



Drop Test/Impact Test Simulation using Ansys LS-DYNA

Ban Banerjee,
Senior Applications Engineer

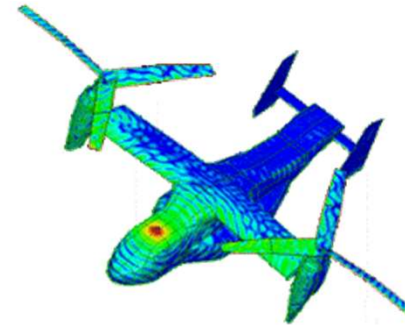
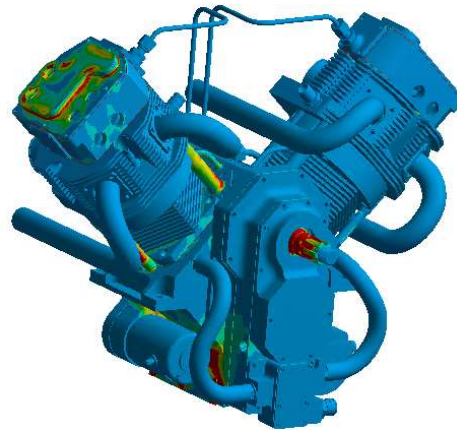
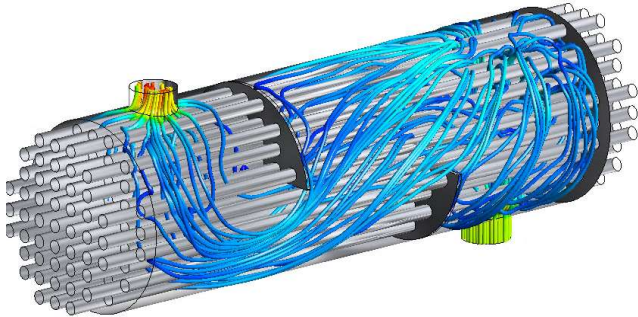
July 23, 2024

Agenda

- ❑ DRD Mission Statement and Support Options
- ❑ Types of Drop Test/Impact Test
- ❑ Theory and Background on Ansys LS-DYNA
- ❑ Typical Applications of Ansys LS-DYNA
- ❑ Drop Test Wizard
- ❑ Real World Examples for Drop Test/Impact Test
- ❑ Summary
- ❑ Questions

Mission Statement

DRD Technology helps engineering teams accelerate product development. With in-house expertise spanning the entire range of physics, we ensure customers succeed when using Ansys simulation tools for virtual prototyping and design verification.



Ansys

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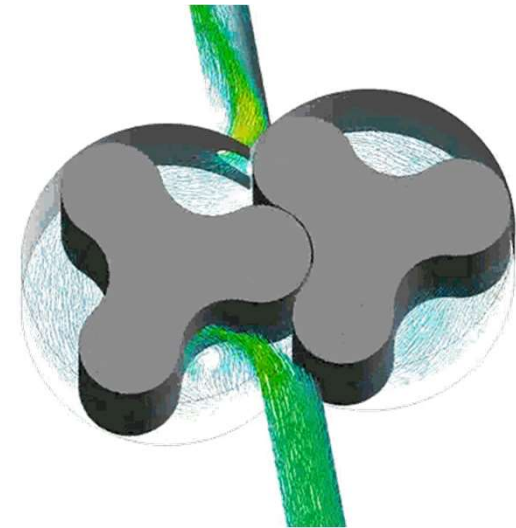
DRD History

Since 1980, DRD Technology has been focused on engineering simulation.

In 1984, DRD became an Ansys Channel Partner.

I've been working with DRD for 29 years. Working with your team has been one of the more enjoyable parts of my career. You have always been ready to help in any way.

- Rick Kunc
Sr. Research & Development Engineer



Lobe pump

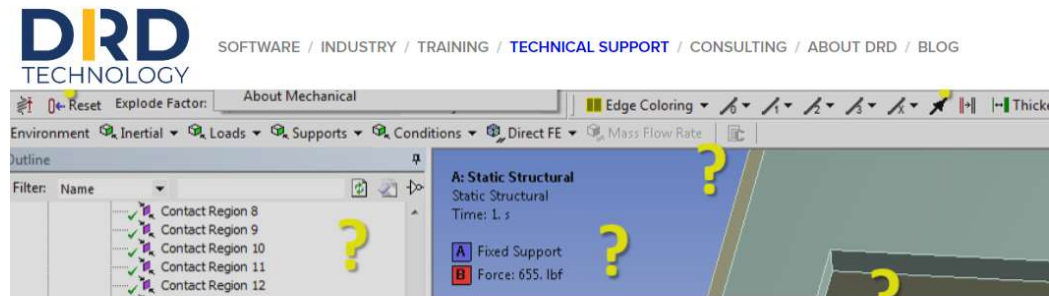


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Technical Support Contact Coordinates

Support:
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Submit a Technical Support Question

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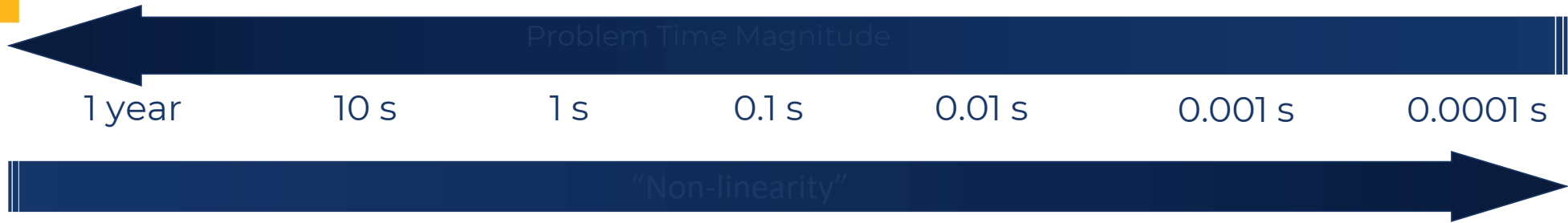
Email Address *

For more than five years, I have worked closely with DRD Technology to execute tactical and strategic initiatives here at EaglePicher due to our unprecedented growth. We've been very happy with DRD and will continue to work with them as our business partner for using Ansys tools effectively and efficiently.

- *Doug Austin*
Director of Research and Development

EaglePicher™
Technologies, LLC

Types of Drop Test/Impact Test



1 year

10 s

1 s

0.1 s

0.01 s

0.001 s

0.0001 s

Creep

Static/Dynamic

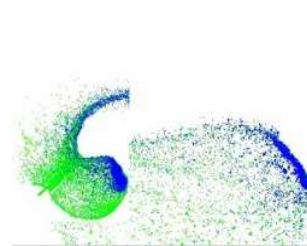
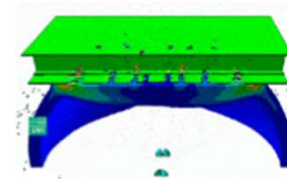
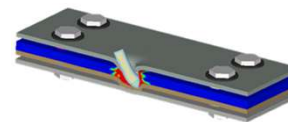
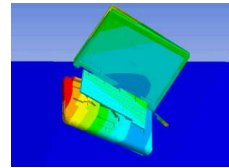
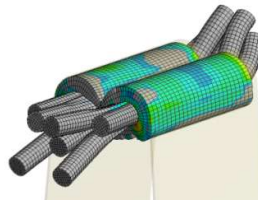
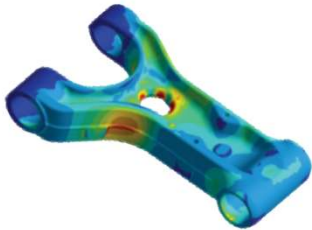
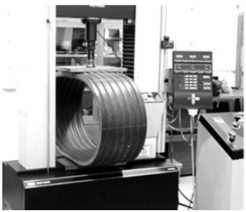
Quasi-Static

