CADCAM GROUP

What is new in Abaqus 2016

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SIMULIA seminar

Ljubljana, 12.4.2016

Agenda

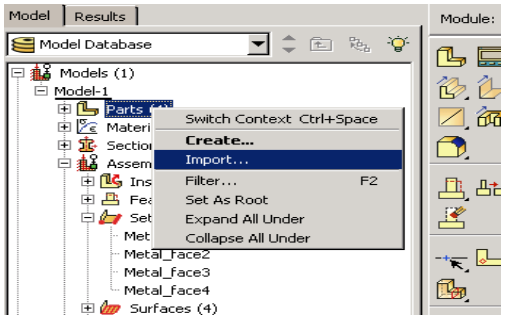
- Abaqus technical overview
  - Abaqus/CAE
  - Abaqus/Standard
  - Abaqus/Explicit
  - Abaqus/CFD
- Powerfull but frequently overlooked features
- Latest capabilities in Abaqus
  - CEL
  - SPH
  - DEM
- What is new in latest release Abaqus 2016

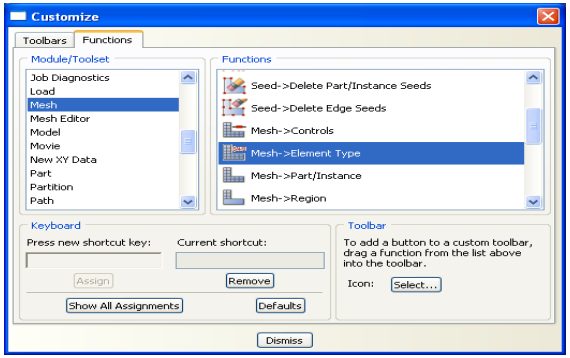
Abaqus/CAE

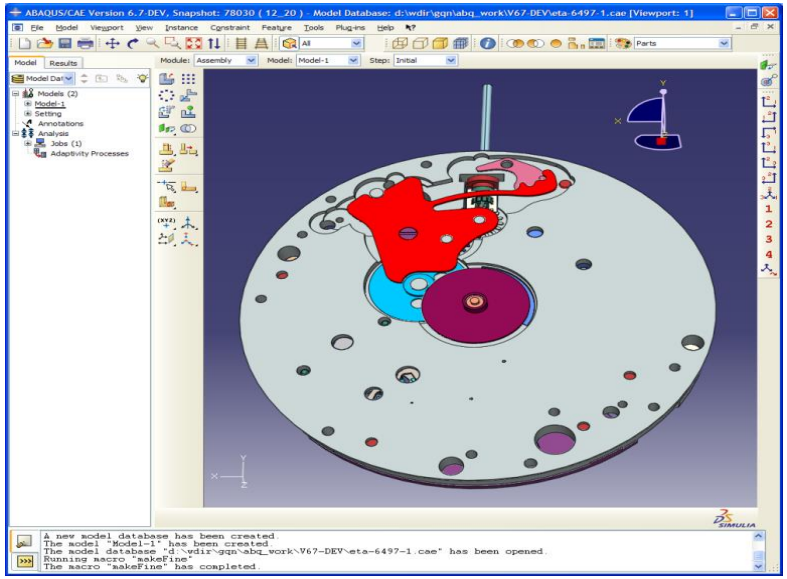
Abaqus/CAE

Modern graphical interface

- Modular & well organized
- Easy to learn & use
- Object-action paradigm
- Model Tree
- Customizable toolbars
- CAD-compatible view manipulation



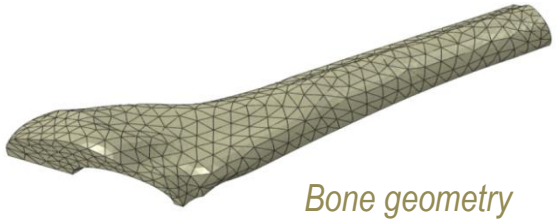




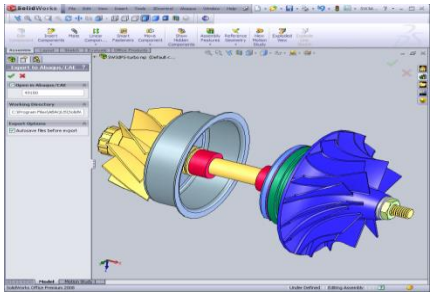
Abaqus/CAE

Geometry & model import

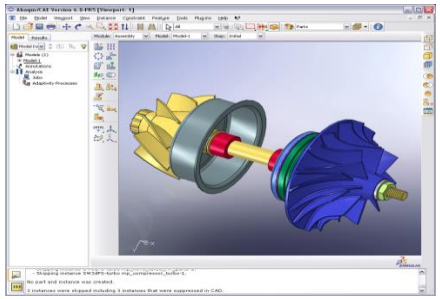
- Create moderately complex geometry
- Import neutral CAD formats
- Associative CAD interfaces preserve analysis attributes when geometry changes
- Complete set of geometry repair tools



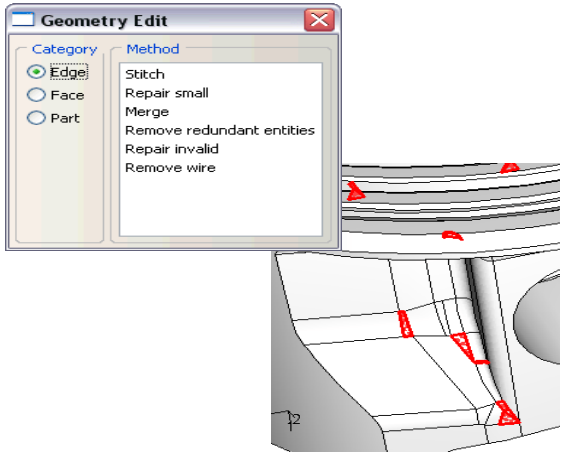
Bone geometry imported from STL file



CAD



Abaqus/CAE

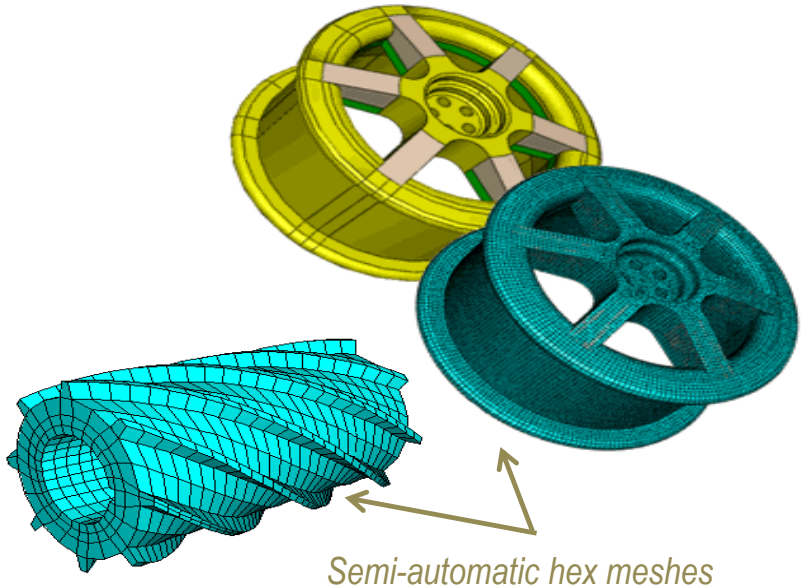


Geometry repair toolset

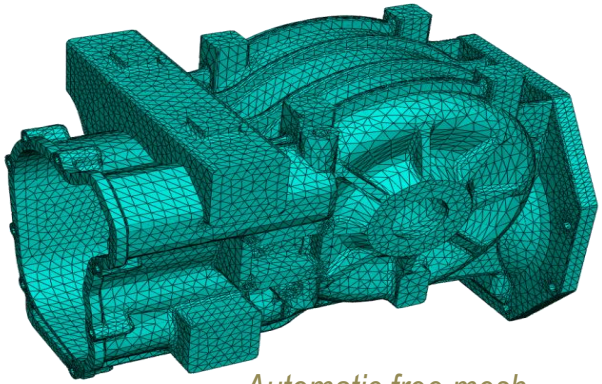
Abaqus/CAE

Powerful & flexible meshing

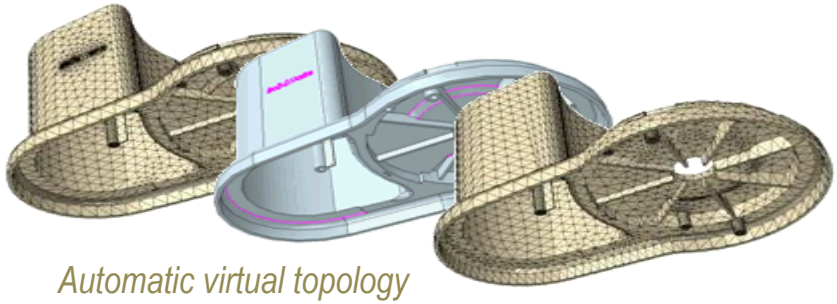
- Fast, automatic free meshing
- Semi-automatic hex meshing
- Abstract away unimportant features using virtual topology



Semi-automatic hex meshes



Automatic free mesh

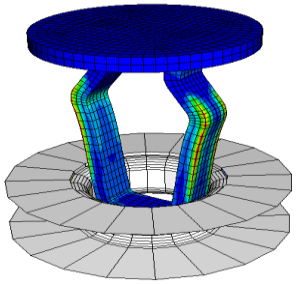


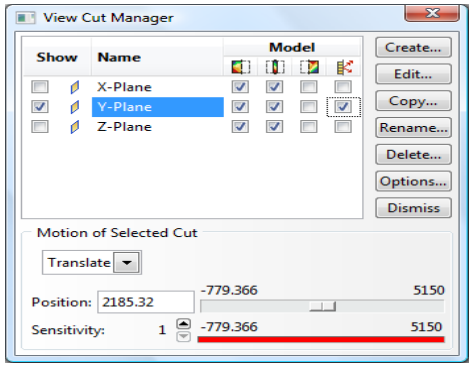
Automatic virtual topology removes step-like feature

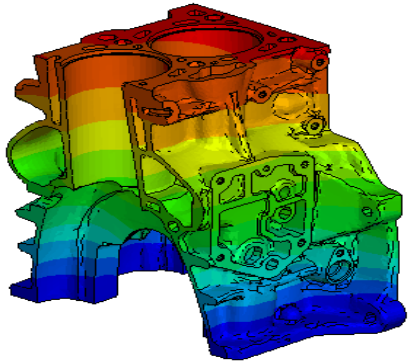
Abaqus/CAE

Preferred tool for visualizing Abaqus results

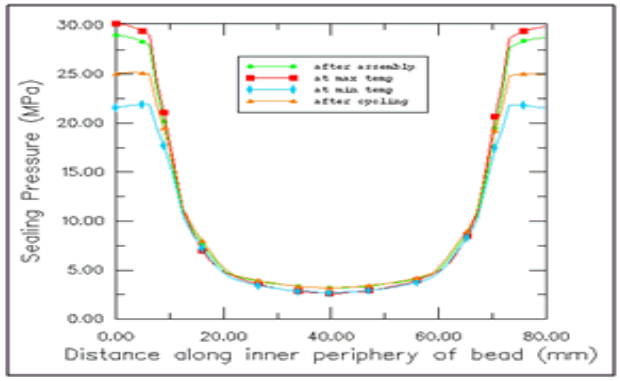
- High performance for large models
- Transparency
- View cuts
- Probing
- XY plotting
- Much more . . .







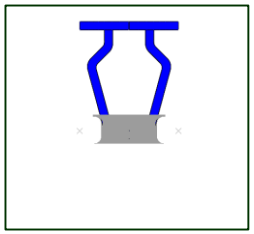
(Courtesy of AVL List GmbH)



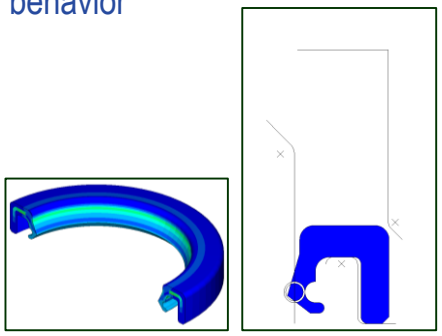
Abaqus/Standard
&
Abaqus/Explicit

Abaqus/Standard

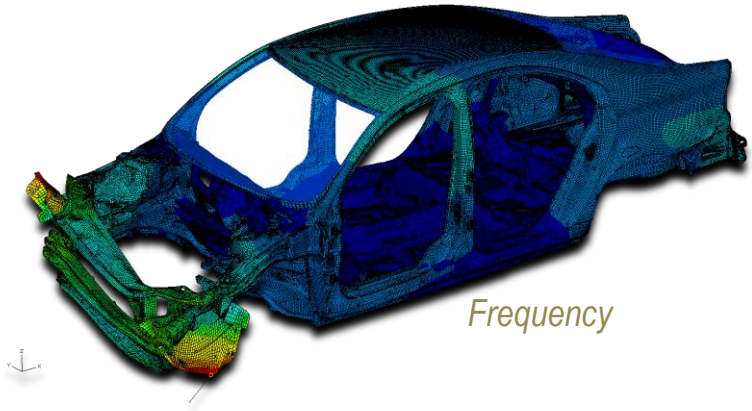
- Based on implicit solution techniques
  - Intended for static and structural dynamic events
  - Linear or nonlinear behavior



