STRUCTURES .AERO

Solution Partner PLM SIEMENS

Analyzing Composites Using Finite Element Analysis

Part 1: Composites in FEMAP

Presented By: Structures.Aero (SDA)

Femap. Real FEA made easy.

This two-part series will detail the role that composites can play in Finite Element Analysis. Running on consecutive Wednesday afternoons, this series will show the use and value of composites in two separate Finite Element Modelers. The first week, we will show the analysis of composites in FEMAP. The second week, you will be able to see a similar process as we compare composite analysis in a software called Hypersizer.

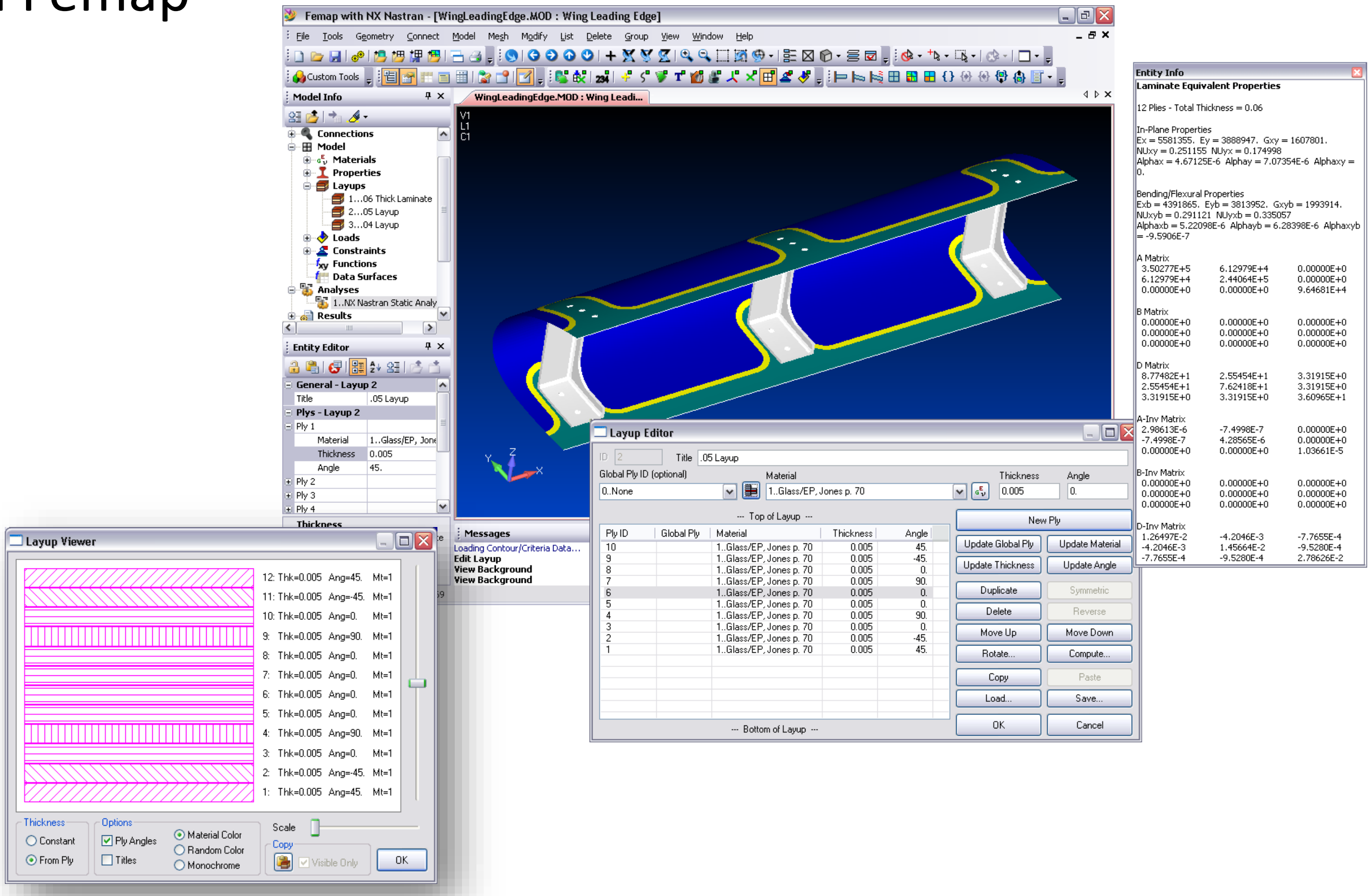
Presenters:

