DELIVERING
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Wind Turbine Blades: Building Reliability

2009 Wind Turbine Reliability Workshop

Sandia National Laboratories
Albuquerque, New Mexico

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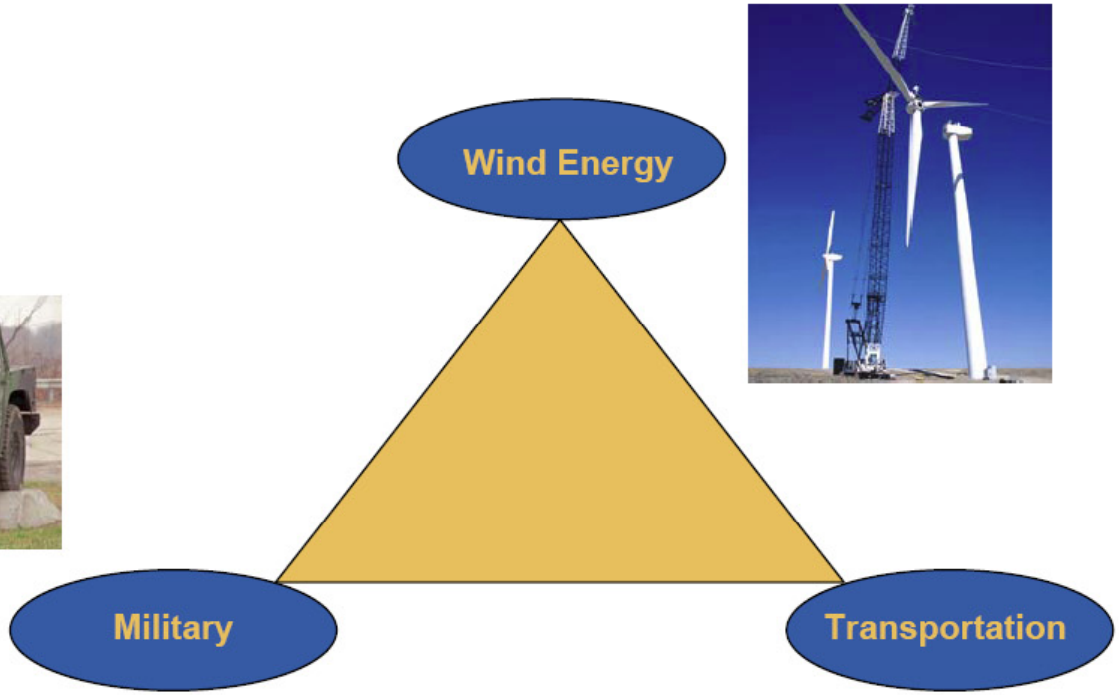
TPI Composites, Inc.

Deliver structural composite solutions in volume to the wind energy, military and transportation markets. Solid growth through long term partnerships with major players in each of these industries.



Wind Energy – Commercial Products
Mitsubishi Heavy Industries

MHI 1MW Class 1
26.8M Blades

MHI 1MW Class 2
29.5M Blades

Wind Energy – Commercial Products
Mitsubishi Heavy Industries (continued)

- MHI's 2.4 MW wind turbine
  - MWT92/2.4 and MWT 95/2.4
- 44.7m WTB Class II Service
- 46.2m WTB Class III service