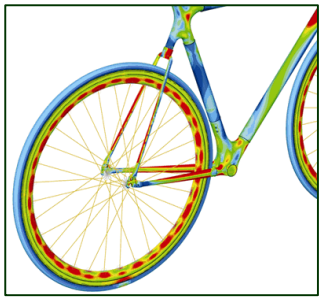
Clip insertion



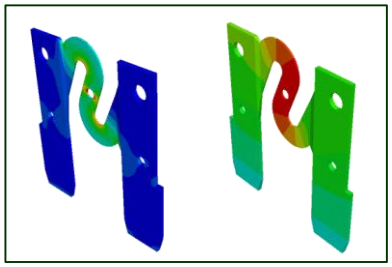
Shaft seal insertion



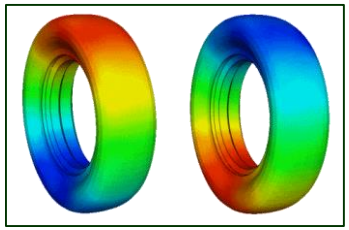
Frequency



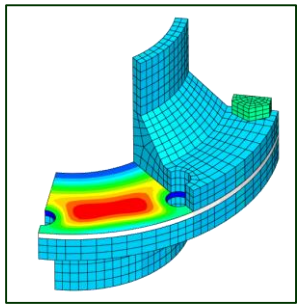
Bicycle frame stress



Electrical fuse heating



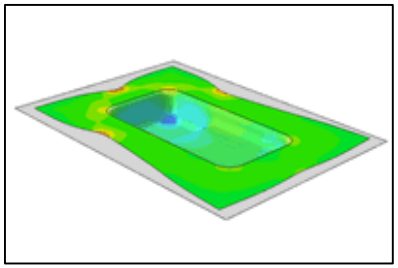
Tire noise



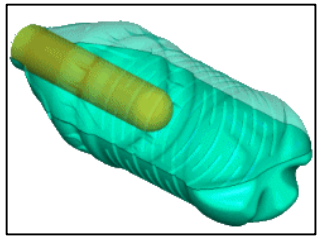
Gasket sealing

Abaqus/Explicit

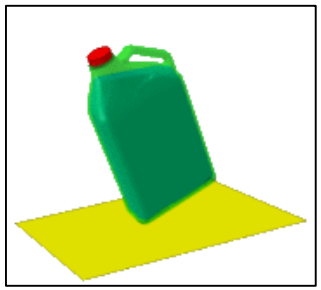
- Based on explicit time integration
  - Intended for high-speed transient dynamic events
  - Also suited for highly nonlinear quasi-static events



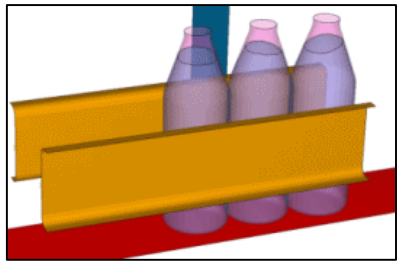
Deep drawing



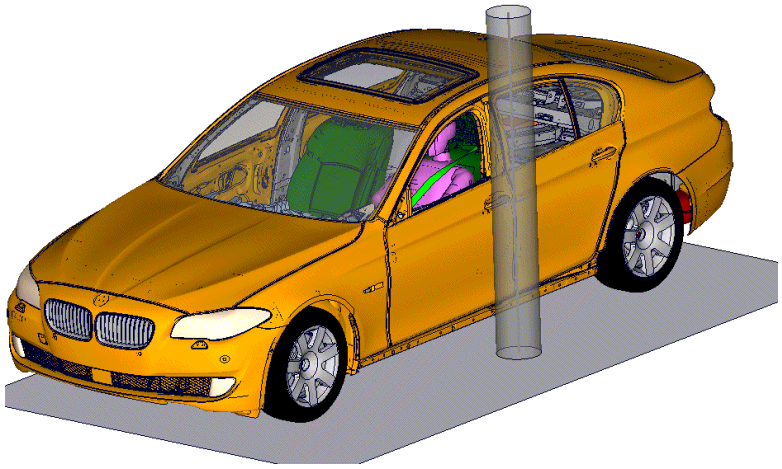
Blow molding



Bottle drop



Bottle conveying system



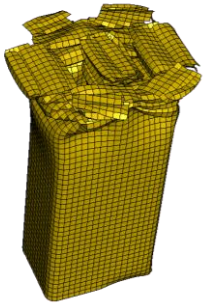
"…the goal at BMW to completely eliminate prototype hardware and testing, such issues can only be subsequently evaluated through simulation."

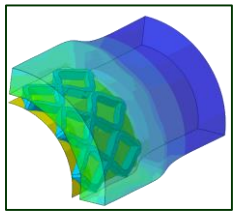
Extensive Material models in Standard & Explicit analysis

- Metals, rubbers, and composites
  - Linear/nonlinear elasticity and plasticity
  - Isotropic or anisotropic
  - Rate and temperature dependence
- Additional materials include:
  - Soils and rocks
  - Concrete and ceramics
  - Pastes and polymers
- Damage & failure modeling

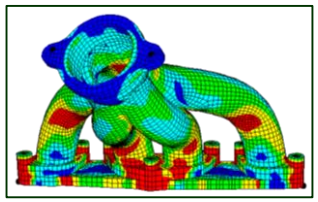
TEST

SIMULATION

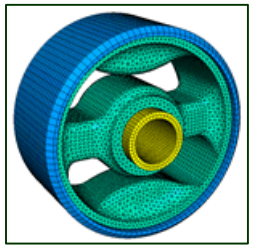




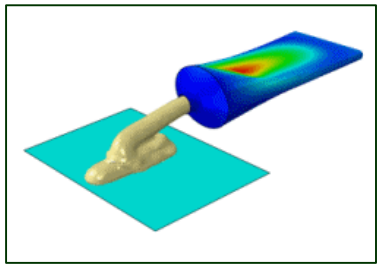
Human tissue



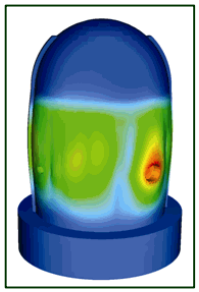
Cast iron plasticity



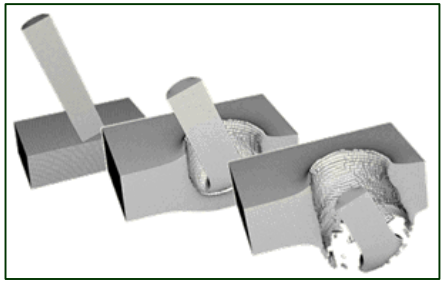
Viscoelastic rubber



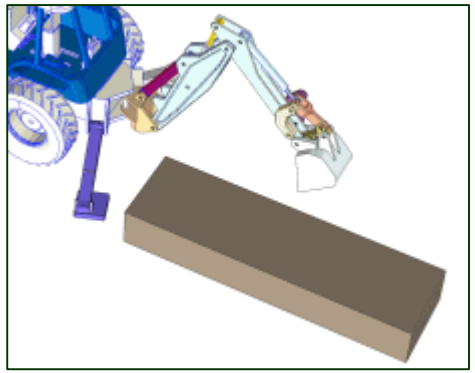
Viscous paste



Reinforced concrete



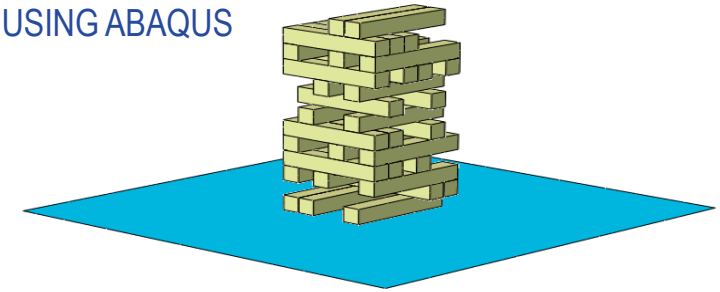
Bulk failure



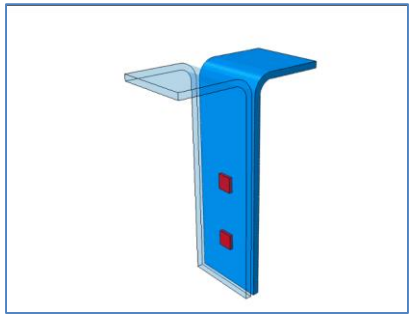
Soil & rock

Awesome contact and joining functionality in Standard & Explicit analysis

JENGA USING ABAQUS

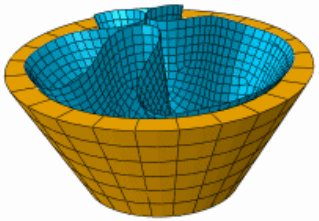


Awesome contact functionality



Advanced joining techniques to simulate adhesives and delamination

WIPE DISPENSING



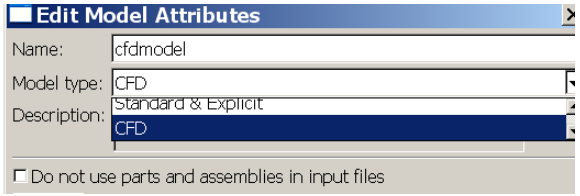
Large deformation with changing contact conditions

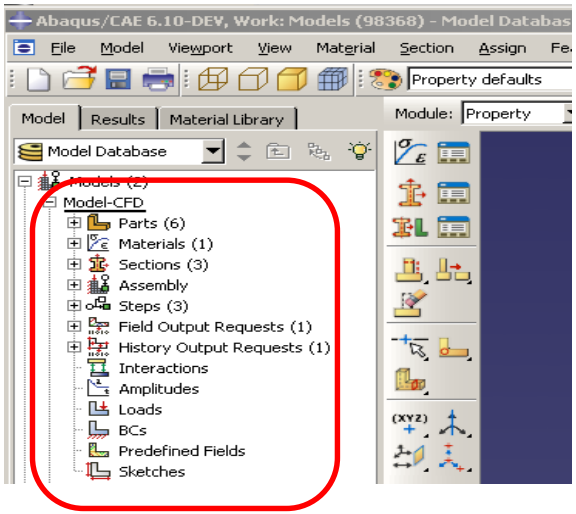
Abaqus/CFD

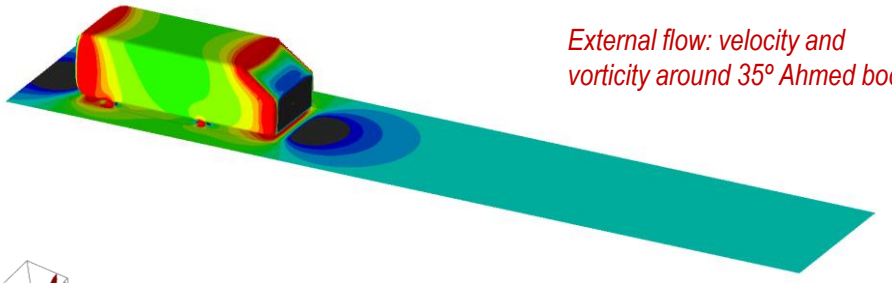
Abaqus/CFD

- Today: Abaqus/CAE
  - Concept of “model type” in Abaqus/CAE
  - Model type “CFD” enables CFD model creation
- Transient solver, Steady-state solver
- Laminar and turbulent flows

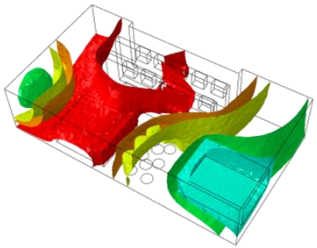
Pre-Processing and modeling support

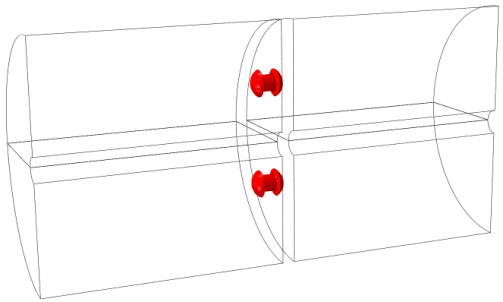


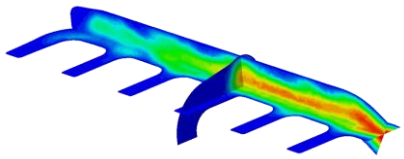




External flow: velocity and vorticity around 35° Ahmed body



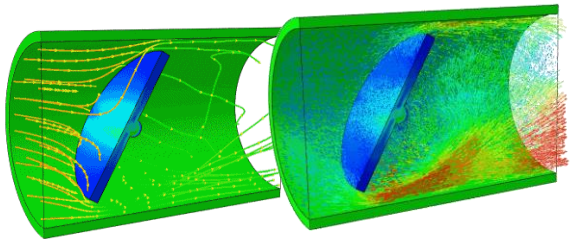


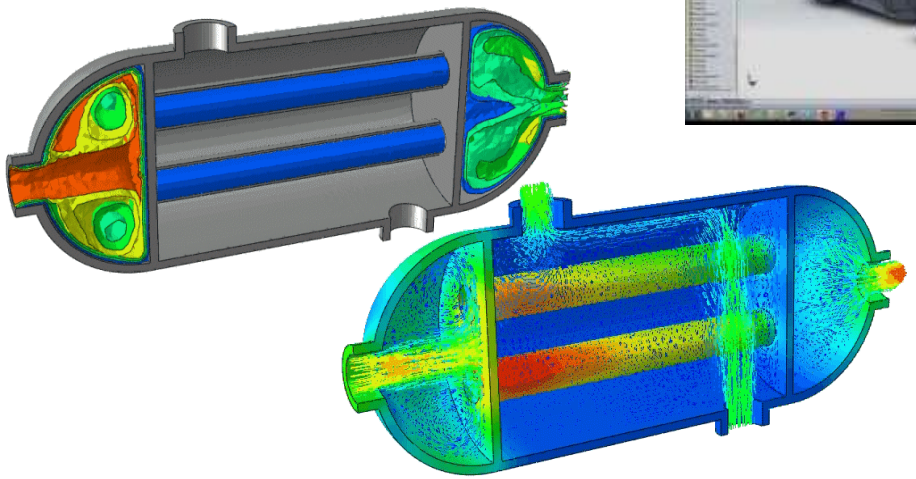


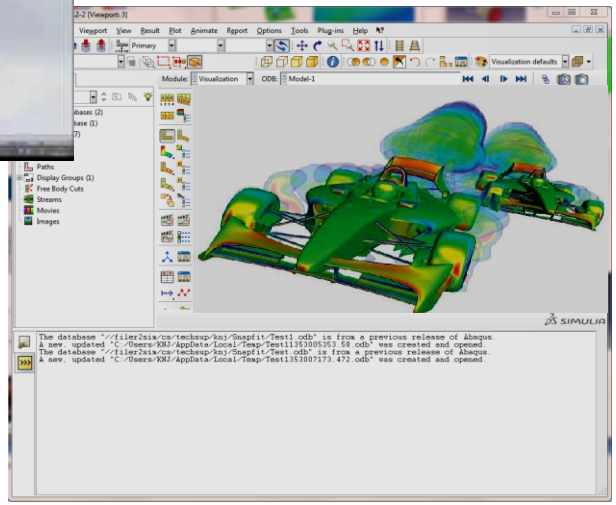
Abaqus/CFD

- Co-simulation engine (CSE)
- Couple Abaqus/Standard/Explicit with Abaqus/CFD
- Stabilized segregated FSI algorithm for unstable problems

