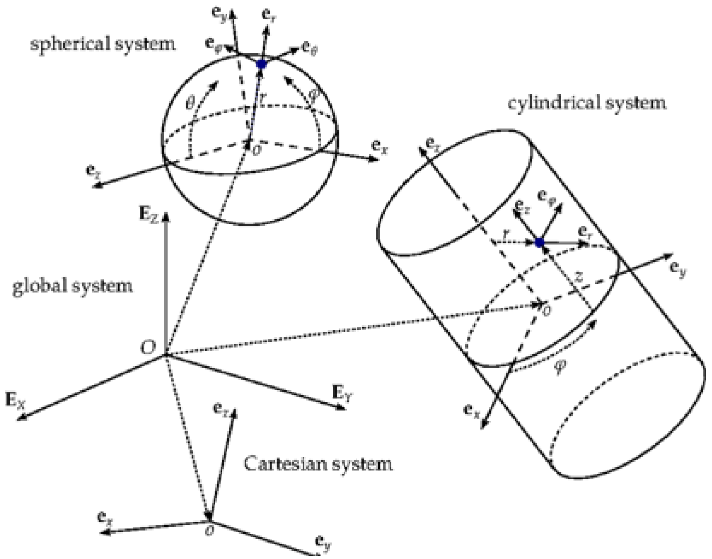
Modular Contact:

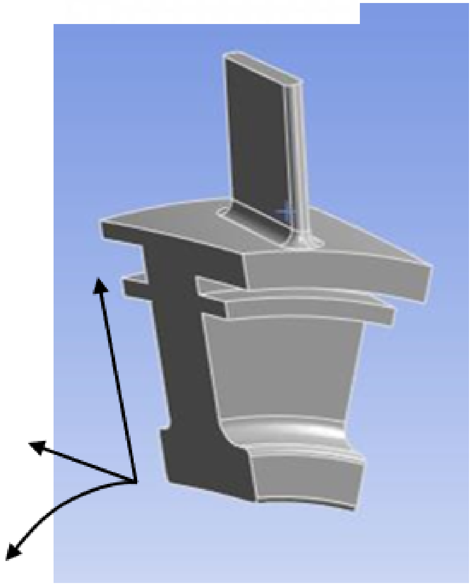


AWG ERIF Test Case 2.2 https://awg.ansys.com/QA+Test+Example+2.2
(uniformly refined model)

Cylindrical and Spherical Coordinate System

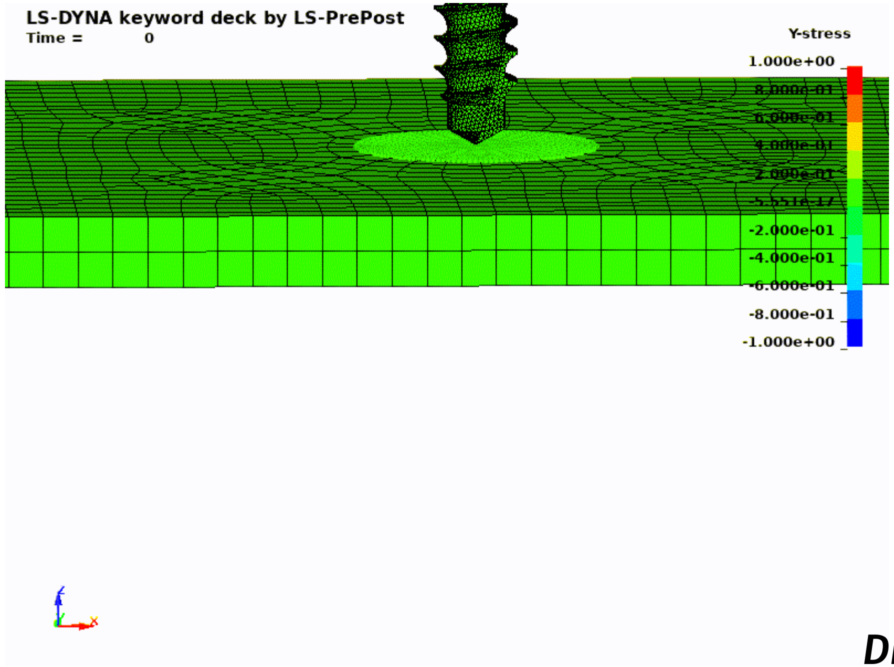
- Facilitates the input of boundary conditions in problems with circular or spherical symmetry
  - Set flag TYPE = 1(cylindrical) or TYPE =2 (Spherical) on:
    - *DEFINE_COORDINATE_NODES
    - *DEFINE_COORDINATE_SYSTEM.
  - Local system option on nodes will honor TYPE flag for the following keywords: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

