Bi-Angle Tape
Shear Lag Finite Element Analysis

Presented by:

T. Kim Parnell, PhD,PE

PEC-Parnell Engineering & Consulting

www.parnell-eng.com

www.linkedin.com/in/parnellpec

kim.parnell@stanfordalumni.org

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Outline of Presentation

- Introduction
- Material Behavior Discussion
  - Bi-Angle NCF Tape Material
- Finite Element Analysis
  - Model
  - Results
- Summary

T. Kim Parnell, PhD,PE - Biography

- T. Kim Parnell, Ph.D.,P.E. is Principal & Founder of Parnell Engineering & Consulting (PEC). Kim holds Ph.D. and MSME degrees in Mechanical Engineering from Stanford University, a BES from Georgia Tech, and is a registered Professional Mechanical Engineer in the State of California. Kim is a Senior Member of IEEE and a Member of ASME and ASM. Kim is 2011 Chair of the IEEE Santa Clara Valley Section (IEEE-SCV) with over 12,000 members and Past-Chair of the IEEE Consultants' Network of Silicon Valley (IEEE-CNSV).
- Dr. Parnell is on the Mechanical Engineering faculty at Santa Clara University teaching materials, design, and manufacturing applications. He currently participates as a Lecturer in the Stanford Composites Design Program. He works extensively in Composite material issues including Damage, Delamination, and Failure. Dr. Parnell is active in areas such as alternative energy, finite element analysis, robust design, and the use of computer simulation to achieve better designs in shorter time. He frequently works in medical devices and is an expert in the areas of failure analysis and accident investigation, and uses this expertise to help develop more reliable product designs. He has extensive experience in the analysis and simulation of structures, heat transfer, and fluid flow using finite elements and other numerical procedures..
- Dr. Parnell was recently at MSC.Software Corporation as Senior Manager in the Product Management group. He was the MSC Product Manager for Fatigue and Wind Energy. Before starting PEC, Kim was at Exponent Failure Analysis Associates (Senior Manager), Rubicor Medical (R&D Director), SST Systems, ATT Bell Laboratories, Stanford University and General Motors. He also was appointed as a Visiting Associate Professor in the Mechanical Engineering Department at Stanford University, teaching graduate courses in Mechanics.

Bi-Angle NCF Tape

- 2-Ply, Bi-Angle NCF material in standard 6” (150mm) width for automated tape laying
- Each tape pass lays 2 plies – 0° ply & off-axis ply (typically 45° or 22.5°)
- Adjacent tape runs create seams or discontinuities in the fibers of the off-axis plies

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Bi-Angle NCF Tape

- Assess the effect of seams on
  - Stiffness
  - Strength
  - Degree of Localization of discontinuity
- Evaluate options for staggering seams
- 3D model to evaluate thickness and interlaminar effects
- Compare Seam with Continuous Panel

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T700 64% VF Material Properties
Bi-Angle NCF Tape

	(MPa)	
E1	1.408E+05	
E2	9.300E+03	
E3	9.300E+03	
G12	5.80E+03	
G23	3.10E+03	
G31	5.80E+03	
Nu12	0.3000	Nu13
Nu23	0.5000	Nu32
Nu31	0.0198	Nu21

	(MPa)
X	2940
X’	1980
Y	66
Y’	220
Z	66
Z’	220
XY	93
YZ	93
ZX	93

T 0.0625mm

Bi-Angle NCF Tape FEA

- 3D Tape Shear lag model
- Quasi-isotropic layup, continuous stacking
- $[0/+45/90/-45]_{4T}$
- 1mm total thickness for 16 Ply
- Seam => traction-free BC on off-axis ply; parallel to tape run