Native fluid-structure interaction modeling capability



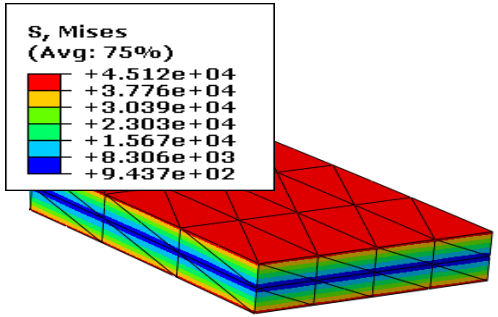




Two powerfull but frequently overlooked features in Abaqus

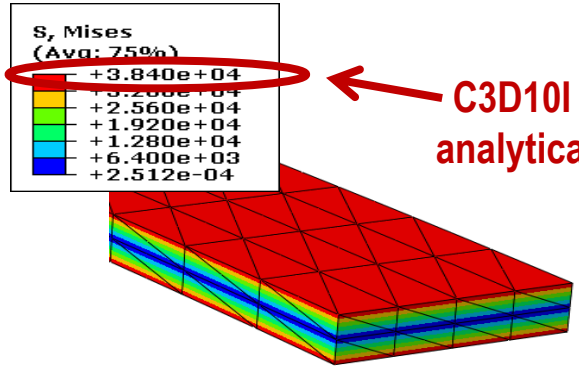
C3D10I: General-Purpose Tetrahedral Element

- I = “Improved Surface Stress”
  - Not Incompatible Modes
- Key features
  - Provides accurate surface stress predictions
  - Suitable for bending-dominated problems
  - Handles incompressible material behavior
  - Works well with contact
  - Some added computational expense
- Benefit
  - Simplifies element selection



Analytical solution: 38,400 psi

C3D10M

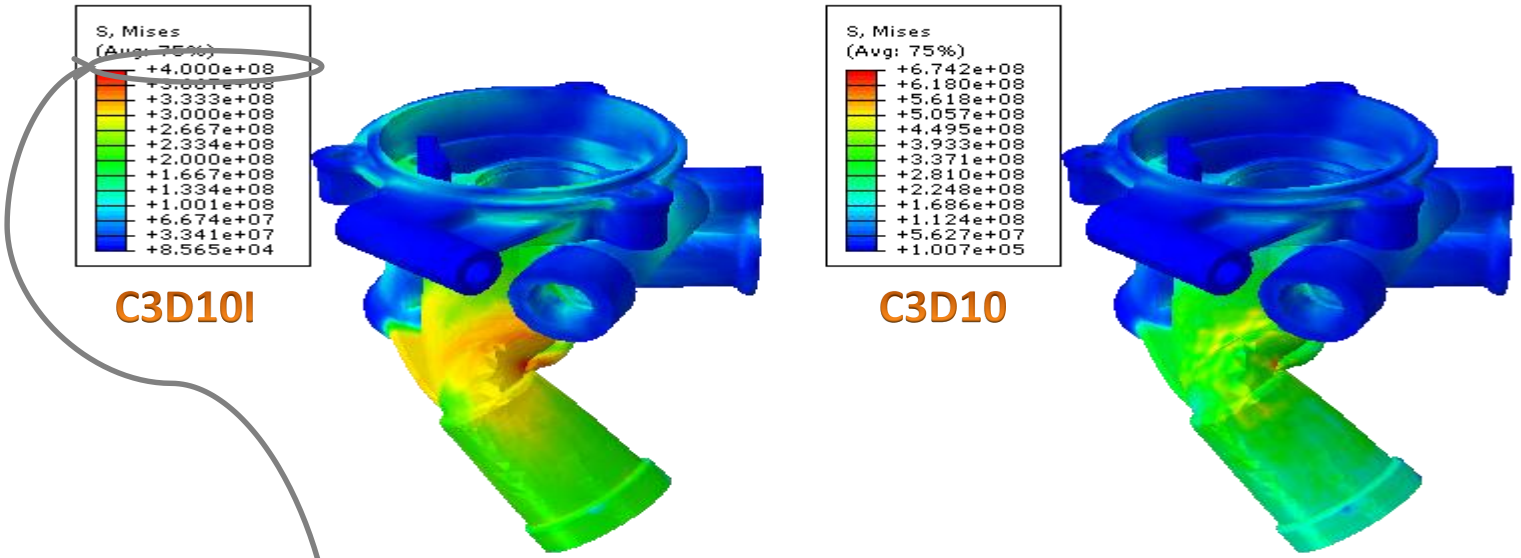


C3D10I matches analytical solution

C3D10I

C3D10I: General-Purpose Tetrahedral Element

- Elastoplastic knuckle

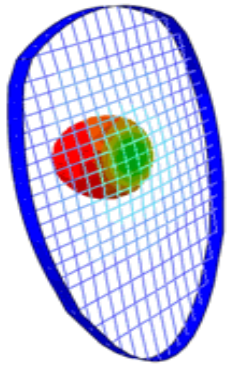


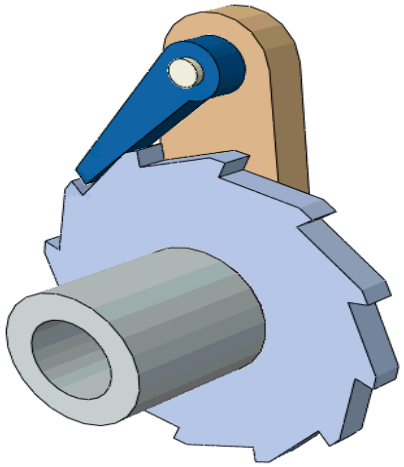
Note no extrapolation
error in stress contour plot.

Implicit Dynamics

Introduced in Abaqus 6.9EF

- Very good for certain quasi-static problems in which the timescale is measured in seconds but statically unstable
  - Rubber tracks
  - Belt drives
  - “Snap-fit” problems
- Keyword: “*DYNAMIC, Application=… ”
  - Quasi-static (for aggressive damping in quasi-static models)
  - Moderate dissipation (for moderate damping— “dynamic” problems for which contact does not need most accurate precision)
  - Transient fidelity (for most accurate solution—truly “dynamic” problems)
- Often a good “standard practice” tool for well-understood quasi-static problems
  - Often a superior solution to quasi-static problems currently being run in /Explicit



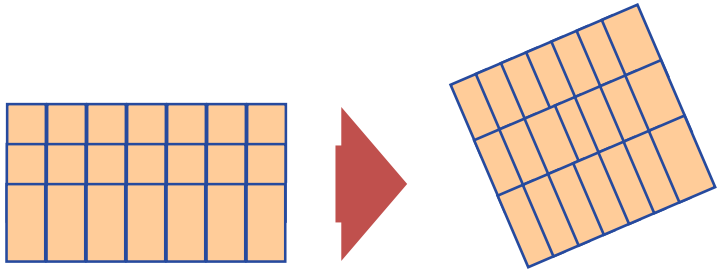


Latest capabilities in Abaqus

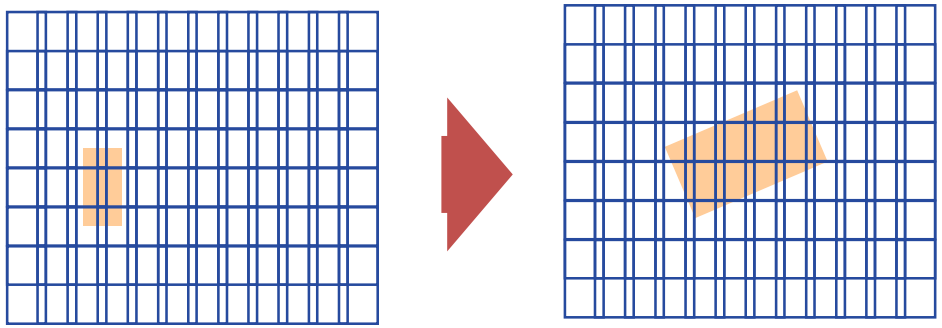
CEL/SPH/DEM

Coupled Eulerian-Lagrangian Method (CEL)

- Lagrangian elements
  - nodes are fixed within material
  - elements deform as material deforms
  - material boundary = element boundary

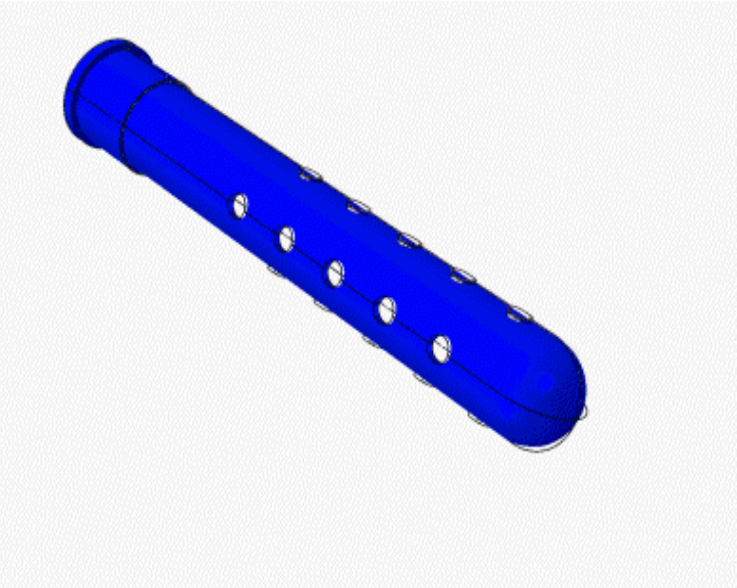


- Eulerian elements
  - nodes are fixed in space
  - material flows through elements
  - material boundary is represented by volume fraction
  - Interface reconstruction + advection



Explosion inside a gun barrel

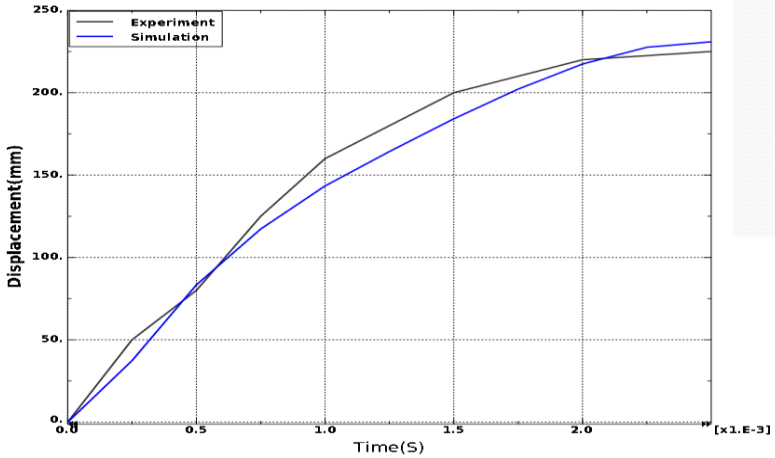
- Eulerian material is ideal gas
- Explosives are modeled with gas inflators inside the barrel
- Contour plot shows Mises stress in the structure

