

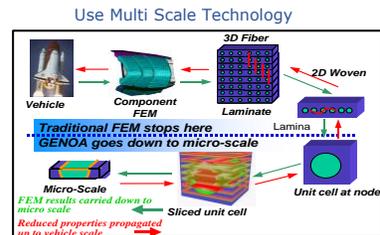
GENOA PROGRESSIVE FAILURE ANALYSIS

- Test Validated™ Solutions
- Obtain static solutions with NASTRAN, ABAQUS, ANSYS, OPTISTRUCT, MHOST.
- Augments finite element analysis (FEA) with multi-scale composite mechanics.
- Damage tracking and fracture to determine all stages of damage evolution under static, fatigue, and impact loadings.
- Predict and simulate all 5 stages of the damage process.
- Switch solvers/boundary condition/analysis type before or after simulation and maintain 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.
- Account for defects (void shapes and sizes), fiber waviness, and residual stresses – Voids/Defects Will Reduce Fatigue Life.
- 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.

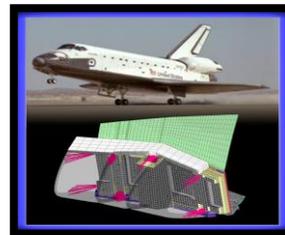
GENOA PROGRESSIVE FAILURE ANALYSIS provides engineers with the predictive computational technology to characterize and qualify advanced composite materials and structures considering manufacturing anomalies (i.e., matrix distortion, residual stress), effects of defects (void shapes sizes and fiber waviness), and scatter for "as-built/as-is" states of composite material and structures. GENOA augments FEA analysis tools for Multi-Scale Progressive Failure Analysis of structures made from advanced composite materials subject to static, fatigue, and impact loadings. GENOA has a full-hierarchical modeling that goes down to the micro-scale of sub-divided unit cells composed of fiber bundles and their surrounding matrix. GENOA's solution can be used for Polymer Composite Structures, Hybrid Composites, (i.e. Fiber Metal Laminates) and Nano composites. In GENOA's progressive failure displacements, stress and strains are derived from the structural FEA solution at every element and are decomposed to the laminate, lamina and micro-scale using laminate and micro-stress theory. This analysis is performed progressively all the way to failure, and assesses damage initiation and progression including fracture initiation on a micro level using failure criteria. GENOA integrates damage & fracture mechanics into one platform.

GENOA PROGRESSIVE FAILURE ANALYSIS

- ✓ **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 Static Service Loading**
 - **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) with appropriate licenses
- ✓ **Includes Tutorials/Solutions**

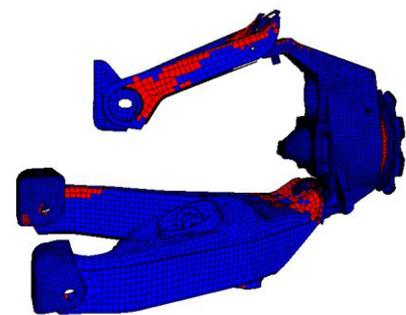


Chosen to Simulate Columbia Accident

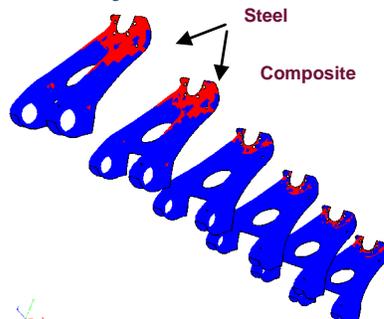


Easily Identify Damage Types and Location.

Predict and Locate Damage



Peel the Onion to find Ply Damage and Location



% Damage wrt Total Damage or Total Volume

Damage	
Element Damage	
All Damages	
Fiber Damage Only	
Matrix Damage Only	
Delamination Damage Only	
13.868% - (S11T) Longitudinal Tensile	
62.135% - (S11C) Longitudinal Compressive	
19.478% - (R11C) Fiber Crush	
61.044% - (F11C) Fiber Micro-Buckling	
55.317% - (S22T) Transverse Tensile	
0.078% - (S22C) Transverse Compressive	
6.233% - (S12S) In-Plane Shear	
95.559% - (MDE) Modified Distortion Energy	
Fractured Elements	