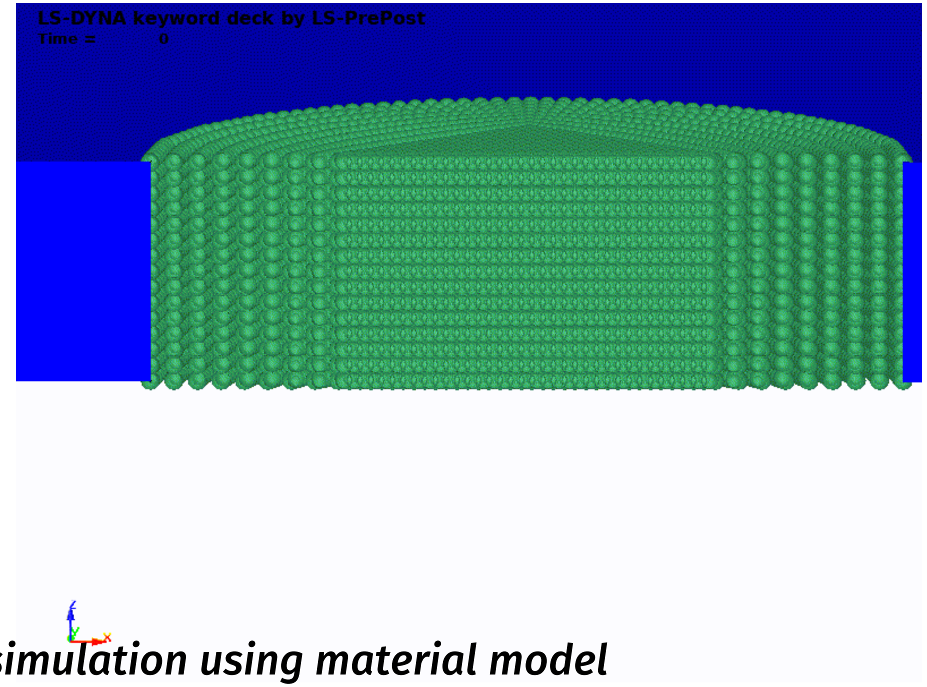




Material Models: Support for Orthotropic Material Models

- Support ***AOPT*** in orthotropic 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)





Drilling process simulation using material model *MAT_COMPOSITE_DAMAGE

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, >= 1: failure

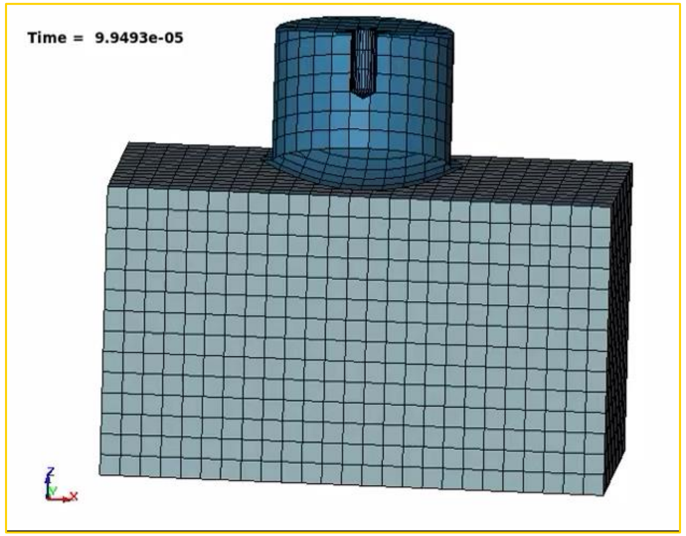
- C style computations

- Printf writes to screen, mes0xxx, d3hsp

```
*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 FAILED AT T=%.7e\n",int(eid),time);
  }
$ RETURN VALUE
  return dmg;
}
```

Example: Max. volumetric strain same as “VOLEPS=0.001”

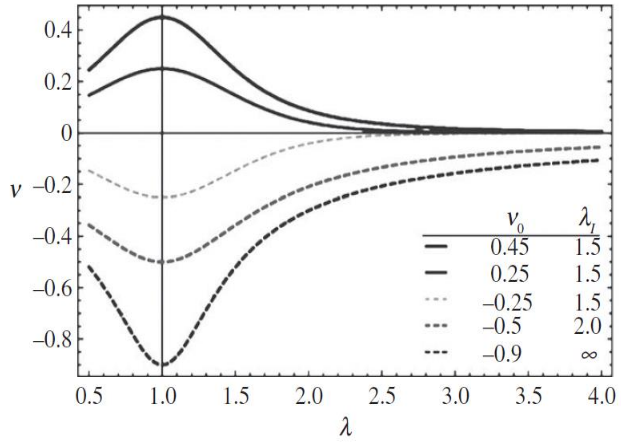
Example: Special Failure Criterion for Foam



