

## GENOA USER MATERIAL FOR EXPLICIT RADIOSS SIMULATIONS (URD)

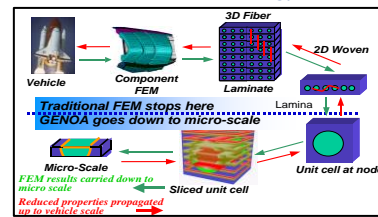
- Obtain Integrated Explicit Dynamics Solutions with RADIOSS using GENOA libraries in RADIOSS subroutines
- Augments Explicit Dynamics (ED) finite element analysis (FEA) with multi-scale composite mechanics.
- Damage tracking and fracture to determine all stages of damage evolution under static, impact, crush, or crash loading condition.
- Predict and simulate all 5 stages of the damage process.
- Switch solvers/boundary condition/analysis type before or after simulation and keep residual damage and stresses.
- Calculates crack density, micro-cracks in the matrix, delamination within the plies, and fiber failure in tension and compression including micro-buckling.
- The damage tracking is done by identifying and accumulating damage at the "root cause" of the composite in matrix and fiber using dedicated physics based damage and failure criteria.

GENOA URD allows engineers that use RADIOSS to stay within their environment and perform a GENOA Multi Scale Progressive Failure Analysis PFA using GENOA libraries inside of RADIOSS subroutines. At the end of the simulation a GENOA PFA file is produced that is used to characterize static and impact behavior of composite structures. This analysis determines: laminate and ply damage (types: fiber, matrix, delamination – transverse shear, interlaminar shear, relative rotation, fiber microbuckling, fiber pullout), damage and fracture initiation, energy absorbed, and residual strength. GENOA PFA will accurately predict the behavior of advanced composite laminates (2-D/3-D) considering effects of (1) defects, voids, fiber waviness, (2) micro-crack density (leakage, stiffness reduction), (3) residual stresses (winding, curing).

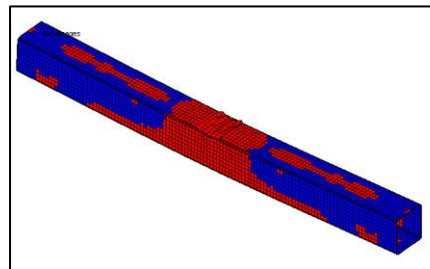
## GENOA URD Highlights

- ✓ **Supports full breadth of 2D/3D composite architectures**
  - Laminated Tape Lay-Up, Polymer, Metals, Ceramics
  - Fiber Architecture (Woven, Triaxial, Harness Satin Weave, Braided, and Stitched)
  - Fiber Coating (InterPhase)
  - Effects of manufacturing defects and residual stresses
- ✓ **Determines composite damage**
  - Laminate and Ply Damage initiation and propagation to final failure
  - Damage types (fiber, matrix, several delamination types)
  - Change ply layups to meet design requirements
  - Residual strength behavior (TAI, CAI, FAI)
- ✓ **Supports Failure Criteria (In-built and User Defined)**
  - Translaminar (Matrix, Fiber, Ply)
  - Interlaminar/Delamination (Tension, Shear, Relative Rotation)
  - Interactive Strength (Tsai-Wu, Tsai-Hill, Puck, MDE, Hoffman, Hashin)
  - Interactive Strain- Strain Invariant Failure Theory (SIFT)
  - Maximum Stress, Maximum Strain, User Defined
- ✓ **Supports Detailed Micromechanical Degradation**
  - **Matrix Defects** – Void shape, size distribution reducing stiffness and strength, matrix creep, fatigue
  - **Residual Stresses** – Curing and other manufacturing effects
  - **Fiber Strength Statistics** – Gradual failure "Rope effect" – Probabilistic Weibull distribution
  - **Interphase Mechanics** – Fiber bridging
- ✓ **Supports Service Loading**
  - Static, Impact, Post Impact
  - **Export Damage/Residual Stresses used in another simulation/solver**
  - Change boundary conditions/solver/ analysis type
  - Static or Impact to static/fatigue/creep (any combination and sequence)
- ✓ **Includes Tutorials/Solutions**