Drop /
impact

Ballistics

Detonation
& Blast

Hypervelocity
Impact



IMPLICIT METHODS

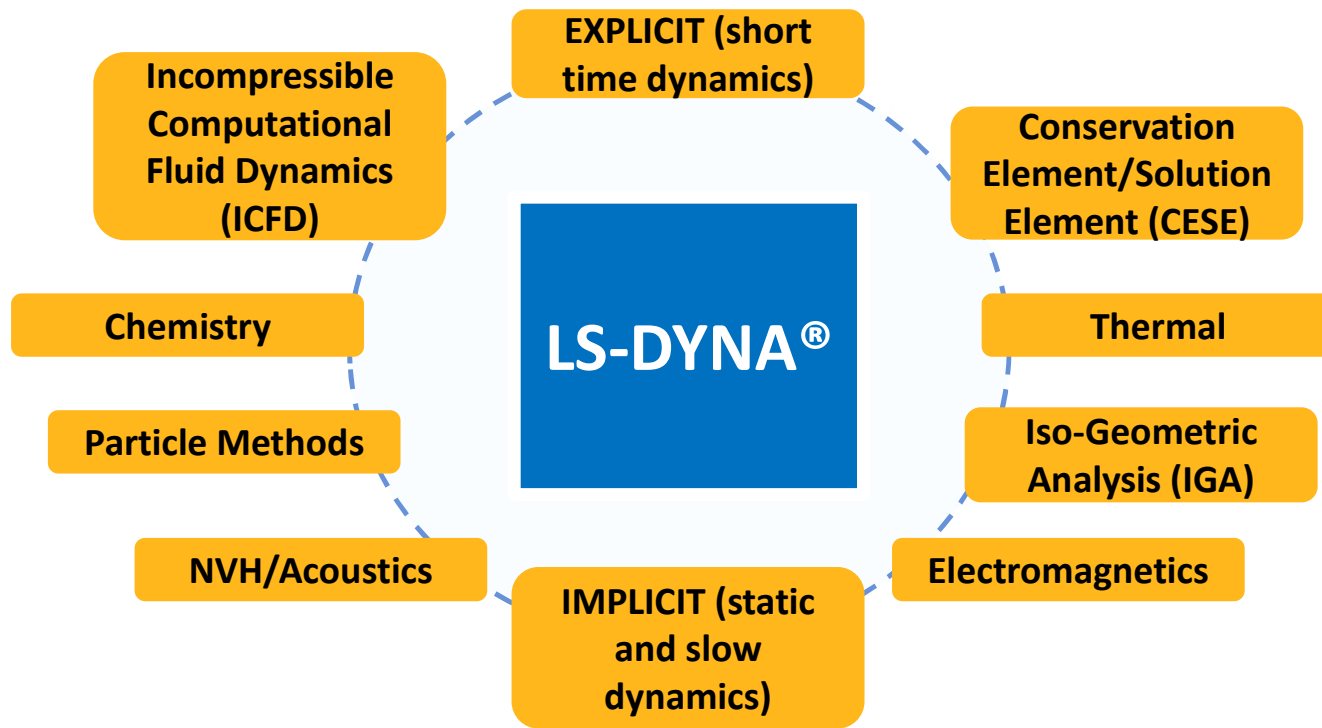
EXPLICIT METHODS

LS-DYNA

Theory and Background on Ansys LS-DYNA

LS-PrePost
All LS-DYNA Pre & Post Processing

LS-TaSC
Shape, Topology Optimization

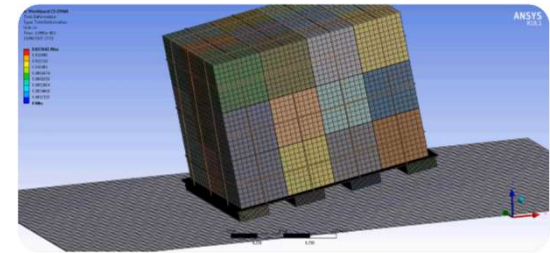
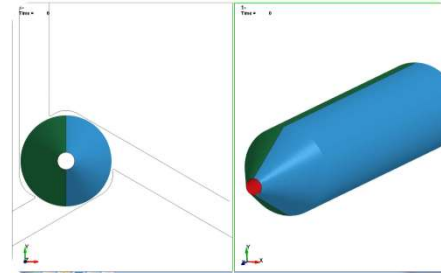
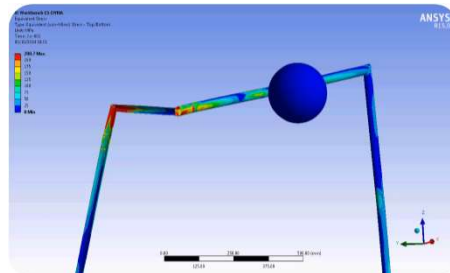
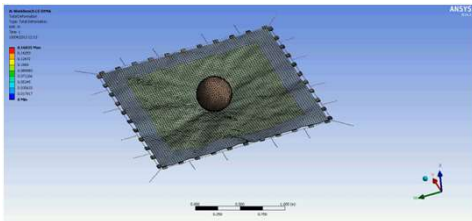
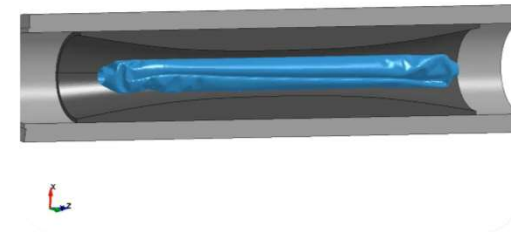
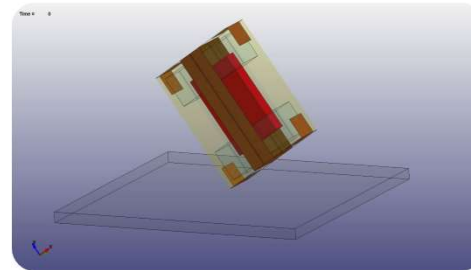
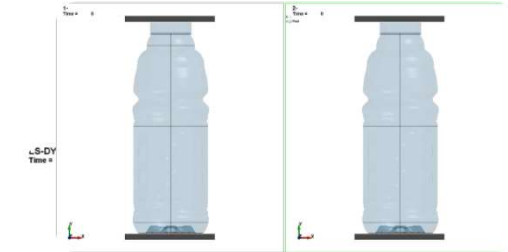
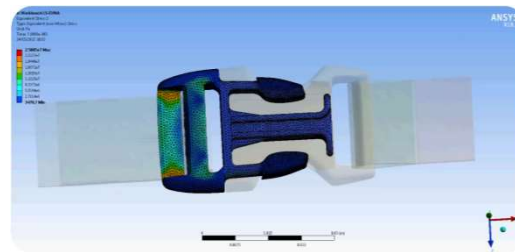


LS-Opt
Optimization Robustness

Barriers Occupant
Validated barriers and Occupants

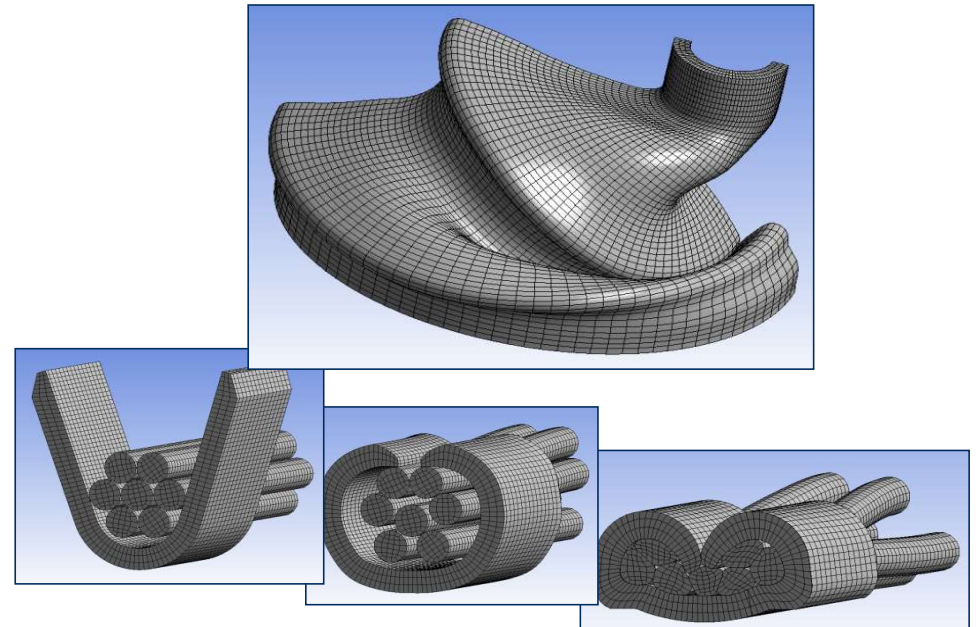
Typical Applications of Ansys LS-DYNA

- Drop test of all forms
- Impacts
- Product misuse / severe loadings
- Product failure / fragmentation
- Containment safety and penetration mechanics
- Large plasticity in mechanisms
- Sports equipment design
- Manufacturing processes like machining / cutting / drawing



Typical Applications of Ansys LS-DYNA

- Large deformations
 - Large displacements
 - Large rotations
 - Large strains
- Complex contact
 - Efficient self contact
 - Abrupt status change
 - Eroding contact
- Nonlinear Material
 - Plasticity
 - Hyperelasticity
 - Failure



- ✓ **Short time dynamics**
- ✓ **Highly non-linear applications (quasi-static)**

Drop Test Wizard

- The Drop Test Wizard provides a fully automated way of setting up a drop test analysis in LS-DYNA
- Requires only a file containing the geometry of the objects being dropped
- What does it do?
 - Creates rigid construction geometry representing a plane upon which the objects are dropped
 - Allows orientation of the objects and the drop plane
 - Calculates and applies impact velocity based upon drop height
 - Applies standard earth gravity
 - Fully constrains the drop plane
 - Defines Body Interaction between the drop plane and objects
 - Meshes the model
 - Sets analysis End Time

Wizard

Drop Test

ANSYS / ACT

Target Rotation (X)

Drop Rotation (X)

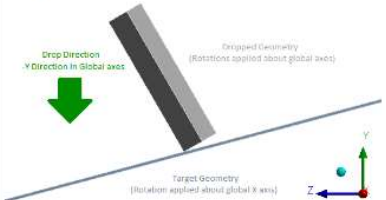
Drop Rotation (Y)

Drop Rotation (Z)

Define By

Drop Height m

Help



Target Rotation (X) orients the automatically generated Target geometry about the global X axis. The Target geometry is created on entering a non-zero value into this input field.

The orientation of the geometry to be dropped is specified using the Drop Rotation (X), Drop Rotation (Y), and Drop Rotation (Z) input fields. Drop rotations are about the center of mass of the dropped geometry and are applied instantaneously to allow immediate visual inspection. The center of mass is stored in a coordinate system named 'Rotation Point'. The dropped geometry rotation is achieved using a Part Transform defined on the 'Rotation Point' coordinate system.

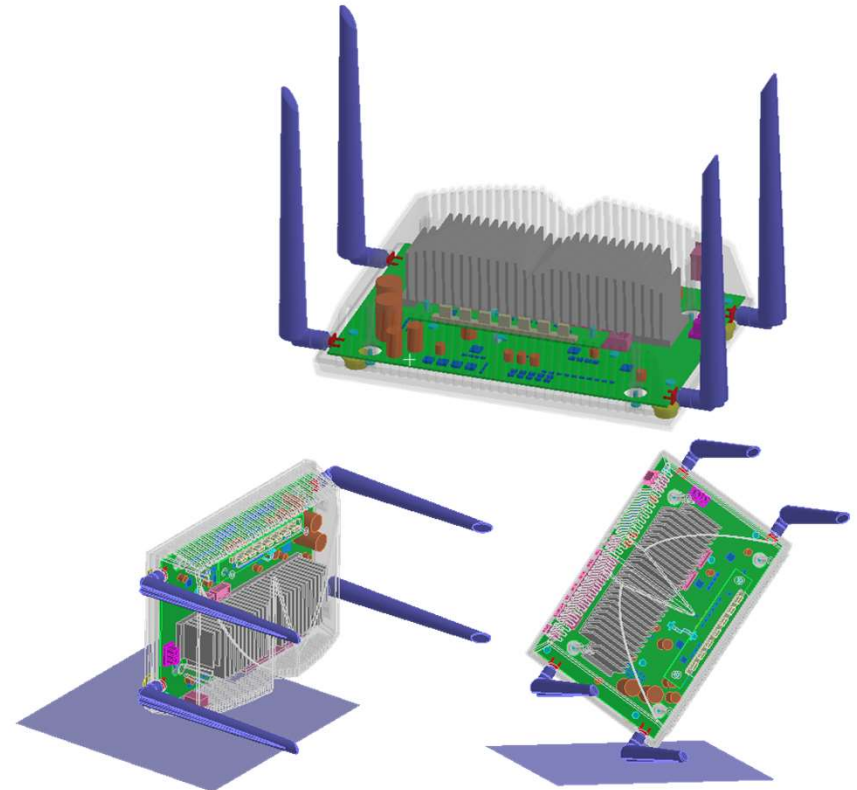
Impact conditions can be defined by either Drop Height or Impact Velocity.