Material Models: Support For Auxetic Foams

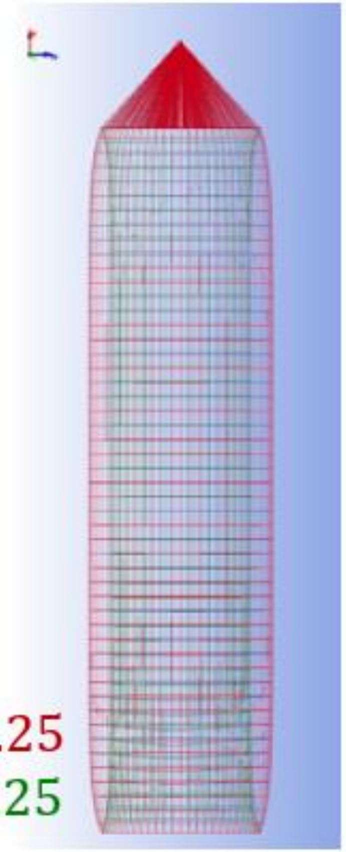
- Counter-intuitively expand (shrink) under stretching (compression)
  - Negative Poisson's ratio due to folded microstructure
- Available as a new option on *MAT_038 (Blatz-Ko foam)

Card 1	1	2	3	4	5	6	7	8
Variable	MID	RO	G	REF	IMODEL	PR	FMOD	XLINV
Type	A	F	F	F	F	F	F	F



=0: default foam model with constant PR = 0.25
=1: user specified PR with FMOD
=2: user specified PR value with Ciambella model

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

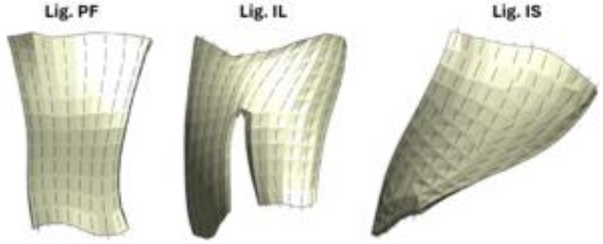


Material models: Soft tissues

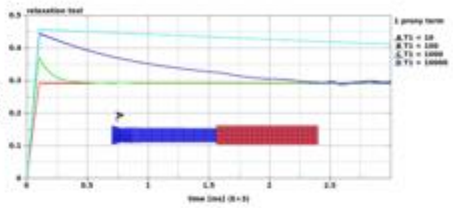
- Enable reference geometry to be used with *MAT_SOFT_TISSUE (*MAT_091)
  - e.g. for pre-stressed ligaments in human body models

A.-L. Bernecker, Ligament Modeling in Human Body Models: A Methodological Approach for improved biomechanical representation

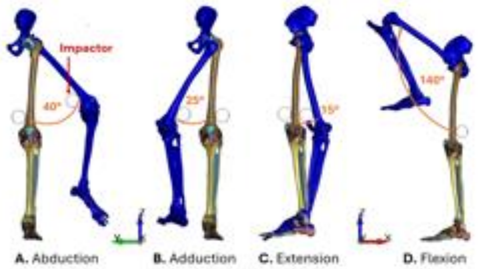
1 Switch to ***MAT_SOFT_TISSUE**
Updated fiber directions