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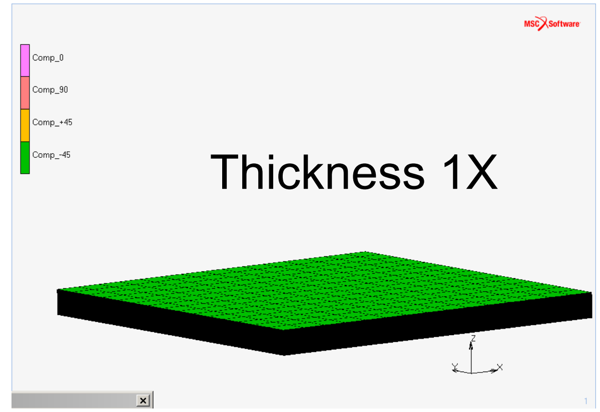
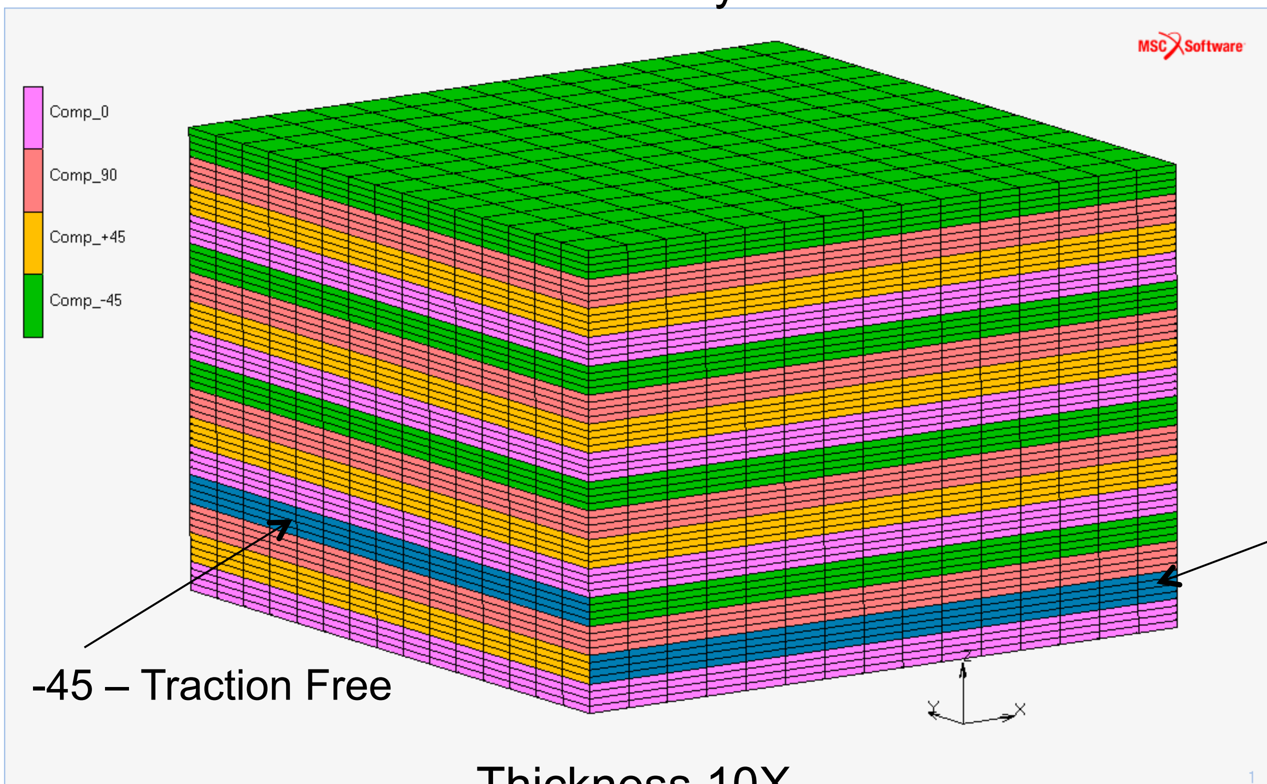
Bi-Angle NCF Tape FEA

- Model of 15mm x 15mm panel
- Quasi-isotropic layup, continuous stacking
- $[0/+45/90/-45]_{4T}$
- 1mm total thickness for 16 Ply





+45 – Traction Free

Thickness 10X

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Bi-Angle NCF Tape FEA Results

- Minimal reduction in modulus for extension/ compression for $[0/+45/90/-45]_{4T}$ with seam discontinuity on 1-ply +45 & -45

- Strain contours ??

