AlphaSTAR Products Overview

MCQ

GENOA M S - P F A

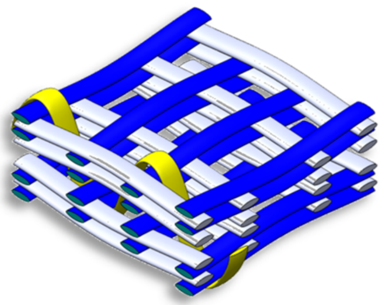
GENOA 3DP SIMULATION

AlphaSTAR

Our Products

MCQ

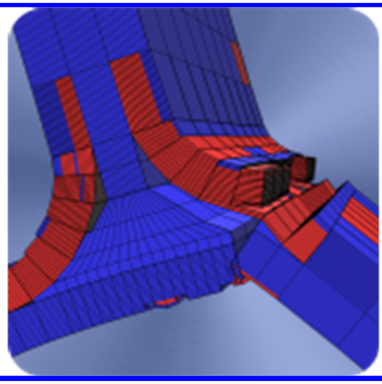
Material Characterization & Qualification



- Facilitates Material Qualification, Modeling and Design Analysis of Advanced Materials
- Supports Full Breadth of 2D/3D Composite Architecture
- Considers Defects: Voids, Fiber Waviness, Manufacturing Anomalies, Environment (Moisture & Temperature)

GENOA

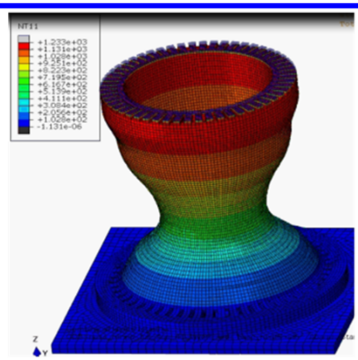
Multi-Scale Progressive Failure Analysis to Assess Durability and Damage Tolerance



- Augments Commercial Finite Element Solvers (e.g. Abaqus, Ansys, Lsdyna)
- Identifies Damage Initiation and Fracture Evolution
- Determines When, Where and Why Failure Occurs

GENOA
3DP SIMULATION

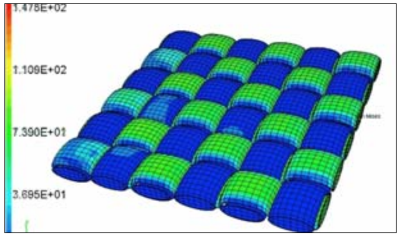
AM Material and Process Parameter Simulation for Optimized Build

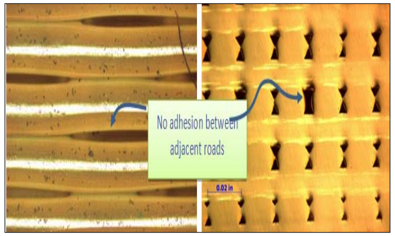


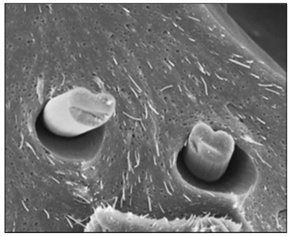
- Automated FE Mesh & Model Generator
- Prediction of Delamination and Other Manufacturing Anomalies
- Prediction of Mechanical Properties at Different Temperatures
- Assess Both Material and Process Parameter Sensitivities

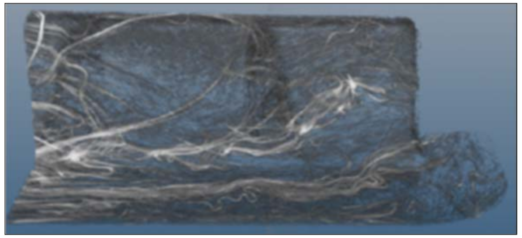
What Sets MCQ Apart

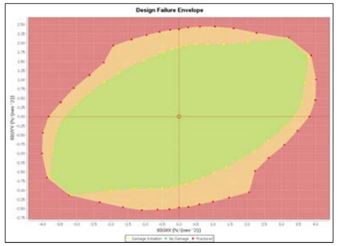
- ✓ Utilizes De-Homogenized Approach
- ✓ Independent of FEM (Unit Cell)
- ✓ Rapid Assessment of Material Properties
- ✓ Reduces Testing Resulting in Cost Savings
- ✓ Identifies Strength Allowables for Reliability
- ✓ Identifies Damage Initiation and Propagation
- ✓ Identifies Damage/Failure Modes
- ✓ Maintains a Validated Material Library
- ✓ Consider Defects, Voids, Fiber waviness, Agglomeration, Manufacturing Anomalies, and Environment (e.g. Moisture & Temperature)