1.1M Sq Ft of Manufacturing Space

Warren, RI, 60K sq ft, Development Center, Manufacturing

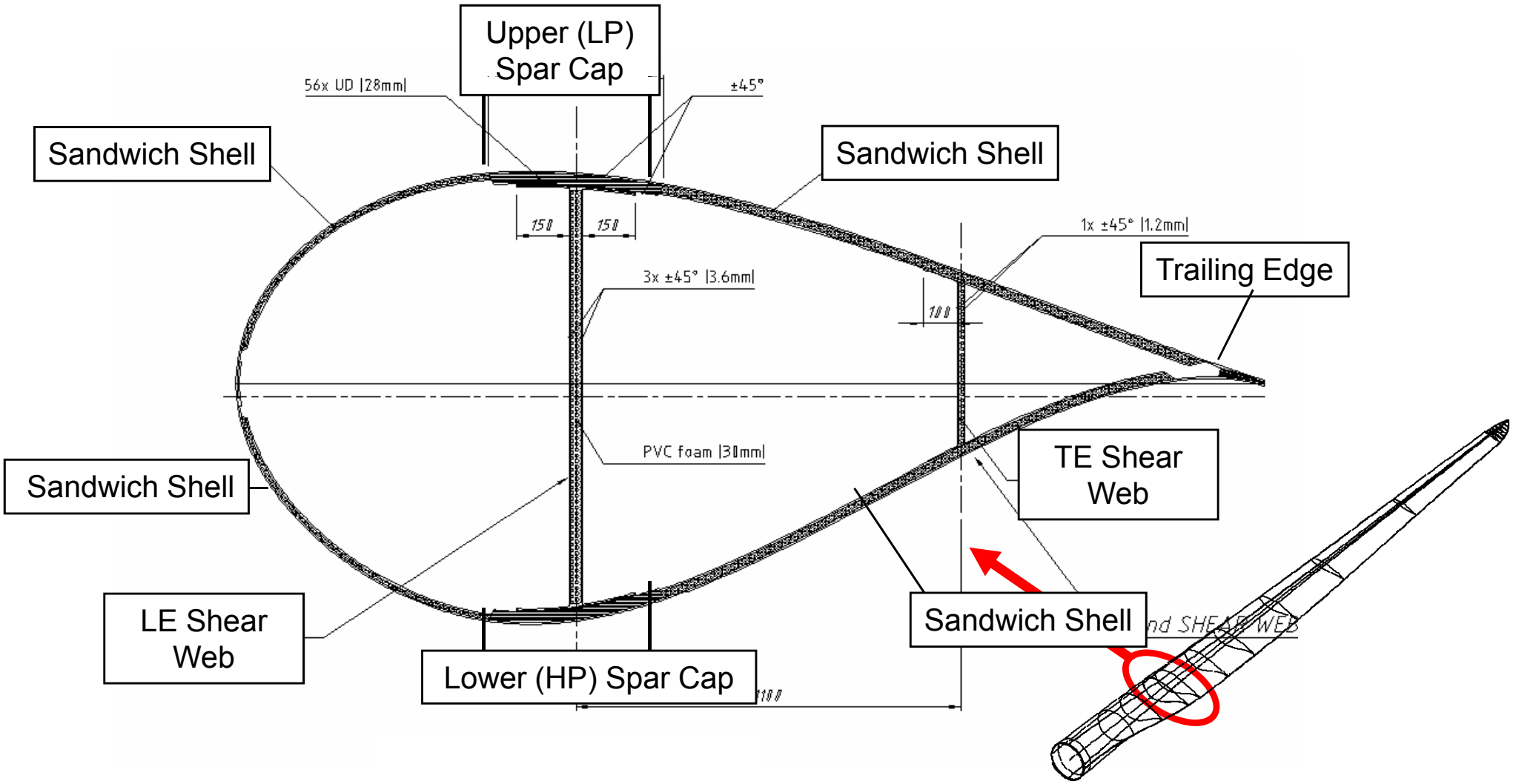
Taicang Port, China, 190K sq ft to supply wind blades to GE

Newton ,Iowa, 316K sq ft to supply wind blades to GE

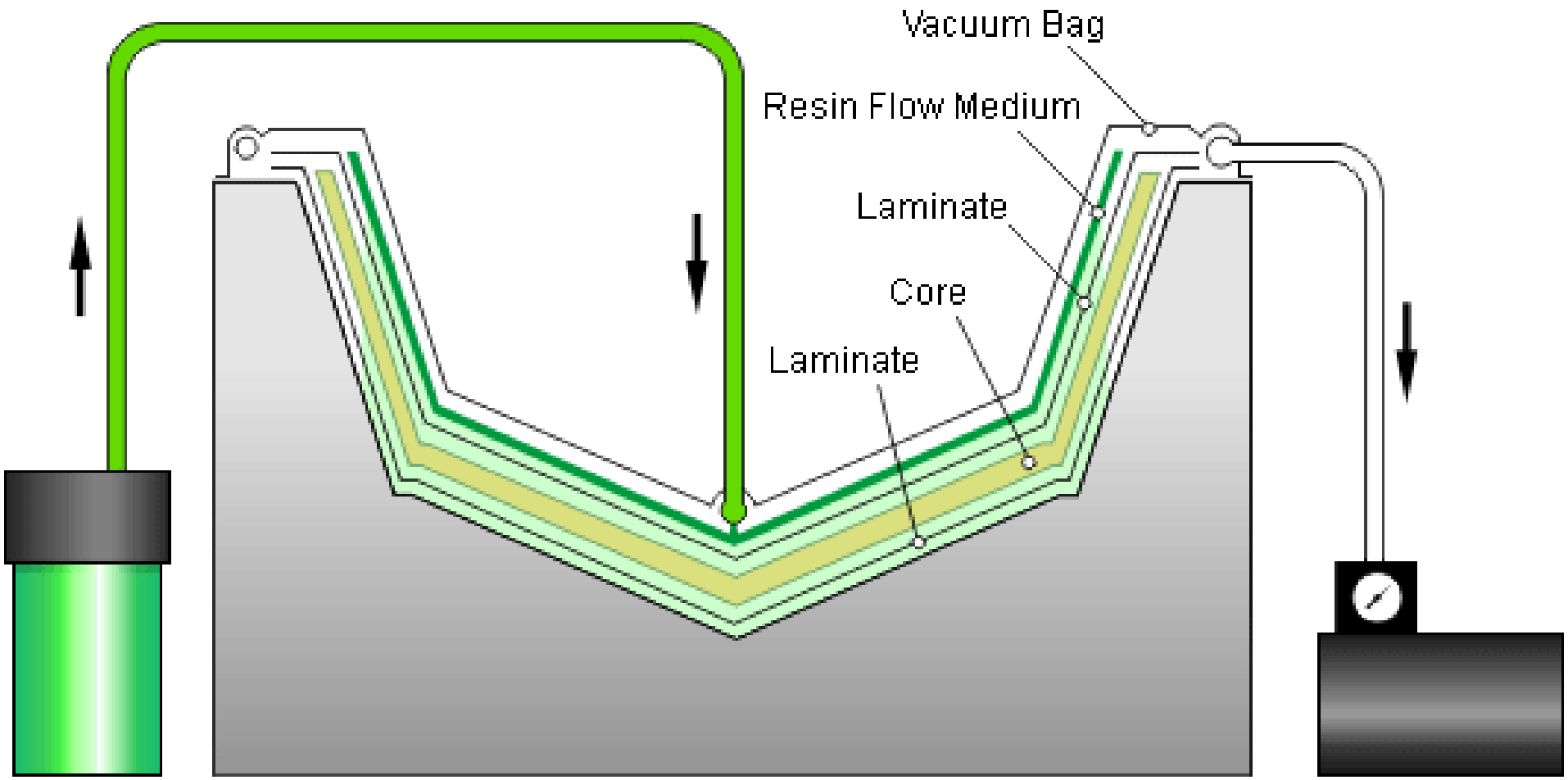
Juarez, Mexico, 2 Plants 477K sq ft, Wind blade JV with Mitsubishi