Drop Height reflects the height from which the object is dropped where it undergoes gravitational acceleration.

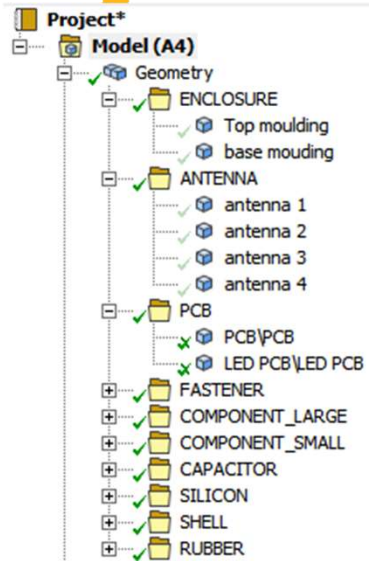
Exit Wizard

Real World Examples for Drop Test/Impact Test : Consumer Goods Drop Test

- **Scope**
 - Consumer Electronics Drop Test
 - System level nonlinear transient explicit analysis
- **Objective**
 - To predict area under risk
- **Geometry**
 - Full assembly of a generic Router
- **Tools used**
 - Ansys Workbench
 - SpaceClaim
 - Ansys Lsdyna
 - LS-Run
 - LS-PrePost
 - LS-Reader

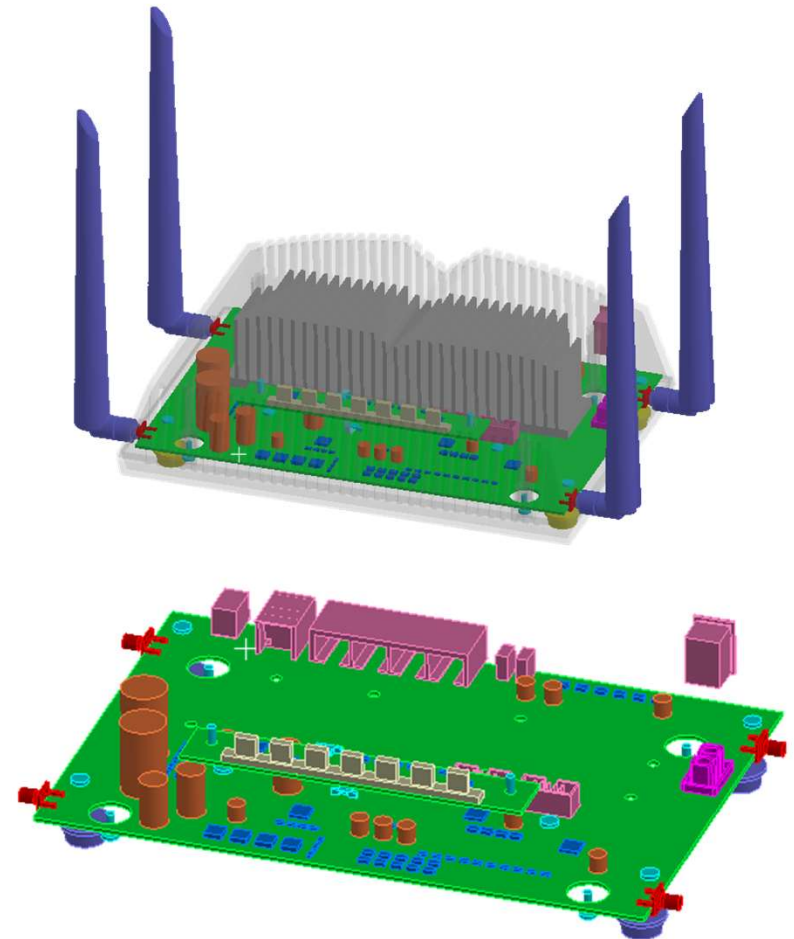


Import CAD Assembly



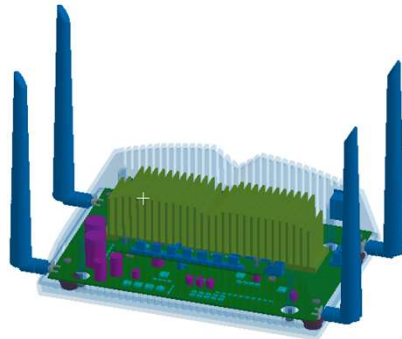
140 parts

- Enclosure
- Antenna
- PCB
- IC component
- Fastener
- Rubber Mount

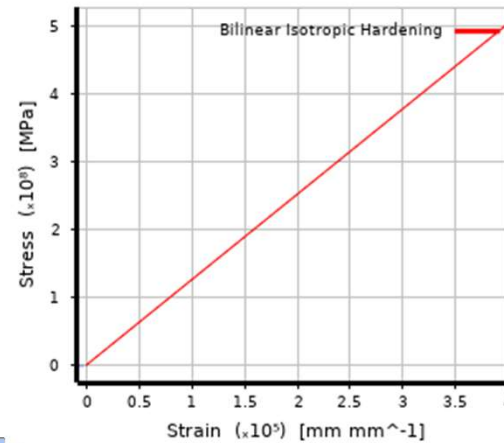


Material Models

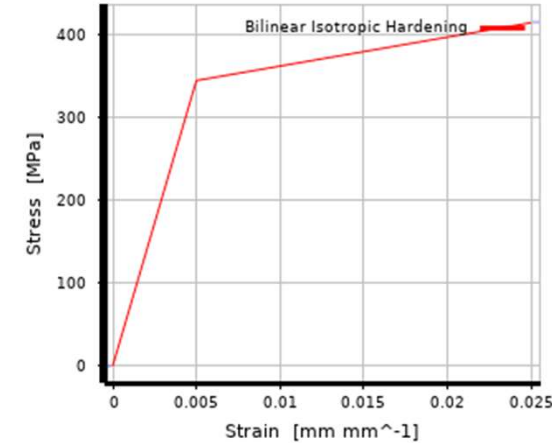
- Aluminum alloy
- Capacitor
- Copper
- PCB, FR-4
- Plastic, ABS
- Rubber
- Silicon
- SS 316



Copper

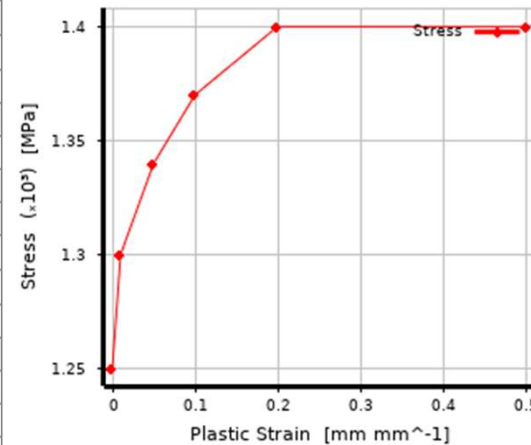


Aluminum

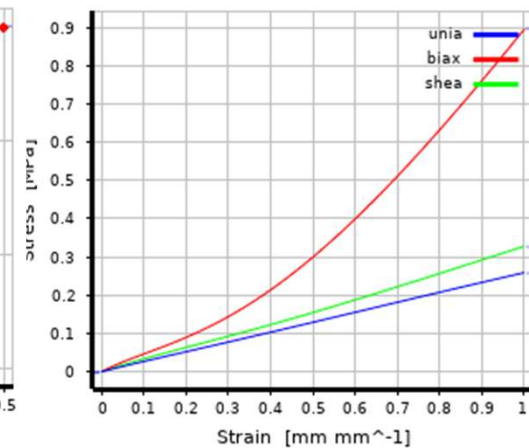


1	Property	Value	
2	Material Field Variables	Table	
3	Density	7.969E-09	tonne mm ⁻³
4	Isotropic Elasticity		
5	Derive from	Young's Modulus and Poisson's...	
6	Young's Modulus	1.95E+05	MPa
7	Poisson's Ratio	0.27	
8	Bulk Modulus	1.413E+05	MPa
9	Shear Modulus	76772	MPa
10	Cowper Symonds Piecewise Linear Hardening		
11	Piecewise Linear Hardening		
12	Strain Rate Correction	Scale Yield Stress	
13	Initial Yield Stress A	0	MPa
14	Strain Rate Constant C	0	
15	Strain Rate Constant P	0	
16	Effective Stress	Tabular	
17	Scale	1	
18	Offset	0	MPa

SS 316



Rubber



Drop Orientation

Project

- Model (A4)
 - Geometry
 - Materials
 - Virtual Topology
 - Coordinate Systems
 - Connections
 - Mesh
 - Explicit Rigid Bodies
- LS-DYNA (A5)
 - Initial Conditions
 - Analysis Settings
 - Contact Properties
 - Tet4_Solid_13
 - Drop Test Plugin
 - CG
 - Drop Test
 - Load Case 1 - bottom
 - Load Case 2 - back
 - Load Case 3 - antenna
 - Load Case 4 - corner
 - Load Case 5 - front edge
 - Load Case 6 - back edge
- Solution (A6)
 - Solution Information