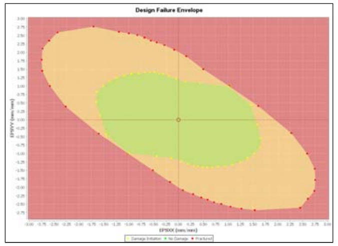


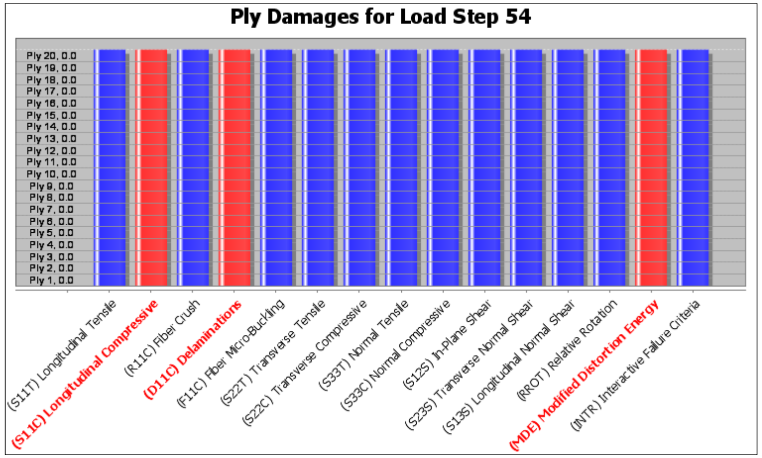












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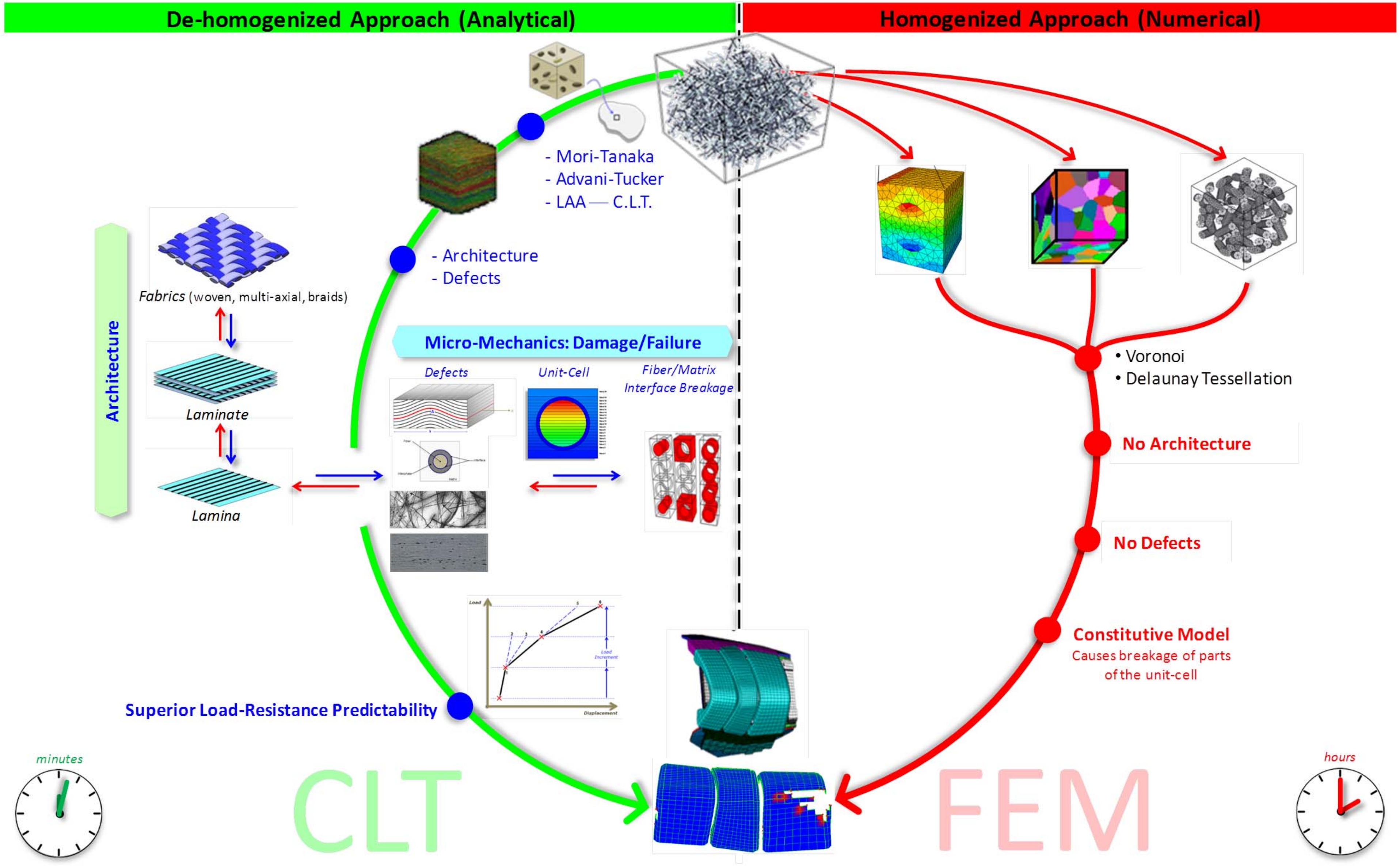
MCQ Utilizes De-Homogenized Approach



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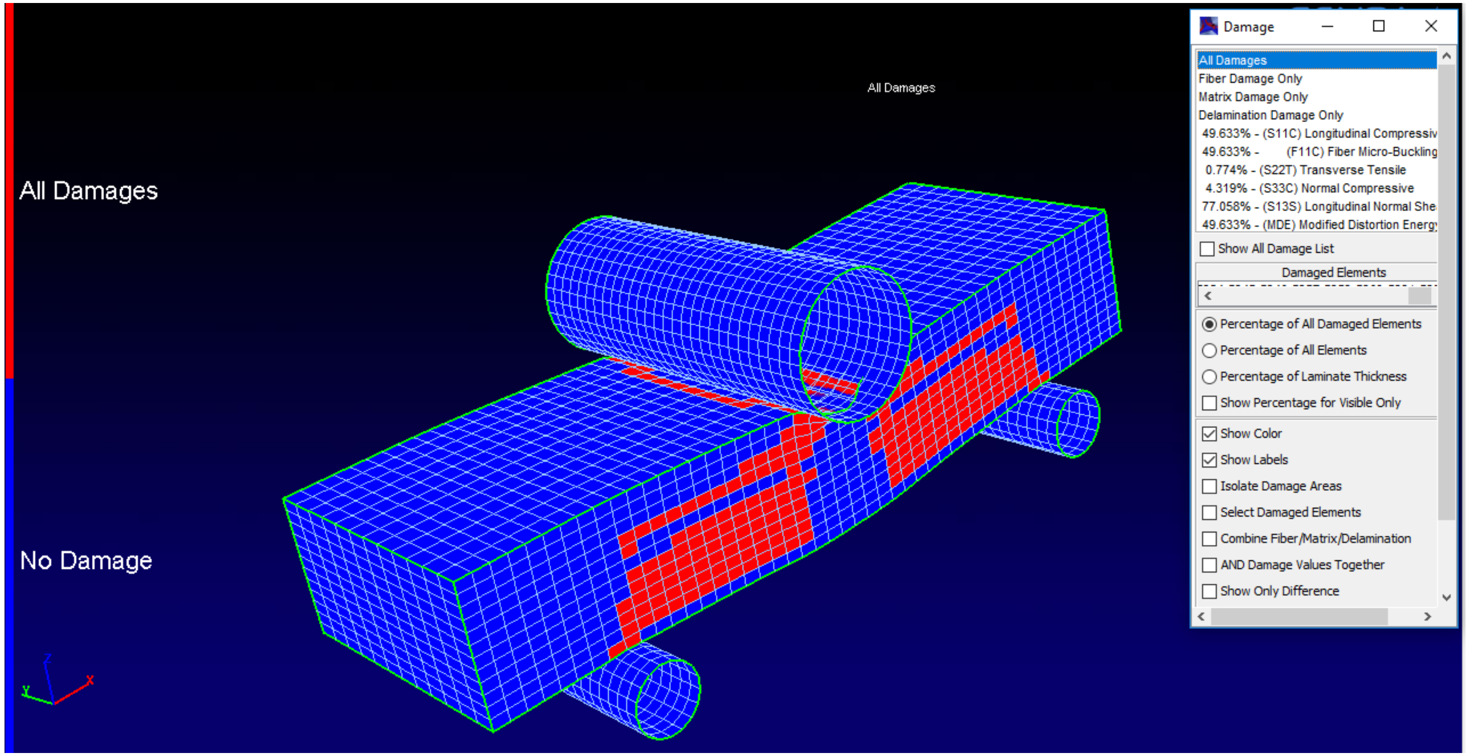
What Sets GENOA Apart