Springfield, OH - 66K sq ft, Military and Transportation Mfg

Anatomy of a Wind Turbine Blade (Max Chord)



Seemans Composite Resin Infusion Molding Process (SCRIMP®)



Catalyzed Resin

Typical SCRIMP™ Schematic

Vacuum Pump

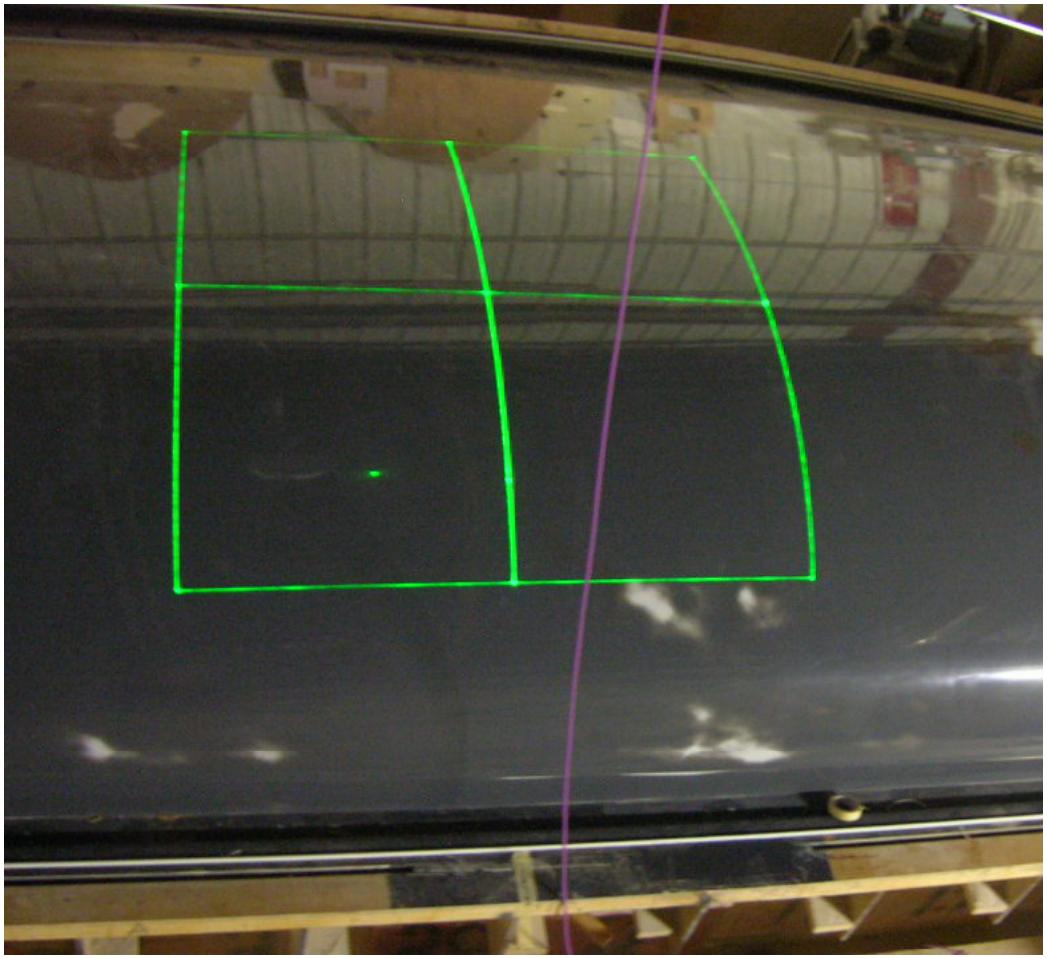
Wind Blade Manufacturing: Infusion, Demolding, and Assembly

Reusable Silicon Bag Technology for SCRIMP

- Silicone bags are rapidly fitted to the infusion tool.
- Feed lines, vacuum lines and embossed distribution channels are integrated into the bag improving the repeatability of the process.
- Setup time and process robustness greatly improved.