2 Material Calibration



3 Reverse engineering **ligament pre-stress** (through reference geometry) using ROM literature test data



4 Full scale verification

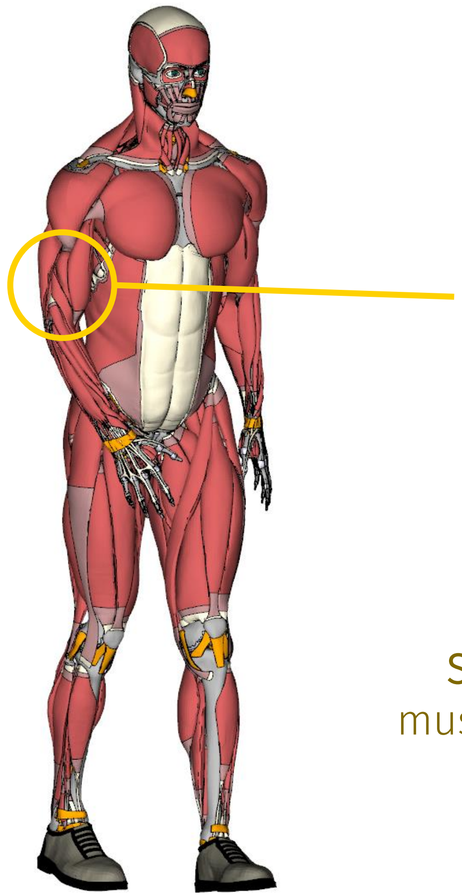
Uriot et al

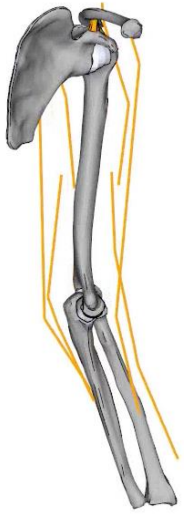
5 Roll out to all major joints

Hans V2.0

Material models: Soft tissues

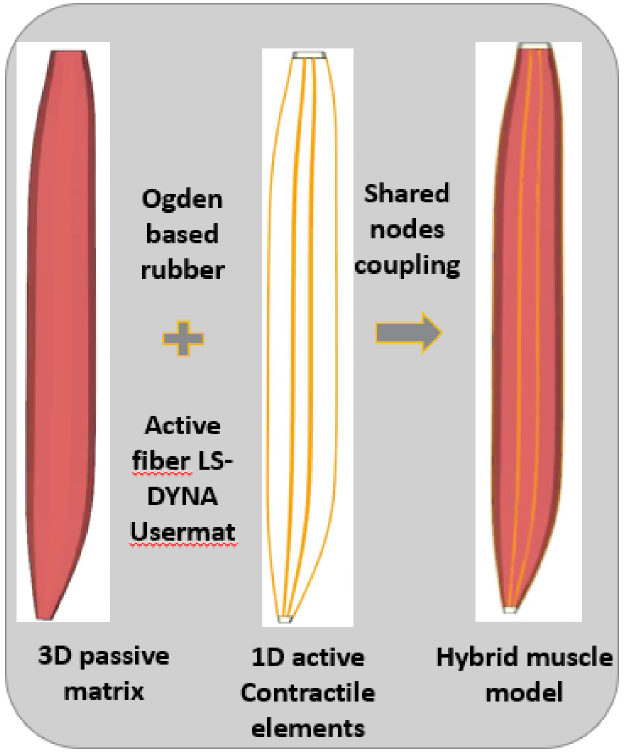
HANS
Our human body model





State of the art:
muscles represented
by 1D beams

New concept:
Hybrid solids-beams model



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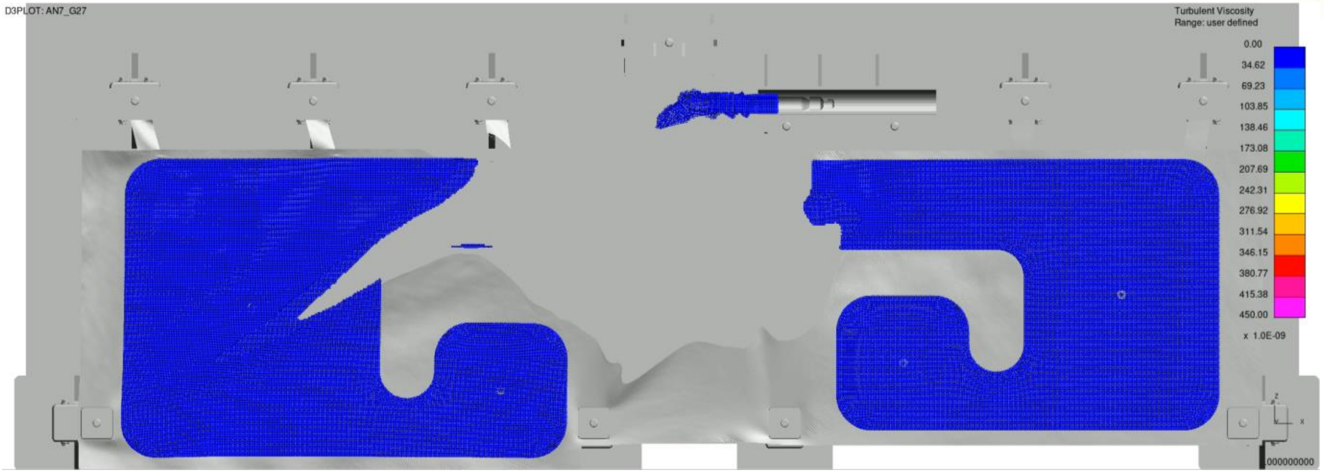
Physics Enhancements

CPG, ICFD, EM, Fatigue

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.
- 2-way thermal coupling with shell parts through LS-DYNA's thermal solver.
- Vents can open once given pressure is reached (PPOP)
- 1-way and 2-way coupling with Discrete Element particles (mechanical and thermal coupling available).



- Standard k-epsilon turbulence model.