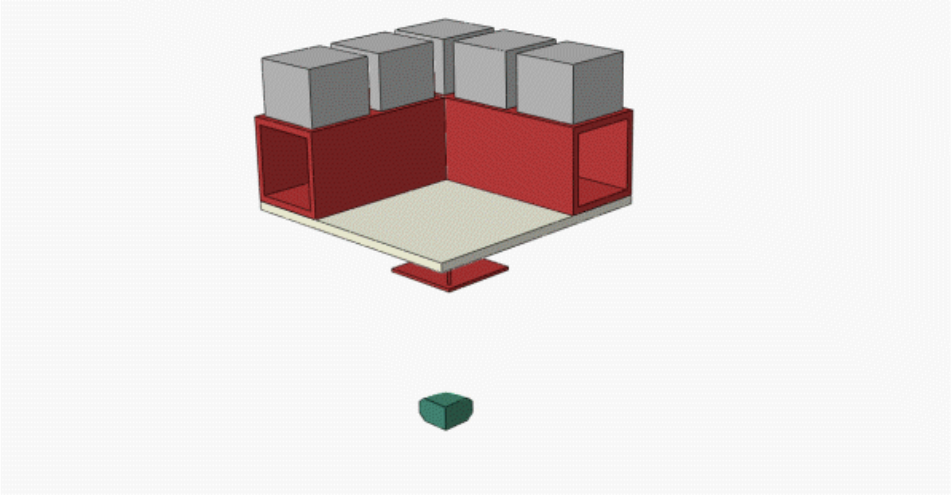


Coutesy of Picatinny Arsenal

Land mine explosion

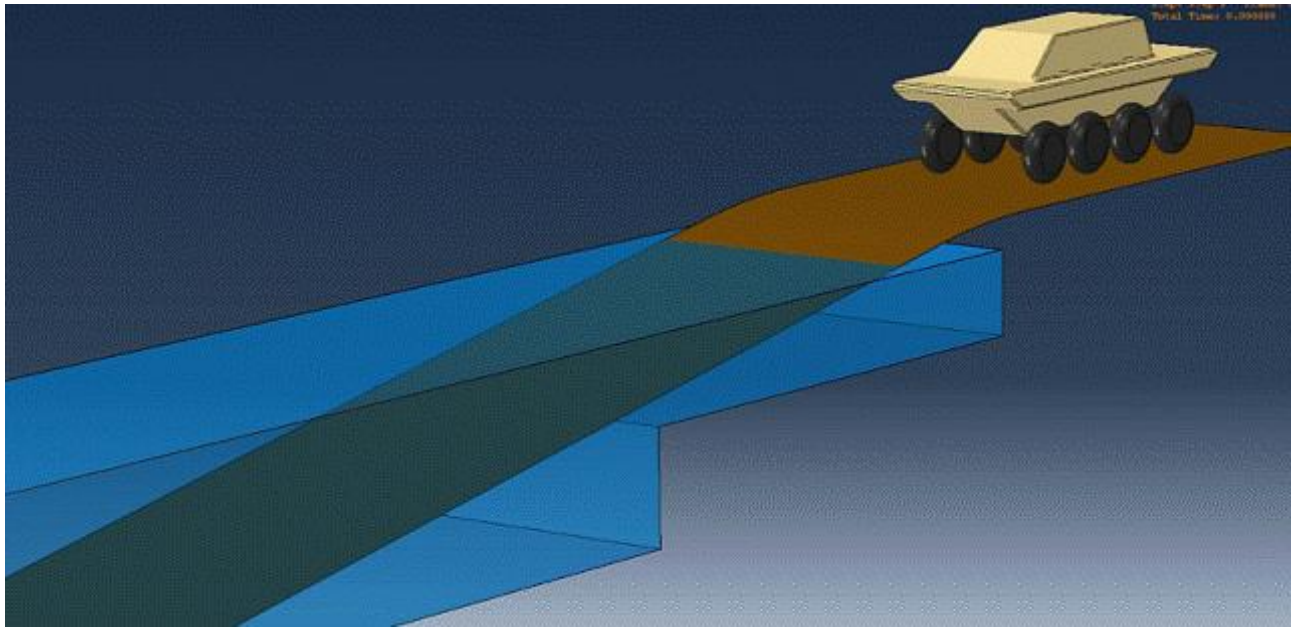
- JWL + ideal gas (air)
- Rigid structure + deformable plate





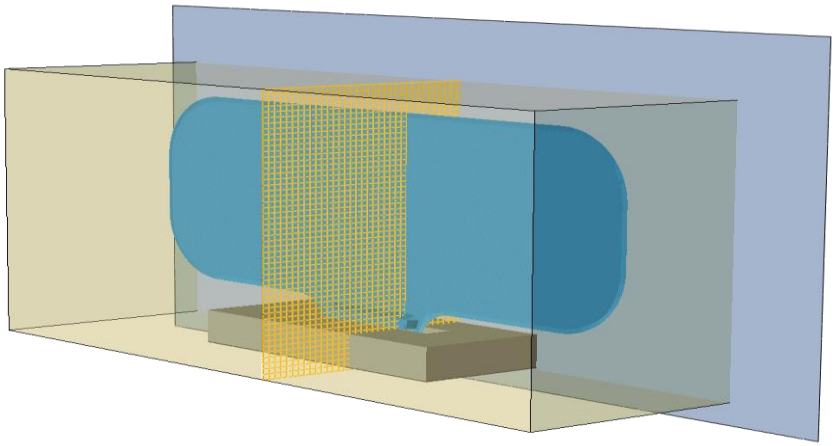
Water entry of an all-terrain vehicle

- Water + void
- Rigid structure



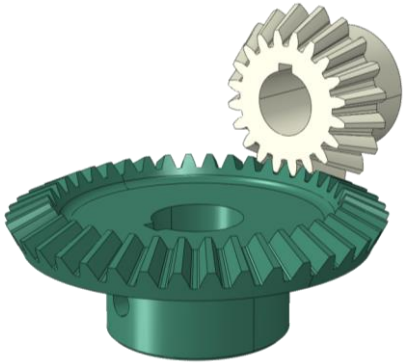
Curtain airbag deployment

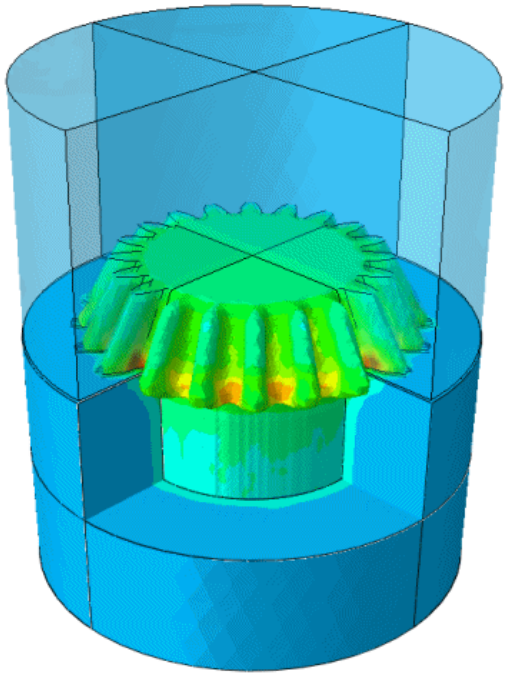
Courtesy of Takata



Thermal Interaction with CEL

- Extended CEL to thermal stress simulation with contact interactions
  - Complements thermal stress element introduced in Abaqus 6.11
- Applications include forging, mold filling, manufacturing processes, …





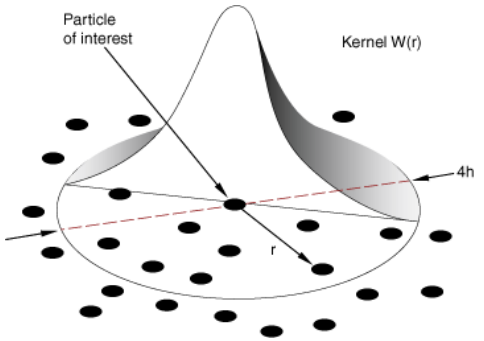
Hot forging

Recent Developments in SPH

SPH Implementation within Abaqus/Explicit

- SPH Concept
  - Mesh-free Lagrangian computational method (incepted in 1977)
  - Continuum modeling method (like FEM) derived in the context of interpolation theory
  - Extreme deformation with fragmentation

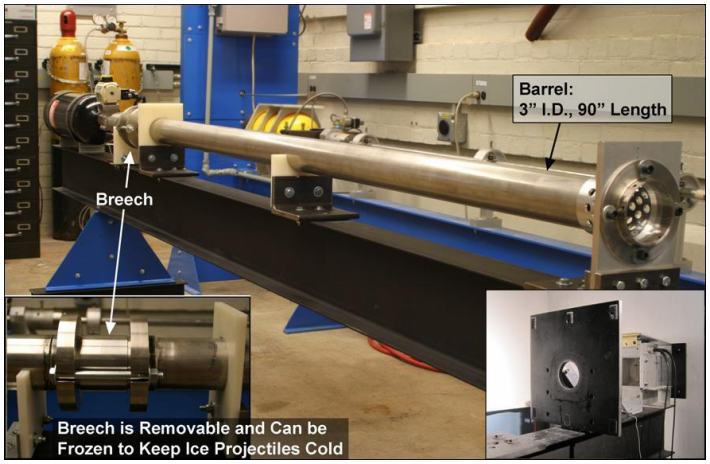
- Extremely high deformations problems where CEL is inefficient and Lagrangian FEM is difficult
  - Impact fracture: ballistics, shattering, fragmentation
  - Spraying
  - Snow compaction



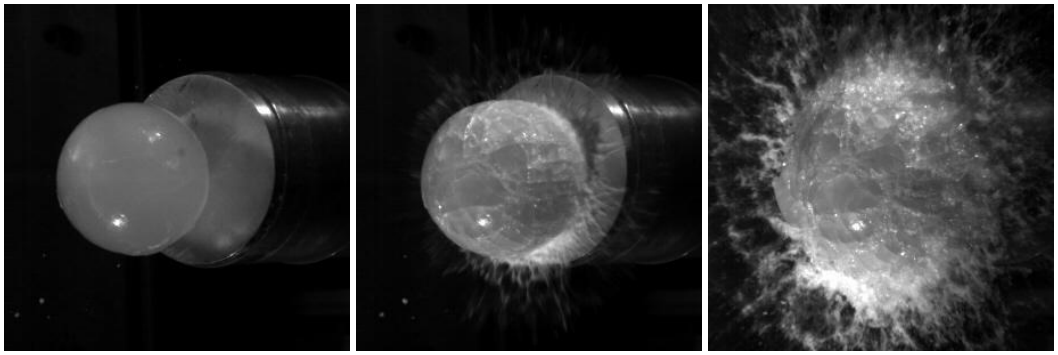
Ice Impact Analysis

- Study of Ice balls (hails) impact to construct material model and comparison with experimental data.
- Model derived from

  Jeffery Dwayne Tippmann, 'Development of a Strain Rate Sensitive Ice Material Model for Hail Ice Impact Simulation 2011'
- Uses a Elastic-Rate dependent plastic with tensile failure material definition.

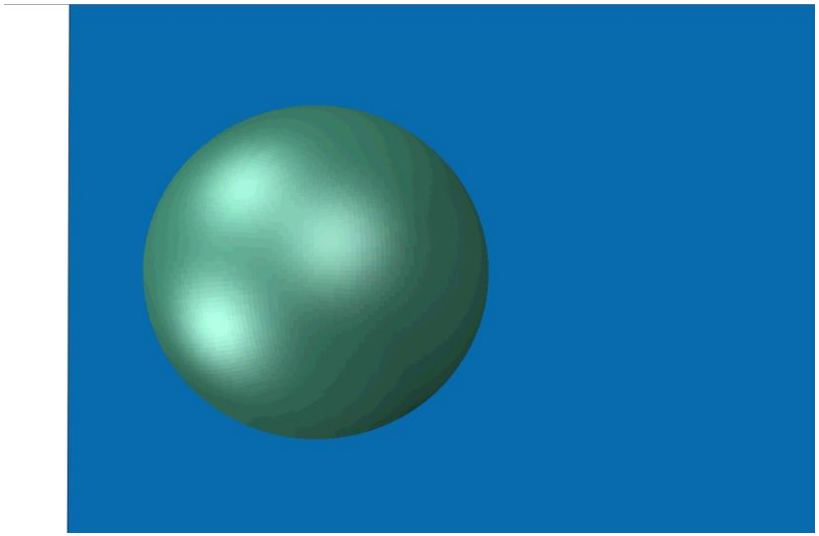


Experimental Set Up

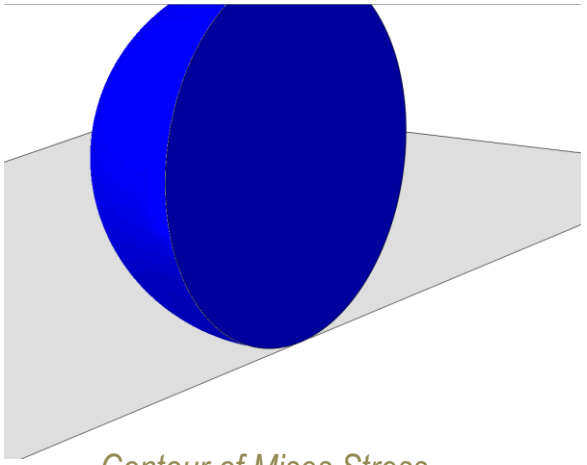


Ice deformation and breakage patterns

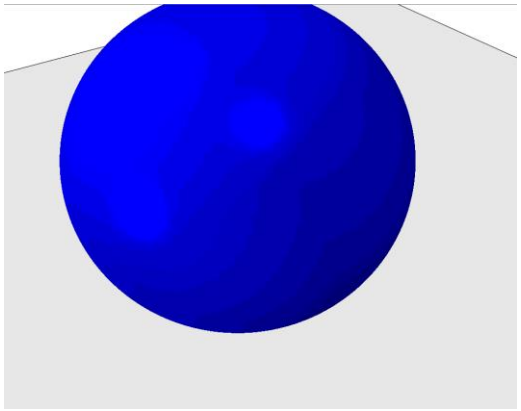
Ice Impact Analysis: Mises Stress



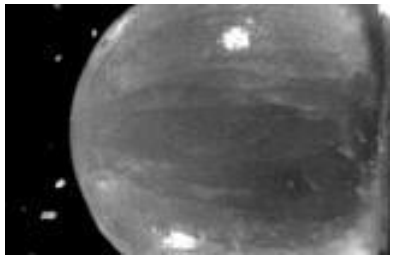
50.8 mm Ice impacting with an initial velocity of 60 m/s



