Addressing the Need for Nondestructive Inspection of Wind Turbine Blades

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Sandia National Labs

2010 Wind Turbine Blade Workshop

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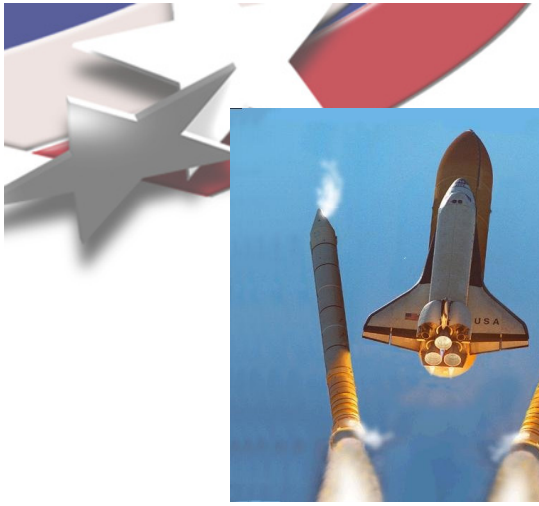
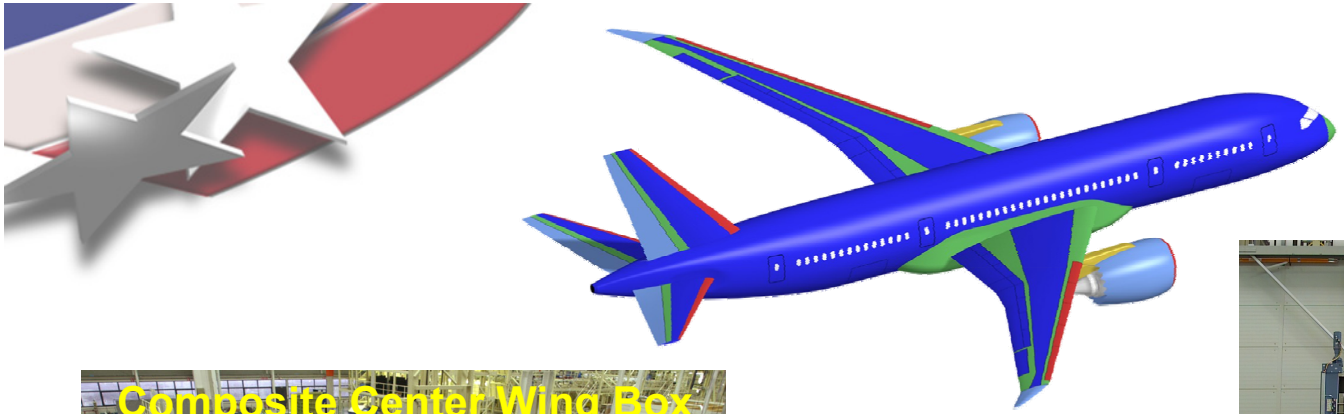
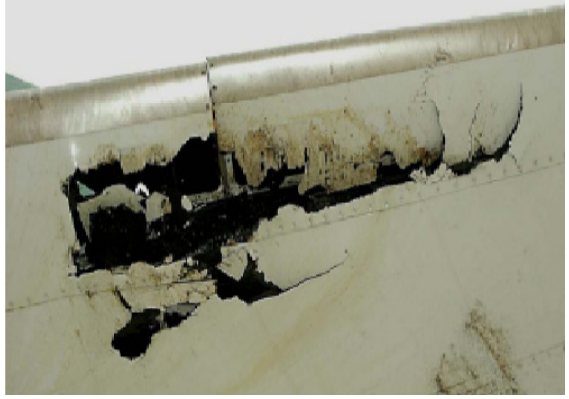




Aviation Industry Composites

Lightning Damage

Foreign Object Damage



Ground Handling Damage

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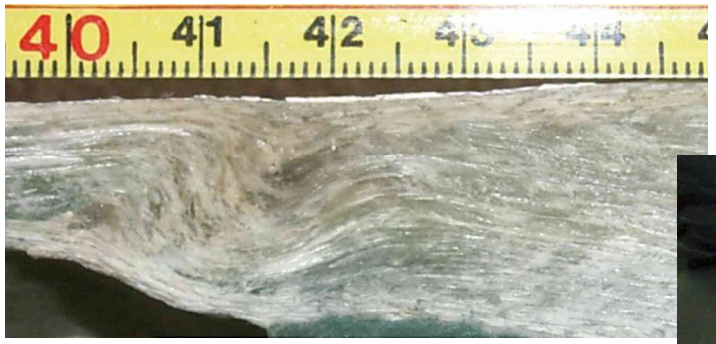
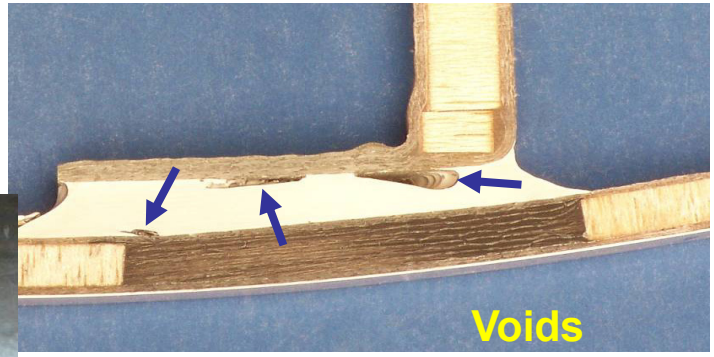
Objectives of Sandia Wind NDI Programs

- Develop, evaluate and validate the array of potential nondestructive inspection methods for the detection of flaws in composite wind turbine blades
- Plan and implement a national capability – including a physical presence and methodology - to comprehensively evaluate blade inspection techniques
- Produce optimum deployment of automated or semi-automated NDI to detect undesirable flaws in blades (time, cost, sensitivity)





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Multi-Phase Effort

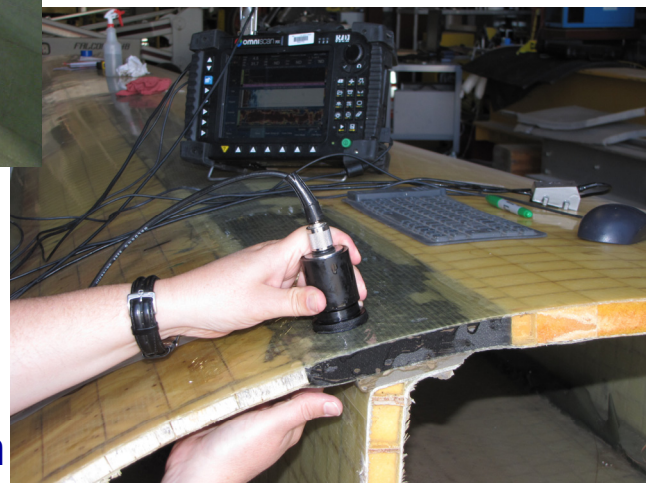
- Phase I - initial screening of NDI methods; determine methods that show the greatest promise for flaw detection and potential deployment on wind turbine blade geometry & construction
- Phase II - produce a statistically-valid, Probability of Flaw Detection (POD) study to quantitatively evaluate the ability of advanced NDI to find hidden flaws in turbine blades; implement study
- Phase III - deploy NDI methods to allow for routine use of the validated NDI method(s) in blade production environments (technology transfer)