Alex Carra- Stress Engineer
(MS, Aerospace Engineering, 2013)

Alex Carra- Stress Engineer
(Ph.D., Aerospace Engineering, 2014)

Preprocessing
FE Model Creation: Composite Materials

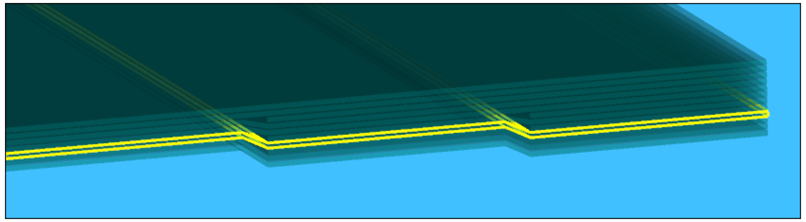
- Composites Modeling with Femap
  - –Layup Viewer
  - –Layup Editor
    - •Copy and rotate plies
    - •Edit ply properties
  - –Entity Info pane
    - •Live property updates
  - –Groups
    - •View, organize and manipulate plies

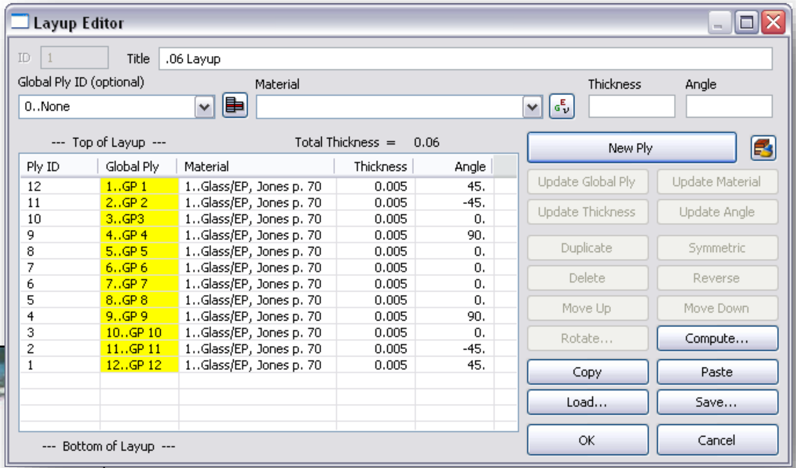


Preprocessing
FE Model Creation: Composite Materials

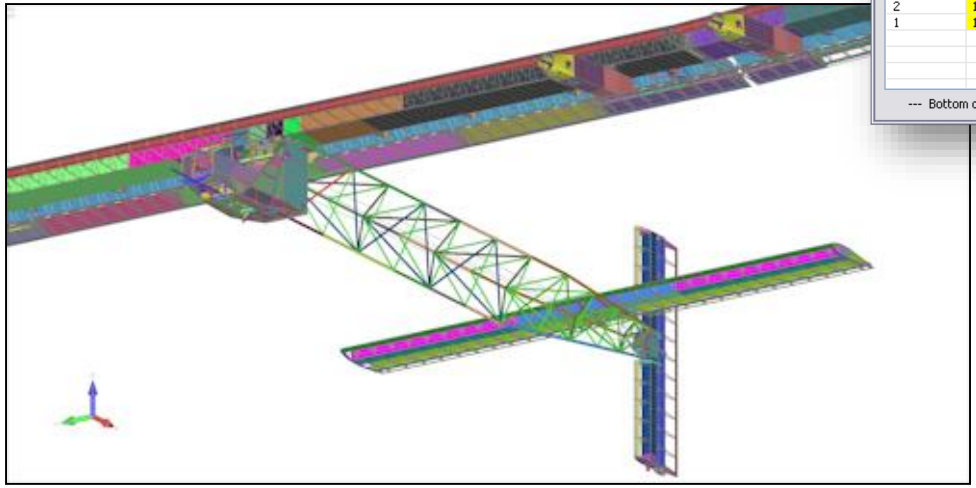
Femap composite global ply

- Preprocessing
  - Define and maintain global plies
  - Visualize extent of global ply across laminates
- Postprocessing
  - Visualize results for global plies across the structure





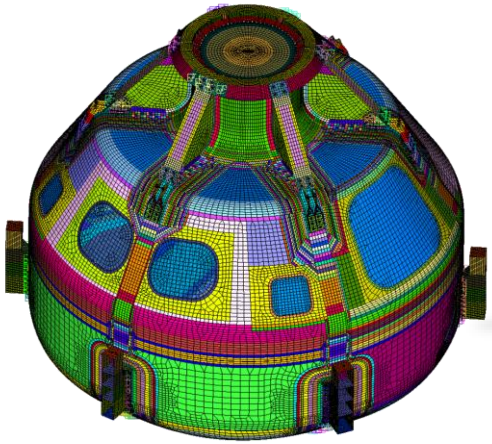
Ply ID	Global Ply	Material	Thickness	Angle
12	1..GP 1	1..Glass/EP, Jones p. 70	0.005	45.
11	2..GP 2	1..Glass/EP, Jones p. 70	0.005	-45.
10	3..GP3	1..Glass/EP, Jones p. 70	0.005	0.