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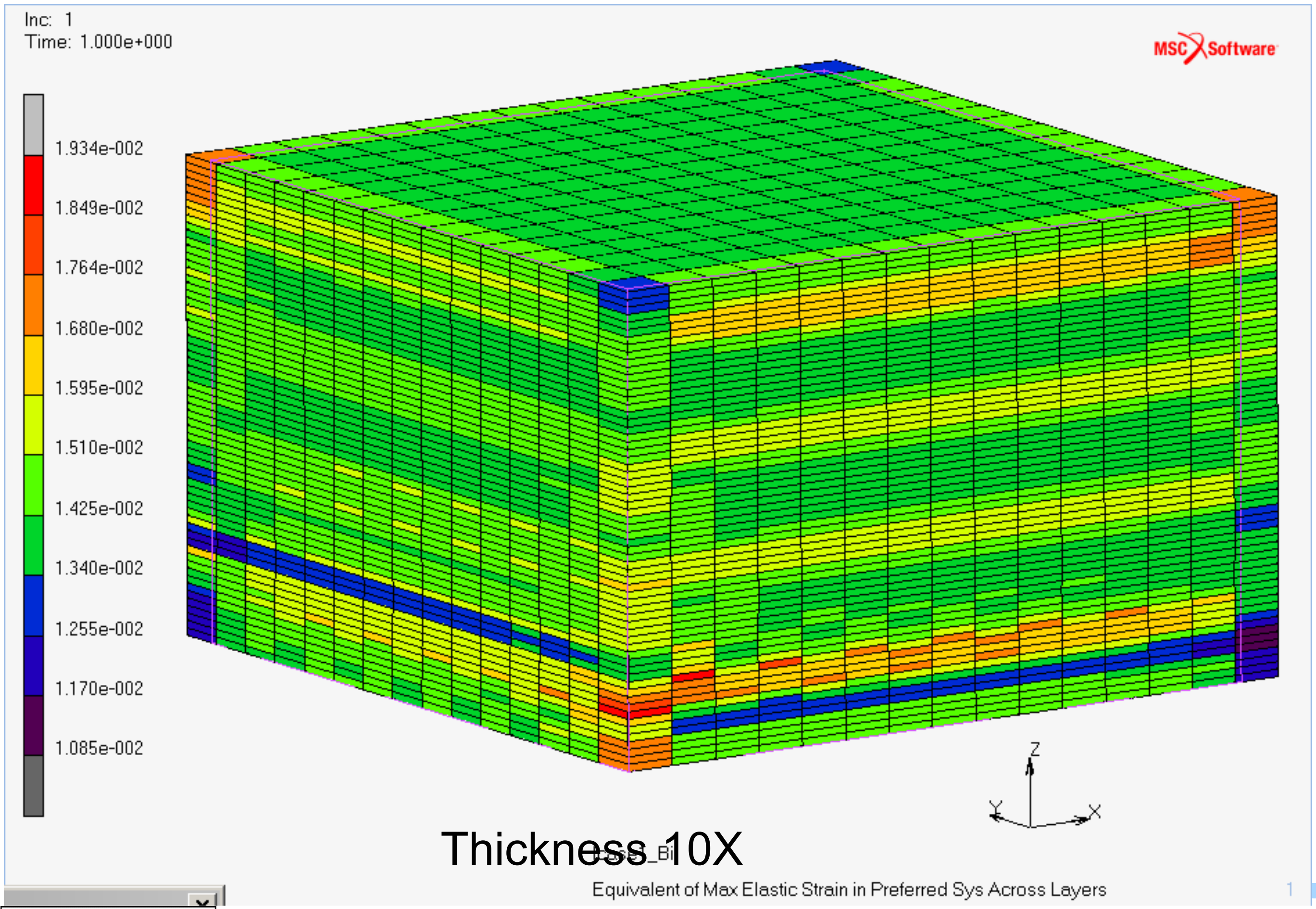
Bi-Angle NCF Tape FEA