Key Benefits

- Rapid assessment/selection of composite damage tolerance to meet design requirements
 - Predict structural performance considering effects of defects (voids shapes, sizes, fiber waviness, curing residual stresses)
 - Predict structural failures at initiation, 0.01-inch crack length, and include propagation and final fracture
 - 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)

- Identification of damage initiation and propagation to final failure & modes of damage/failure
- Identify damage types and magnitude to assess risk
- Accredited software can be used for certification (Strength)

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 and editing of composite laminates. Quickly study multiple designs.**

System Requirements

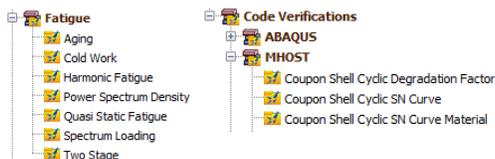
- Windows XP/Vista/7/8/10 (64-bit) or Linux (64-bit)
- Java 1.7 minimum Runtime Libraries
- Java3D 1.5

Minimum Configuration

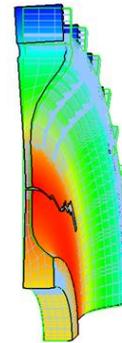
With the minimum configuration, performance and functionality may be less than expected.

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

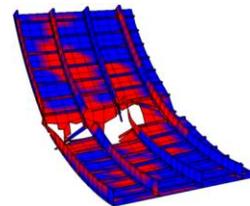
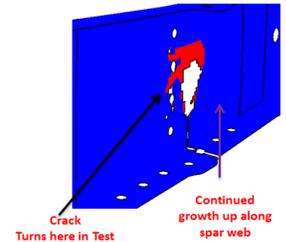
Tutorials with Solutions and Code Verifications



Fully Supports Complex Models

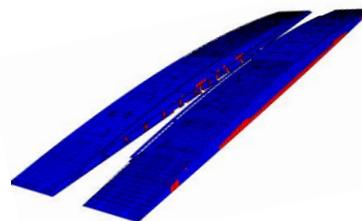


Track Crack Growth



Quickly Check On/Off Damage Types and Run Multiple Simulations (Fiber, Matrix, Delamination; By Stress, Strain, Interactive, User)

Maximum Stress Based Failure Criteria	true
Fiber Failure Criteria	
(S11T) Longitudinal Tensile	true
(S11C) Longitudinal Compressive	true
(F11C) Fiber Micro-Buckling	true
(R11C) Fiber Crush	true
(D11C) Delaminations	false
Matrix Failure Criteria	
(S22T) Transverse Tensile	true
(S22C) Transverse Compressive	true
(S33C) Normal Compressive	true
(S12S) In-Plane Shear	true
Delamination Failure Criteria	
(S33T) Normal Tensile	true
(S23S) Transverse Normal Shear	true
(S13S) Longitudinal Normal Shear	true
(RR0T) Relative Rotation	true
Maximum Strain Based Failure Criteria	true
Fiber Failure Criteria	
(EPS11T) Longitudinal Tension Strain	true
(EPS11C) Longitudinal Compression Strain	true
Matrix Failure Criteria	
(EPS22T) Transverse Tension Strain	true
(EPS22C) Transverse Compression Strain	true
Delamination Failure Criteria	
(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
Interactive Failure Criteria	
(MDE) Modified Distortion Energy	true
(TSAI) Tsai Wu	false
(HILL) Tsai Hill	false
(HOF) Hoffman	false
(HASH) Hashin	false
(PUC) PUCK	false
(SIFT) Strain Invariant Failure Theory	false
Honeycomb Failure Criteria	false
(WRNK) Wrinkling for Honeycomb	false
(CRMP) Crimping for Honeycomb	false
(DIMP) Dimping for Honeycomb	false
Miscellaneous	
(UDFC) User Defined Failure	false



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More of Alpha STAR's Test Validated products:
 MCQ: Composites, Ceramics, Metals, Nano, Chopped
 GENOA: PFA, PFDA, UAB, URD, ABS, PCP, PA, Quasi
 Static Fatigue & Random Fatigue, Harmonic & PSD
 Fatigue, Fatigue with Fracture Mechanics,
 PFA_AGING, VCCT, DCZM, Filament Winding,
 Jobspooler, GENOA_CLOUD