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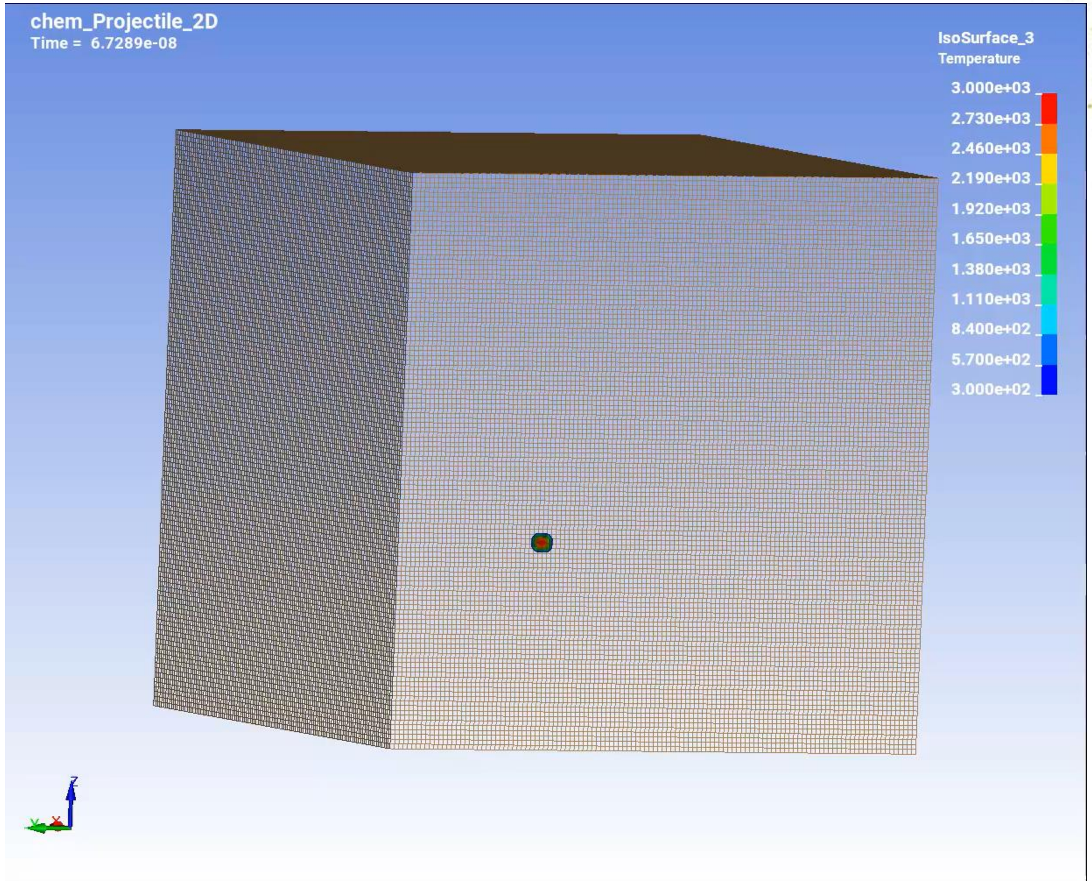
CFD: Chemically Reacting Dual CESE Solver

- 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

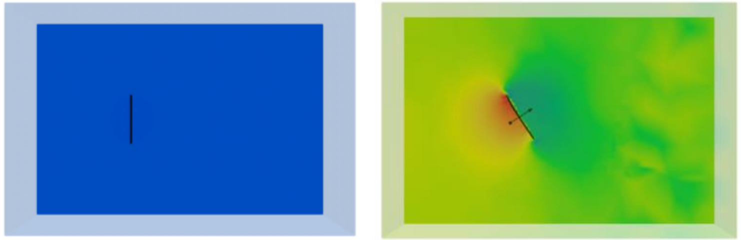


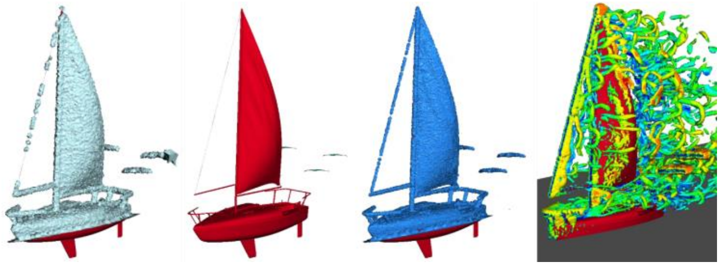
SVS FEM

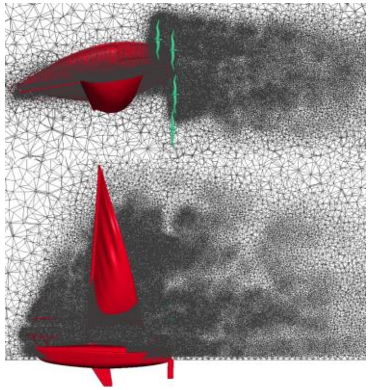
CFD: ICFD Solver Enhancements - 1

Immersed FSI

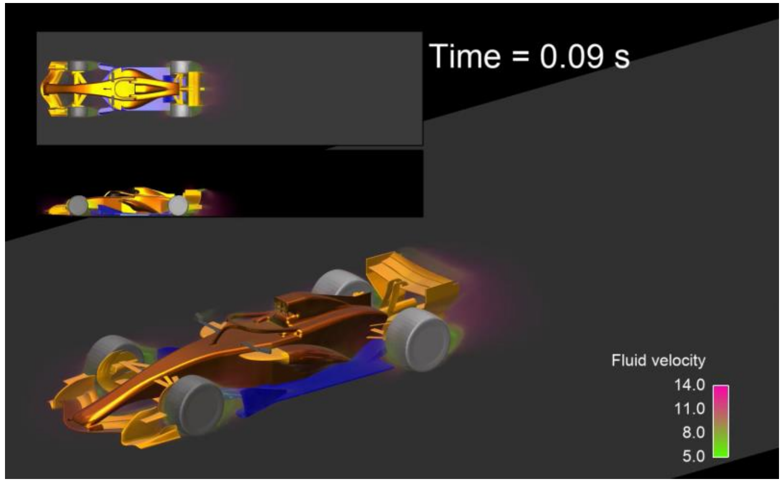
- New immersed finite element formulation for fluid-structure interaction based on Finite Element enrichment.
- Simplified UI for Resistive Immerse Implicit Surface (RIIS) method.
- Improved adaptive meshing capability. Improved interface recognition accuracy.