Acquisition of Full Blade Sections

9, 25, and 30 Meter Blades

Ominscan Phased Array UT inspection With encoder

Pulse Echo UT inspection with focused probe and water coupling system



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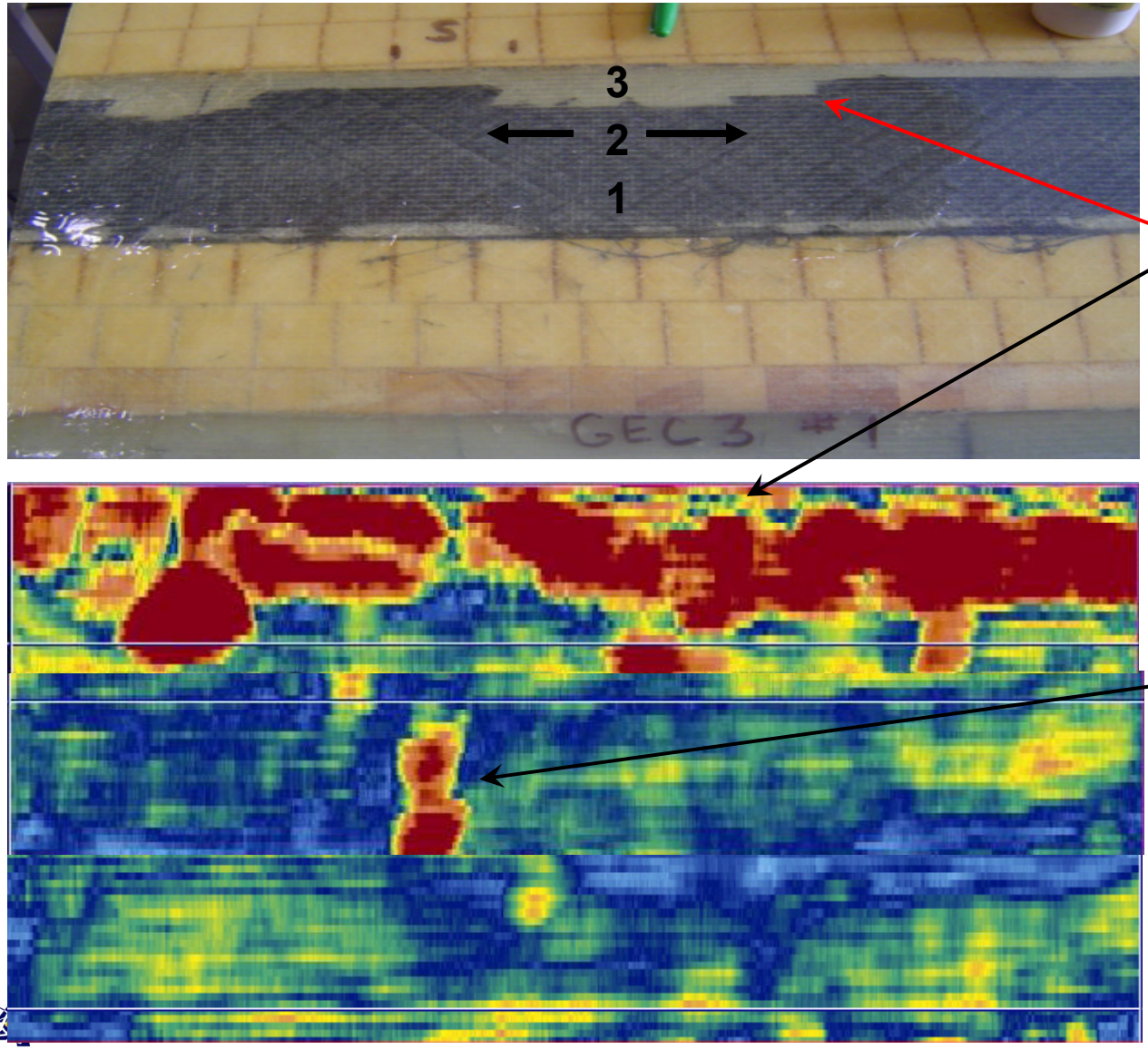
Omniscan Phased Array Inspection Results on Sandia Blade at NREL



