GENOA 5

Tested and Verified.™

GENOA QUASI STATIC FATIGUE AND RANDOM FATIGUE

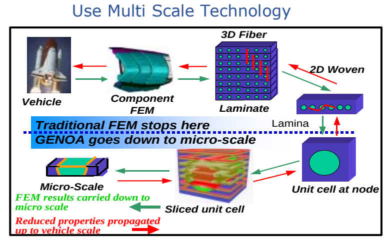
- **Test Validated™ Solutions**
- **Obtain fatigue solutions with NASTRAN, ABAQUS, ANSYS, OPTISTRUCT, MHOST, xDYNA, LS DYNA, RADIOSS**
- **Augments finite element analysis (FEA) with multi-scale composite mechanics.**
- **Damage tracking and fracture to determine all stages of damage evolution under quasi static and random fatigue.**
- **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.**
- **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 QUASI STATIC FATIGUE AND RANDOM FATIGUE allows engineers to perform a GENOA Multi Scale Progressive Failure Analysis and characterize the fatigue 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 QUASI STATIC FATIGUE AND RANDOM FATIGUE

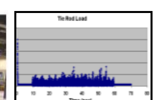
- ✓ **Supports full breadth of 2D/3D composite architectures**
  - Laminated Tape Lay-Up, Polymer, Metals, Ceramics
  - Fiber Architecture (Woven, Triaxial, Harness Satin Weave, Braided,and Stitched)
  - Fiber Coating (InterPhase), Effects of manufacturing defects and residual stresses
- ✓ **Determines 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**
  - Quasi Static Fatigue and Random Fatigue (low, high, random, PSD, two stage)
  - **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**

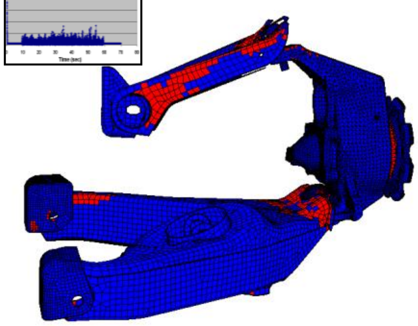
Use Multi Scale Technology



HMMWV Double Arm Suspension

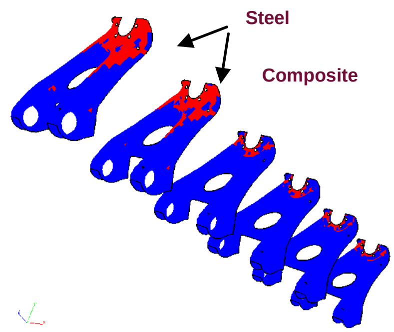
Predict Damage



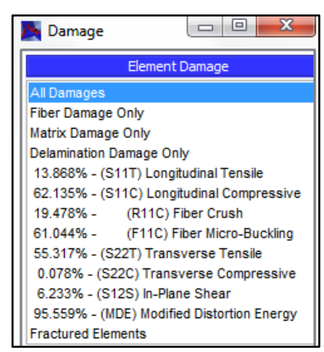


Easily Identify Damage Types and Location.

Peel the Onion to find Ply Damage and Location



% Damage wrt Total Damage or Total Volume



Key Benefits

- Rapid assessment/selection of composite fatigue life and damage tolerance to meet design requirements
- Predict structural fatigue failures at initiation, 0.01-inch crack length and final fracture
- Reduce physical tests by over 65-70% thus saving significant costs

  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 asses risk
- Certification (Fatigue after impact damage)
- Retirement (95% of natural Frequency)
- Crack growth uncertainty in direction predicted

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

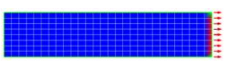
- Windows XP/Vista/7/8 or Linux (64-bit)
- Java 1.7 minimum Runtime Libraries
- Java3D 1.5

Minimum Configuration

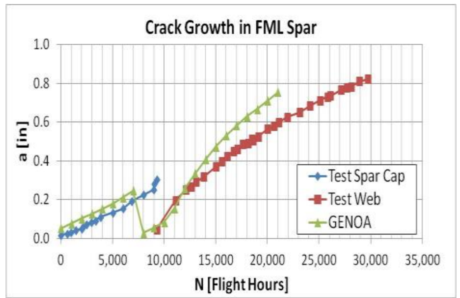
With the minimum configuration, performance and functionality may be less than expected.