Use Multi Scale Technology



Predict Damage

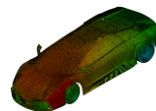


Easily Identify Damage Types and Location

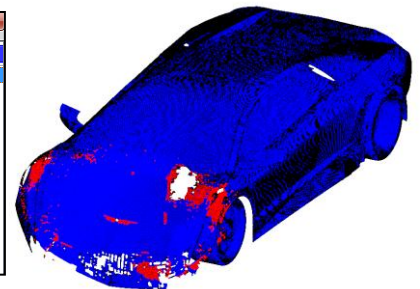
All Damages	
Fiber Damage Only	
Matrix Damage Only	
Delamination Damage Only	
45.023% - (S11C) Longitudinal Compressive	
2.450% - (D11C) Delaminations	
45.023% - (F11C) Fiber Micro-Buckling	
86.830% - (S22T) Transverse Tensile	
7.351% - (TOPS_N) Transverse Out-Of-Plane Shear (-)	
10.567% - (LOPS_N) Longitudinal Out-Of-Plane Shear (-)	
100.000% - (MDE) Modified Distortion Energy	
0.613% - (TENS) Tension Strain	

Build in HyperCrash Or Other Environment

Run RADIOSS with GENOA USERMAT, Track Damage Initiation and Propagation



Element Damage	
All Damages	
Fiber Damage Only	
Matrix Damage Only	
Delamination Damage Only	
4.523% - (S11T) Longitudinal Tensile	
63.294% - (S11C) Longitudinal Compressive	
7.251% - (R11C) Fiber Crush	
62.811% - (F11C) Fiber Micro-Buckling	
80.318% - (S22T) Transverse Tensile	
0.035% - (S22C) Transverse Compressive	
3.315% - (S12S) In-Plane Shear	
96.927% - (MDE) Modified Distortion Energy	
Fractured Elements	



## Key Benefits

- Rapid assessment/selection of composite static, impact and post impact damage tolerance to meet design requirements
- Reduce physical test by over 65-70% thus saving significant cost
- Ease of use, results verified with test data for class of materials:
  - Polymer: chopped, continuous, thermoset, thermoplastic, elastomer
  - Ceramic
  - Metals: Fracture Toughness, fatigue crack growth
  - Nano
  - Hybrid Composite (Glare)
- Compression, Tension, Fatigue, and Reliability After Impact
- Identification of damage initiation and propagation to final failure & modes of damage/failure
- Identify damage types and magnitude to assess risk

## User Friendliness

- Graphic User Interface (GUI) is easy to learn with navigation tutorials and videos. Manages multiple projects, input and output for material characterization
- Quick import/export of material properties and laminate layups with commonly used third-party FE Solvers and UMATS: NASTRAN (.bdf), ABAQUS (.inp), ANSYS (.cdb), RADIOSS (.rad), LSDYNA (.k) and Optistruct (.fem)
- **Easy creation, editing of composite laminates. Quickly study multiple designs.**

## System Requirements

- Windows XP/Vista/7/8/10 (64-bit) or Linux (64-bit)
- Java 1.7 minimum Runtime Libraries
- Java3D 1.5

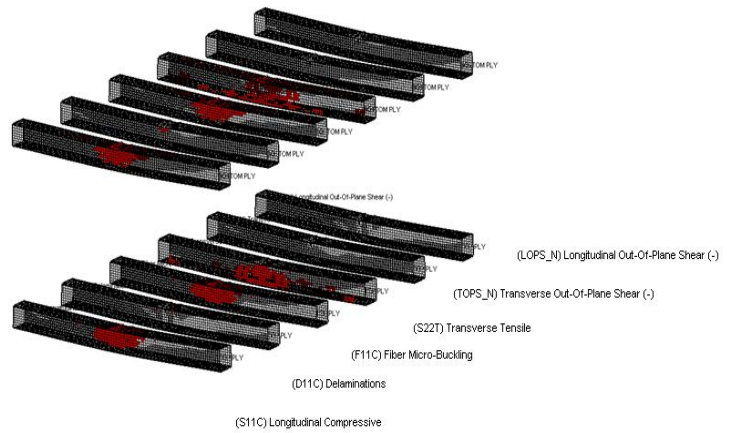
## Minimum Configuration

With the minimum configuration, performance and functionality may be less than expected.