Delam of fiberglass skin over carbon spar cap

Scan 3

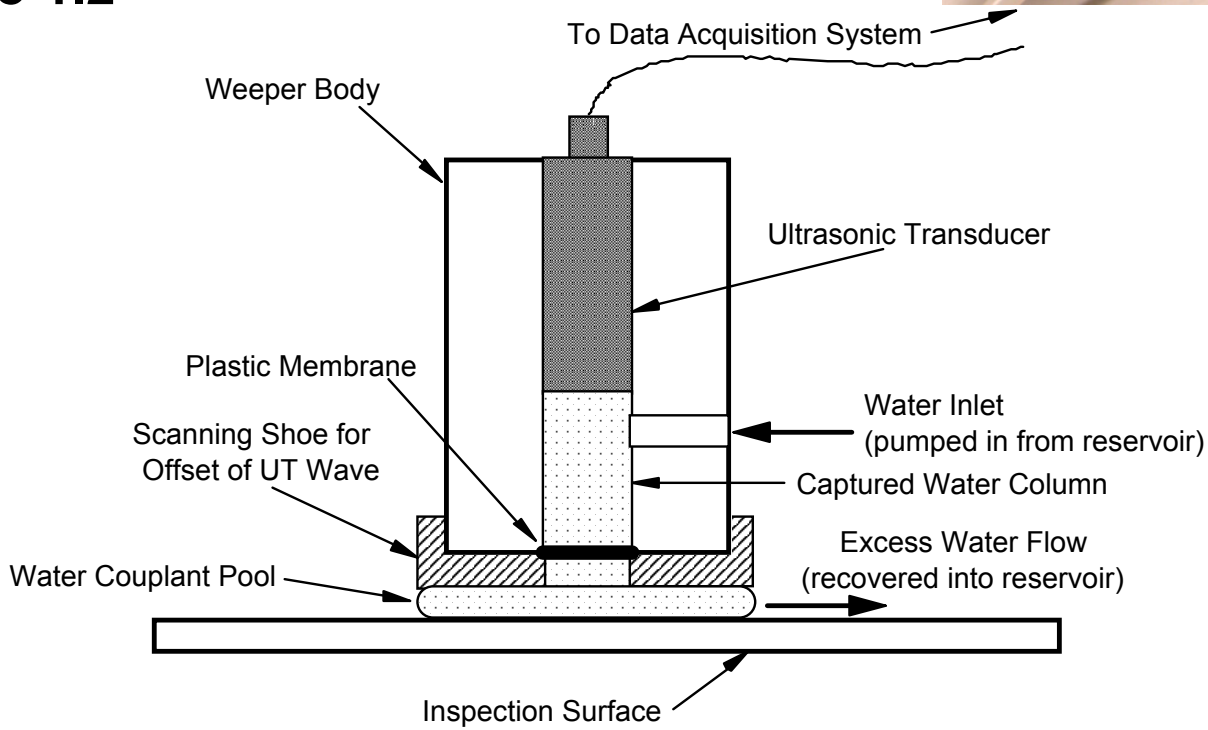
Suspect area

Scan 2

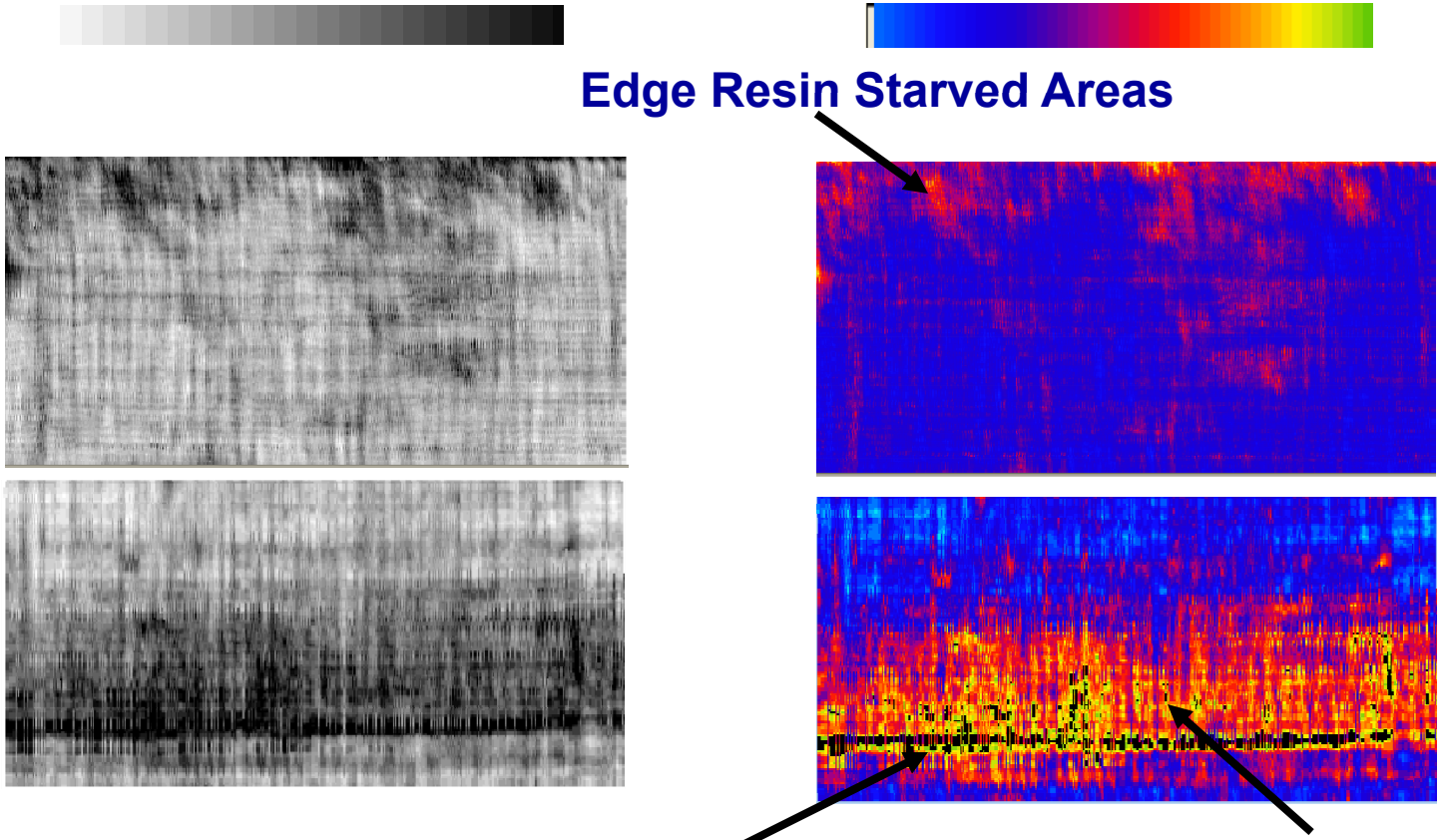
Scan 1

Pulse-Echo Ultrasonic Set-Up

- **Match with high energy pulser to maximize depth of penetration**
- **Probe optimization – 1 MHz, 1” dia., 2” focus**
- **Probe offset – water column of 1.1” to 1.2”**

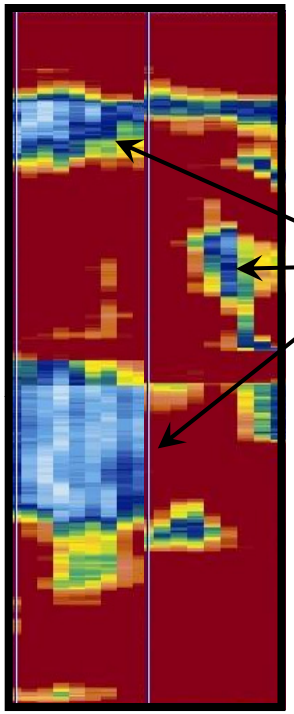


Inspection Results from MAUS P-E UT System using a 1MHz, 2” Focus Probe on Thick Blade Section with Resin Starved Areas