- Runs in R17 or Dev
- External aero
- Cad model meshed in LSPP with default values in the automesher



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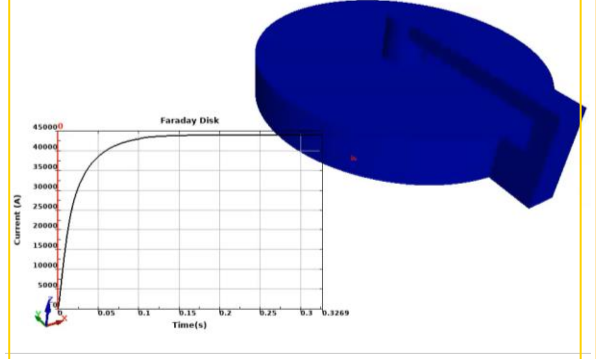
EM Solver Enhancements -1

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.

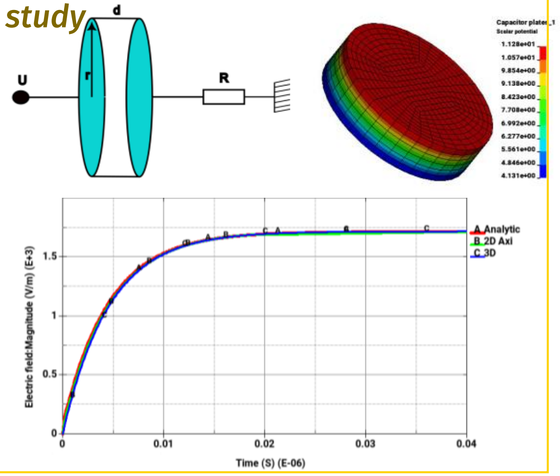
Validation example : Faraday Disk



Dielectric Heating

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

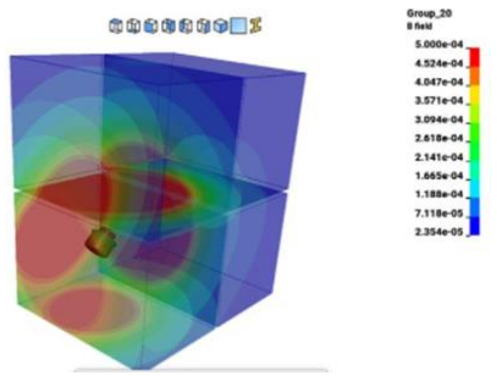
Validation example : Capacitor study



Biot Savart two step solve

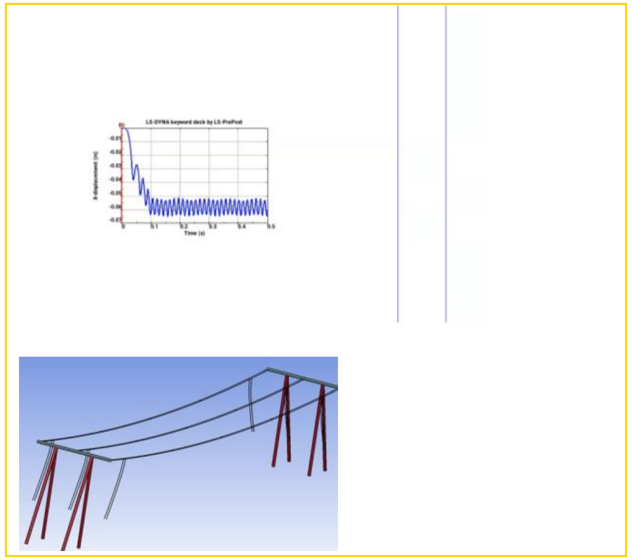
Results from a previous magnetostatic analysis can be reused in a subsequent analysis to map magnetic fields on non-magnetic parts.

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).



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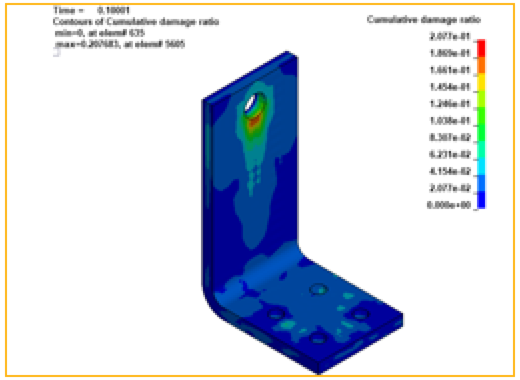
Fatigue Solver Enhancements