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

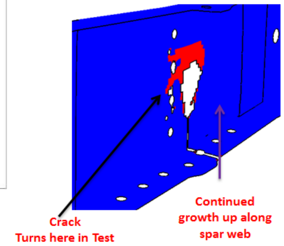
Step By Step Instructions

Quasi Static Fatigue	
Case Description:	Composite coupon subject to tensile cyclic loading
Example Location:	**Tutorials > Fatigue > Quasi Static Fatigue**
	
Model Description:	Nodes: 261; Elements: 224 Length: 1.0 (1.013091); Width: 0.1964 (0.196248); and Thickness: 0.10198
Material Description:	Fiber/Matrix (FVR = 55%), with nonlinear matrix stress-strain response Layup: [0/90/0/90/0/90/0] woven
Objective of Analysis:	Predict the fatigue life of the coupon
ASTM Number:	-
Control Type:	Load Control
Analysis Type:	Quasi-Static Fatigue
Solution:	***Fatigue 10**
Input Requirements:	GENOA data bank (including experimental stress-strain and S-N curves) GENOA model files

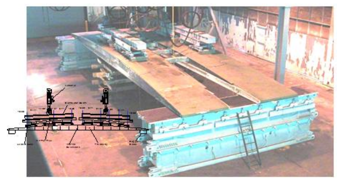
Test Validated Cases For Army, Navy, Airforce, NASA and Infrastructure



T-38 Talon Spar Redesign with FML (Hybrid) Composite



Composite Army Bridge



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

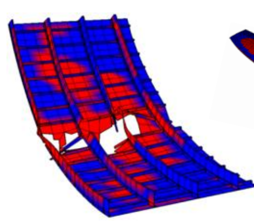
Maximum Stress Based Failure Criteria	true
Fiber Failure Criteria	
(S11T) Longitudinal Tensile	true
(S11C) Longitudinal Compressive	true
(F11C) Fiber Micro-Buckling	true
(R11C) Fiber Crush	true
(D11C) Delaminations	false
Matrix Failure Criteria	
(S22T) Transverse Tensile	true
(S22C) Transverse Compressive	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
(RROT) 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-plain Shear Strain	true
(EPS13S) Long. Out-of-plain Shear Strain	true
(EPS23S) Trans. Out-of-plain Shear Strain	false
Interactive Failure Criteria	
(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
Honeycomb Failure Criteria	false
(WRNK) Wrinkling for Honeycomb	false
(CRMP) Crimping for Honeycomb	false
(DIMP) Dimpling for Honeycomb	false
Miscellaneous	
(UDFC) User Defined Failure	false

Tutorials with Solutions and Code Verifications

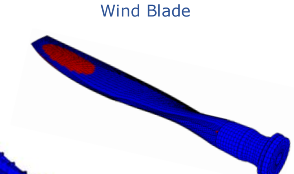
- **Fatigue**
  - Aging
  - Cold Work
  - Harmonic Fatigue
  - Power Spectrum Density
  - Quasi Static Fatigue
  - Spectrum Loading
  - Two Stage
- **Code Verifications**
  - **ABAQUS**
  - **MHOST**
    - Coupon Shell Cyclic Degradation Factor
    - Coupon Shell Cyclic SN Curve
    - Coupon Shell Cyclic SN Curve Material

Fully Supports Complex Models

Stiffened Panel



Wind Blade



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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