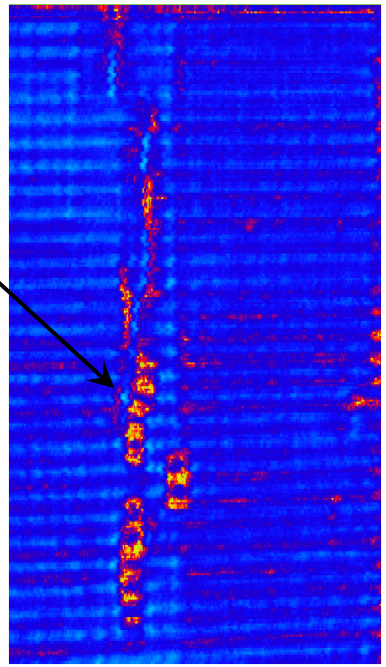


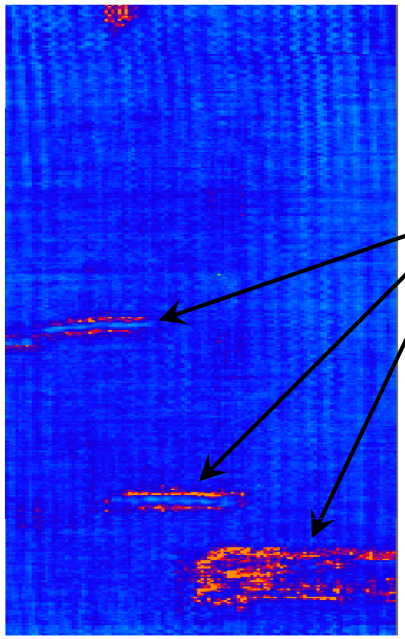
NOTE: Same Scans. Different Palettes.

Inspection Results from Phased Array UT and UT Focused Immersion Transducer on Test Specimens with Wrinkles

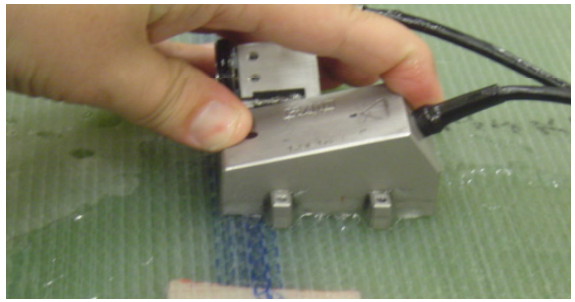


Wrinkled Areas

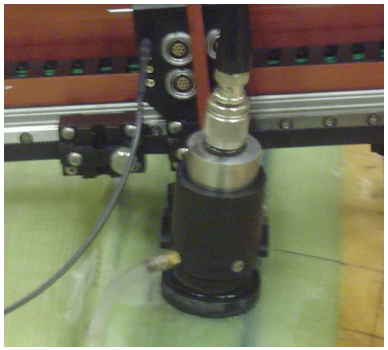




Wrinkles



Omniscan Phased Array UT
1.5L16 Probe



1MHZ Focused
Immersion Transducer

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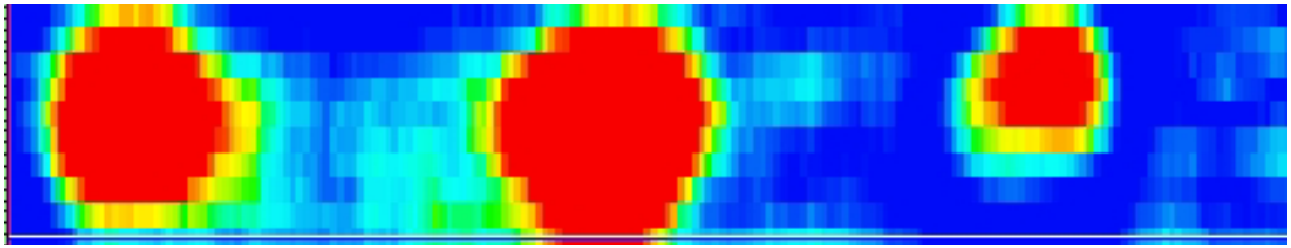
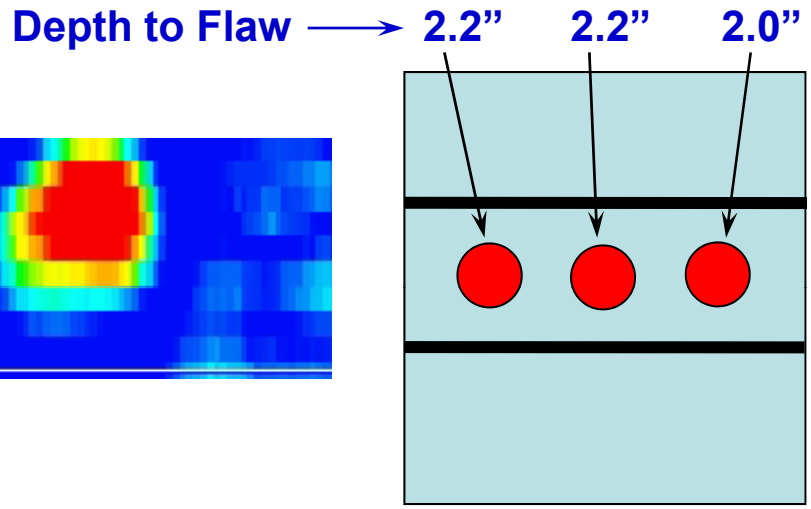
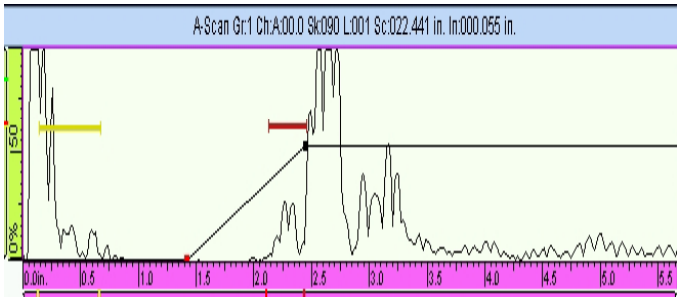
Wind Turbine Spar Bond Line Inspection