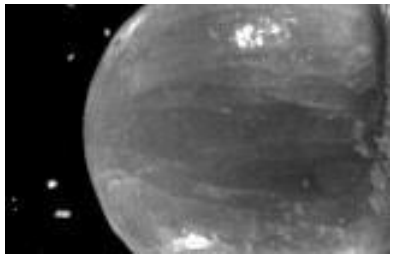
Contour of Mises Stress



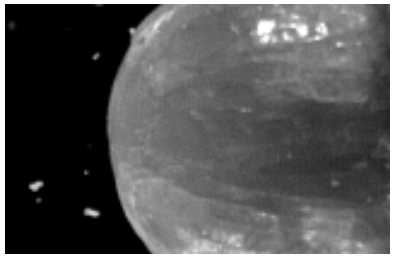
Ice Impact Analysis: Experiment vs SPH Simulation



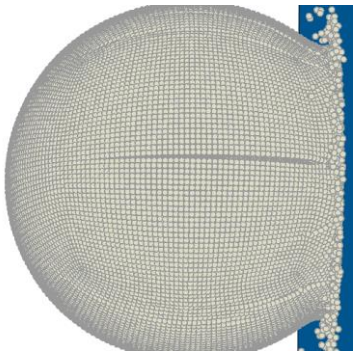
(a) t ~ 91 μs

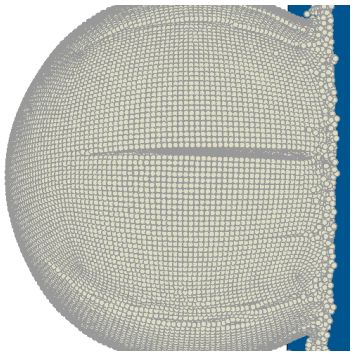


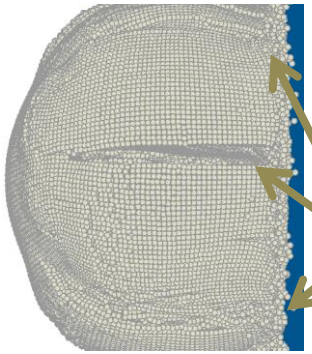
(a) t ~ 135 μs



(a) t ~ 223 μs



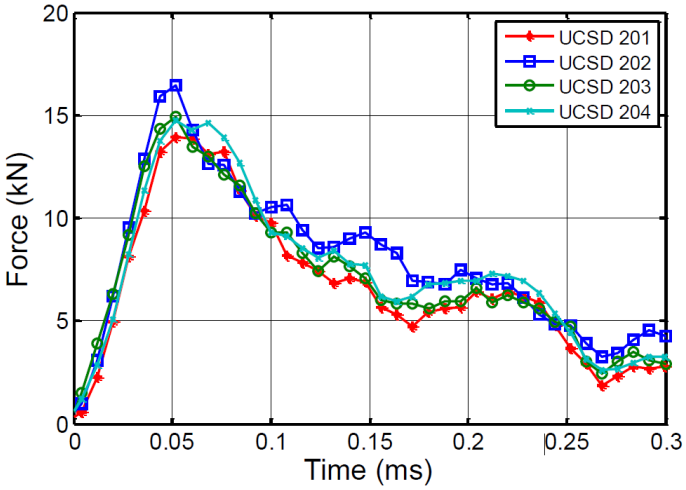


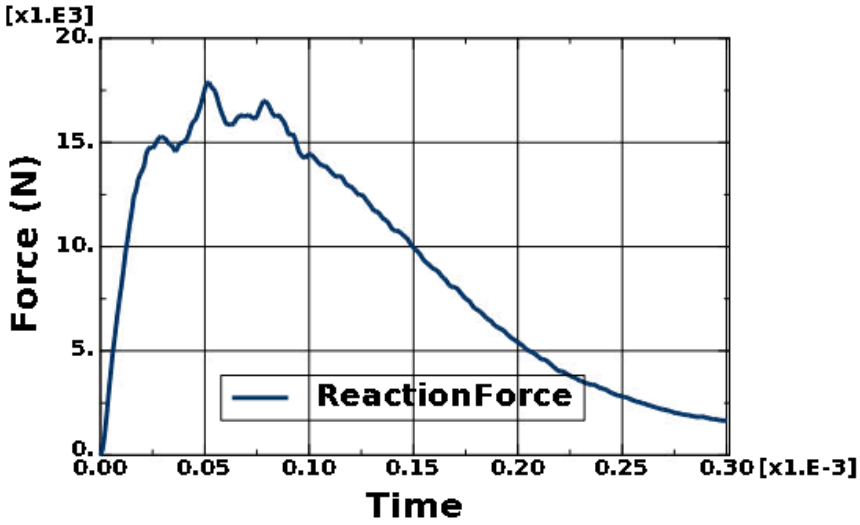


Longitudinal cracking patterns consistent with experiments.

Ice Impact Analysis: Reaction Force-Test vs SPH

Repeated tests of 50.8mm SHI size at velocities ranging between 59.3 m/s and 62.6 m/s (targeted velocity of 60 m/s)

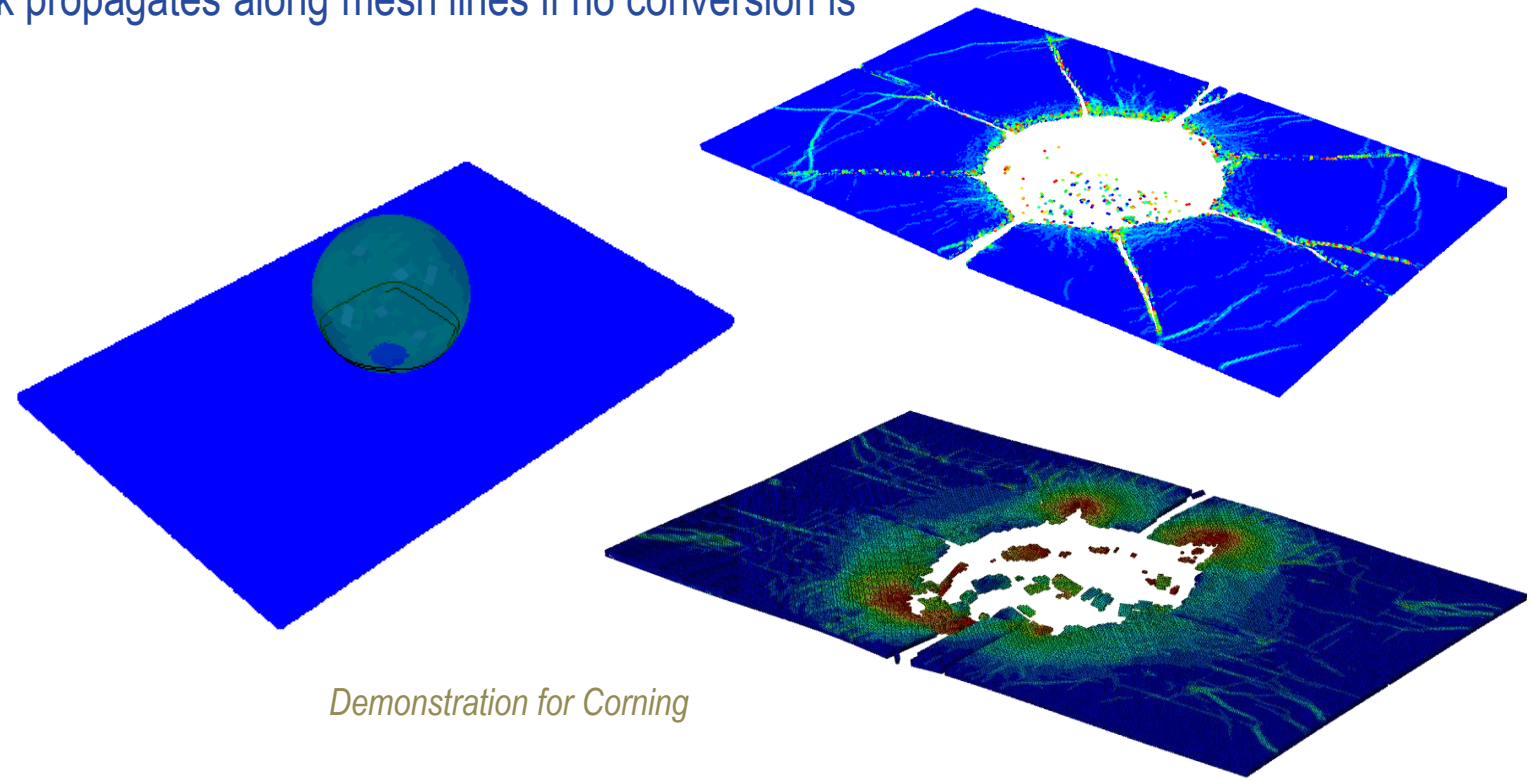




Abaqus/Explicit Results

Impact: rubber ball impact on a glass plate

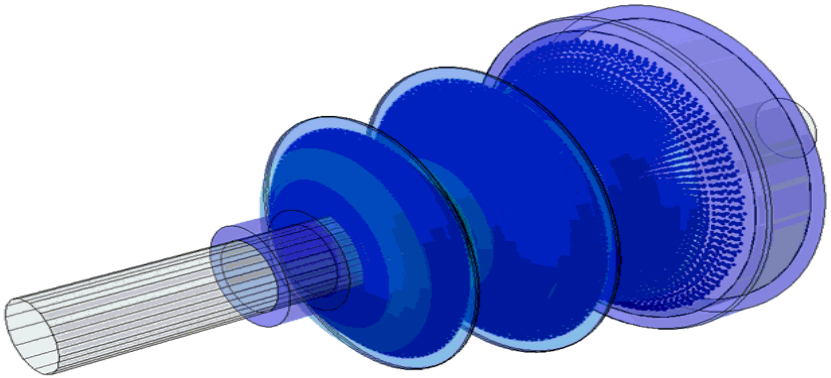
- Star-shaped cracking pattern in SPH
- Crack propagates along mesh lines if no conversion is used

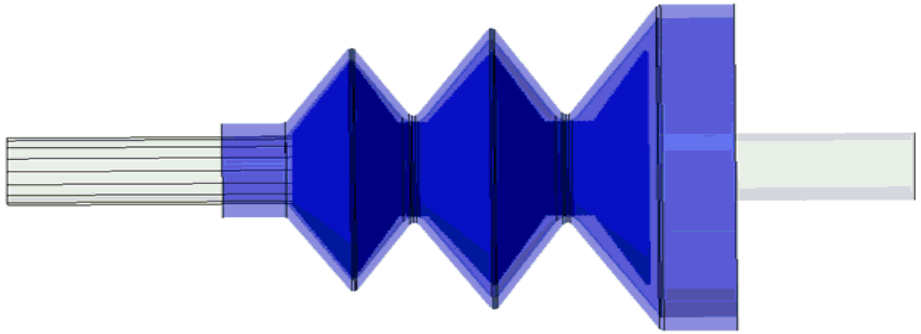


Demonstration for Corning

Grease in a CV Joint – Bending shaft

- Grease migrates from one cavity to the next

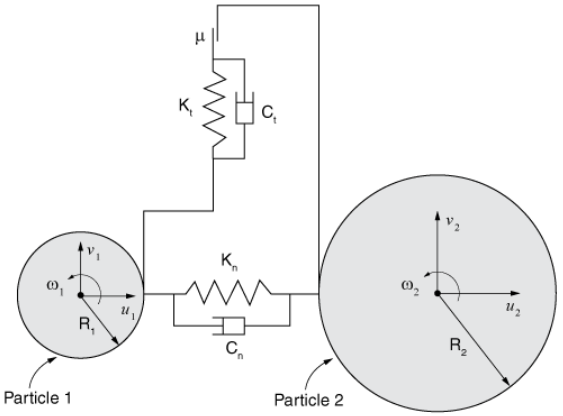


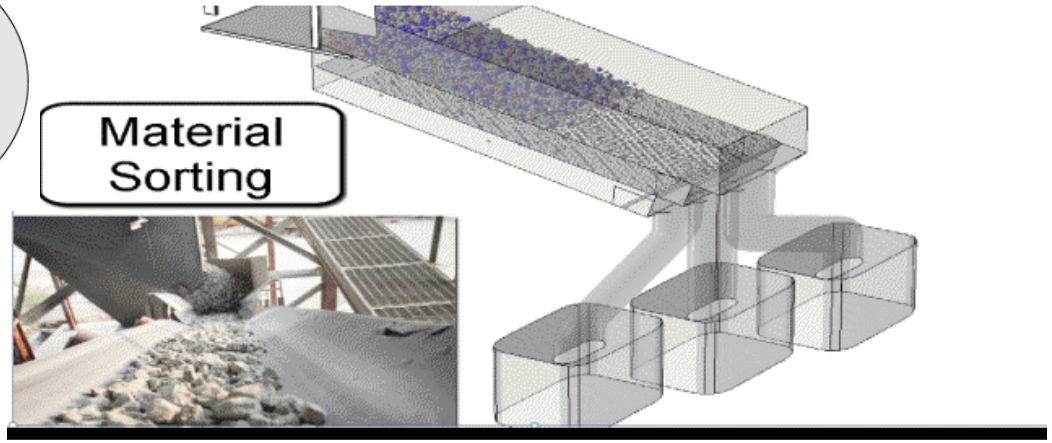


DEM in Abaqus/Explicit

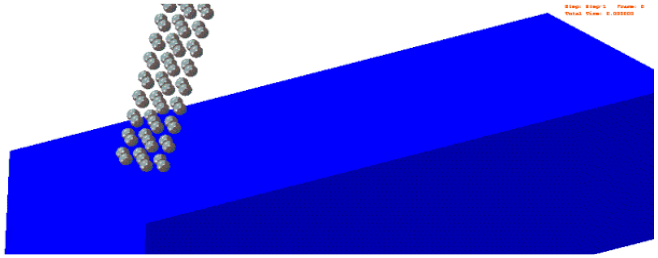
Motivation for Implementing DEM in Abaqus