Skin Lay-up with Reinforcements and Core

3D Laser Projection Systems



- Laser Projection Systems for real time tool based projection of ply locations, bonding adhesive outlines and shear web location.
- Ceiling mounted laser projectors. Up to five “ganged” together to provide full coverage across a single pair of 46.2m molds.
- Technology is now applied to all 2.4MW blade production

Hydraulic "Power Hinges" for Blade Assembly

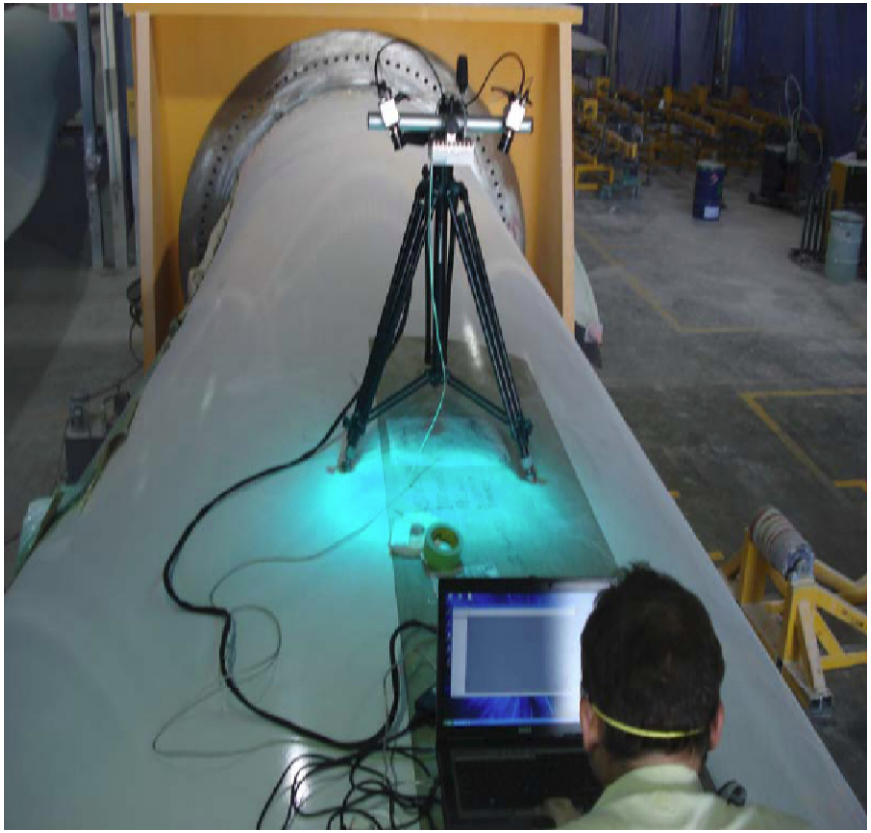
- Hinges eliminate flip fixtures and HP or LP Skin demolding prior to bonded assembly
- Greatly reduces assembly time
- Improves accuracy
- Eliminates risk of damage to either skin as a result of handling

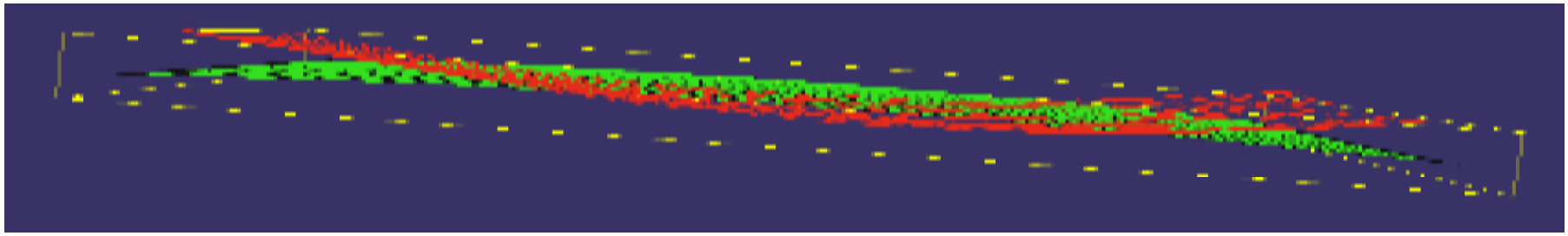
Full-Scale Blade Proof Tests

- 46.2m Blade at 90% Max Operating load during proof testing at Vientek
- Tip deflections exceed 8 meters at max load.
- Root test stand designed to react over 30 million N-m of bending load!