- Runs Multi-Scale Progressive Failure Analysis – Damage & Fracture Evolution (Durability & Damage Tolerance Code)
- Identifies Percentage Contribution of Failure Mechanism (Damage Index) to Show Where, When and Why Failure Occurs
- Predicts Behavior of Advanced Composite Structures Subject to Static, Dynamic, Fatigue and Environmental Loads while Considering Defects and Scatter



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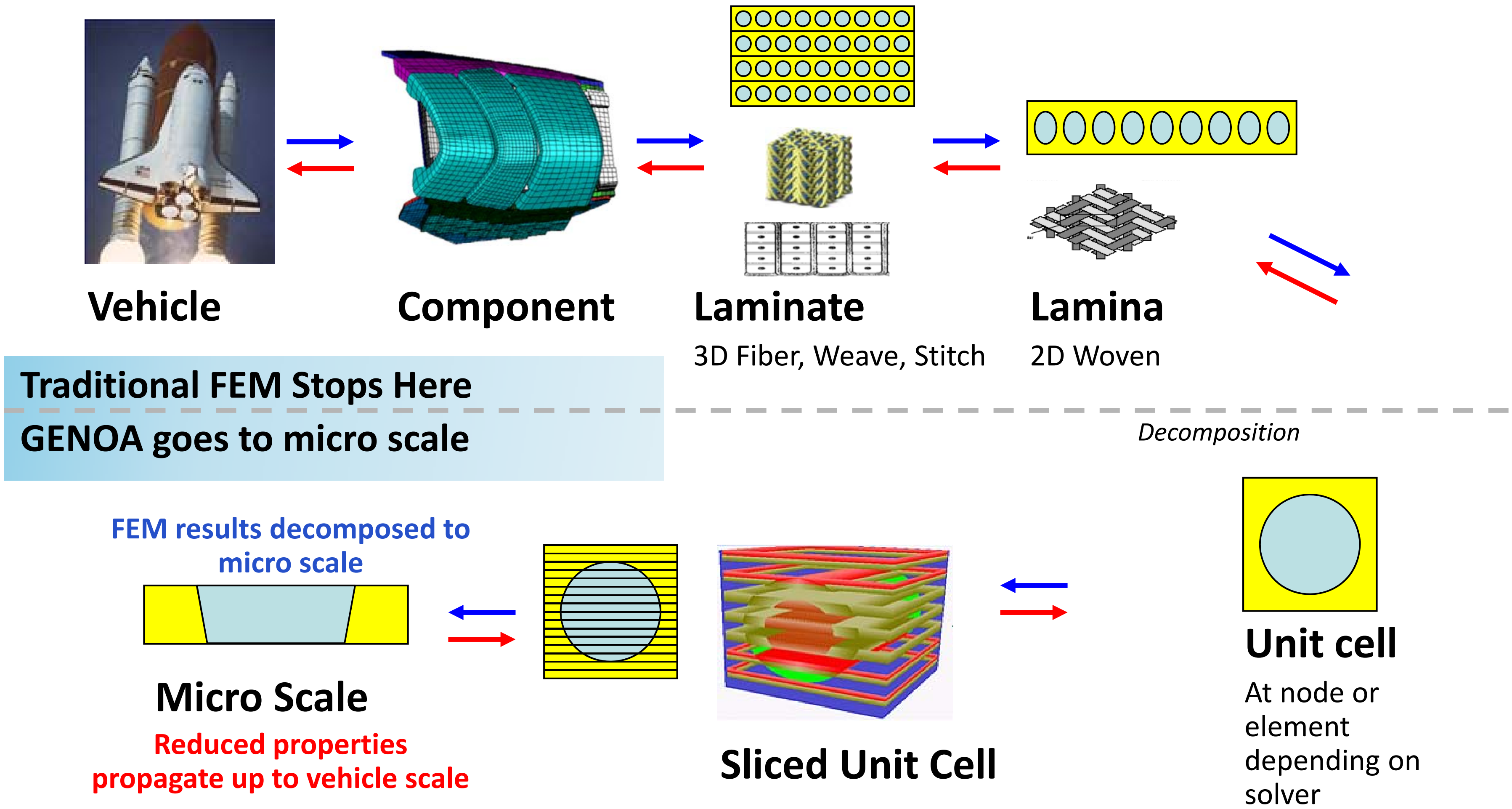
Multi-Scale Progressive Failure Analysis



MS-PFA takes full-scale FEM and breaks material properties down to microscopic level. Material properties are updated, reflecting any changes resulting from damage or crack

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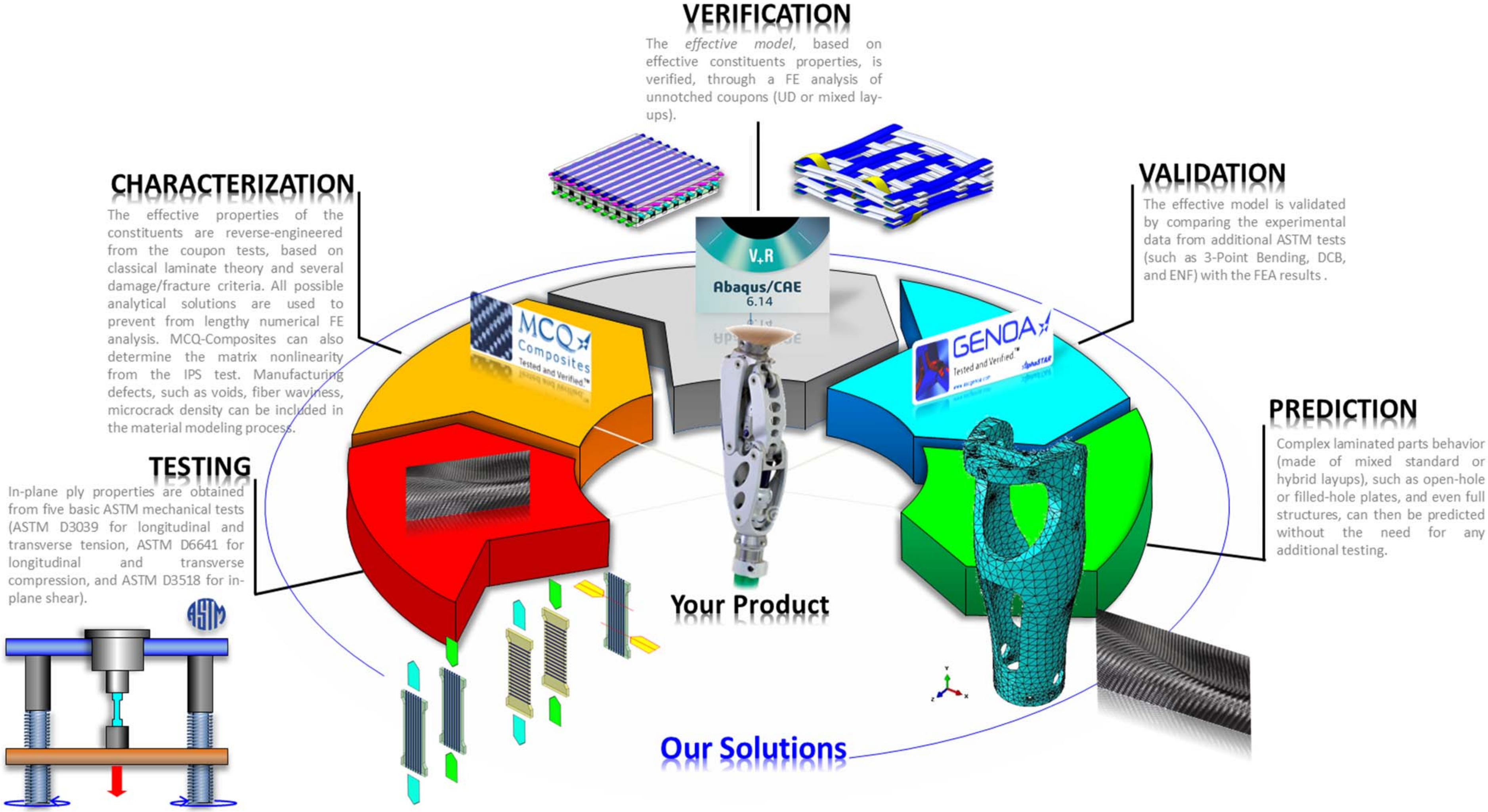
Work-Flow Solution from Test to Prediction