- **More frequent requests to simulate particulate media**
  - Often involving interactions with structures modeled with nonlinear FEM
  - Leverage the strong general contact capabilities of Abaqus

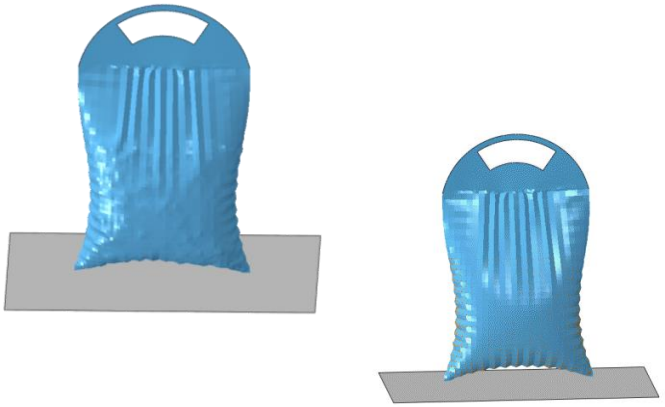


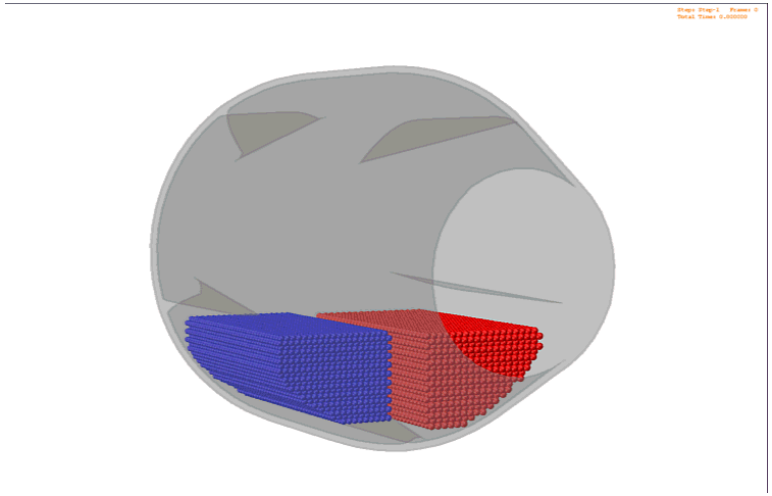


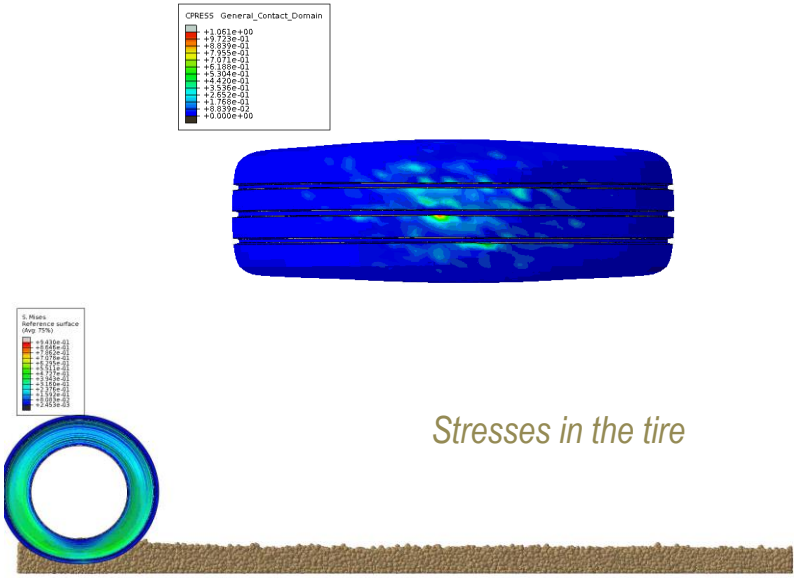
Target Applications



Equivalent Plastic Strain Plot





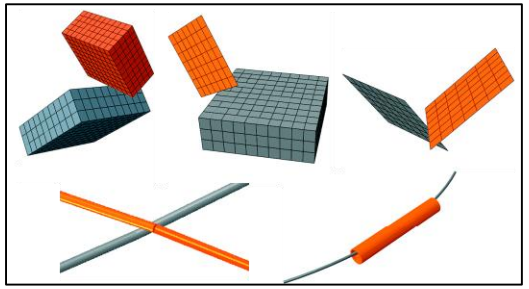


Stresses in the tire

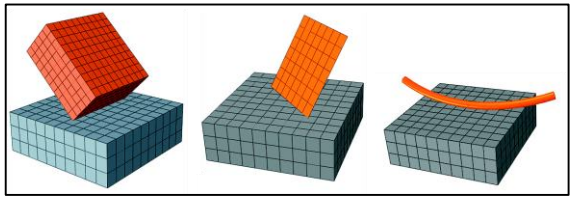
What is new in latest release Abaqus 2016

Advances in general contact

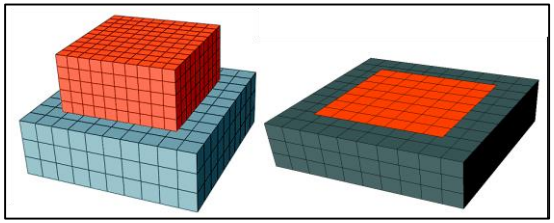
- Improved heuristics for automatically transitioning between different contact formulations can significantly improve convergence behavior in Abaqus/Standard.



Edge-to-Edge
(supplementary formulation)



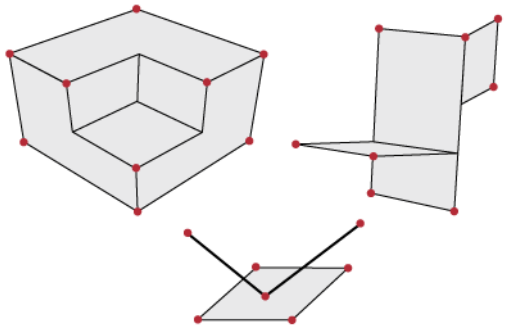
Edge-to-Surface
(supplementary formulation)

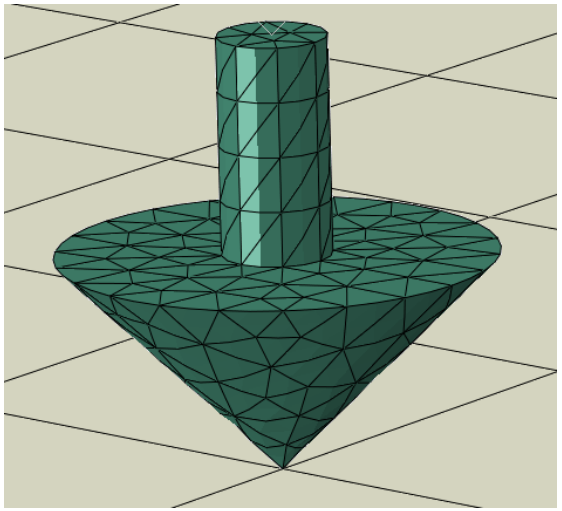


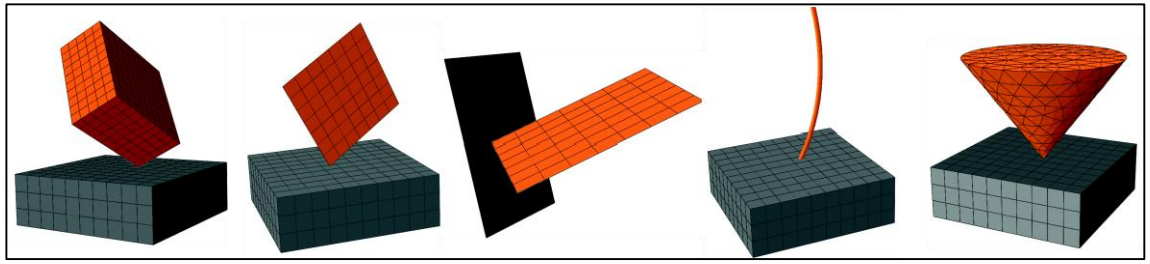
Surface-to-Surface
(primary formulation)

Advances in general contact

- New vertex-to-surface supplementary formulation improves contact behavior at convex corners.