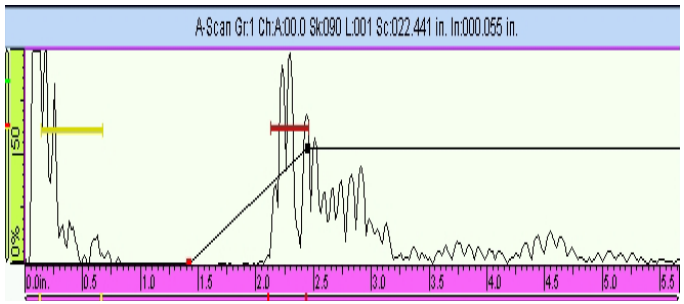
Phased Array 1.5 L16 Probe





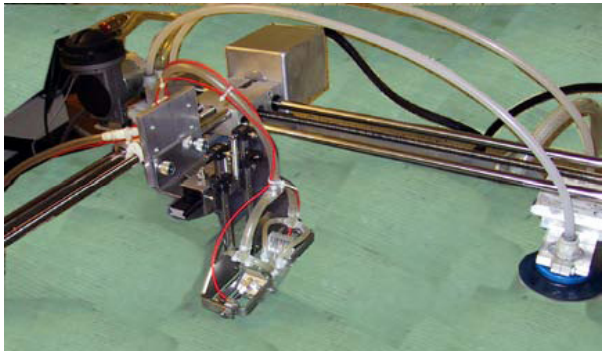


Typical Good Area

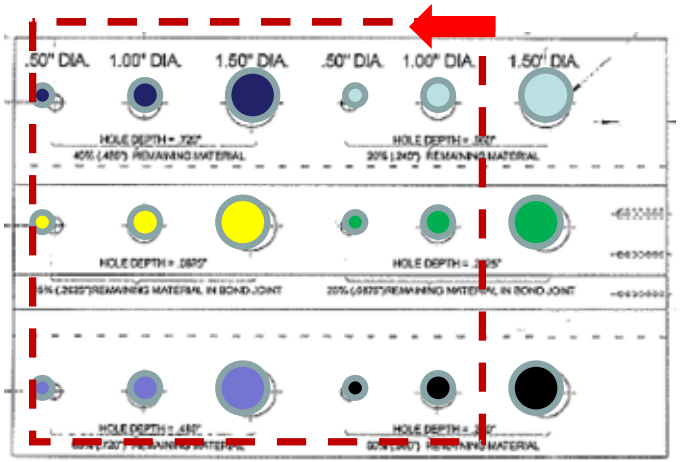


Typical Bad Area

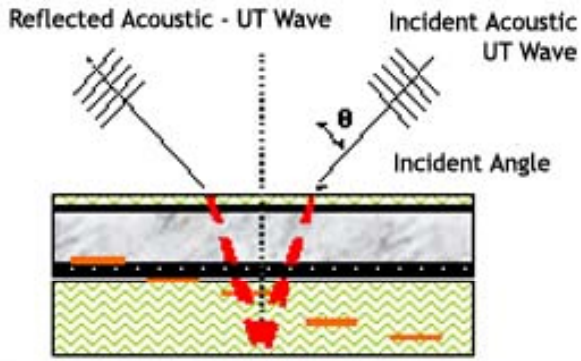
Thick Section Composite Oblique UT (T-SCOUT) Inspection System



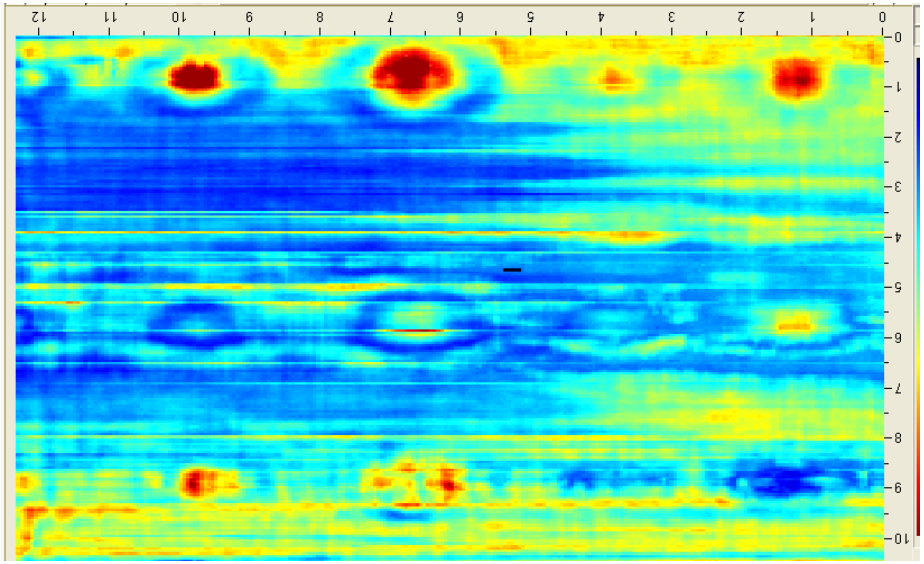
View of portable scanning system with dual-sensor head inspecting composite panel



- 40%
- 75%
- 60%
- 20%
- 25%
- 80%



TSCOUT uses oblique angle, pulse-echo, ultrasonic techniques to scan thick-section composites with access from a single side



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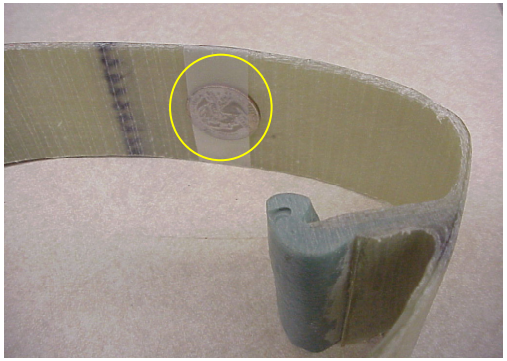
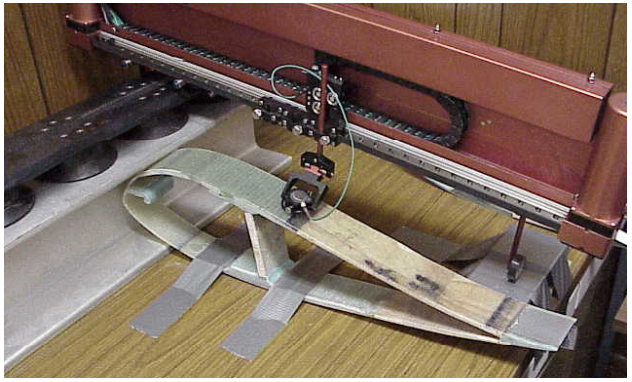
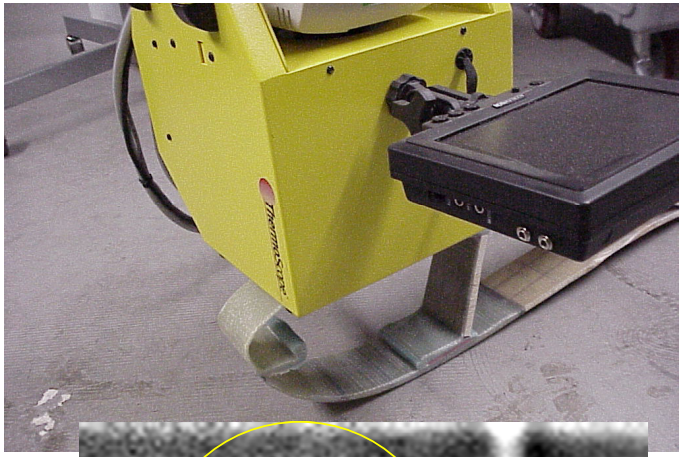
Inspection of Wind Turbine Blades