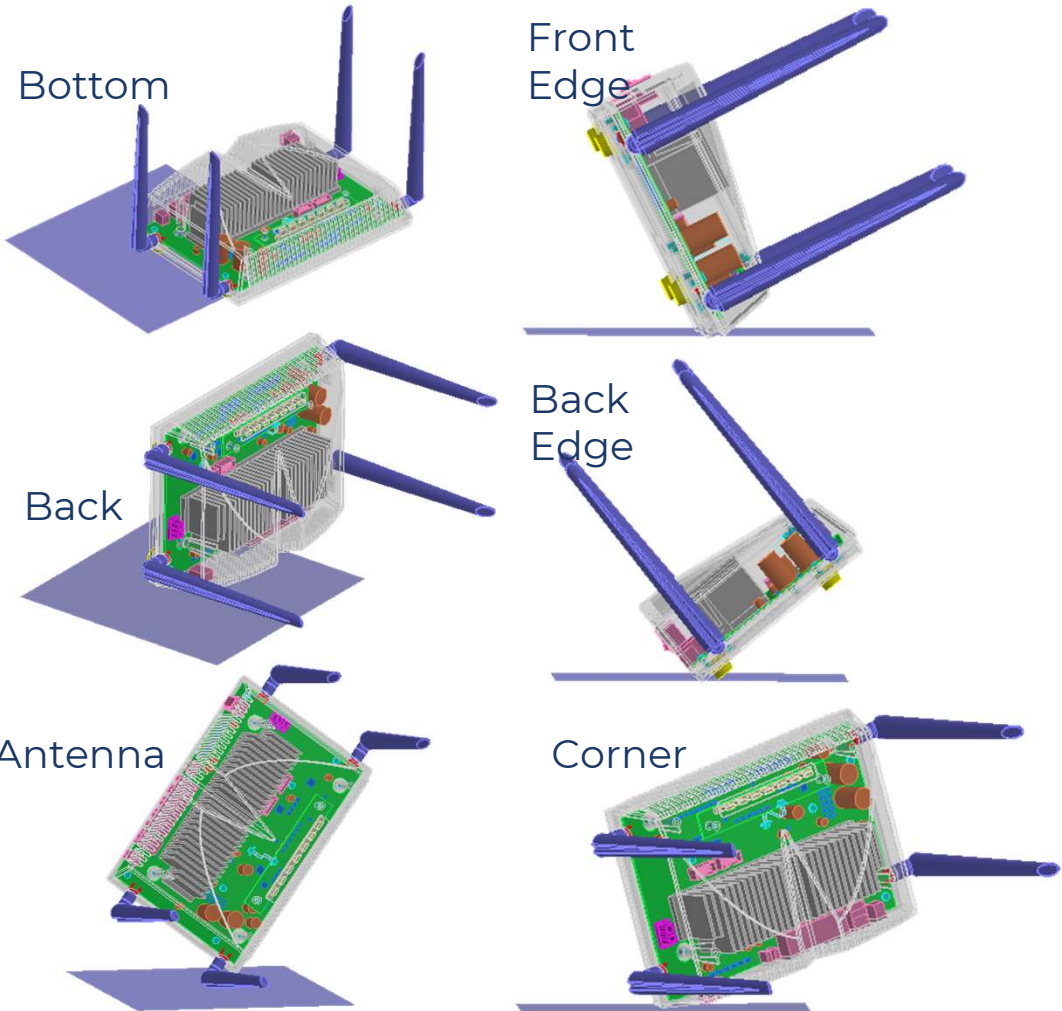
Drop Test Plugin

Details of "Drop Test"	
[-] Drop Load	
Define By	Drop Height
Drop Height	1000 mm
[-] Rigid Wall	
Friction	0.2
Gap	0.01 mm

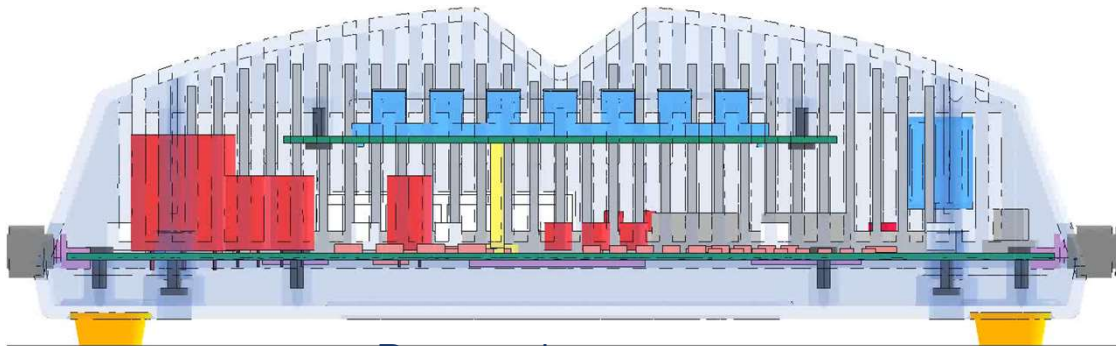
[-] General	
Define By	Principal Plane
[-] Principal Plane	
Normal Axis	Z
Plane	Bottom
[-] Rotation	
Axis	X
Angle	0°

[-] General	
Define By	Vector with 2 Points
[-] Point 1	
Define By	CG
Origin X	383.6 mm
Origin Y	-0.3144 mm
Origin Z	-199.7 mm
[-] Point 2	
Geometry	Click to Change
Origin X	208.9 mm
Origin Y	-45.76 mm
Origin Z	-57.22 mm

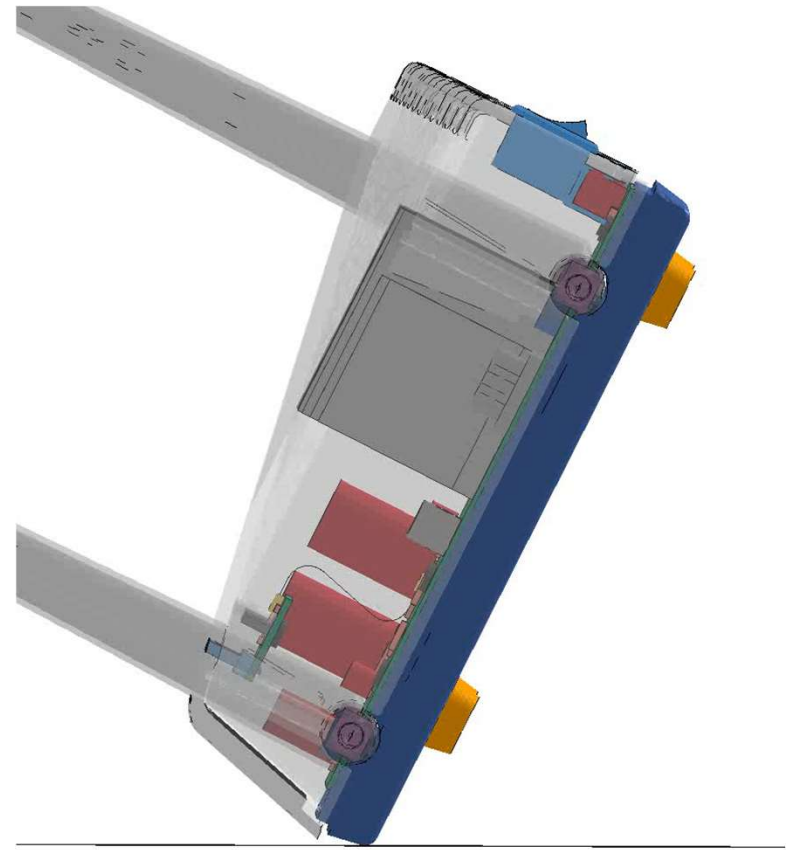
[-] General	
Define By	Plane with 3 Points
+ Point 1	
+ Point 2	
[-] Point 3	
Geometry	Click to Change
Origin X	385.2 mm
Origin Y	-65.85 mm
Origin Z	-308.2 mm



Result – Deformation, zoomed in



Bottom Impact



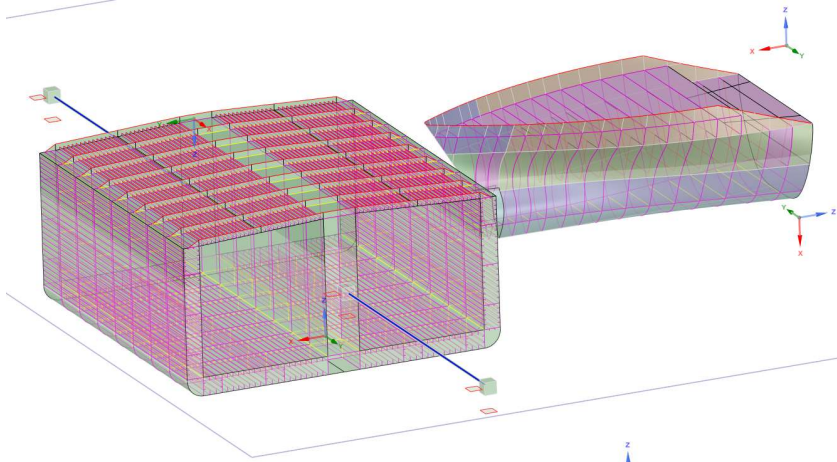
Front Edge Impact

Real World Examples for Drop Test/Impact Test : Impact or Collision Test between Tanker and Ferry



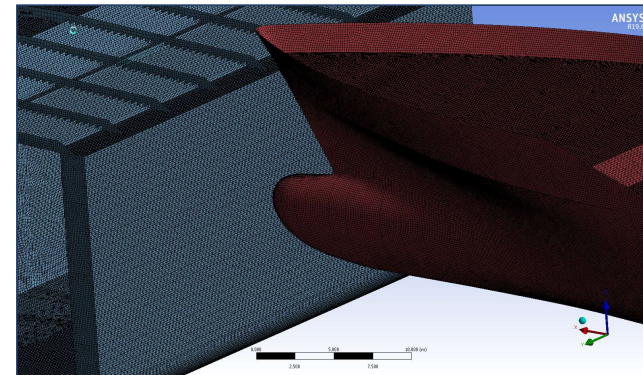
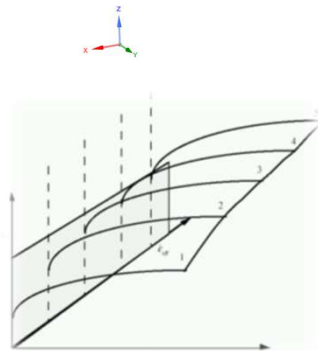
Reference : Benchmark Simulation of collision between a tanker and a ferry:
Ansys, Inc. Presentation