9	4..GP 4	1..Glass/EP, Jones p. 70	0.005	90.
8	5..GP 5	1..Glass/EP, Jones p. 70	0.005	0.
7	6..GP 6	1..Glass/EP, Jones p. 70	0.005	0.
6	7..GP 7	1..Glass/EP, Jones p. 70	0.005	0.
5	8..GP 8	1..Glass/EP, Jones p. 70	0.005	0.
4	9..GP 9	1..Glass/EP, Jones p. 70	0.005	90.
3	10..GP 10	1..Glass/EP, Jones p. 70	0.005	0.
2	11..GP 11	1..Glass/EP, Jones p. 70	0.005	-45.
1	12..GP 12	1..Glass/EP, Jones p. 70	0.005	45.

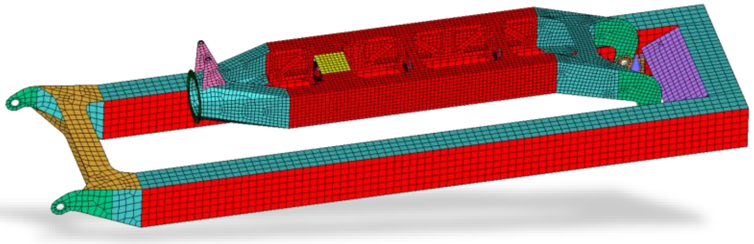


LIVE DEMO

About SDA (aka "Structures.Aero")

- SDA was founded in 1997 and provides expert aerospace structural analysis
- We serve a variety of industries
  - We specialize in composites, and developing strong, lightweight structures that are readily manufacturable
  - Low level support up through developing test plans and advanced stress analysis
  - Typical support programs include small to large UAVs, manned and unmanned spacecraft, naval structures
- Our team consists of over a dozen B.S., M.S., and PhD level engineers
- SDA is located in Sterling, VA, just north of Dulles Airport near Washington DC