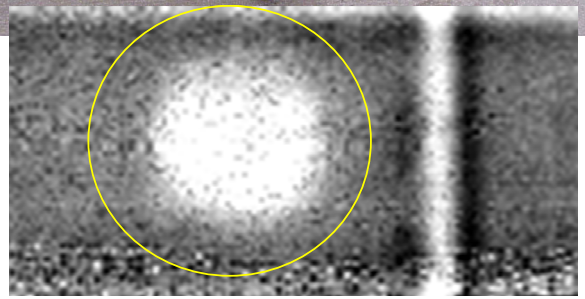
Depth of penetration in thick, attenuative laminates is key issue



Thermography

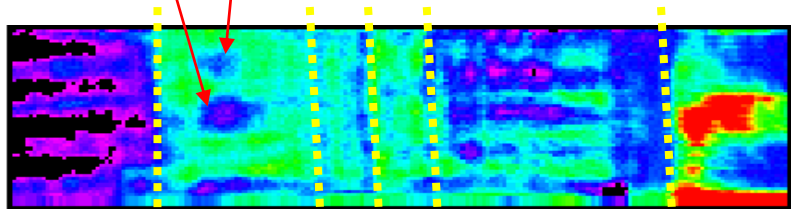


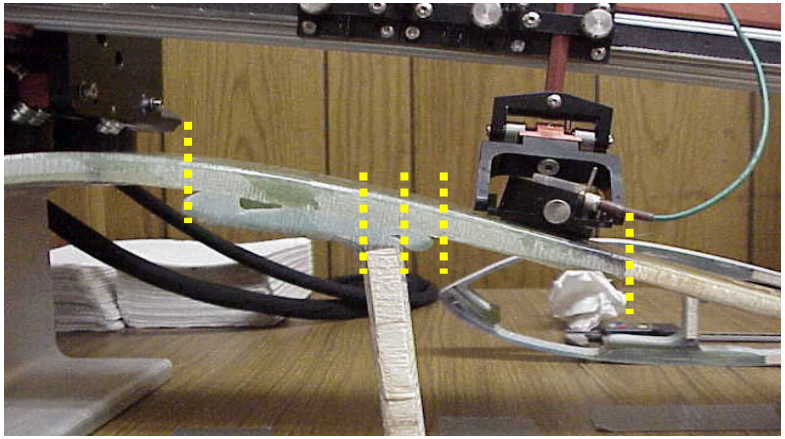




Voids

Resonance Scan 152 kHz





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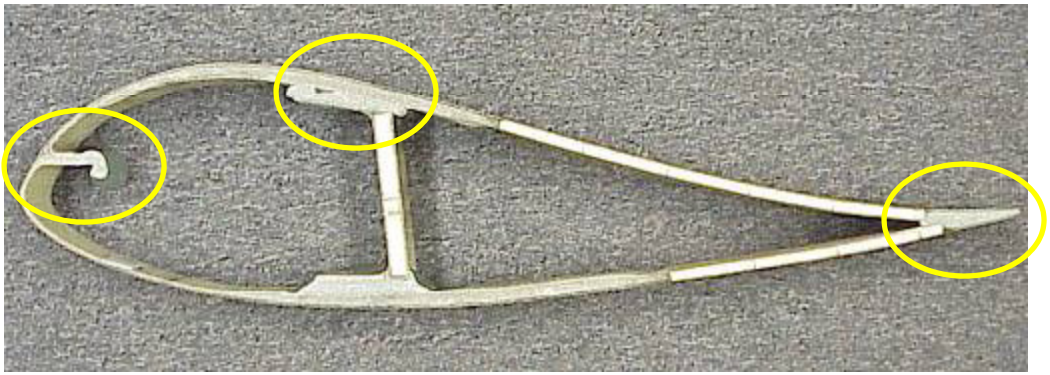
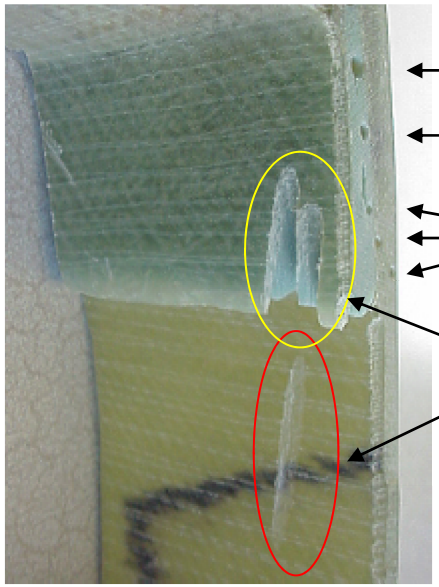
Quality Assurance for Turbine Blades

Areas of interest for inspection



NDI Technique	Inspection Issue
Ultrasound	Attenuation
Pulsed Thermography	Depth of Penetration
X-Ray	Radiation Hazards
Microwave	Maturity of technology
Eddy Current	Fiberglass is nonconductive
Shearography	Thickness/Stiffness

Top of Blade (Near) Shear web



#30 Drill (DIA 0.128, 0.75" Deep)

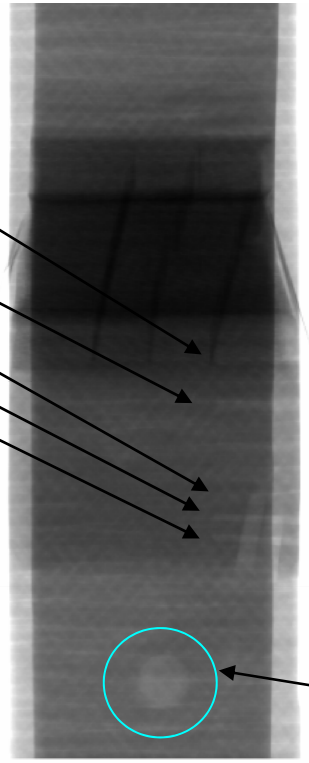
#45 Drill (DIA 0.082, 0.75" Deep)

#51 Drill (DIA 0.067, 0.75" Deep)

Saw cuts caused by the creation of specimen?

Non engineered flaws!