Model for the detailed part of double-hulled tanker



The geometry has been simplified and connected in using SpaceClaim. All geometries are shared and so all common nodes are coincident

Property	Value	Unit
Material Field Variables	Table	
Density	7896	kg m ⁻³
Isotropic Elasticity		
Derive from	Shear M...	
Young's Modulus	2.1268E+11	Pa
Poisson's Ratio	0.3	
Bulk Modulus	1.7723E+11	Pa
Shear Modulus	8.18E+10	Pa
Specific Heat, C _p	452	J kg ⁻¹ ...
Johnson Cook Strength		
Strain Rate Correction	First-Order	
Initial Yield Stress	3.1E+08	Pa
Hardening Constant	2.75E+08	Pa
Hardening Exponent	0.36	
Strain Rate Constant	0.022	
Thermal Softening Exponent	1	
Melting Temperature	1537.9	C
Reference Strain Rate (/sec)	1	
Shear Modulus	8.18E+10	Pa
Plastic Strain Failure		
Maximum Equivalent Plastic Strain EPS	0.15	

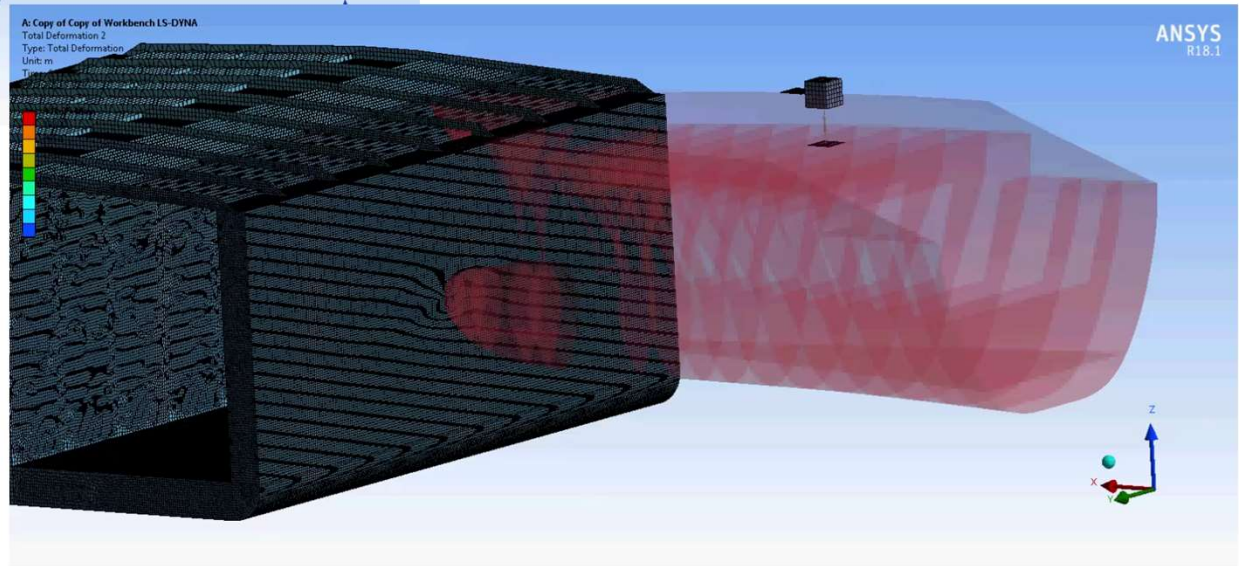
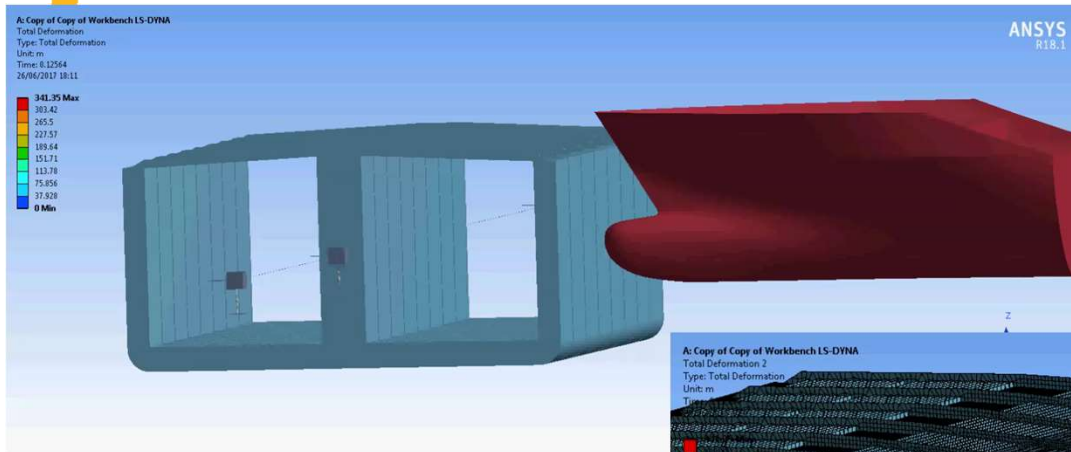


A uniform mesh method is applied : the mesh size is 0.15m on the impact area and elsewhere 0.25m

Johnson cook material law is used for the mechanical behavior and the plastic strain failure has been added too

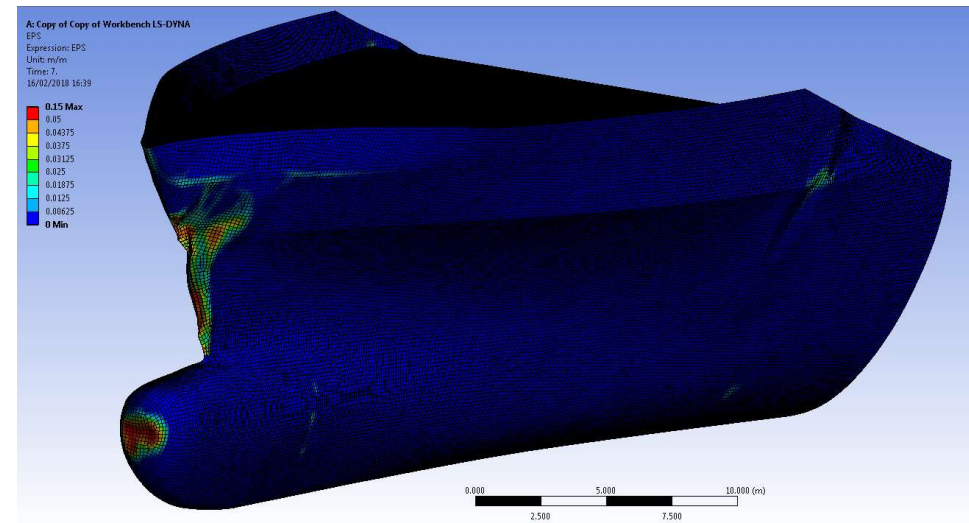
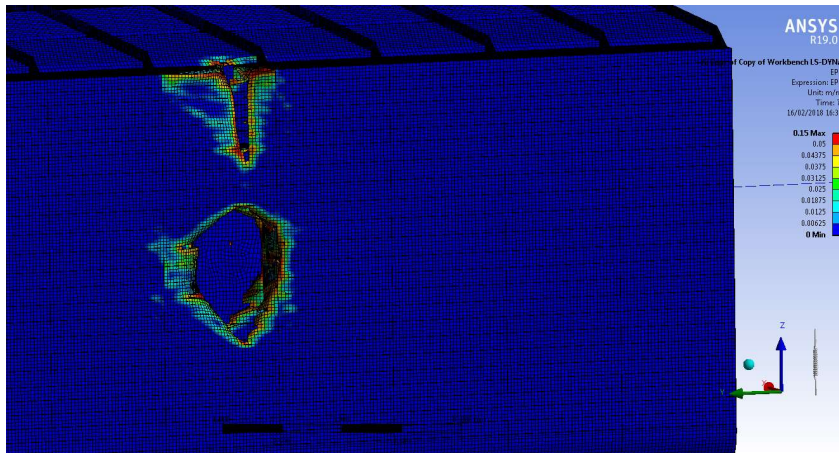
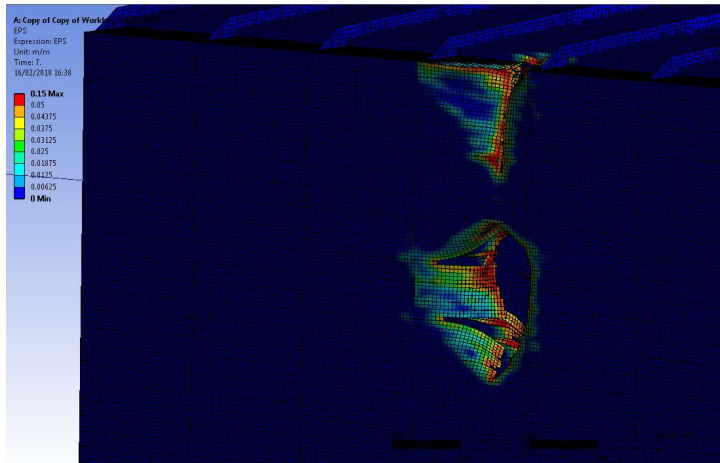
Reference : Benchmark Simulation of collision between a tanker and a ferry: Ansys,Inc. Presentation

Results of Collision



Reference : Benchmark Simulation of collision between a tanker and a ferry:
Ansys, Inc. Presentation

Plastic Deformations



Reference : Benchmark Simulation of collision between a tanker and a ferry:
Ansys, Inc. Presentation

Real World Examples for Drop Test/Impact Test : Packaging Drop Test

Why Packaging is Important – Scenario Selection

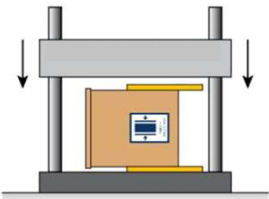
- Protection against
 - Chemicals
 - Temperatures
 - ...
 - **Mechanical Loads**

