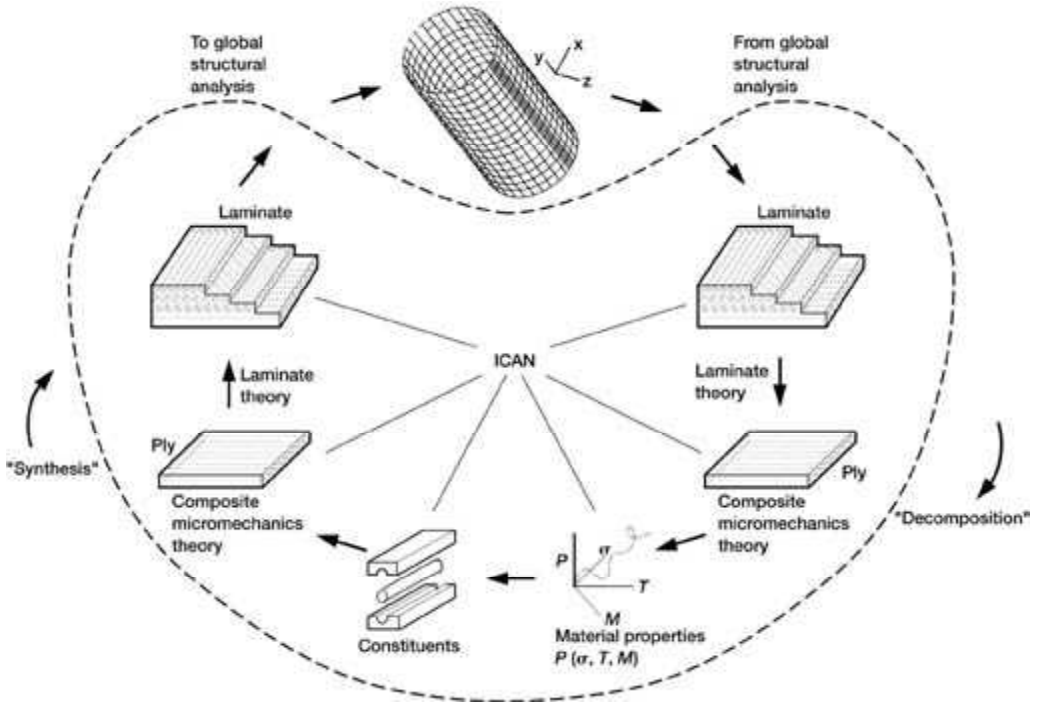
GENOA–PFA: Progressive Fracture in Composites Simulated Computationally

GENOA–PFA is a commercial version of the Composite Durability Structural Analysis (CODSTRAN) computer program that simulates the progression of damage ultimately leading to fracture in polymer-matrix-composite (PMC) material structures under various loading and environmental conditions. GENOA–PFA offers several capabilities not available in other programs developed for this purpose, making it preferable for use in analyzing the durability and damage tolerance of complex PMC structures in which the fiber reinforcements occur in two- and three-dimensional weaves and braids.

GENOA–PFA implements a progressive-fracture methodology based on the idea that a structure fails when flaws that may initially be small (even microscopic) grow and/or coalesce to a critical dimension where the structure no longer has an adequate safety margin to avoid catastrophic global fracture. Damage is considered to progress through five stages: (1) initiation, (2) growth, (3) accumulation (coalescence of propagating flaws), (4) stable propagation (up to the critical dimension), and (5) unstable or very rapid propagation (beyond the critical dimension) to catastrophic failure. The computational simulation of progressive failure involves formal procedures for identifying the five different stages of damage and for relating the amount of damage at each stage to the overall behavior of the deteriorating structure.

In GENOA–PFA, mathematical modeling of the composite physical behavior involves an integration of simulations at multiple, hierarchical scales ranging from the macroscopic (lamina, laminate, and structure) to the microscopic (fiber, matrix, and fiber/matrix interface), as shown in the figure. The code includes algorithms to simulate the progression of damage from various source defects, including (1) through-the-thickness cracks and (2) voids with edge, pocket, internal, or mixed-mode delaminations.



Simulation of composite damage and fracture propagation via CODSTRAN (where M is moisture; P, property; T, temperature, and s*, stress).*

Some of the salient features of the GENOA–PFA software follow:

1. Inclusion of the material's nonlinearities through periodic updates of the stiffness and inclusion of geometric nonlinearities through Lagrangian updating

2. Simulation of the initiation and growth of cracks and of the ultimate failure of the composite under static, cyclic, creep, and impact loads

3. Identification of the fractional contributions of various possible composite failure modes involved in critical damage events, and determination of the sensitivities of failure modes to such design parameters as fiber volume fractions, ply thicknesses, fiber orientations, and adhesive bond thicknesses.

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