- Bi-Axial Tension - e_x +1.0%, e_y +1.0%



Thickness 10X

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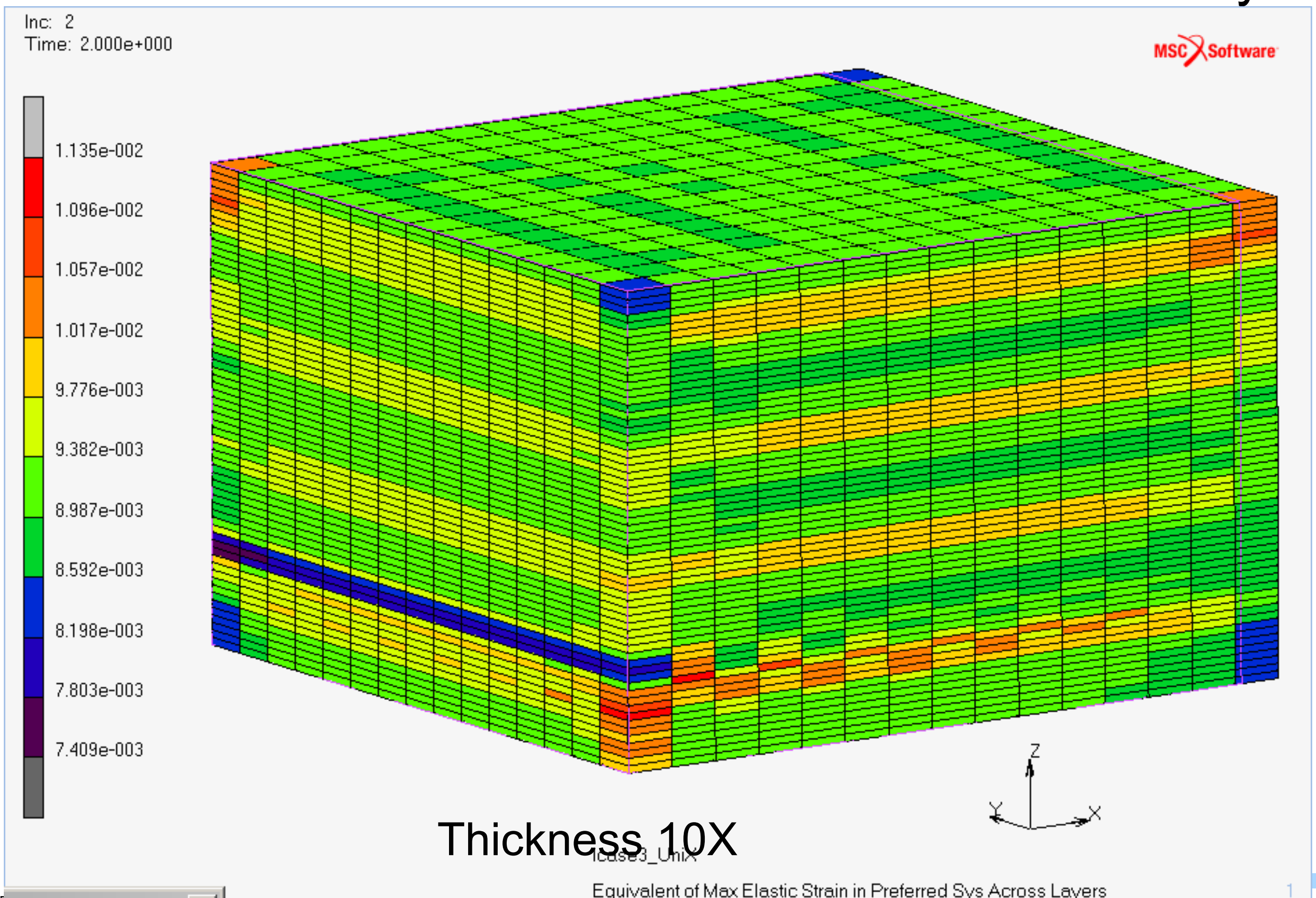
Bi-Angle NCF Tape FEA