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MCQ

MCQ : Material Characterization & Qualification

- Suite of material modeling tools for:
  - Polymer Matrix Composite Material
    - ✓ MCQ-Composites (Continuous Fiber)
    - ✓ MCQ-Chopped (Chopped Fiber)
    - ✓ MCQ-Nano (Nano Particles)
  - Ceramic Matrix Composite Material
    - ✓ MCQ-Ceramic
  - Metals
    - ✓ MCQ-Metals
- Allows Engineers to Characterize and Optimize Material Layouts while Considering the Effect of Defects
- Delivers Rapid Assessment of Material Properties Needed for FEA

MCQ COMPOSITES MCQ CHOPPED

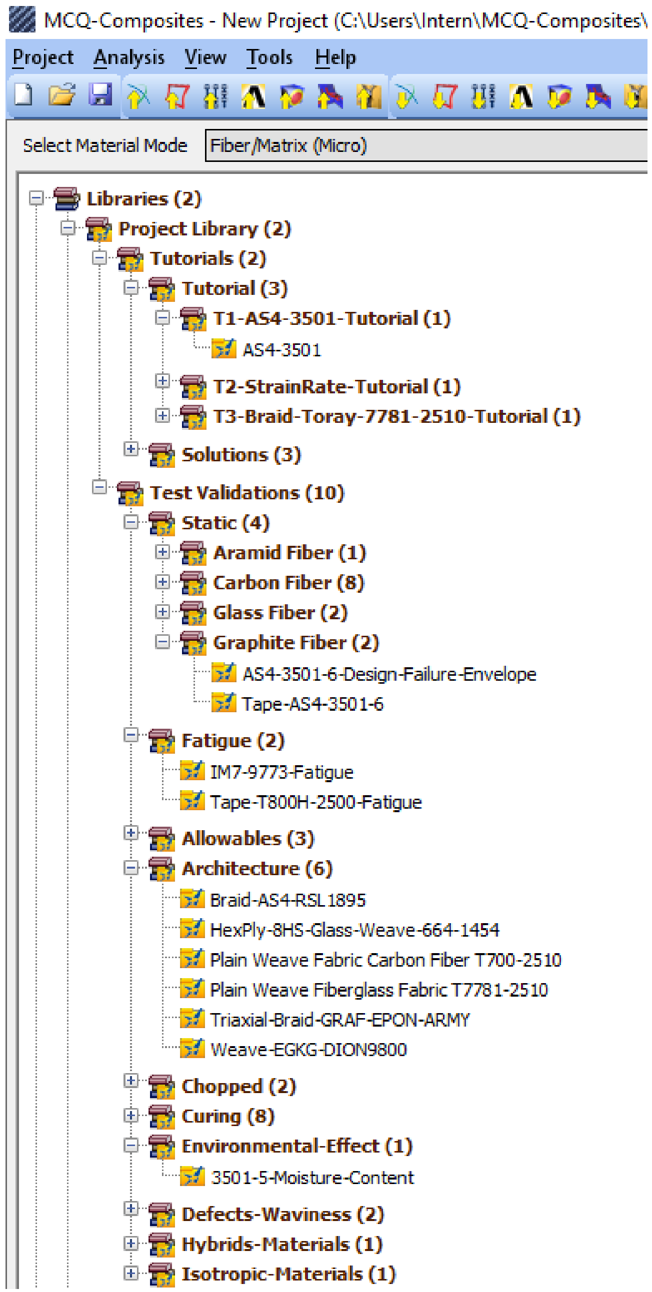
MCQ NANO MCQ CERAMICS MCQ METALS

MCQ COMPOSITES

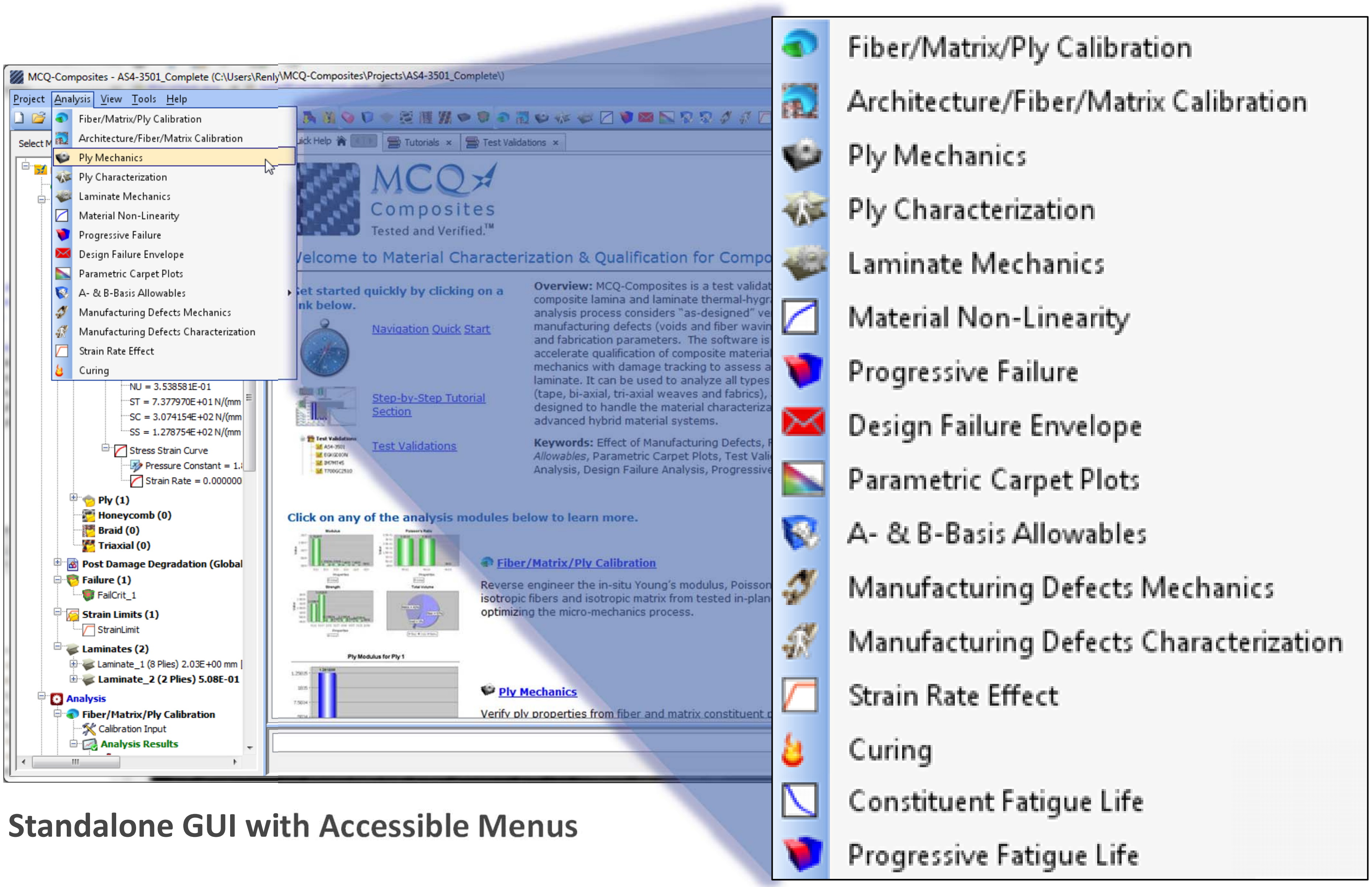
- **52** Test Validation Examples
- **6** Step-by-Step Tutorials