Transient Shocks

→ Droptest Simulation

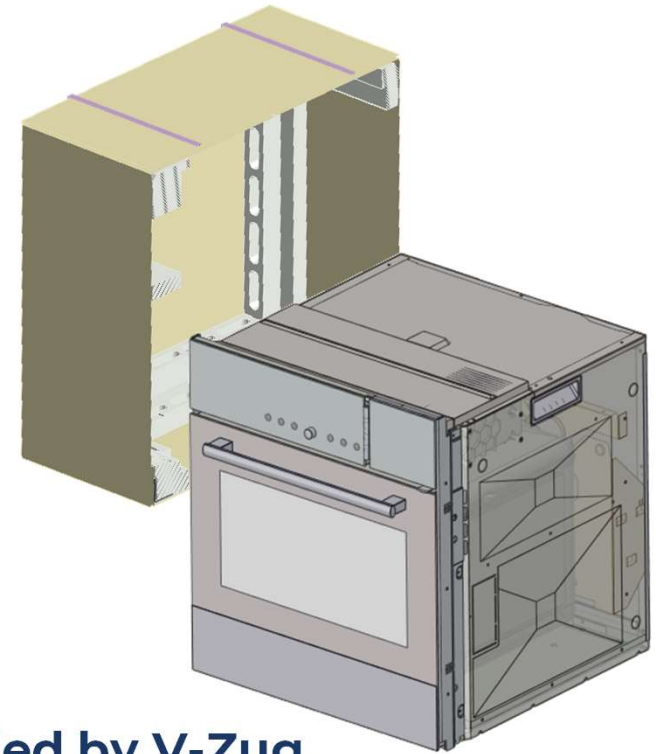
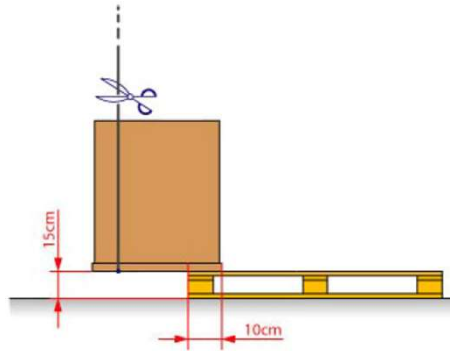
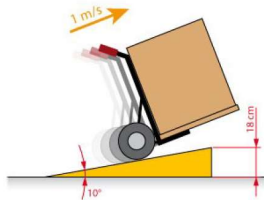
Static Loads

Storage
Clamping



Dynamic Loads

Transportation

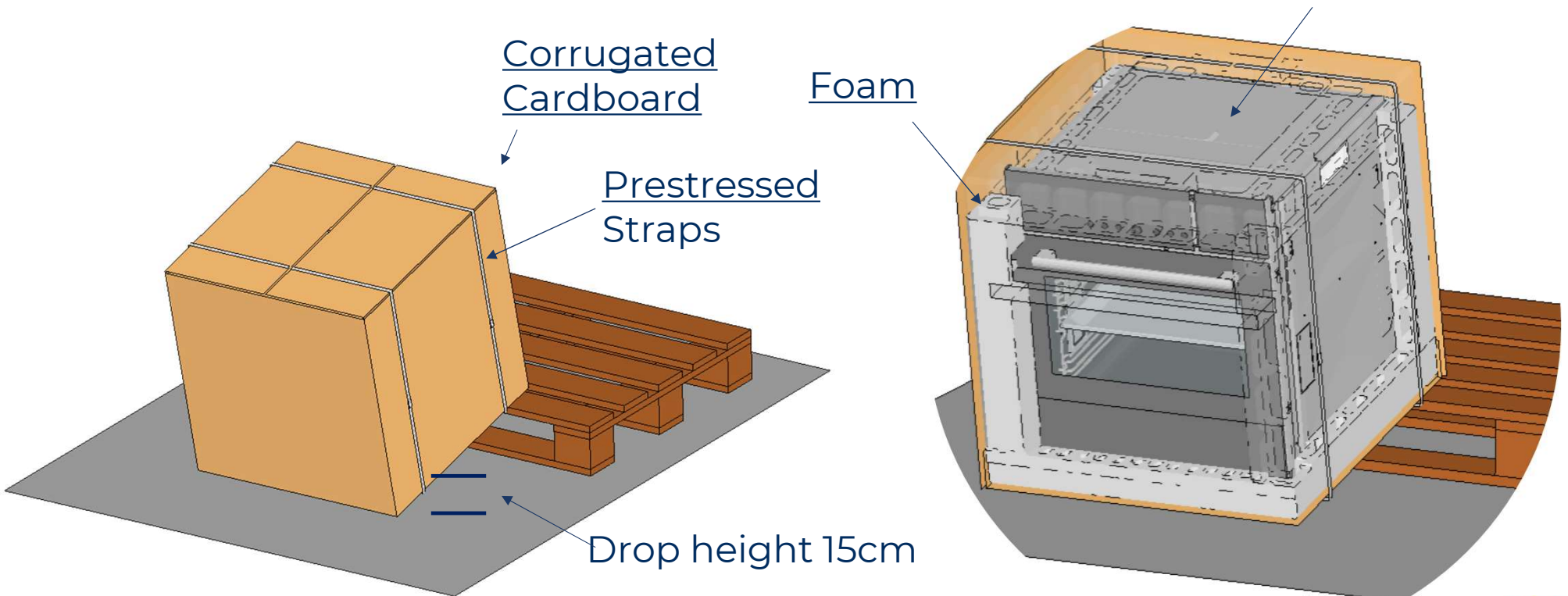


Detailed Steamer **Provided by V-Zug**

Scenario

Packaging – Interesting Features

- Droptest of a Steamer **Provided by V-Zug**



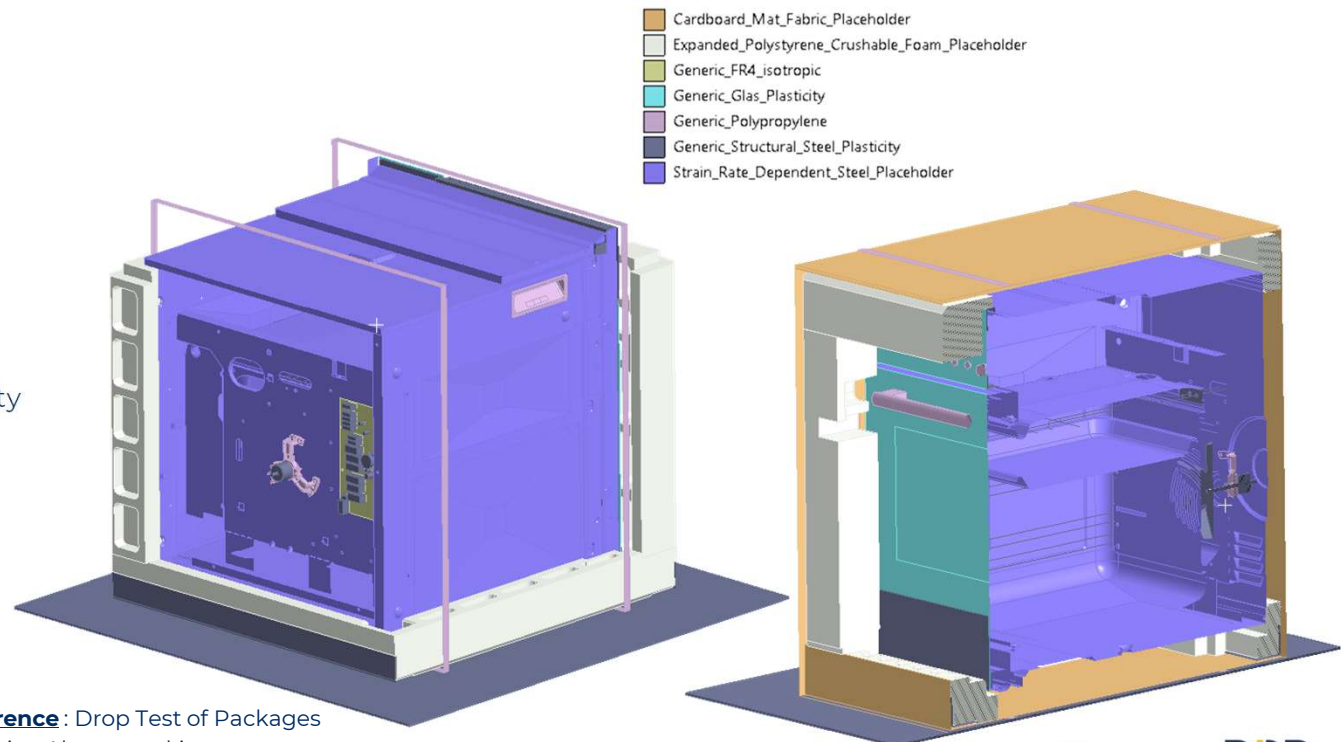
Packaging

Reference: Drop Test of Packages
CADFEM GmbH, Hannover

Parts & Material behavior Overview

- Materials and material models:
 - **Straps**
 - Polypropylene
 - Multilinear Isotropic Plasticity
 - **Cardboard**
 - Anisotropic Layered Composite
 - Nonlinear (Focus on linear Portion)
 - **Foam**
 - Crushable Foam – Plasticity
 - Expanded Polystyrene (EPS)
 - **Metal Sheets:**
 - Multilinear strain rate dependent plasticity
 - **Plastic Parts**
 - Handles, Brackets, ...
 - **Other:**
 - Glas
 - PCB FR4
 - Generic Plasticity Steel