- UniAxial Tension - e_x +1.0%, e_y +0.0%



Thickness 10X

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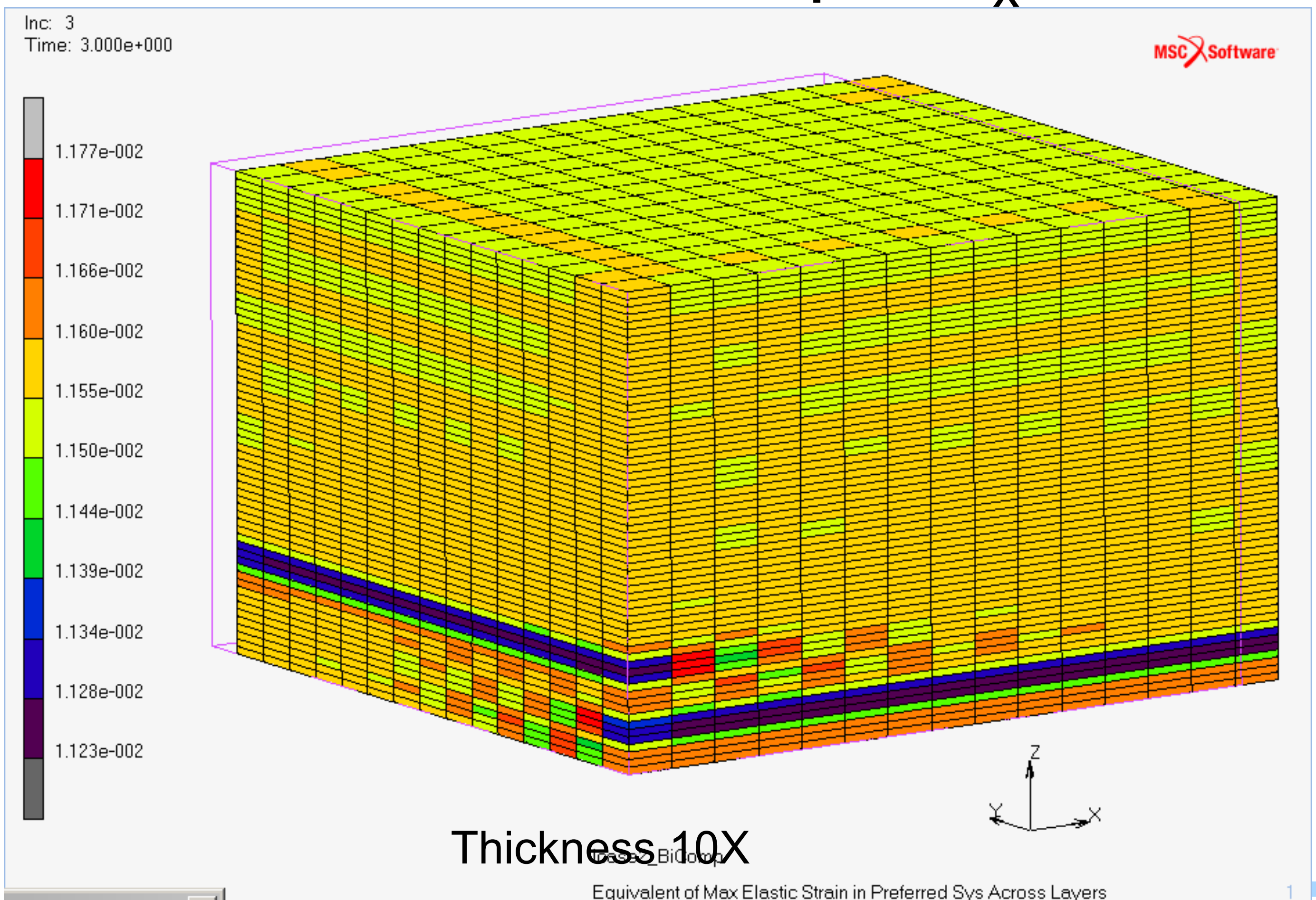
Bi-Angle NCF Tape FEA