Digital Radiography Image



Bottom of Blade

Semi Flat Bottom Hole:

0.4375 DIA and 0.0615 Deep

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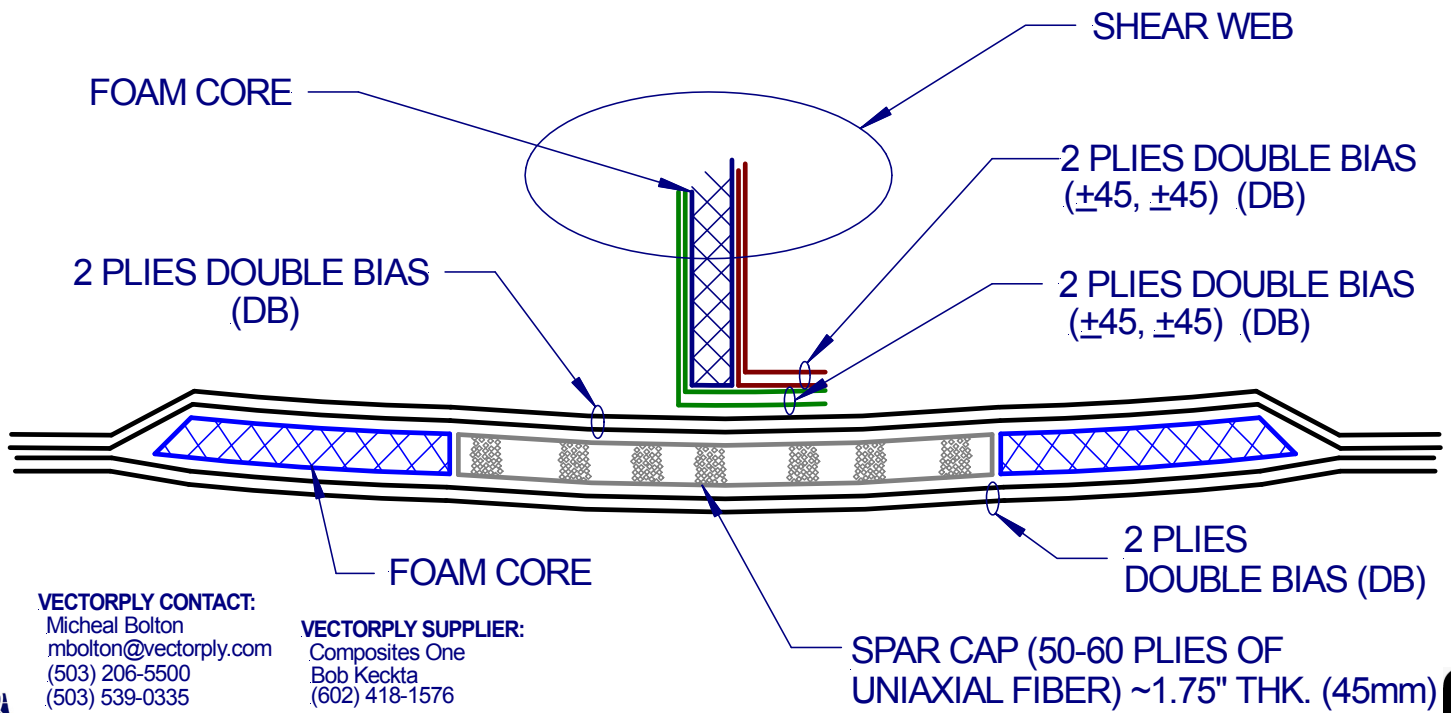
NDI Reference Standards

- **Designs cover range of thicknesses and blade designs**
- **Flaw depth, location and type (Flaw types to include: snowflaking, porosity, resin-starved regions, voids, interply delaminations, spar and shear web disbonds, ply waviness, erosion, impact, lightning strike, and fluid ingress)**
- **Identify critical areas – blade root, spar, shear web bond lines, leading and trailing edges**



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VECTORPLY SUPPLIER:
Composites One
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(602) 418-1576

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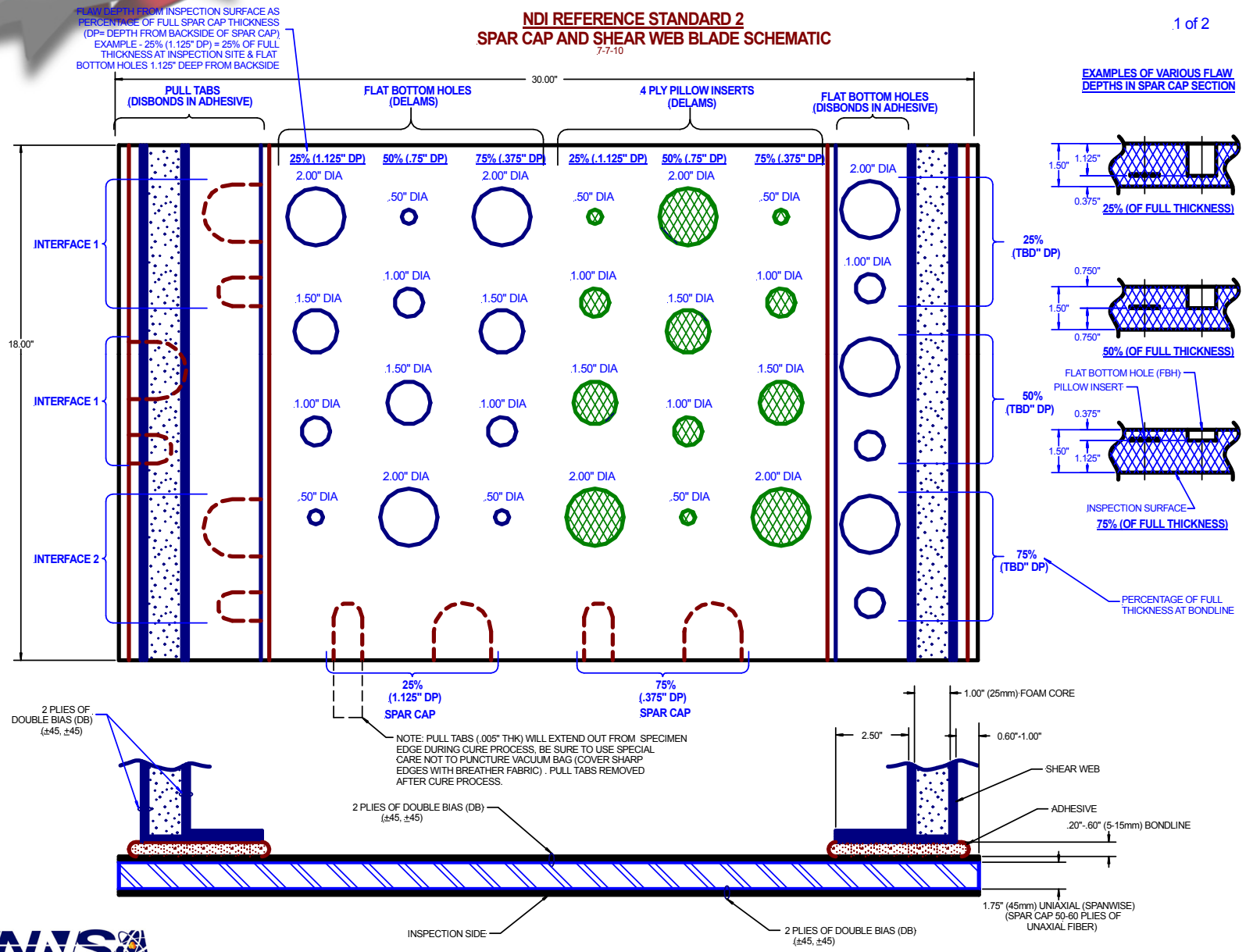
Spar Cap and Shear Web Ref. Std.