Total of 37 Examples

- **37 Materials in Library**



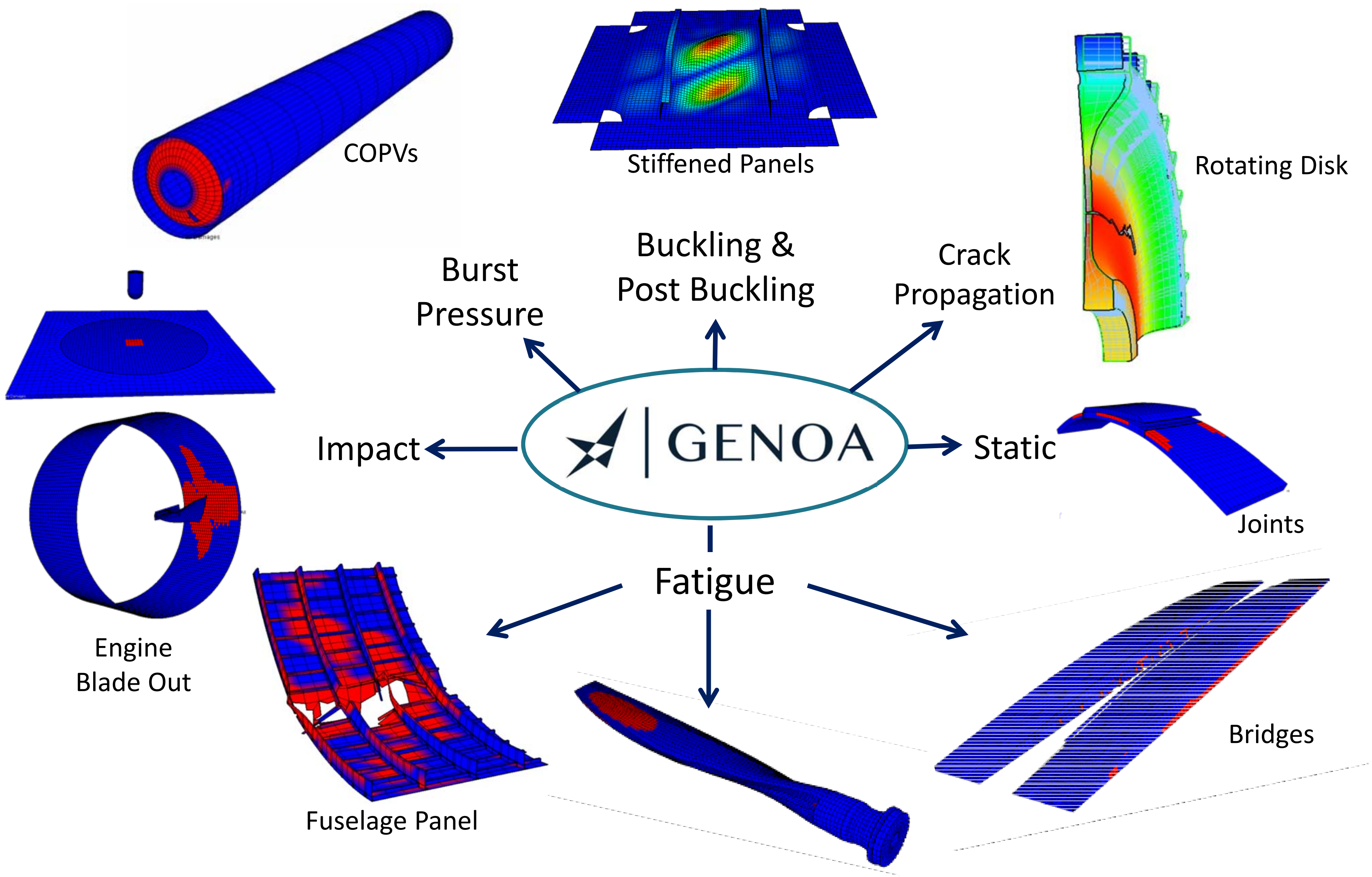
MCQ-Composites Analysis Modules



Standalone GUI with Accessible Menus

GENOA

GENOA Addresses Multiple Problems

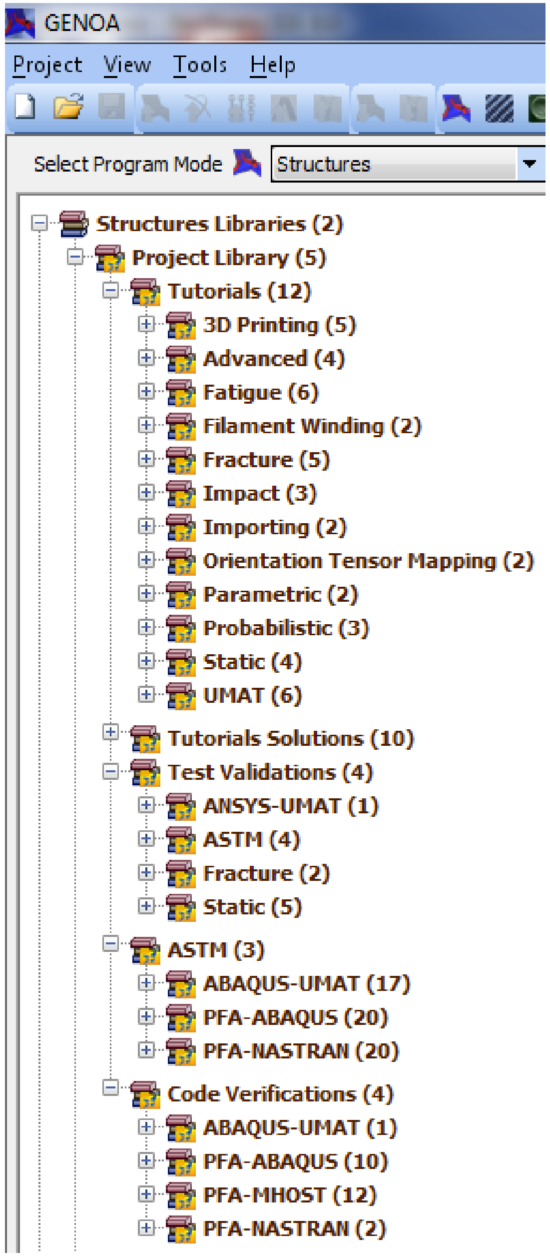


GENOA MS-PFA

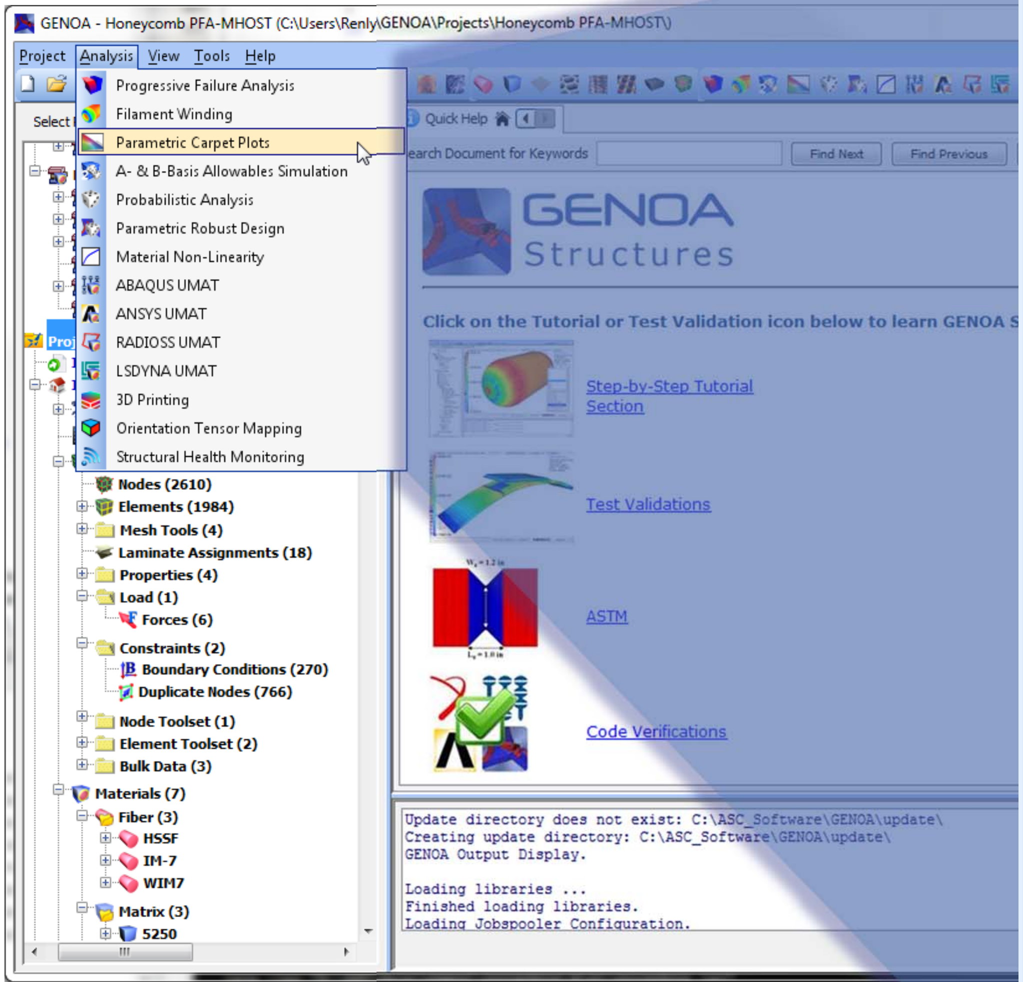
- **44** Step-by-Step Tutorials
- **31** Test Validation Examples
- **37** Code Verifications Examples
- **69** ASTM Models

Total of 181 Examples

- 37 Materials in Library



GENOA Analysis Modules



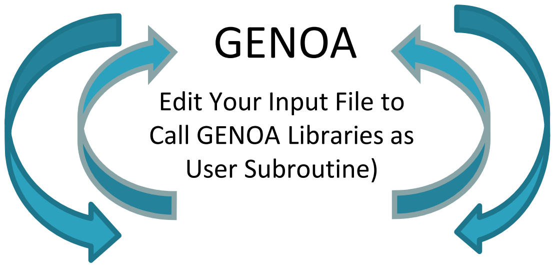
Standalone GUI with Accessible Menus

- Progressive Failure Analysis
- Filament Winding
- Parametric Carpet Plots
- A- & B-Basis Allowables Simulation
- Probabilistic Analysis
- Parametric Robust Design
- Material Non-Linearity
- ABAQUS UMAT
- ANSYS UMAT
- RADIOSS UMAT
- LSDYNA UMAT
- 3D Printing
- Orientation Tensor Mapping
- Structural Health Monitoring

GENOA: Two Ways to Activate

GENOA May be Activated by Direct Integration or Through User Material (UMAT) Subroutine

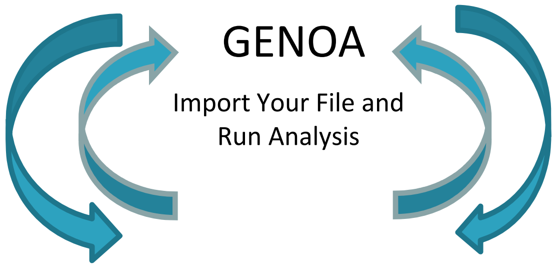
UMAT + GENOA



Currently Available for ABAQUS, ANSYS, LS DYNA

GENOA GUI tracks damage and fracture (identical for both approaches)