- Bi-Axial Tens/Comp - e_x +1.0%, e_y -1.0%



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Direct Comparison Tape vs. Continuous

- Tape (Left)   vs.   Continuous (Right)

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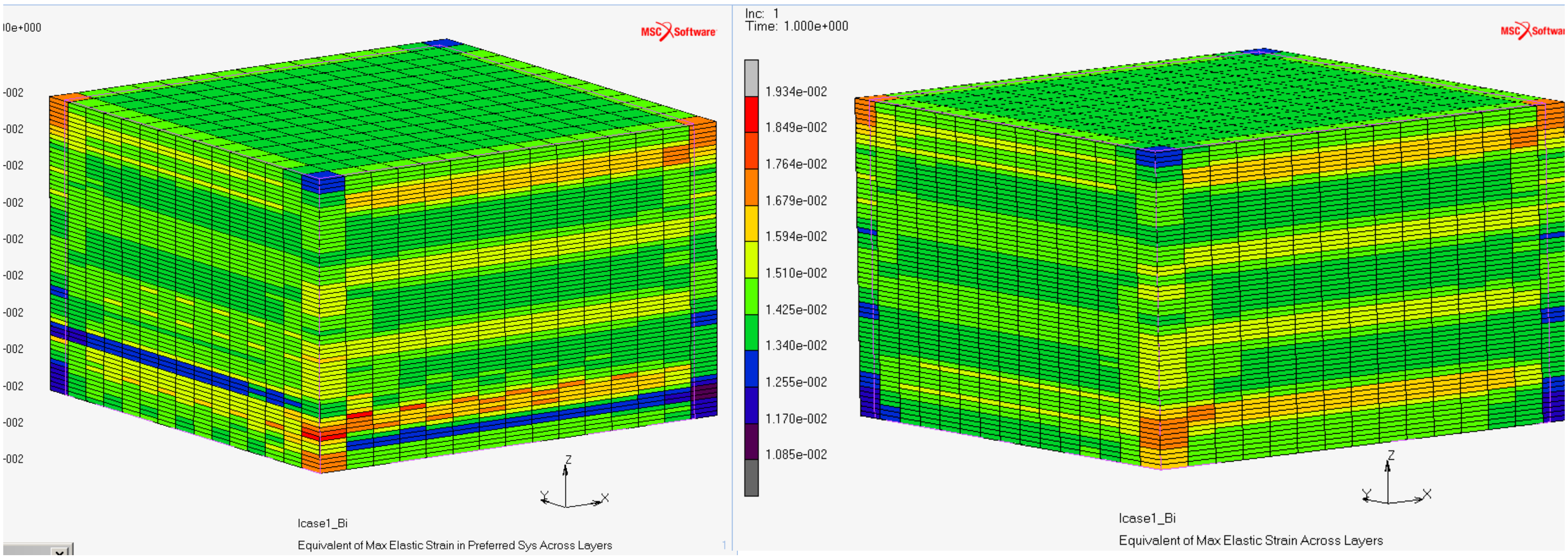
Bi-Angle NCF Tape FEA vs Continuous