Packaging

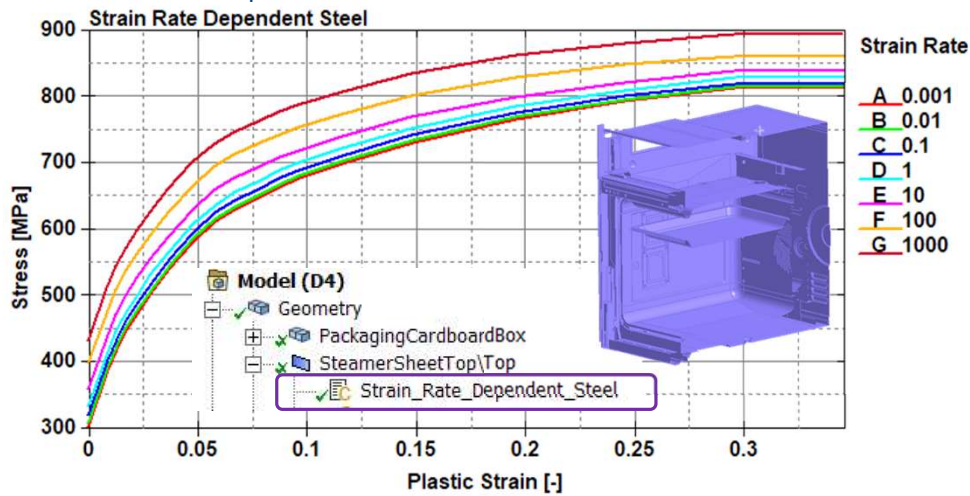


Reference: Drop Test of Packages
Christian Abramowski
CADFEM GmbH, Hannover

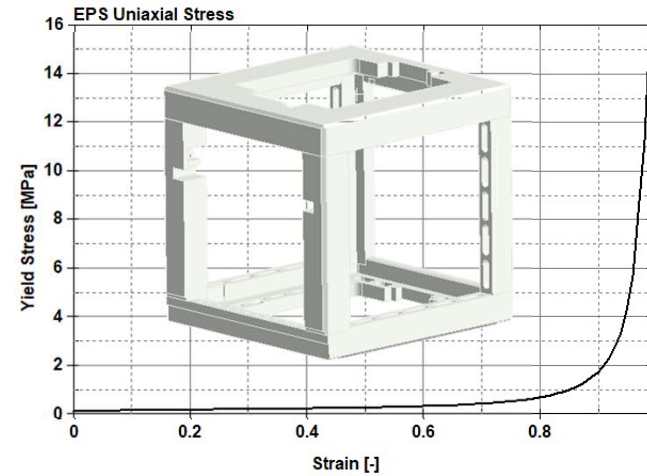
Material behavior (Overview)

Reference : Drop Test of Packages
 Christian Abramowski
 CADFEM GmbH, Hannover

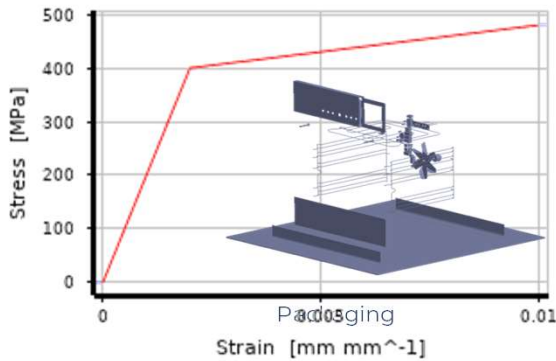
Strain rate dependent steel



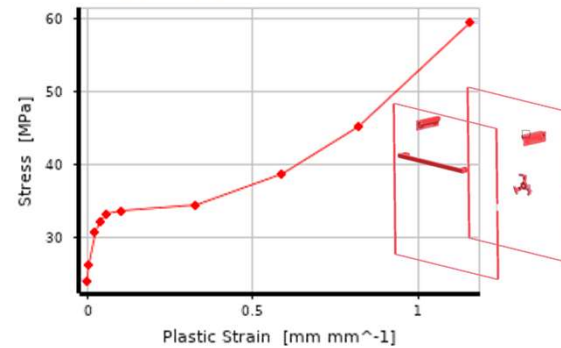
EPS – Crushable Foam



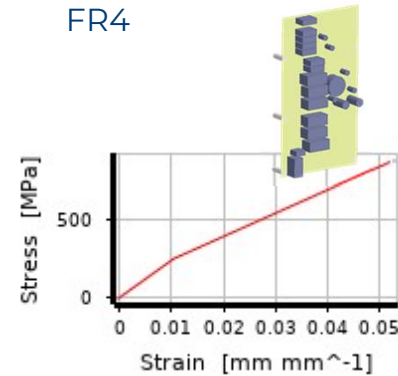
Generic ‚High Quality Steel‘



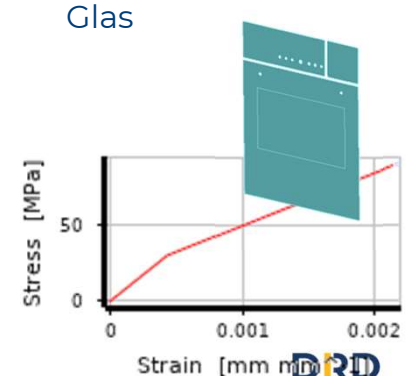
Polypropylene



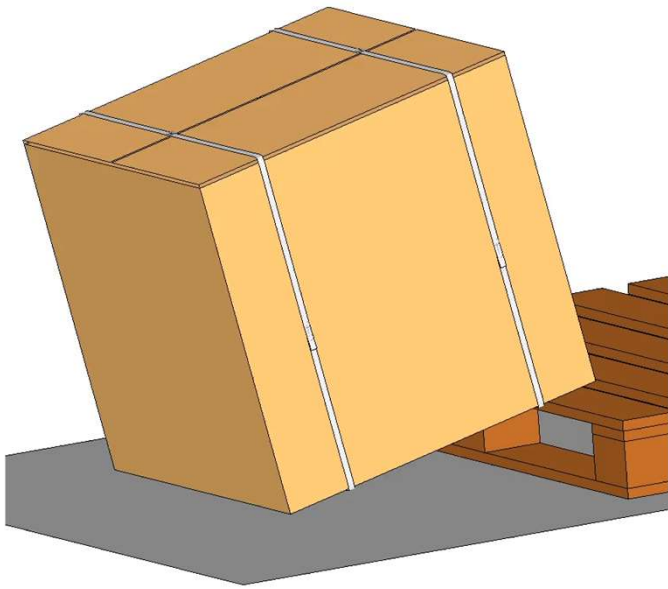
FR4



Glas



Animation of the Packaging Drop Test



Reference : Drop Test of Packages
Christian Abramowski
CADFEM GmbH, Hannover

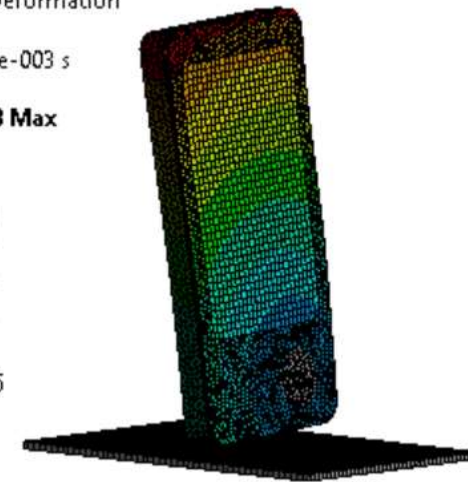
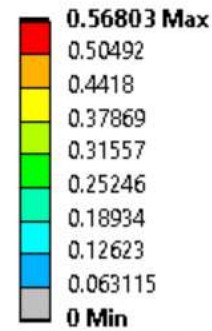
Real World Examples for Drop Test/Impact Test : Cell Phone Drop Test

Geometry

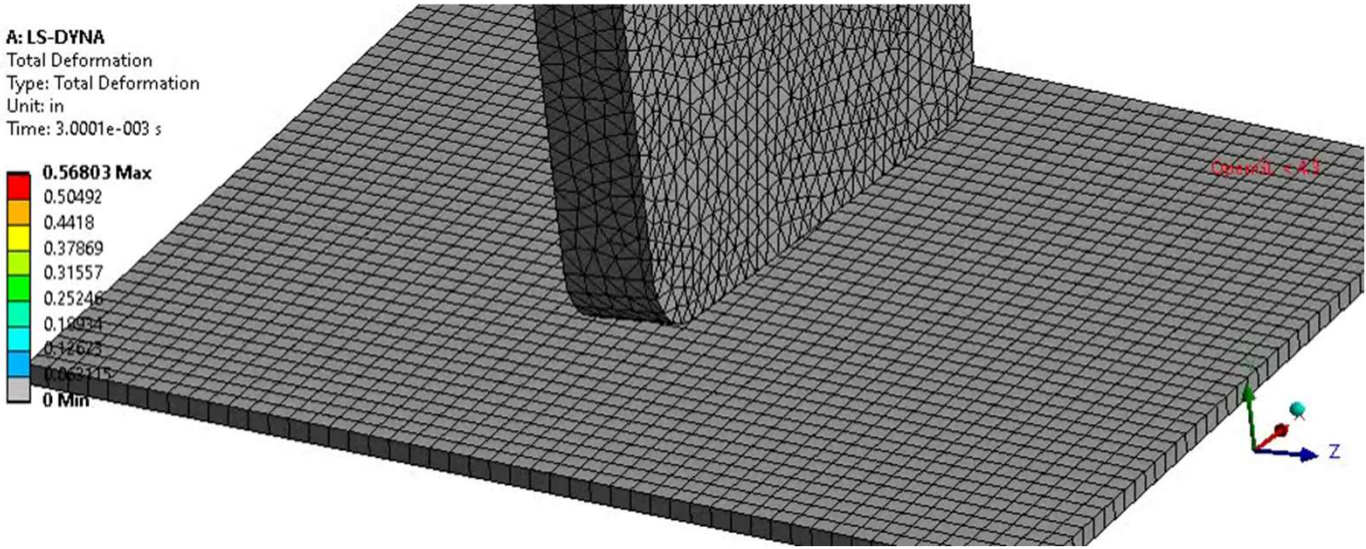
- Acrylcglas_PMMA
- Batterie_Pack_Homogeneous
- PCBA_Homogeneous
- Plastics
- Spring Steel
- Steel



A: LS-DYNA
Total Deformation
Type: Total Deformation
Unit: in
Time: 3.0001e-003 s