Blade Testing, Inspection & Storage

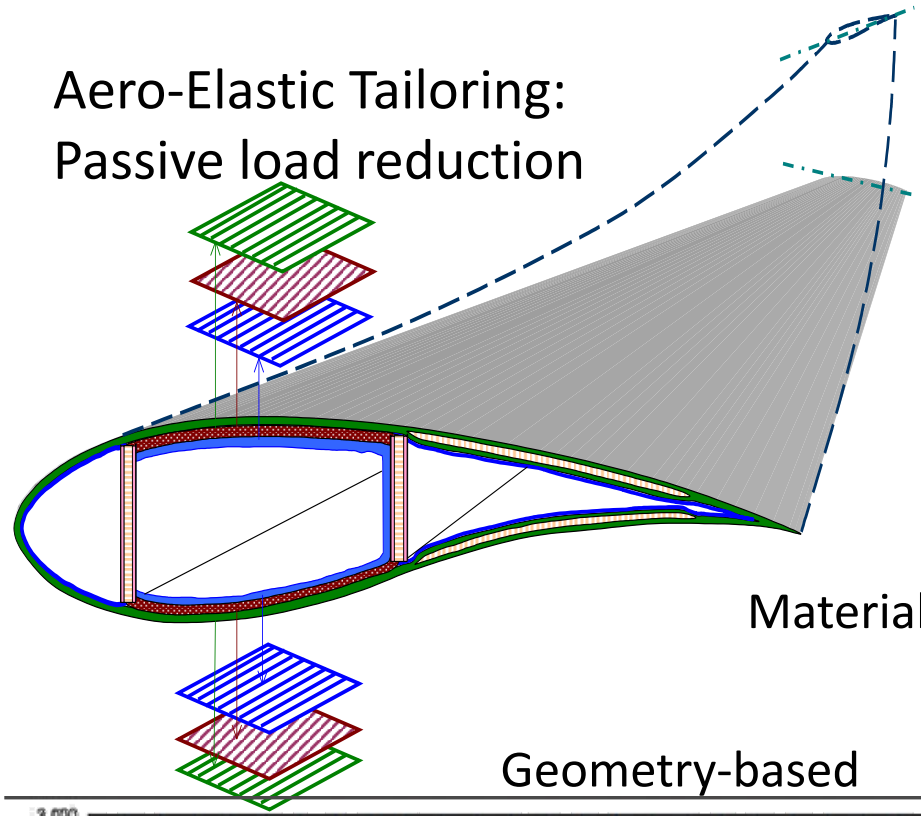
Digital Image Correlation for Wide Area Strain Measurement and NDI