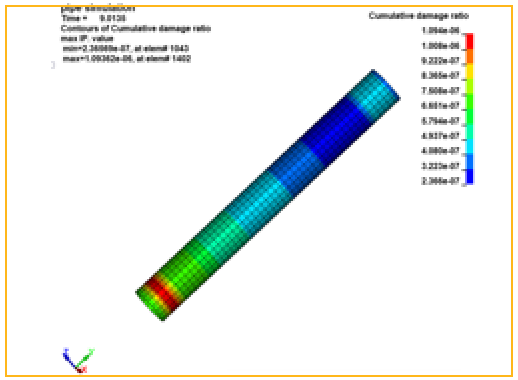
D3Part

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



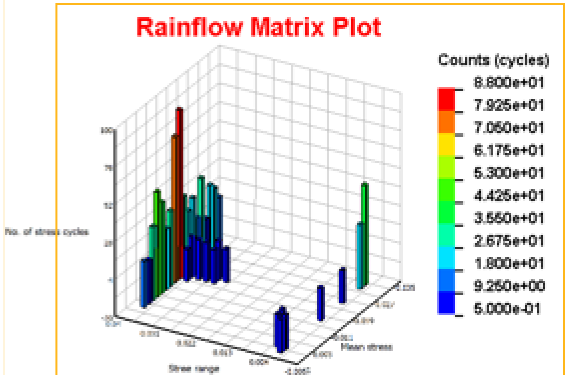
Early Termination due to Fatigue damage

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

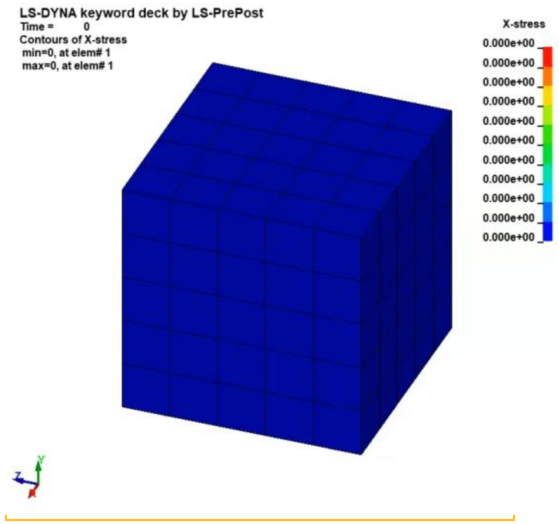


Rainflow Matrix Plot

- 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



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HPC

CPU/GPU

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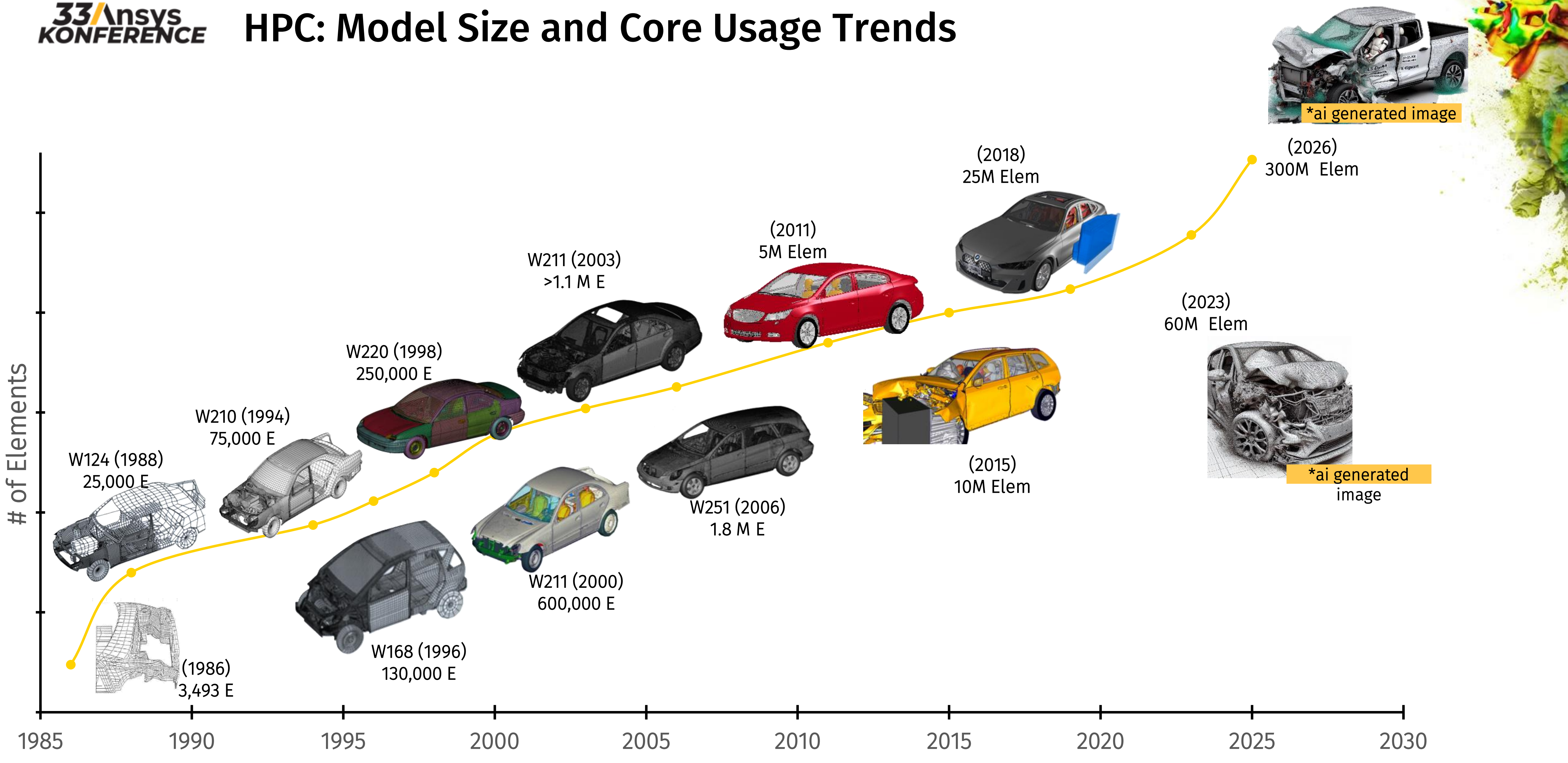
HPC: Model Size and Core Usage Trends



