Blade Reliability Collaborative
Overview

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy’s National Nuclear Security Administration under contract DE-AC04-94AL85000.
Relationship of Reliability Efforts

Increasing Breadth

NERC – GADS
Wind Turbine Generation

National Reliability CREW Database (Sandia/DOE)

- Gearbox Reliability Database (NREL)
- Blade Reliability Database (Sandia)
Blade Reliability

Motivation

- Blades are being delivered to the site in a condition that often requires additional treatment of quality issues before they can be installed.

- Rare installations need to have all the blades replaced after the discovery of a batch problem.

- Blade failure can cause extensive down time and lead to expensive repairs.

- **Blade reliability issues need early attention because of the lost production and cost of significant failures.**

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“80% of the blades that require repair have never been flown.”
Gary Kanaby, Knight & Carver Wind Blade Division.
Preliminary Survey of Operators 2008

- Five Plants – over 400 turbines
- Mostly 3+ years old
- About 80 blade replacements (40 at one plant)
- Replacement times range from 2 weeks to 2 months

Blade Issues Cited:
- Manufacturing Issues – waviness and overlaid laminates
- Bad bonds, Delamination, and Voids
- Leading Edge Erosion
- Trailing Edge Splits
- Lightning – Comments:
  - At one plant - Every blade has been struck at least once
  - Many repairs and replacements
  - Scorching and splits
Major Issues for Improved Blade Reliability

“Delphi” Expert’s Group Assessment of Issues

- Experts from Industry, consulting, academia, and national labs convened to identify critical issues
- Collected expert knowledge as a basis for planning to address blade reliability needs

1. Infusion Quality
2. Bonding Quality
3. Inspection Capability
4. Environmental Protection
5. Multiple Assembly Plants or Assembly Lines
6. Certification, Tracking and Feedback
### Major Activities

#### Blade Reliability Collaborative

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<th>Description</th>
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<td>Survey &amp; Root Cause Analysis</td>
<td>Conduct root cause analysis of field-failures and document the issues</td>
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<td>Inspection Validation</td>
<td>Create the ability for manufacturers to determine the quality of their product before it leaves the factory</td>
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<td>Effects of Defects</td>
<td>Determine how critical manufacturing flaws are progressing to failures under typical loading</td>
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<td>Analysis Evaluation</td>
<td>Assess the ability of design analysis tools to find and characterize potential failure modes in both fatigue and strength</td>
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<td>Certification Testing</td>
<td>Evaluate the ability of certification testing to uncover potential reliability issues and find innovative ways for testing to provide better insight</td>
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All BRC results will be public
Survey and Root Cause Analysis

Activity Leader: Tom Ashwill

What is causing early field failures and unreliability?

- Operator surveys
- Blade repair data
- Field failure assessments and root cause analysis
- Manufacturer inputs
- Quantify the impact of lightning damage
- Create a blade failure mode database

Field experience & Manufacturing Output

Inspection is the link between the two.
Inspection Validation
Activity Leader: Dennis Roach

- Find aging parts and characterize flaws
- Manufacture known flaws
- Bring in vendors to Validate their capabilities
- Sandia’s Aviation Assurance NDT Validation Center (AANC)

The Boeing 787 is 50% composite material in structural elements
Composite Inspection is growing in technical sophistication

- Composites 50%
- Carbon laminate 15%
- Carbon sandwich 10%
- Titanium 15%
- Aluminum 20%
- Other 5%
- Steel 10%

Composite Structures on Boeing 787 Aircraft

Sandia National Laboratories
**Effects of Defects**

Activity Leader: Doug Cairns

- Coupon-level testing to determine how flaws and defects propagate under load
- Montana State University has expertise in this area and know wind turbine blade materials from over a decade of testing (100,000 coupons tested and archived)

![Detectable Flaw Size](image1)

![Nondestructive Inspection](image2)

![Damage Tolerance](image3)

![Allowable Flaw Size](image4)
Design Analysis Evaluation

Activity Leader: Josh Paquette

- Check design loads against material capability
- Create the ability for the analysis to be a predictive tool for evaluating blade design
- Highly instrumented laboratory testing to determine first failure and damage progression
Certification Testing – NREL

Activity Leader: Scott Hughes

- Heavily instrumented blades subjected to certification tests
  - Good blades
  - Pre-damaged blades
- Evaluate how the test works the critical areas and failure modes
- Develop improvements to certification testing
- NREL element of the program

- Full-scale blade testing: Fatigue tests reveal hidden flaws
  - Production blades
  - Detailed inspection
  - Typical manufacturing quality resulting capability
# Current Participating Partners

**Blade Reliability Collaborative**

- Sandia
- Montana State University
- Knight and Carver
- Rope Partners
- NREL
- University of Massachusetts – Lowell

- TPI
- EPRI
- GE
- LM
- Dantec