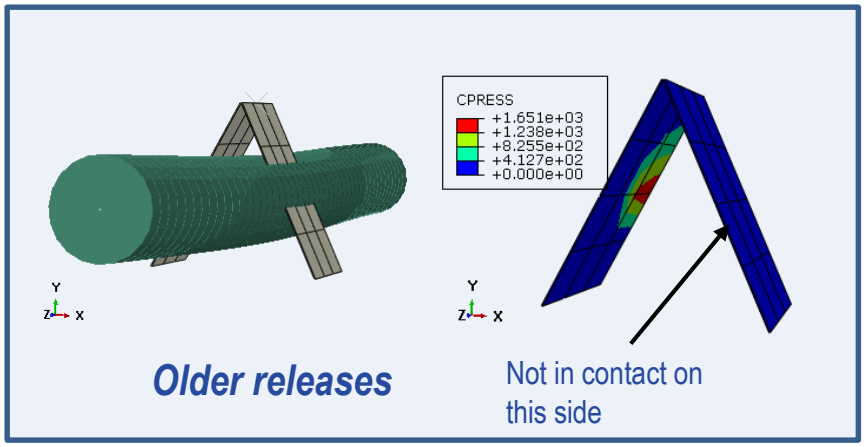


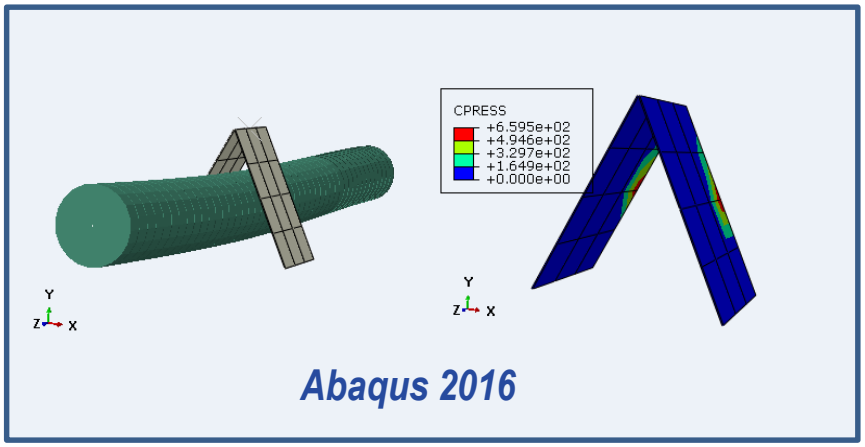




Advances in general contact

- Individual edges can be involved in multiple contacts

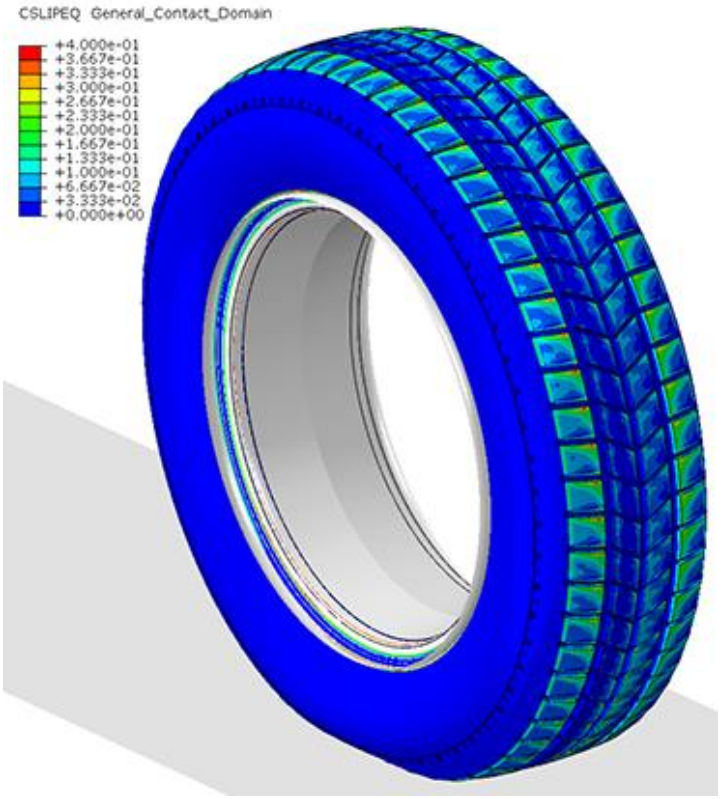




Example: Shell wedge bearing down on a beam pinned at its ends

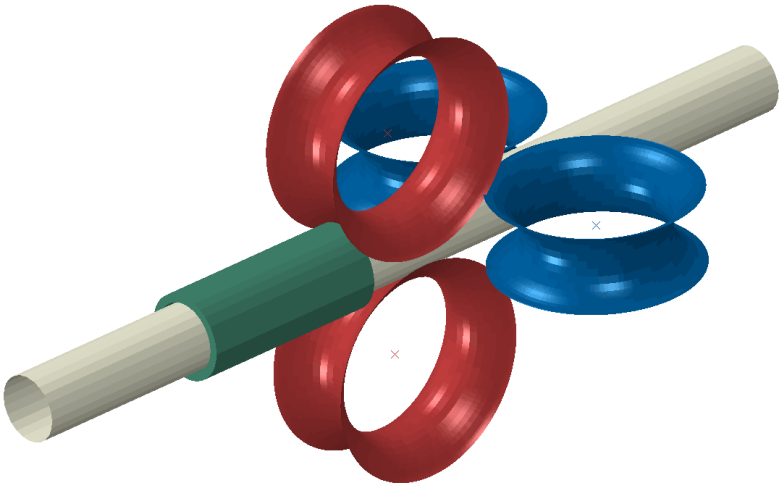
Contact output for Abaqus/Explicit

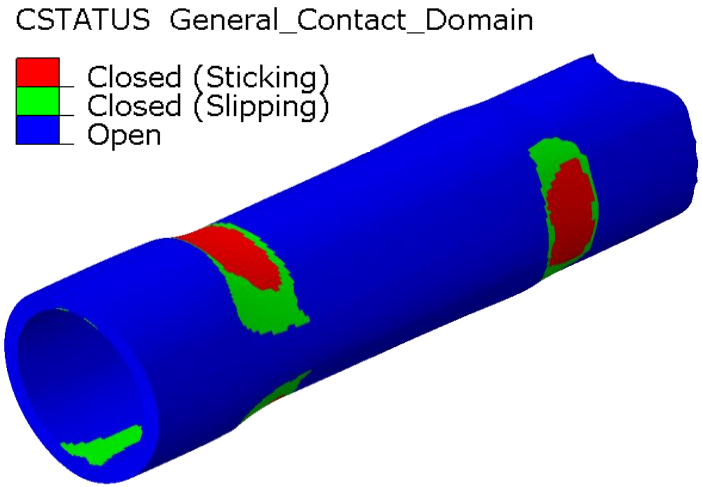
- CDISP “family” of output variables added
  - **COPEN, CSLIP1, CSLIP2**
  - New member of this family: **CSLIPEQ** (total slip length)
- CTANDIR output added
  - **CTANDIR1, CTANDIR2**
  - Vector output of $\mathbf{t}_1$ and $\mathbf{t}_2$ local tangent directions
- Slip rate output variables added
  - **CSLIPR1, CSLIPR2, CSLIPRMAG**



Contact output for Abaqus/Explicit

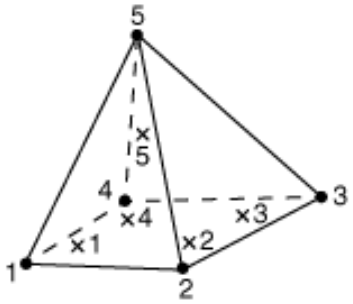
- **CSTATUS** output added



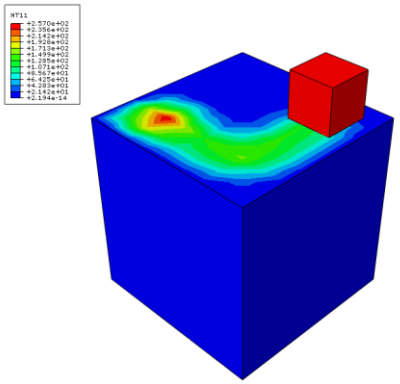


Expanded element library

- Pyramid element for stress analysis
  - Compatible transition between tet and hex mesh
  - Highly requested by customers
- Multiphysics elements
  - Coupled temperature-displacement
    - C3D10T, C3D10HT….
  - Coupled pore pressure-displacement
    - C3D10PH, C3D10P…
  - Coupled pore pressure-temperature-displacement
    - C3D10PHT,C3D10PT...



5 - node element

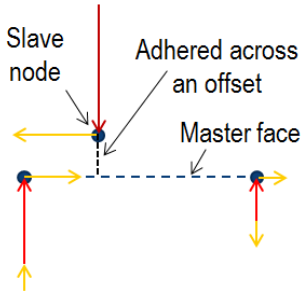


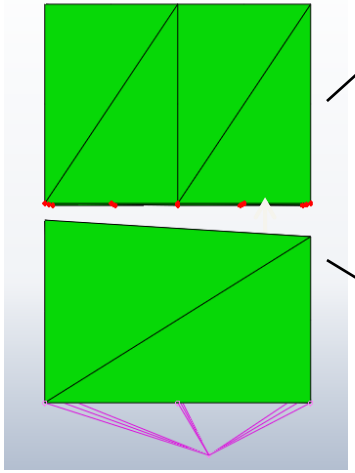
Finite sliding thermal contact

Rigid body rotation of tied solid surfaces

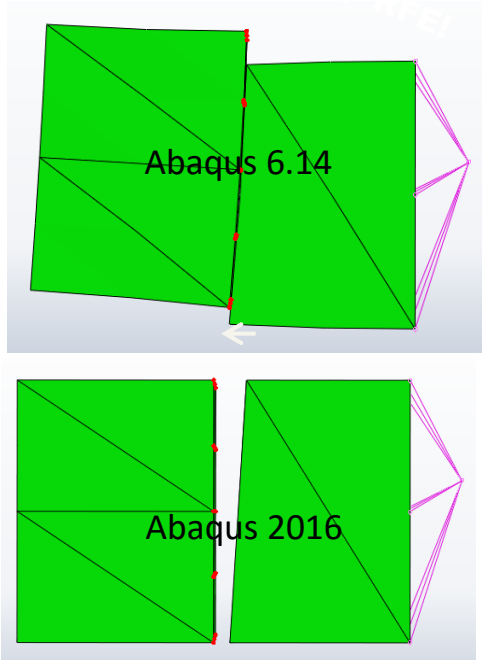
- Abaqus/Standard will by default account for rotations of offsets in solid mesh ties

Similar capability is implemented in Abaqus/Explicit within the framework of surface-based cohesive behavior.





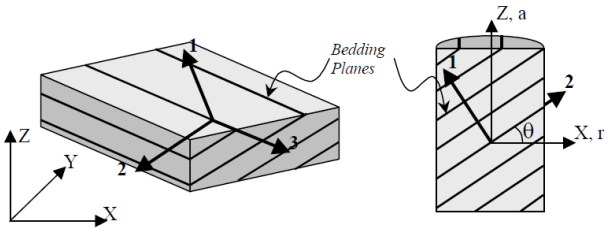
Original configuration



Final configuration

Material modeling enhancements

- Rate dependent nonlinear kinematic hardening plasticity
- Orthotropic clay plasticity for geomechanics applications
- Import of Johnson Cook plasticity for spring back after high rate impact events



(a) General System *(b) Triaxial System*

Figure 1. Local Coordinate System Aligned with Bedding Planes

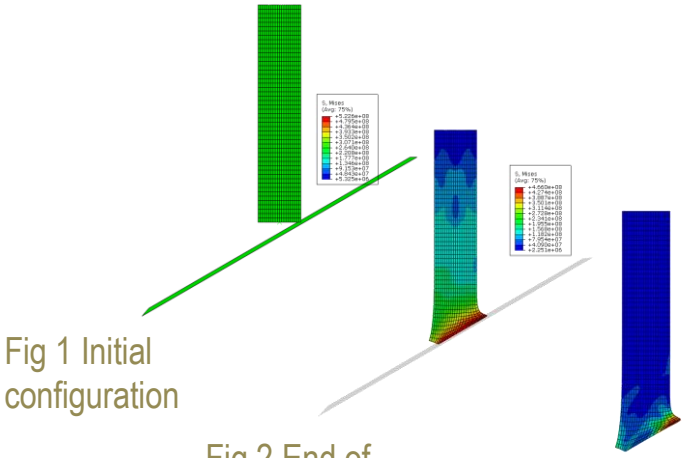


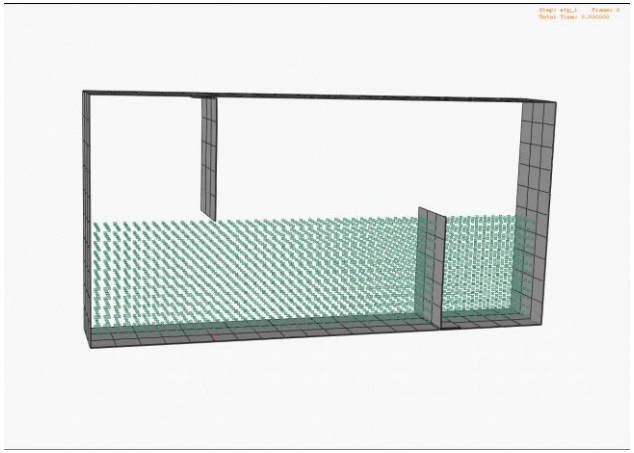
Fig 1 Initial configuration

Fig 2 End of impact event

Fig 3 Final configuration

Tracer particles for CEL

- Tracer particles follow the material motion in CEL simulations and allow extraction of material point results.



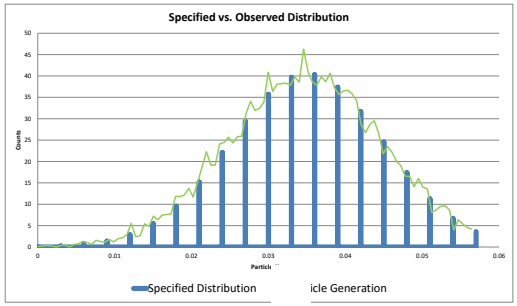
Tank sloshing example w/ tracer particles

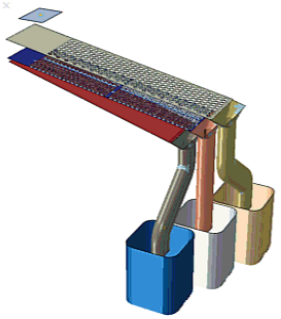
Model	With tracers (seconds)	Without tracers (seconds)
Blast (294k elements, 3400 tracer particles)	1607	1578
Sloshing (13k elements, 2940 tracer particles)	1080	862
Flat airbag (52.5k elements, 1440 tracer particles)	602	582

Minimal impact on performance

DEM particle generation

- Particle generation can now be based on:
  - Evolving inlet surfaces
  - User-specified size distribution
  - User-specified mass flow rate
  - User-specified inlet velocity





Screen Sorter

Expanding inlet

Rotating inlet

Moving inlet

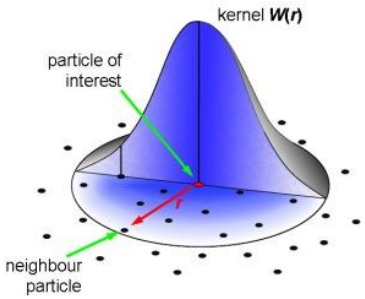
DEM particle interactions

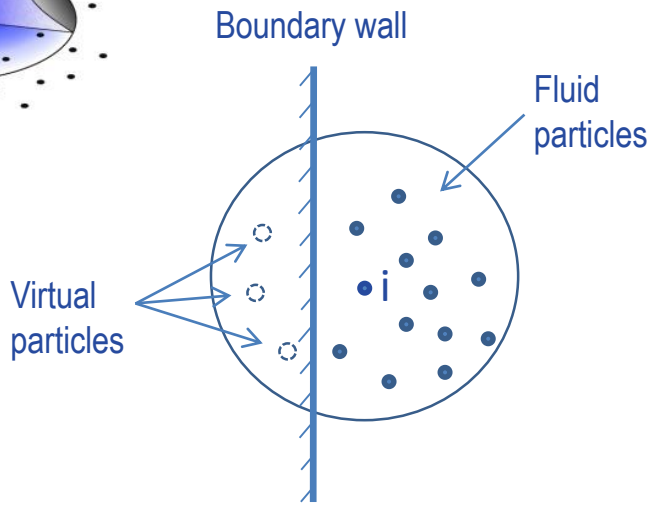
- Simplified specification of Hertz normal contact between particles
- Adhesive contact based upon the Johnson-Kendall-Roberts (JKR) model has been introduced

Comparison of mixing process, without and with adhesion

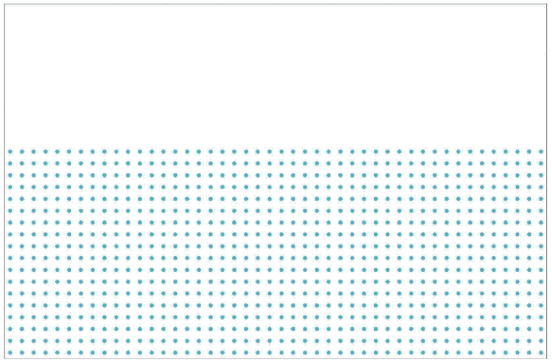
Improved treatment of SPH boundaries

- Introduction of virtual particles improves accuracy of SPH wall conditions.