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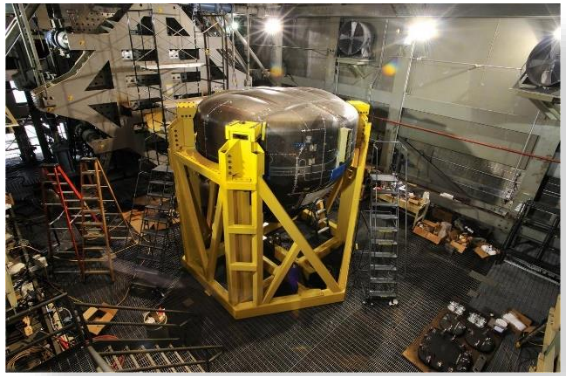
Typical Projects we support

- Some of our previous projects include:
  - Aircraft
    - Aurora Excalibur
    - AAI Shadow
    - AAI Aerosonde
    - Lockheed Constellation restoration for Lufthansa
  - Spacecraft
    - NASA NESC Composite Crew Module (CCM)
    - NASA NESC Max Launch Abort System (MLAS)
    - NASA James Webb Space Telescope/IEC
    - NASA Orion Heatshield mass reduction for NESC
    - NASA Orion Crew Module (with Lockheed)
    - NASA WFIRST Telescope for Goddard

Aerosonde

CCM



Heatshield

Orion Crew Module

Shadow M2

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Additional Resource

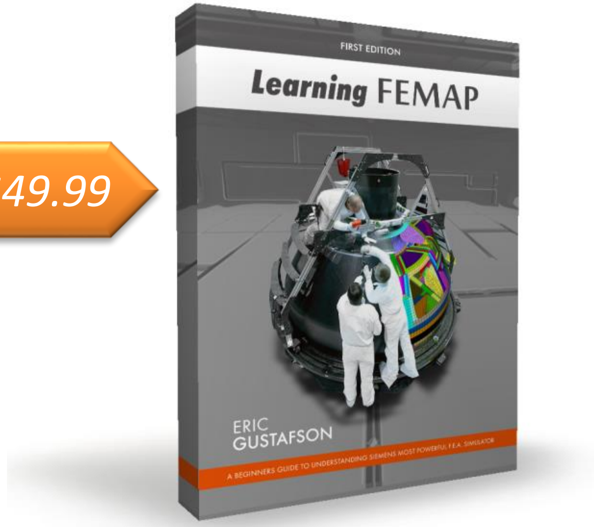
Learning Femap

ISBN 978-1-4951-2963-6

By Eric Gustafson (eric@structures.aero), Senior Aerospace Stress Analyst, SDA

Available online at www.learningfea.com

$49.99

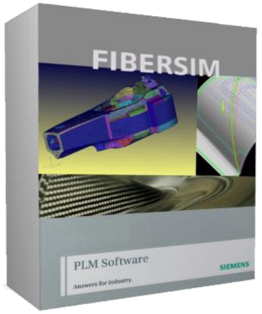


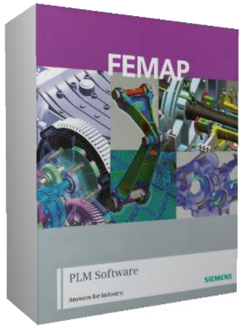
What	**New book published Fall 2014**
Why	Learning with the help documentation can be like drinking from a fire hose. *Learning Femap* succinctly covers the bases on using Femap without being a "bible".
Covers	✓ Introduction ✓ Femap Application Interface ✓ Modeling/ Pre-Processing ✓ Analysis ✓ Post-Processing ✓ Programming Femap
How	✓ Explanation of features ✓ Numerous illustrations ✓ Annotated examples ✓ Guided tutorials

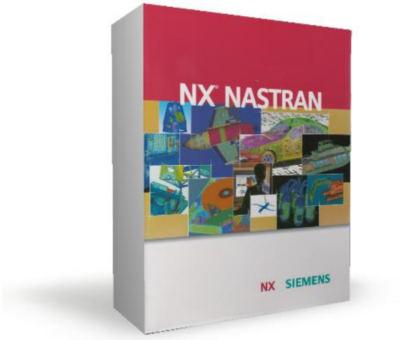
Partnerships

- Siemens Value Added Reseller and Certified Provider of First-Line Support , specializing in:
  - FEMAP
  - ★ **FEMAP with NX/NASTRAN**
  - NX/NASTRAN Enterprise
  - FiberSIM
  - Solid Edge