- 1 GHz or higher CPU, 4GB RAM, 10GB disk space

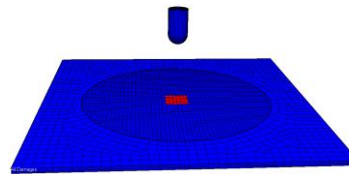
Easily Identify Damage Types and Location

Peel the Onion To Determine Ply Damages, Type, and Location

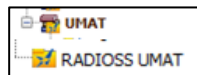


Fully Supports Complex Models

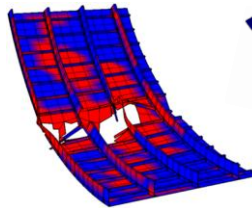
Ballistic Impact



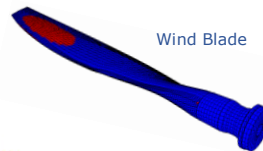
Tutorials with Solutions



Stiffened Panel



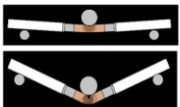
Wind Blade



Step By Step Instructions

**Using RADIOSS UMAT with PFA**

**Introduction**  
This tutorial demonstrates how to utilize GENOA's PFA embedded in RADIOSS user material subroutine (UMAT) solver within GENOA versus running RADIOSS with GENOA as a UMAT. Below is a table of some of these high cost bonding setups (see figure below). The objective of the tutorial is to learn how to perform analysis with



**Note:** You will need to have RADIOSS installed on your workstation and it does not come with GENOA.  
RADIOSS running GENOA-PFA as a UMAT

**Advantages**  
Significantly faster due to user subroutine being called internally during solver's analysis  
Can be used within RADIOSS environment

**Overview of Analysis**  
To run RADIOSS with GENOA-PFA UMAT, the following steps need to be performed:  
Preparing the RADIOSS input files (0000.rad and 0001.rad) with the UMAT definitions.  
Adding the RADIOSS UMAT Analysis Module in GENOA GUI  
Selecting the RADIOSS input file (0000.rad).  
Running the RADIOSS UMAT Analysis Module  
After analysis, post-processing damage evolution results into GENOA GUI

Maximum Stress Based Failure Criteria	true
<b>Fiber Failure Criteria</b>	
(S11T) Longitudinal Tensile	true
(S11C) Longitudinal Compressive	true
(F11C) Fiber Micro-Buckling	true
(R11C) Fiber Crush	true
(D11C) Delaminations	false
<b>Matrix Failure Criteria</b>	
(S22T) Transverse Tensile	true
(S22C) Transverse Compressive	true
(S33C) Normal Compressive	true
(S12S) In-Plane Shear	true
<b>Delamination Failure Criteria</b>	
(S33T) Normal Tensile	true
(S23S) Transverse Normal Shear	true
(S13S) Longitudinal Normal Shear	true
(RROT) Relative Rotation	true
<b>Maximum Strain Based Failure Criteria</b>	true
<b>Fiber Failure Criteria</b>	
(EPS11T) Longitudinal Tension Strain	true
(EPS11C) Longitudinal Compression Strain	true
<b>Matrix Failure Criteria</b>	
(EPS22T) Transverse Tension Strain	true
(EPS22C) Transverse Compression Strain	true
<b>Delamination Failure Criteria</b>	
(EPS33T) Normal Tension Strain	false
(EPS33C) Normal Compression Strain	true
(EPS12S) In-plane Shear Strain	true
(EPS13S) Long. Out-of-plane Shear Strain	true
(EPS23S) Trans. Out-of-plane Shear Strain	false
<b>Interactive Failure Criteria</b>	
(MDE) Modified Distortion Energy	true
(TSAI) Tsai Wu	false
(HILL) Tsai Hill	false
(HOFF) Hoffman	false
(HASH) Hashin	false
(PUCK) PUCK	false
(SIFT) Strain Invariant Failure Theory	false
<b>Honeycomb Failure Criteria</b>	false
(WRNK) Wrinkling for Honeycomb	false
(CRMP) Crimping for Honeycomb	false
(DIMP) Dimpling for Honeycomb	false
<b>Miscellaneous</b>	
(UDFC) User Defined Failure	false

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