GENOA + ALL FEA



Applicable to Most FE Solvers: ABAQUS, LSDYNA, ANSYS, NASTRAN and MHOST

GENOA GUI tracks damage and fracture (identical for both approaches)

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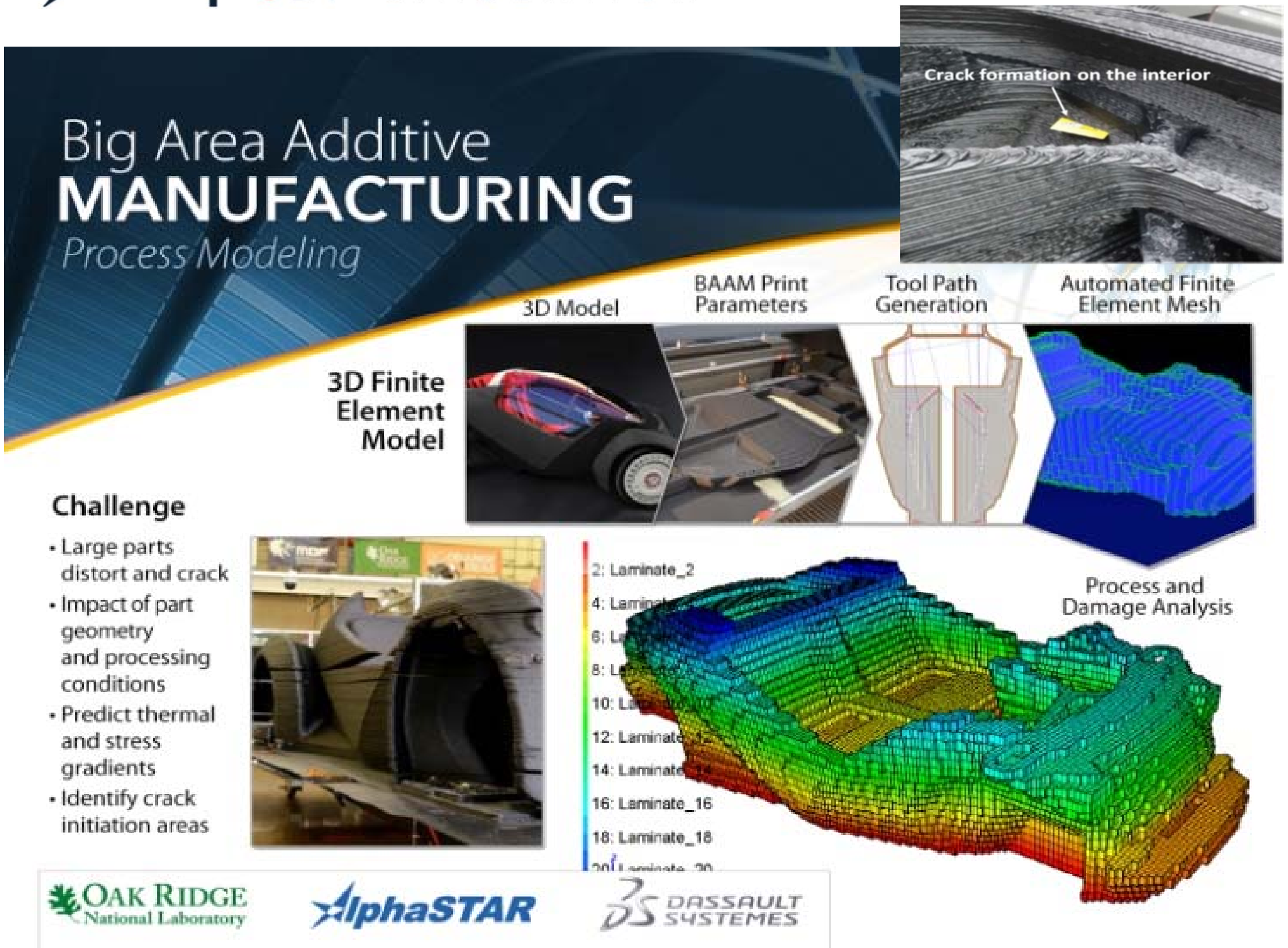
GENOA

3DP SIMULATION

GENOA 3DP : Additive Manufacturing Simulation

GENOA
3DP SIMULATION

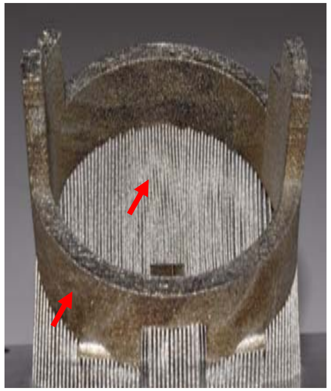


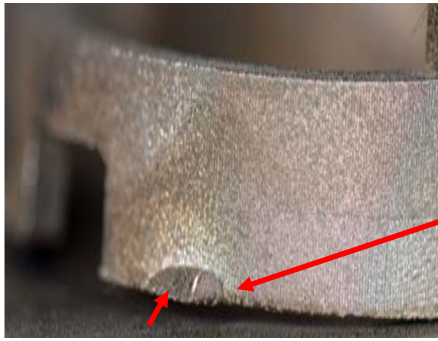
AM Process Simulation: Coupled Thermal / Structural

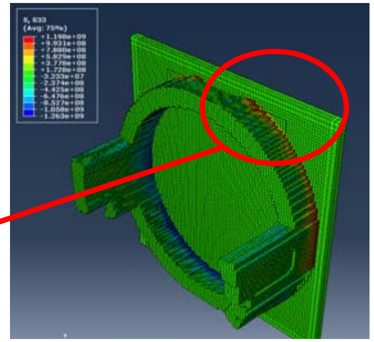
Stress Buildup Leads to Bracket and Support Warpage

Ring Bracket Built on UDRI's ATLAS using Inconel 718 powder

1st Build – Bad Part







Warping/redidual stresses predicted in simulation

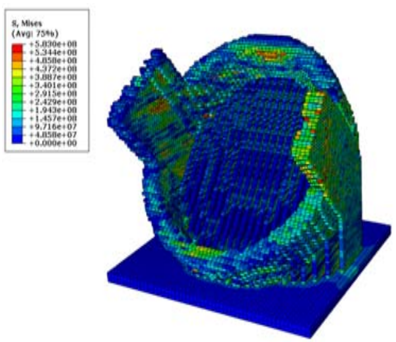
Warping eliminated through simulation DOE: improved support design and optimized build parameters to reduce residual stresses