- Collier Research Corporation Reseller
  - ★ **HyperSizer**, structural analysis and optimization package for composite and metallic structures







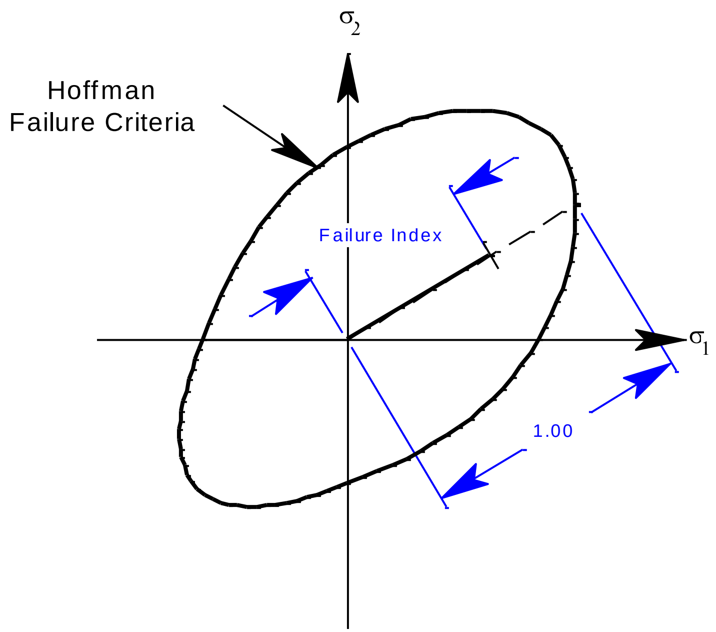
BACKUP

Hoffman Failure Theory

- The Tsai-Hoffman Failure Criterion combines the stresses in a lamina (a single ply of a composite laminate) to predict failure or calculate a margin
- A Failure Index is calculated and can be displayed

$$\text{Failure Index} = \left(\frac{1}{X_t} - \frac{1}{X_c}\right)\sigma_1 + \left(\frac{1}{Y_t} - \frac{1}{Y_c}\right)\sigma_2 + \frac{\sigma_1^2}{X_t X_c} + \frac{\sigma_2^2}{Y_t Y_c} + \frac{\sigma_{12}^2}{S^2} - \frac{\sigma_1 \sigma_2}{X_t X_c}$$

- Where X_t = tension allowable in "1" direction, X_c = compression
- Where Y_t = tension allowable in "2" direction, Y_c = compression
- S = Shear Allowable
  - σ_1 = applied stress in "1" direction
  - σ_2 = applied stress in "2" direction
  - σ_{12} = applied shear stress



Hoffman Failure Theory

- Margins of Safety using the Hoffman Theory are calculated using:

$$F_1 = \left(\frac{1}{X_t} - \frac{1}{X_c}\right); \quad F_2 = \left(\frac{1}{Y_t} - \frac{1}{Y_c}\right); \quad F_{11} = \frac{1}{X_t X_c}; \quad F_{22} = \frac{1}{Y_t Y_c}; \quad F_{66} = \frac{1}{S^2}; \quad F_{12} = -\frac{F_{11}}{2}$$

$$MS = \frac{2}{F_1\sigma_{11} + F_2\sigma_{22} + \sqrt{\left(F_1\sigma_{11} + F_2\sigma_{22}\right)^2 + 4\left(F_{11}\sigma_{11}^2 + F_{22}\sigma_{22}^2 + F_{66}\tau_{12}^2 + 2F_{12}\sigma_{11}\sigma_{22}\right)}} - 1.0$$

  - Which is basically the distance formula