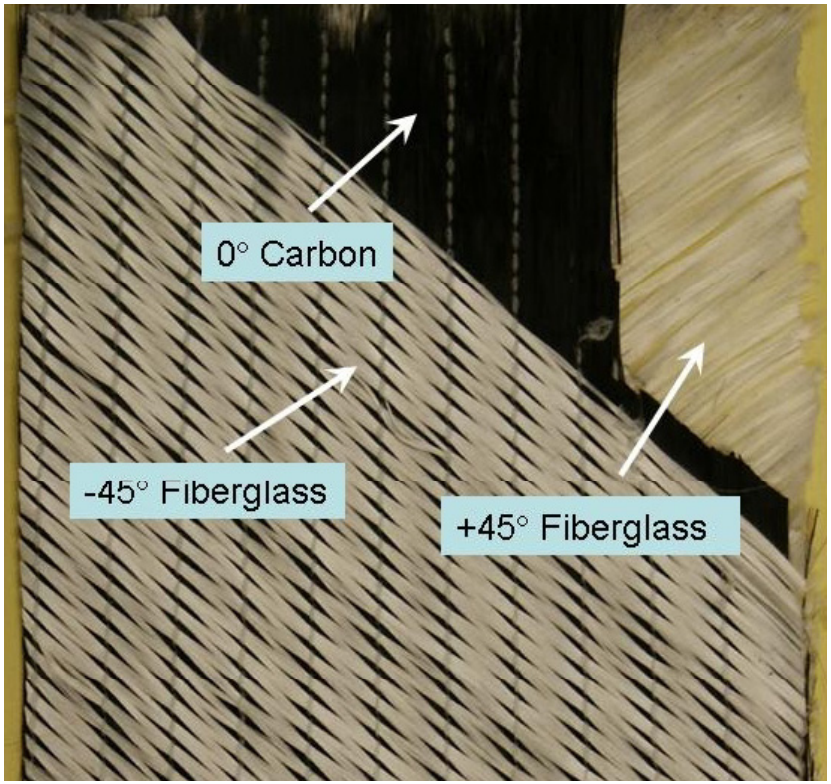


Bend-Twist Coupled Behavior: 2 ways to Skin that Cat

Aero-Elastic Tailoring:
Passive load reduction

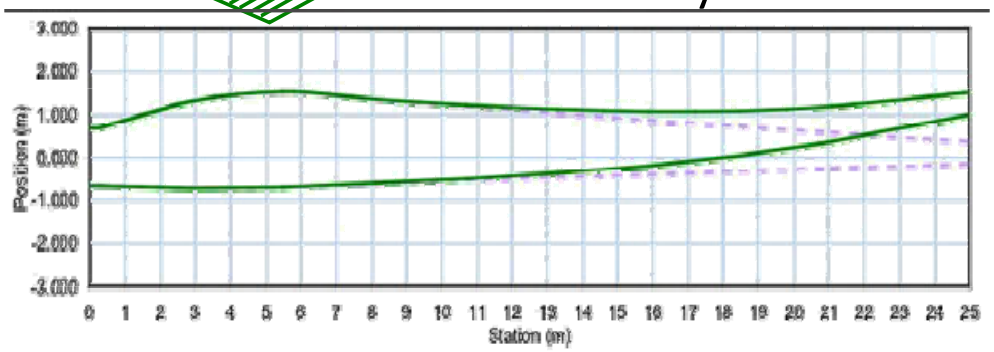


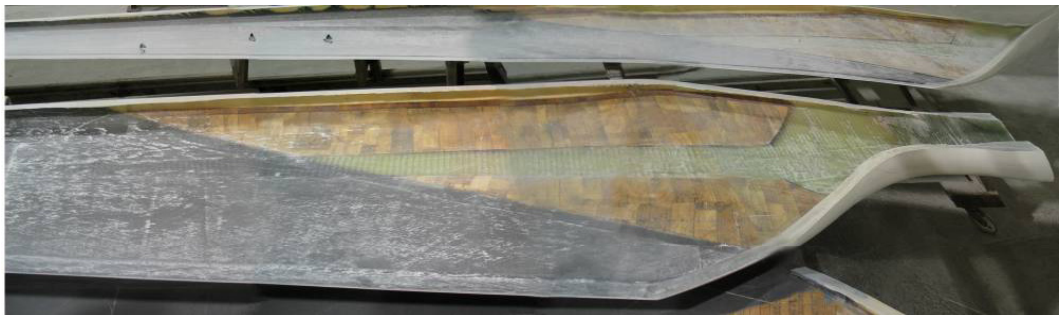
New Materials – Carbon/Glass Hybrid



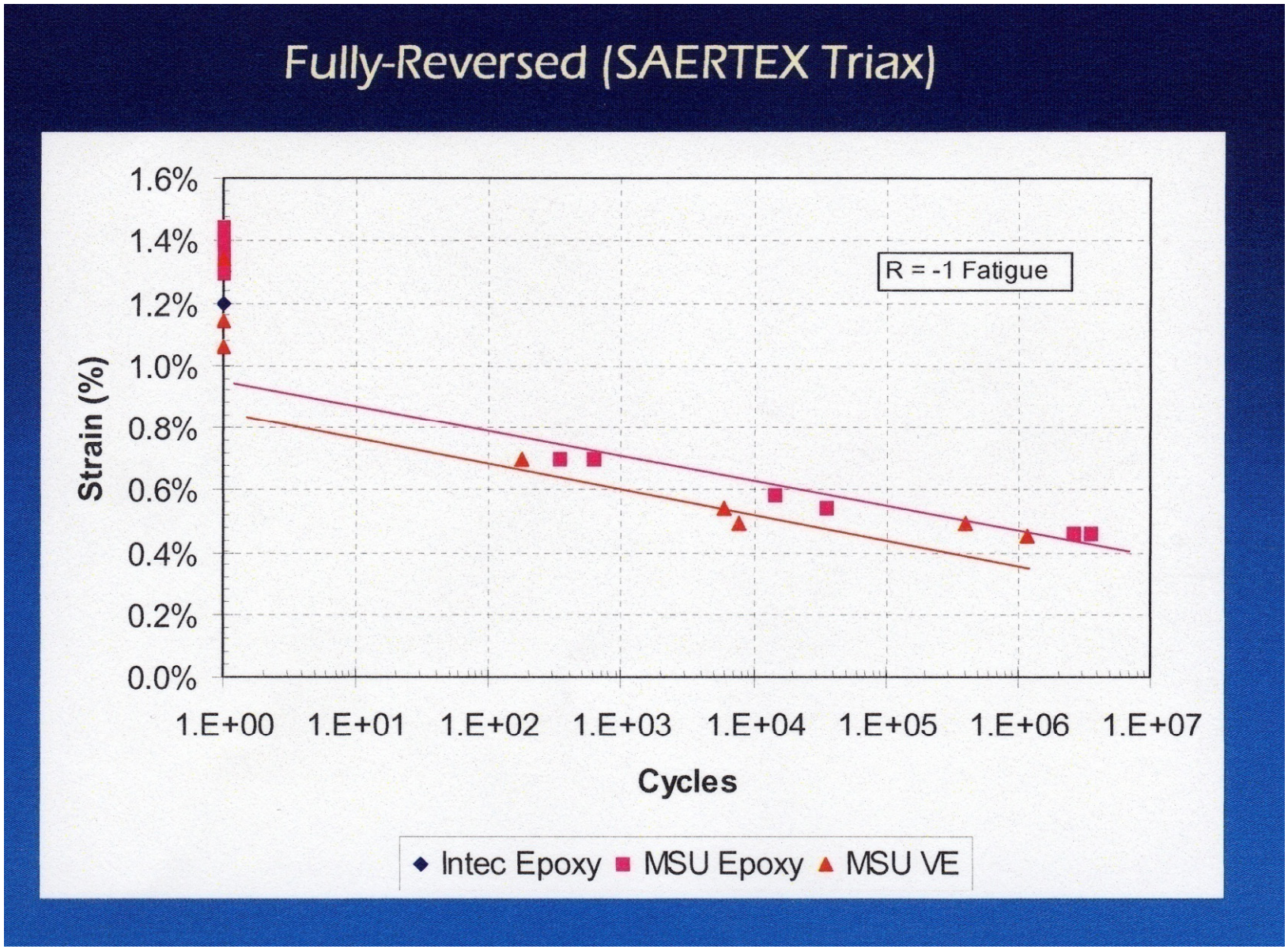
Material-based

Geometry-based

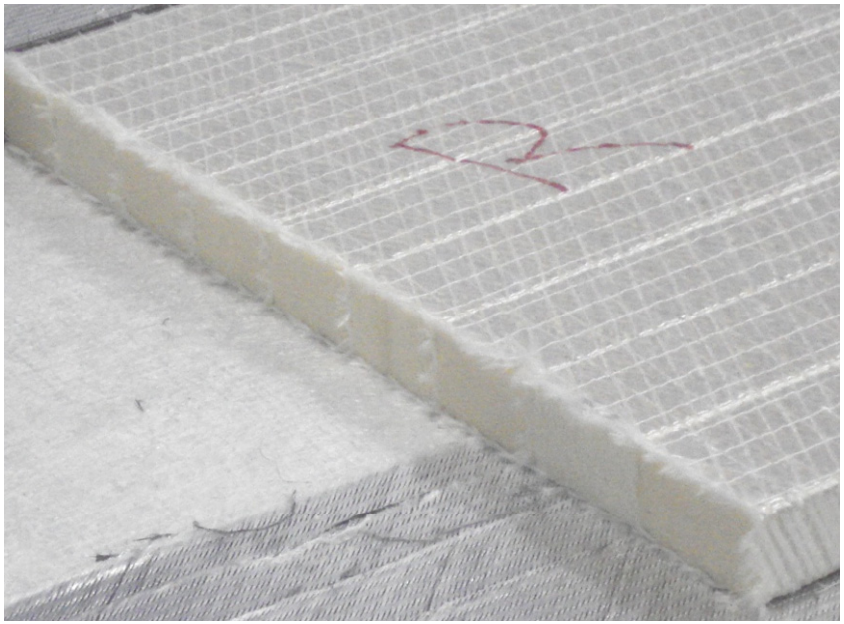




Fatigue Testing of Carbon Fiber Laminates Fabricated at TPI



Webcore Technologies, TYCOR Sandwich Core Materials



- TYCOR material applied to shear webs in production blades for multi-megawatt scale turbine.
- Very low weight, high performance core at a highly competitive price.
- Kitting and assembly in mold has proven to be faster and more accurate than balsa and foam materials.

Sensor Technologies

- Offshore Wind will inevitably drive designs toward larger and lighter weight rotors.
- The cost of failure is unacceptably high, but the cost of R&M may well be prohibitive and require the use of technology to ensure long term reliable operation.
- Health monitoring systems in a variety of forms where innovation rules, may be the answer.