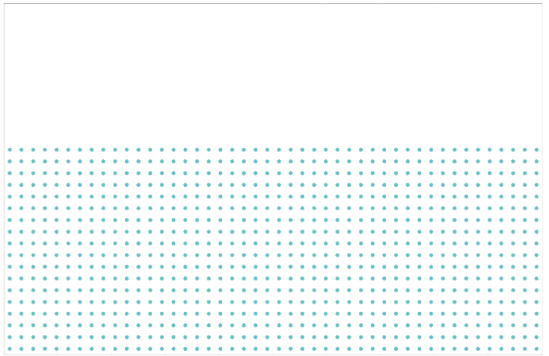




Old

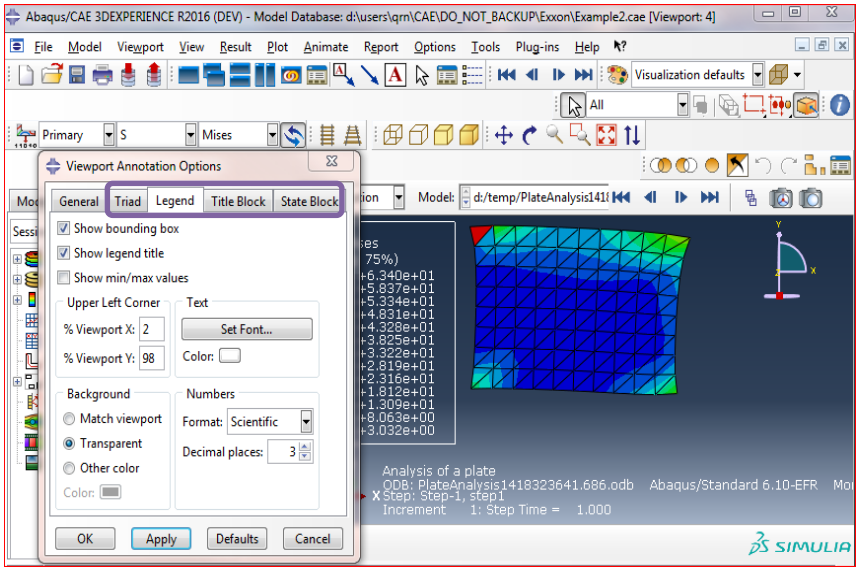


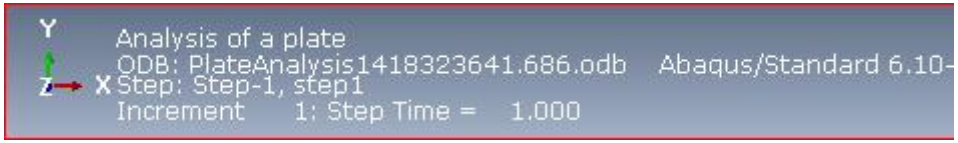
New



Usability

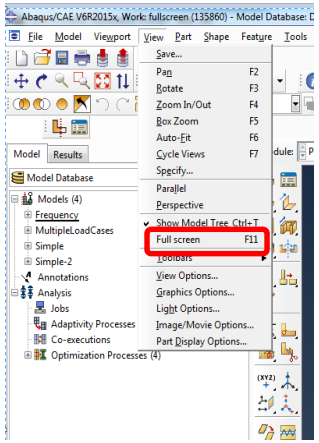
- Fixed Copy/Paste issues in past releases
  - Copy text from prompt area to clipboard
  - Copy content from GUI widgets and paste the contents
    - … after closing the widget window!
- Default font and glyph size modified
  - Default font size for legend, title block, state block, x-y plots is increased to 12
  - Default glyph size for Viewer and CAE entities is increased from 6 to 12

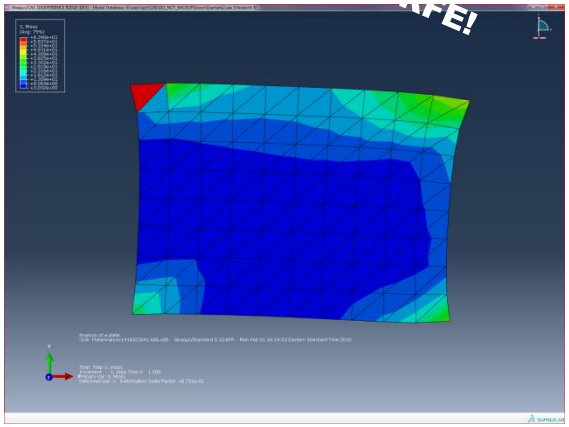


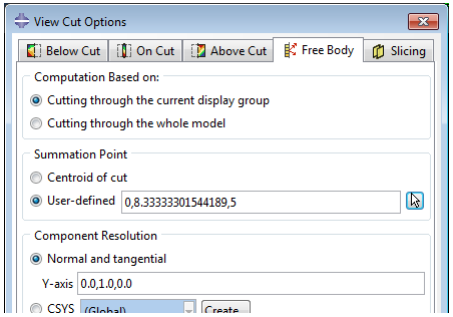


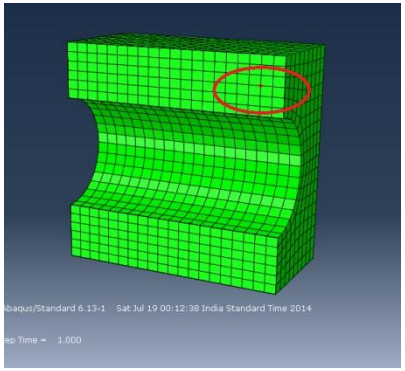
Usability

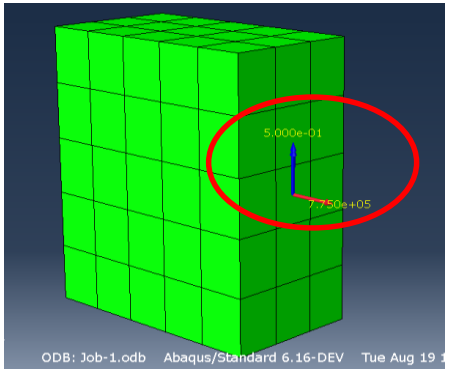
- Expand viewport to Full Screen (F11)
  - F11 toggles back to default view
- Freebody usability
  - Highlights the location of user-defined summation points
  - Improved default colors of Moment arrows





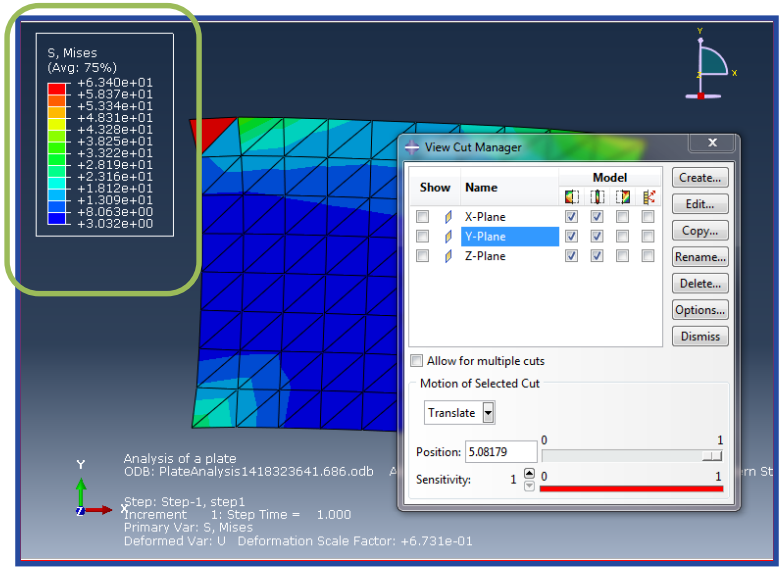




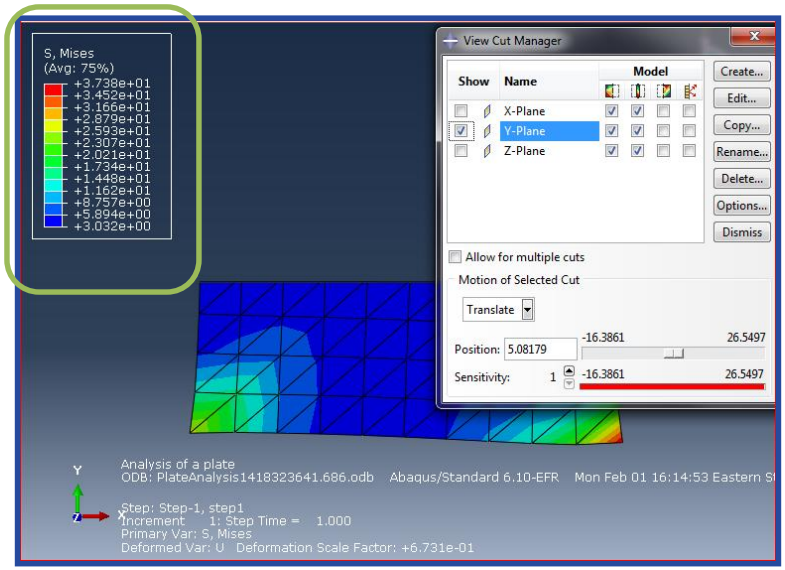


Results visualization

- Update min/max location according to view cut



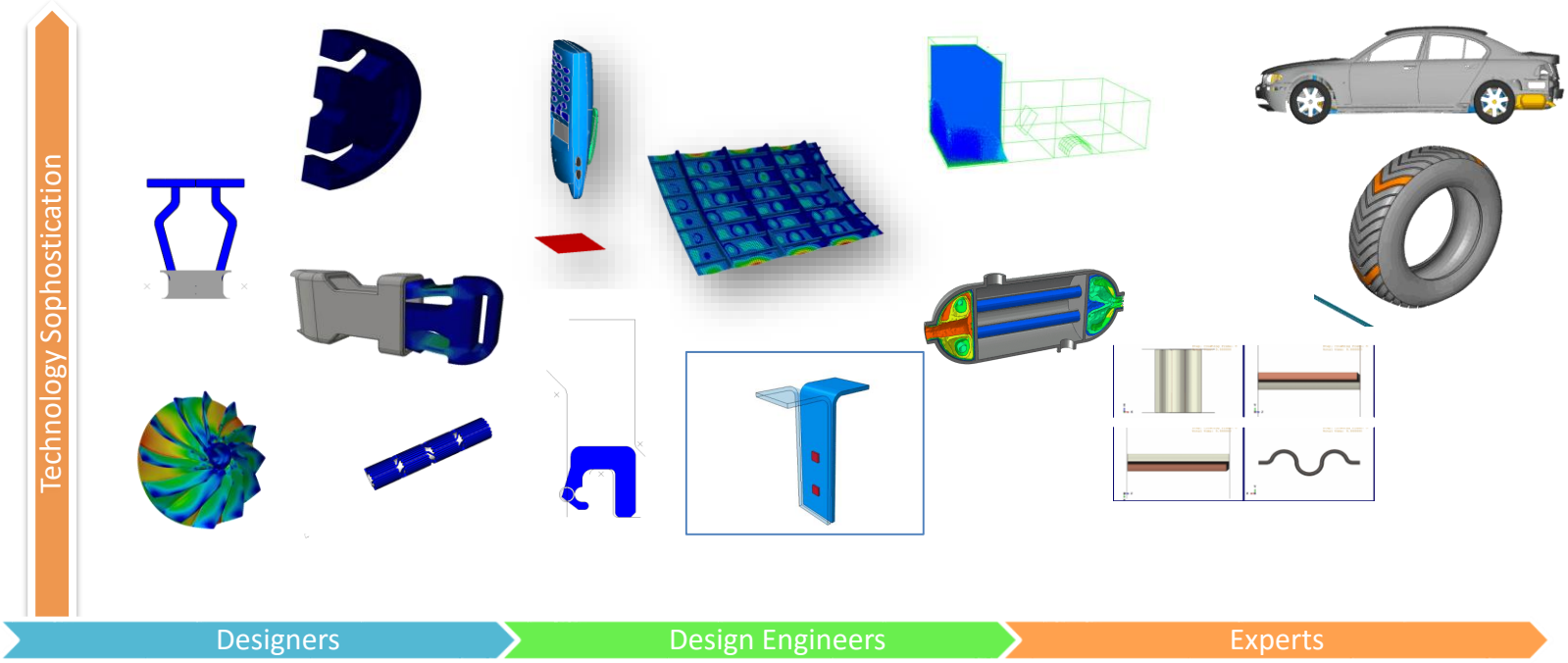
Min/max location before view cut



View cut with updated min/max location

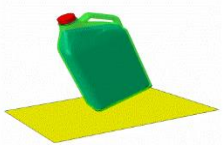
Instead of conclusion

One tool for all

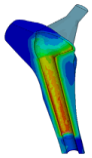


Solutions for the entire range of industries

Consumer Packaged Goods
Plastic and Glass Forming
Conveyor Systems
Container Drop
Pressure Analysis
Thermal Analysis
Bottle Sealing
Adhesives

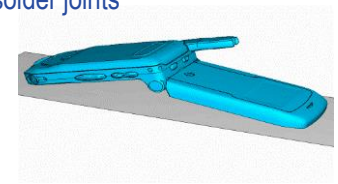


Life Sciences
Tissue Modeling
Surgical Equipment
Stents
Drug Delivery
Orthopedics
Medical Packaging

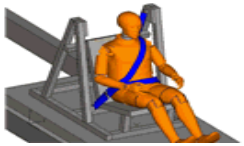


Aerospace & Defense
Avionics
Landing Gear
Aerostructures
Aeroengines
Composites
Defense Systems
Space Systems

High Tech
Thermal cycling of solder joints
Drop Testing
Vibration Analysis
Semiconductors
Circuit Boards
Hand-held Devices
Computers & Peripherals

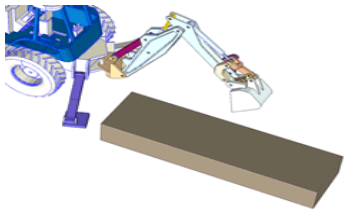


Automotive & Transportation
Chassis
Body
Tires
Interiors
Crashworthiness
Brake Systems
Powertrain
Electronics

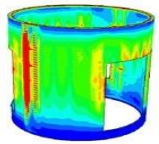


Architecture & Construction
Earthquake loading
Structural integrity due to fire
Concrete analysis
Soil-pore interaction
Failure limits

Industrial Equipment
Nonlinear Stress Analysis
Thermal Analysis
Cyclic Loading
Flexible Multibody Dynamics
Soil-Structure Interaction



Energy
Wave loading on rigs and pipelines
Piping and pressure vessels
Thermal analysis
Blast loading
Drop or Impact



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