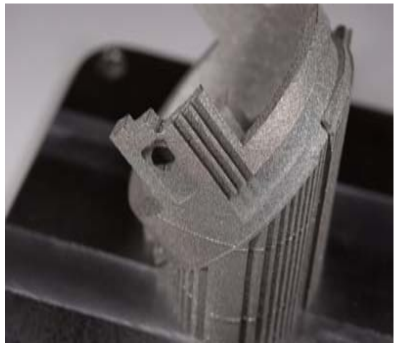
3rd Build – Good Part

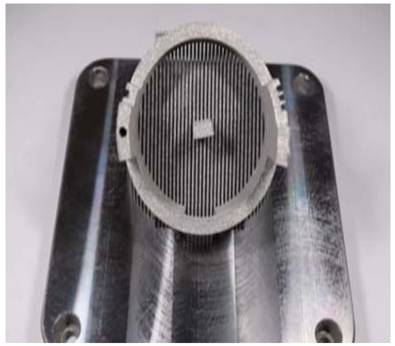
Optimized build changes:

1. Mark speed increased
2. Hatch spacing increased
3. Hatch shifted layer to layer (avoids overlap)
4. Support thickness increased

Lower residual stresses ⇨ Smooth, warp free part







GENOA 3DP: Software Features

Technology/Features	GENOA3D
Process	
FE Mesh Generator model-based layer, scan pattern, and mesh generator	✓
a) Local (Delaney Grain Model); b)Mapping to Global Mesh using Surrogate Approach	✓
Adaptive Meshing Strategies	✓
Dynamic Moving Grid Srategy	✓
Predict AM-Fabricated Material Stress-Strain	✓
ABAQUS FEM	✓
Coupled Thermal-Structural Analysis	✓
Integration with Commercial Topology Optimization	¦
Allowable Generation (Probabilistic Analysis)	✓
Potential to Simulate Big Parts	✓
Metal Powder	
Material Properties Database	✓
Pre-Process Operating Parameters as Inputs (Excluding Parameters Embedded in G-Code)	×
Phase Change (α and α+β)	×
Sub-Grain Size Meshing Technique	✓
Intergranular/Transgranular Void Nucleation/Growth	✓
Surface Roughness Prediction	✓
Environmental Effect (e.g. Oxidation)	✓
Material Fracture Toughness Prediction	✓
Fatigue Crack Growth Prediction	✓
Fatigue Loading Prediction (S-N)	✓
Diffusional Creep Prediction (a-N)	✓

Thermoplastic	✓
Material Properties Database (strength, stiffness)	✓
Test Validate Thermal Analysis	✓
Simulated Big Part (Strati Car): Residual stress, deflection, delamination, thershold crack, Service load performance	✓

Thermoset	✓
Material Properties Database (Graphene)	✓
Multi-Scale Material Modeling (Nano-Micro-Macro)	✓
Material strength, modulus, Fracture Toughness, wrinkle, delamination Prediction/Test	✓

Material Test Validated Database

Composite

AS4-8552 , AS4-ABS13, PP-LGF20, PBT-GF30, PA6, GPN-Epoxy

Powder

Ti-6Al-4V, Inconel 625, Steel (S420M, S690QL)

GENOA has several adaptive meshing technique but it has not been used for AM process simulation.

[1] Under development

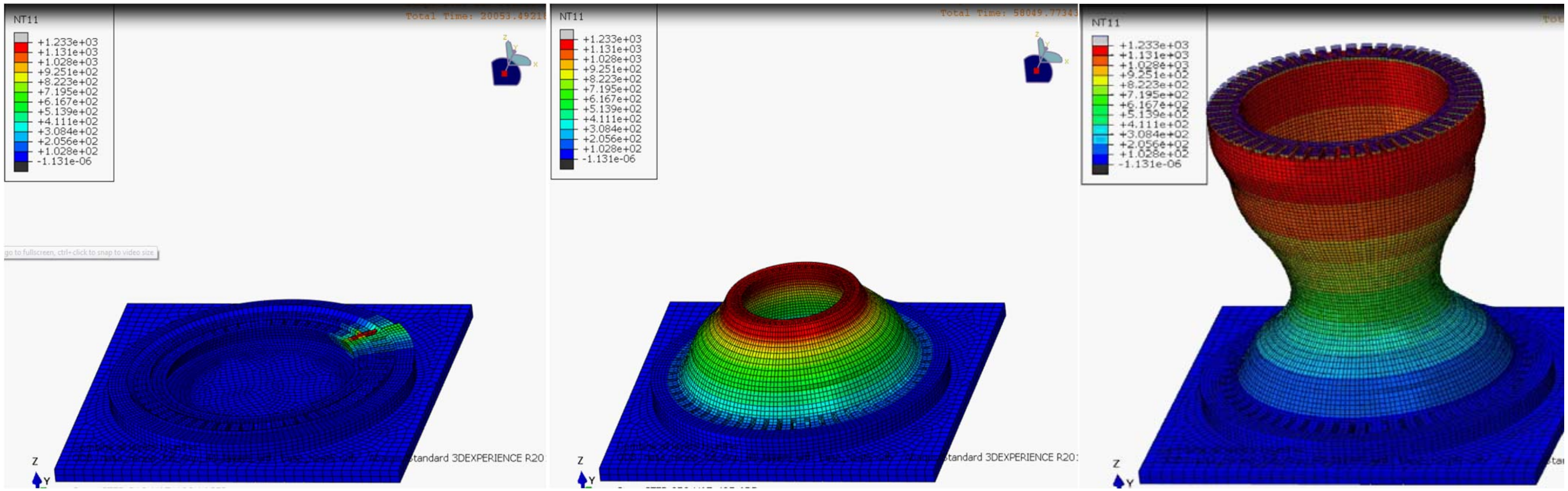
✓ Available

× Not Available

⌂ Available for other application

GENOA 3DP: Key Benefits

- Simulation of the AM Build
- Prediction of Mechanical Properties at Different Temperatures
- Prediction of Delamination and Other Manufacturing Anomalies
- Assess Both Material and Process Parameter Sensitivities
- Prediction of the Residual Strength of the Finished As-Built 3D-printed Part Subject to Service Loading.
- Validated Database for Composites Thermoplastics, Thermoset and Metal Powder



Summary

- ❖MCQ:
  - ✓ **Delivers Rapid Assessment of Material Properties for FEA**
  - ✓ **Supports and Optimizes Composite Material Layups**
- ❖GENOA:
  - ✓ **Multi-Scale Progressive Failure Analysis: Damage- Fracture Evolution (Durability and Damage Tolerance)**
  - ✓ **Augments Commercial FEA Solvers**
- ❖GENOA 3DP:
  - ✓ **Predicts Quality of AM Manufactured Part Considering Defects and Scatter**
  - ✓ **Enhances Build Quality, Reduces Scrap Rate and Trial & Error**