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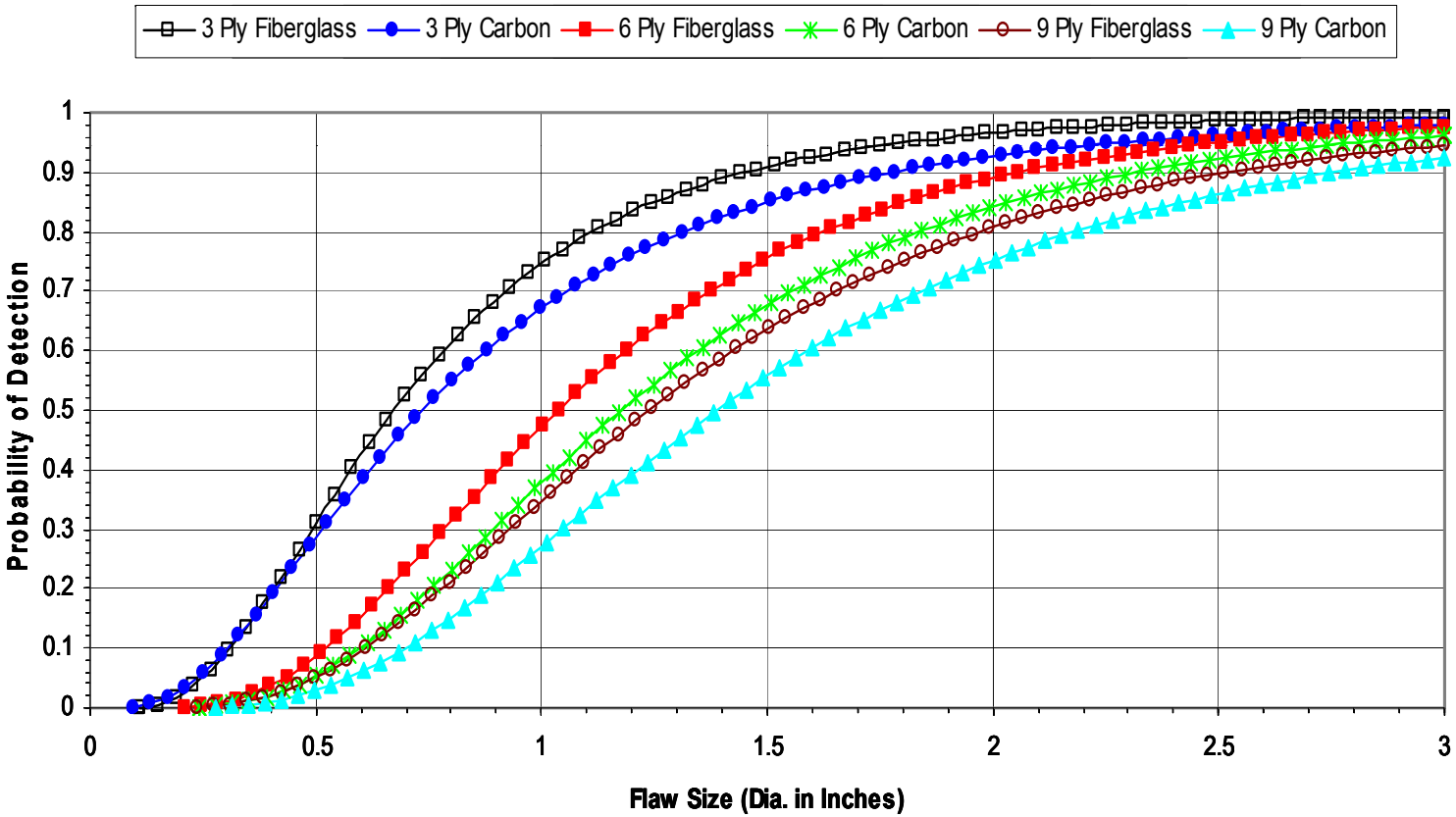
Probability of Detection - Inspection Performance Over a Range of Test Specimen Types

Flaws in Composite Honeycomb Construction



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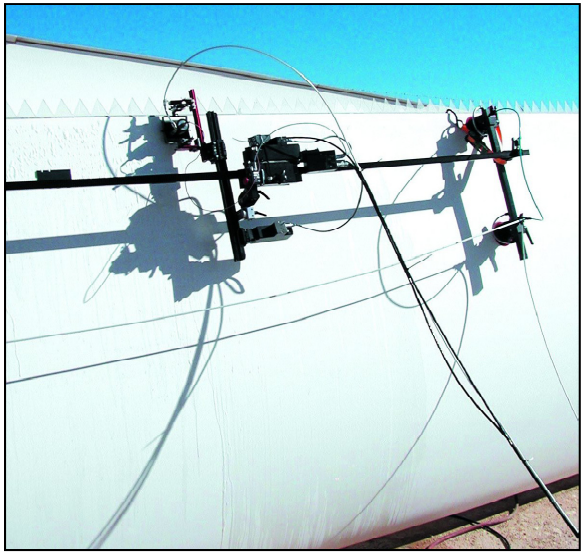
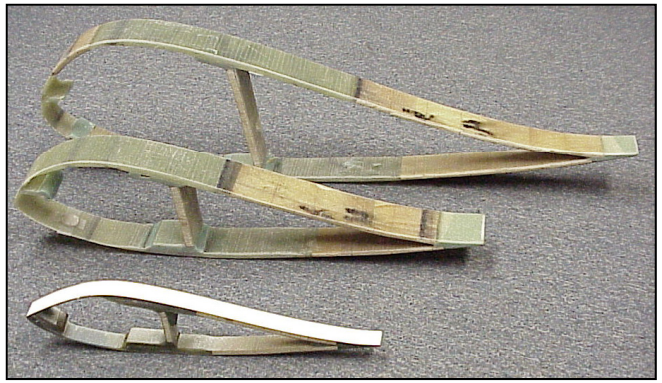
Evolution of NDI for Wind Turbine Blades

- Develop array of inspection tools to comprehensively assess blade integrity (determine needs, challenges, and NDI limitations)
- Achieve this while considering time, cost, & sensitivity issues (minimize production & maintenance costs)
- Develop NDI solutions in concert with related studies: effects of defects, field surveys, analysis, certification, standards
- Identification of impediments to be overcome and NDI test specimen development to move into more in-depth studies
- NDI investigation just underway – some promising results thus far may lead to hybrid approach with multiple NDI tools
- NDI to extend blade design life (??)





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