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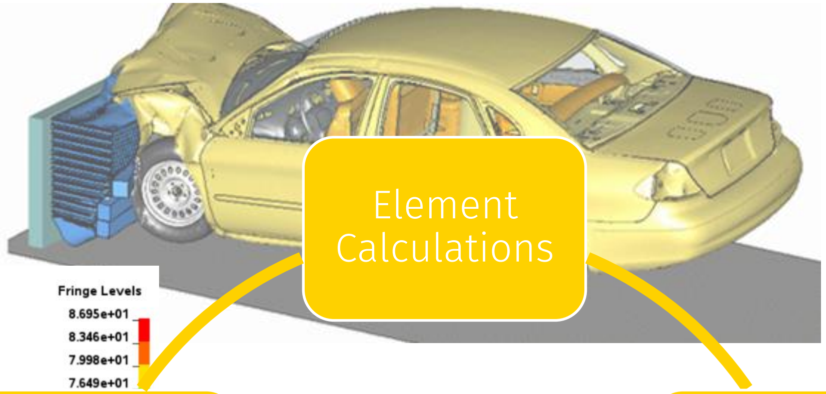
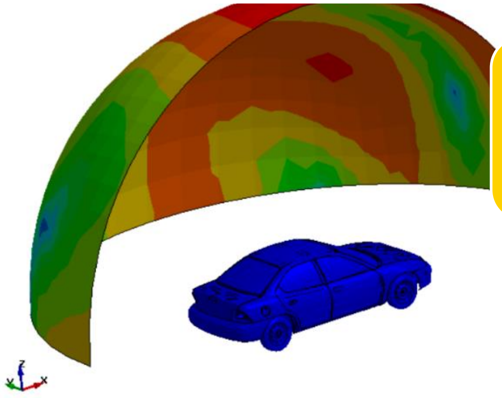
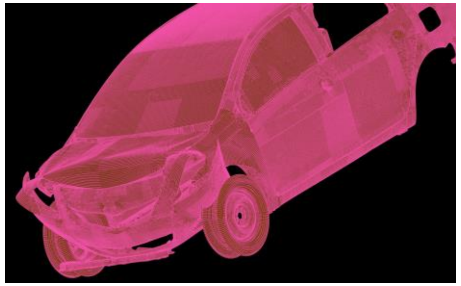
LS-DYNA GPU Solver R&D - Preview

Multi-node / Multi-GPU acoustics simulation

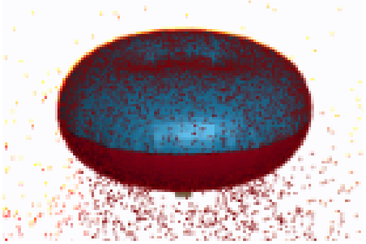


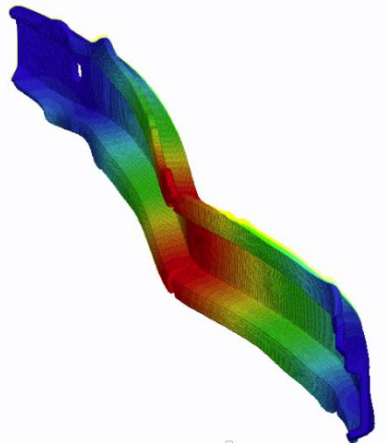


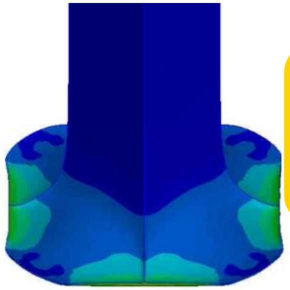
- Element Calculations
- Contact Algorithms
- Particle Methods
- Isogeometric Analysis
- Boundary Element Method



Near-constant search time as number of interactions increases







Large deformation analysis of solid bodies

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

Sledujte SVS FEM ve světě sociálních sítí

Díky za pozornost
a zůstaňme ve spojení

Zuzana Kodajkova