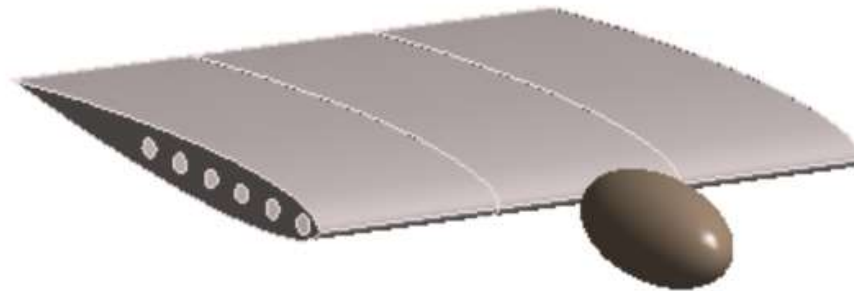
Animation of the Cell Phone Drop Test



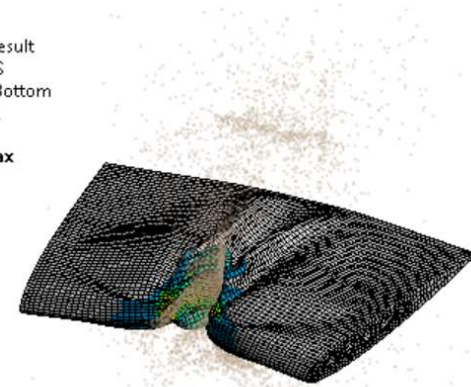
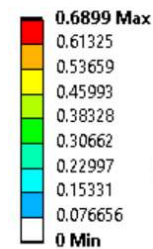
Real World Examples for Drop Test/Impact Test : Bird strike on Aircraft Wing

Geometry

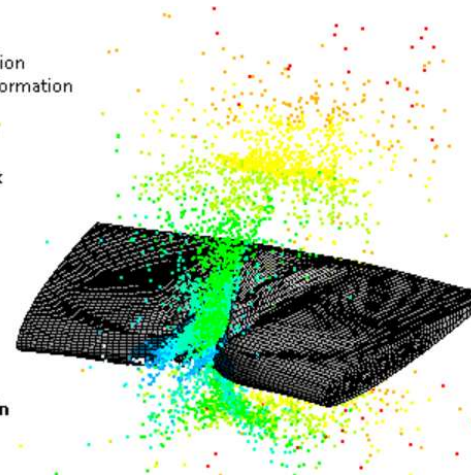
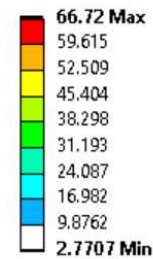
- AL5083H116
- WATER2



A: LS-DYNA
User Defined Result
Expression: EPS
Position: Top/Bottom
Time: 5.e-003 s

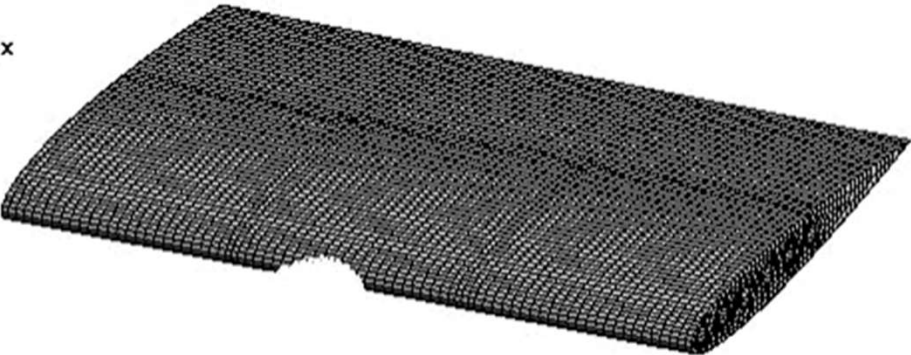
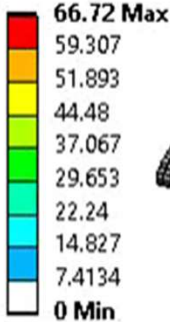


A: LS-DYNA
Total Deformation
Type: Total Deformation
Unit: in
Time: 5.e-003 s

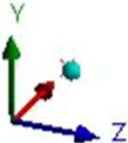


Animation of Bird Strike on Aircraft Wing

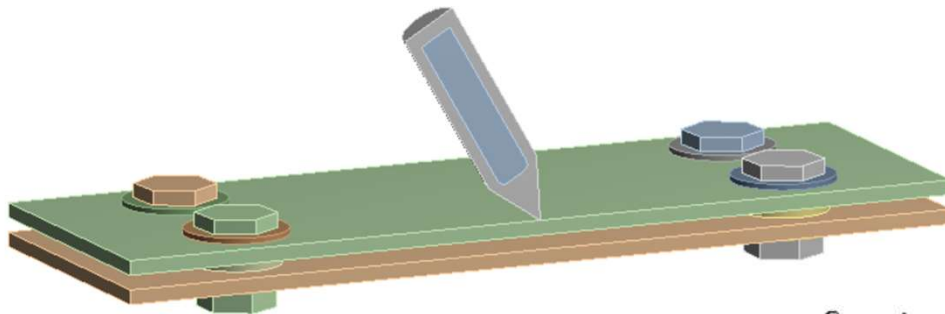
A: LS-DYNA
Total Deformation
Type: Total Deformation
Unit: in
Time: 5.e-003 s



OpenGL < 4.3

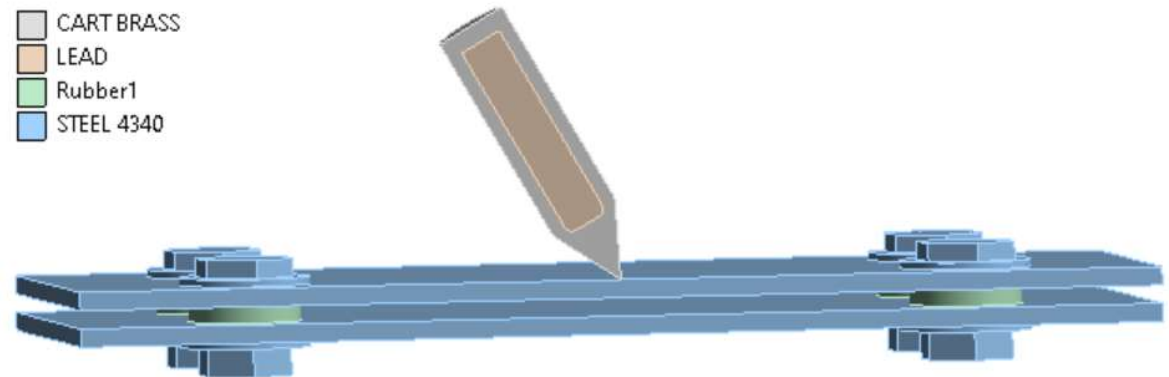


Real World Examples for Drop Test/Impact Test : Oblique Projectile Impact Test and Penetration



Geometry

- CART BRASS
- LEAD
- Rubber1
- STEEL 4340

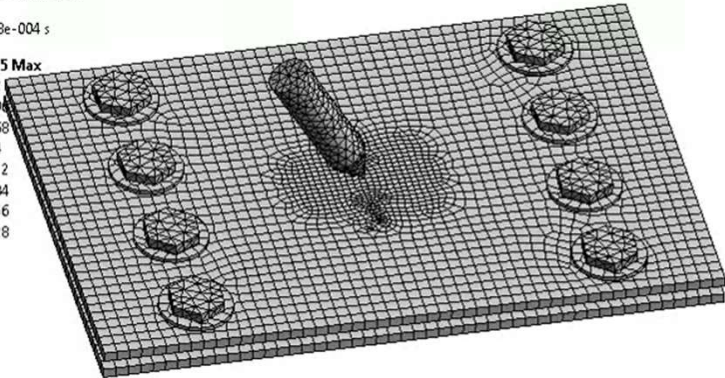


Propertes of Outline Row 3: CART BRASS		
A		
1	Property	
2	Material Field Variables	Table
3	Density	0.30528
4	Specific Heat Constant Pressure, C_p	0.091955
5	Johnson Cook Strength	
14	Shear Modulus	5.424E+06
15	Shock EOS Linear	
20	Plastic Strain Failure	
21	Maximum Equivalent Plastic Strain EPS	0.3

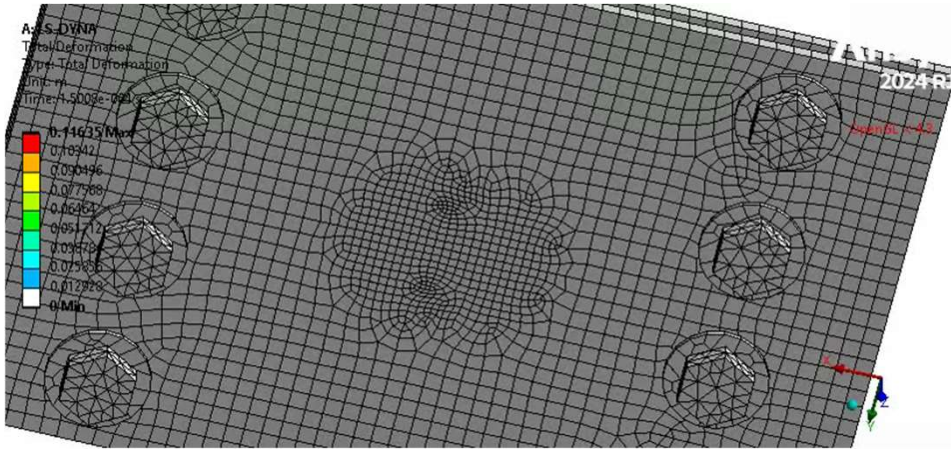
Animation of Bullet Impact on Metal Plate : Top and Bottom Views of Impact and Penetration

A: LS-DYNA
Total Deformation
Type: Total Deformation
Unit: m
Time: 1.5008e-004 s

0.11635 Max
0.10342
0.09049
0.077568
0.06464
0.051712
0.038784
0.025856
0.012928
0 Min



OpenGL < 4.3



Summary

- **LS-DYNA is aptly suited to solve various drop test problems whether dealing with Drop/Low velocity impact, High velocity impact, Ballistic impact or Hypervelocity impact.**
- **The solvers in LS-DYNA are appropriately poised to solve these various types of impact studies as described above. The MEFEM (Lagrangian solvers) can handle almost all structural drop test type applications. When it comes to handling FSI the ALE solvers can be used. For any high, ballistic or hypervelocity impact resulting in material disintegration as in bird strike SPH solvers are used.**
- **For most of the Drop Test applications, the “Drop Test Wizard” makes the problem setup fully automated.**
- **For almost all Impact studies the problem setup is pretty straightforward and with the right material inputs, the user can get pretty good correlation with test data or experimental data.**



Questions ?