- Bi-Axial Tension - e_x +1.0%, e_y +1.0%

Tape vs. Continuous



Thickness 10X

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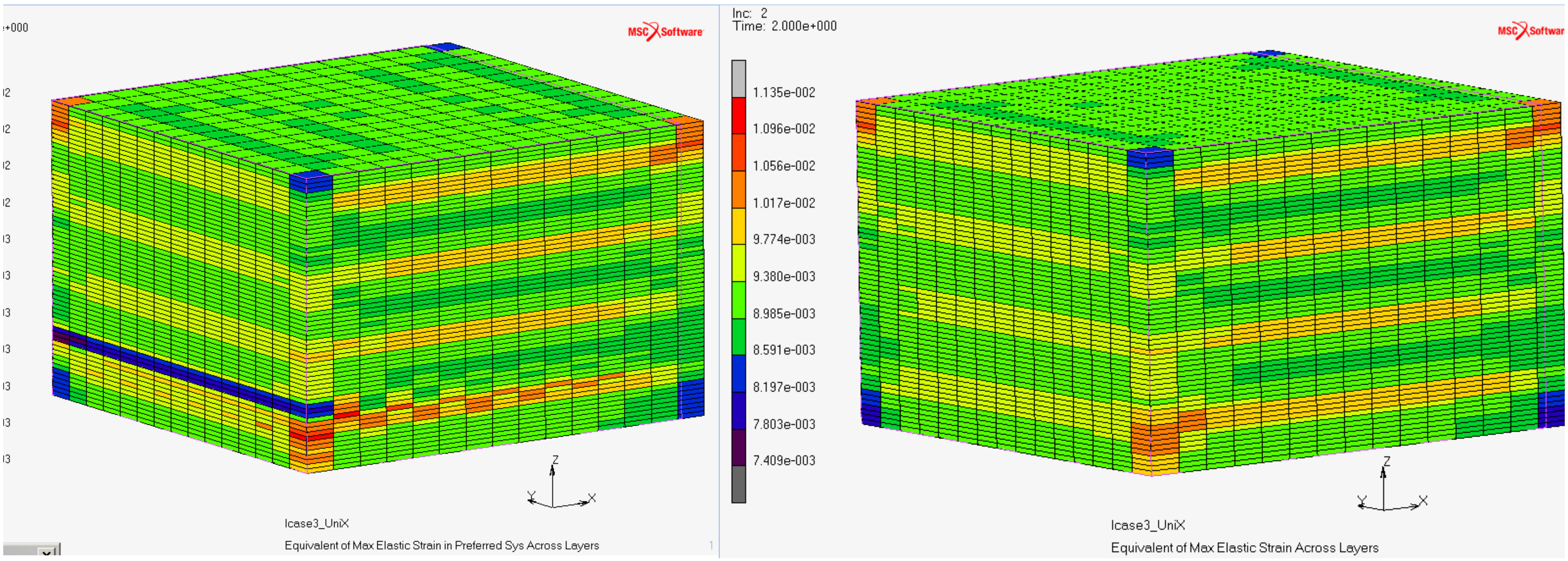
Bi-Angle NCF Tape FEA vs Continuous