Insensys – Independent Pitch Control Load Measurement System

Insensys IPC Load Measurement System IPC

Proven technology for advanced turbine control applications

Key benefits of the Insensys system for IPC applications

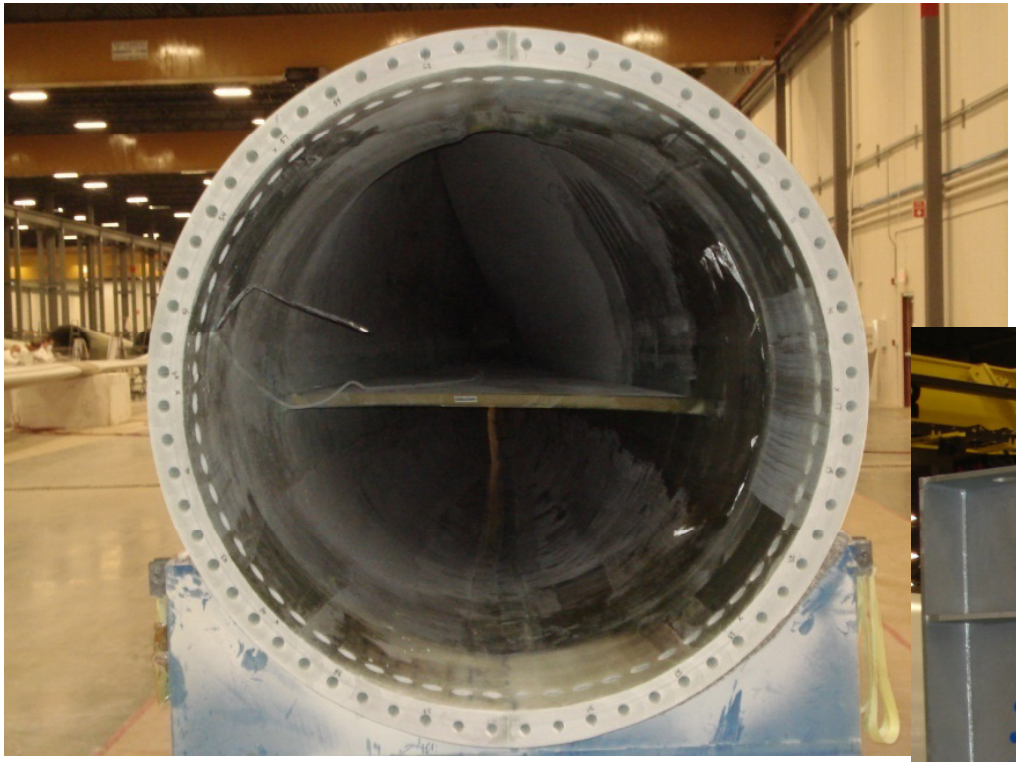
The Insensys IPC load measurement system has been specifically designed for wind turbine operation and is based on a mature fibre optic sensing platform that provides an accurate, reliable and cost effective load signal input.

- Proven, reliable, technology for wind turbine deployment
- OEM-specific design for simple system integration
- Cost effective for series deployment
- Simple interfacing with existing control systems
- Fast, simple, sensor integration into the blade production process
- Excellent long term sensor fatigue performance
- Non-conductive system eliminates EMI and lightning issues in the blade and hub

Typical system specification

Number of blades	3
Number of sensors per blade	8
Range	±4500 microstrain
Measurement resolution	1 microstrain
Measurement frequency	25 Hz/sensor
Power supply	24 V DC
Power consumption	<3 W
PLC interface	RS232, RS422, RS485,CANbus
Weight	2 kg
Dimensions L x D x W	240 x 37 x 120 mm
Operating temperature	-40°C to +80°C
Protection Class	IP40

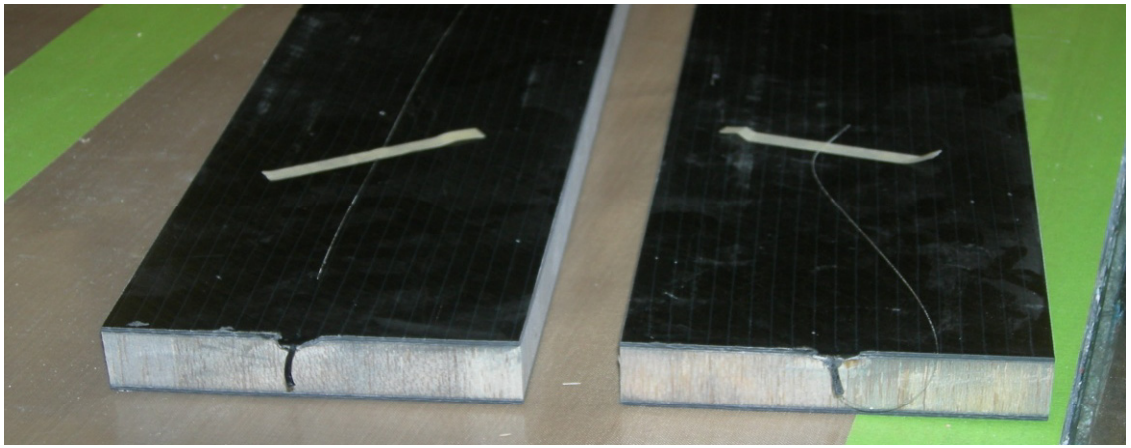
Attachment of Blade to Tower – Another Opportunity for Load Measurement



- Root Studs in the form of "T-Bolts" typically are used to anchor mega-watt scale blades to the hub.

- Instrumented bolts in development include "wireless", low power products that can provide accurate root moment measurement for IPC or Condition Monitoring Systems.

Embedded Sensors: FBG/Accelerometers/Foil Strain Gages



- Recently, TPI, Aither Engineering and Purdue University with support from Sandia labs completed a new CX-100 with fully integrated FBG strain instrumentation and accelerometers for real time measurement on a NWTC test turbine at Bushland, Texas.
- Test panels with embedded fibers as well as mechanical testing for characterization of material systems completed to provide analytical predictive capability.

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