- UniAxial Tension - e_x +1.0%, e_y +0.0%

Tape vs. Continuous



Thickness 10X

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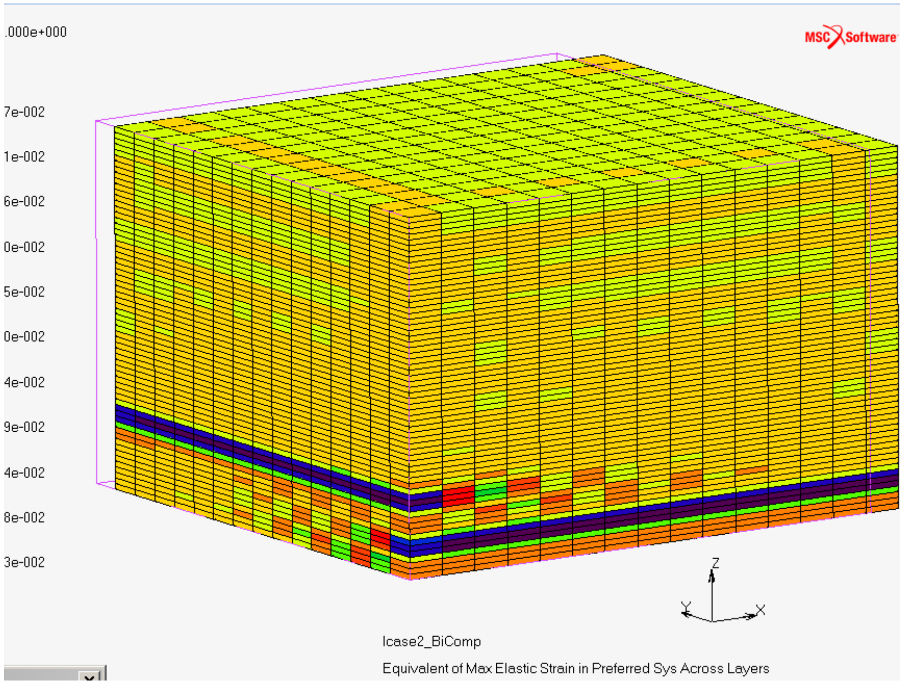
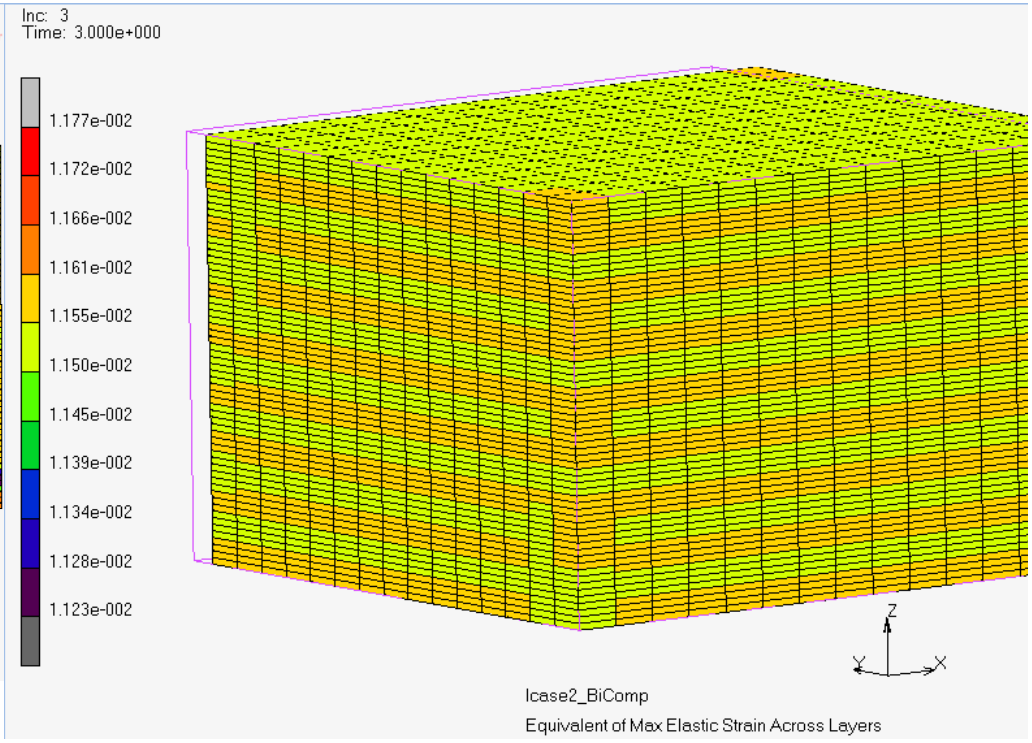
Bi-Angle NCF Tape FEA vs Continuous

- Bi-Axial Tens/Comp - e_x +1.0%, e_y -1.0%

Tape vs. Continuous





Thickness 10X

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