

2nd US Wind Turbine Supply Chain Conference

**Wind Energy Update
Detroit, Michigan
April 5-6, 2011**

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Sandia National Laboratories

Sandia National Laboratories

“Exceptional Service in the National Interest”

- National Security Laboratory
- Safety, security and reliability of our nation's nuclear weapon stockpile
- Broad mission in developing science and technology applications to meet our rapidly changing, complex national security challenges



The graphic features a large globe with the word "Sandia" in red script and "VISION" in blue block letters. A red banner curves around the globe with the text "helping our nation secure a peaceful and free world through technology". To the left of the globe is a vertical column of five yellow stars, each containing a value: Integrity, Excellence, Service to the Nation, Each Other, and Teamwork. In the top left corner is the Sandia National Laboratories logo.

Our highest goal is to become the laboratory that the U.S. turns to first for technology solutions to the most challenging problems that threaten peace and freedom for our nation and the globe.

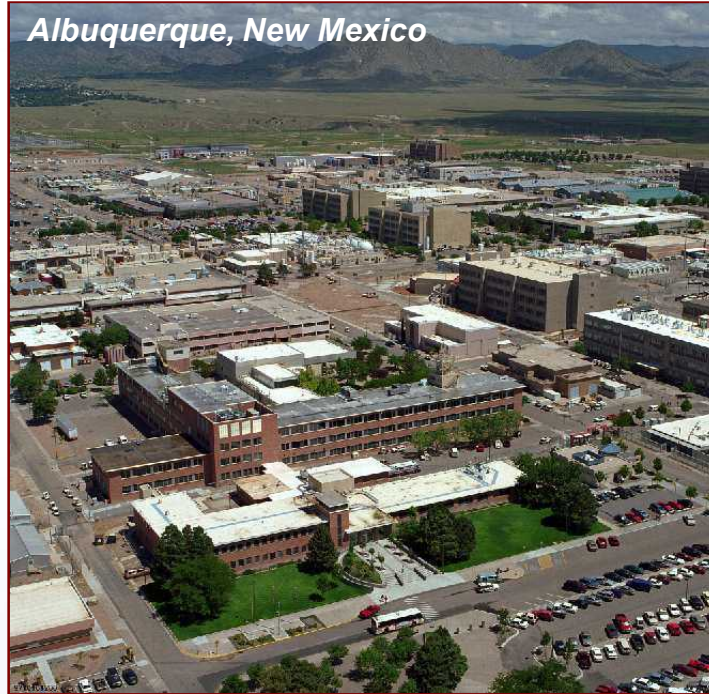


Sandia National Laboratories is Geographically Distributed

Tonopah, Nevada



Albuquerque, New Mexico



Kodiak, Alaska



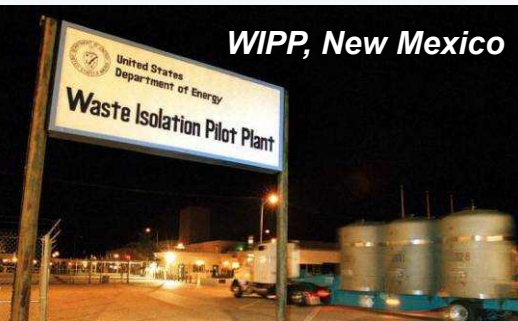
Pantex, Texas



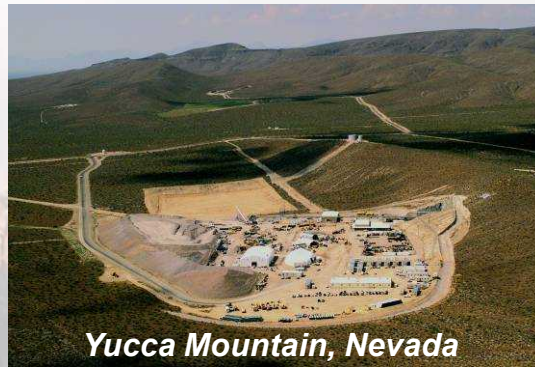
Kauai, Hawaii



WIPP, New Mexico



Yucca Mountain, Nevada



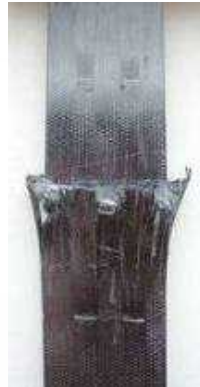
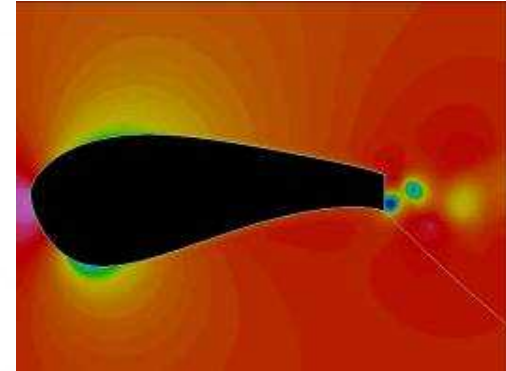
Livermore, California



Sandia Wind Energy Technology

■ Blade Technology

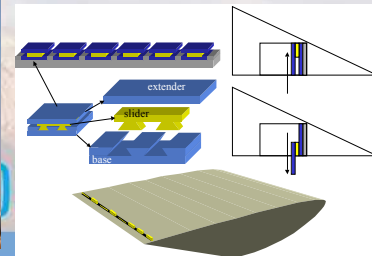
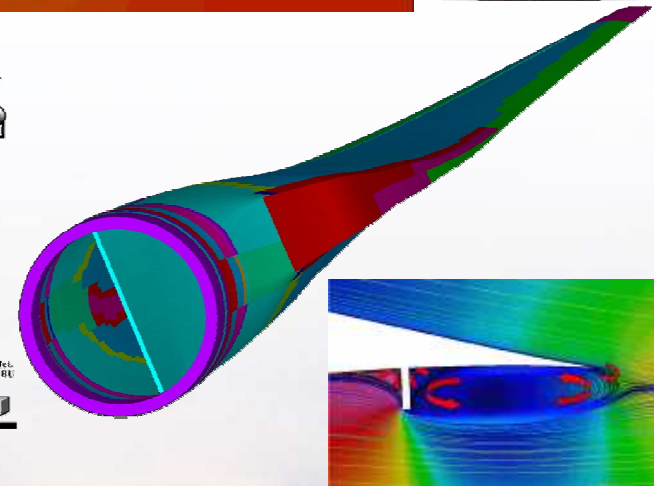
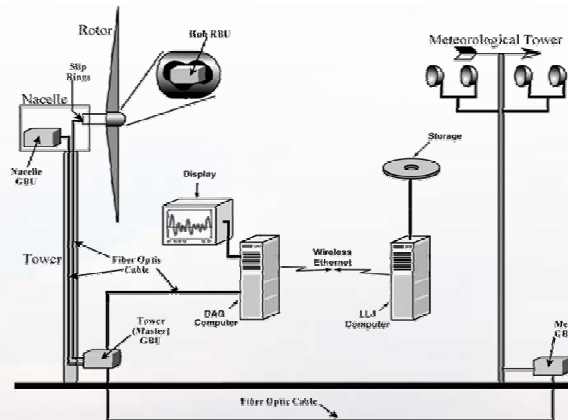
- Materials and Manufacturing
- Structural, Aerodynamic, and Full System Modeling
- Sensors and Structural Health Monitoring
- Advanced Blade Concepts
- Lab - Field Testing and Data Acquisition



■ System Reliability

- Industry Data Collection
- Improve reliability of the existing technology and future designs

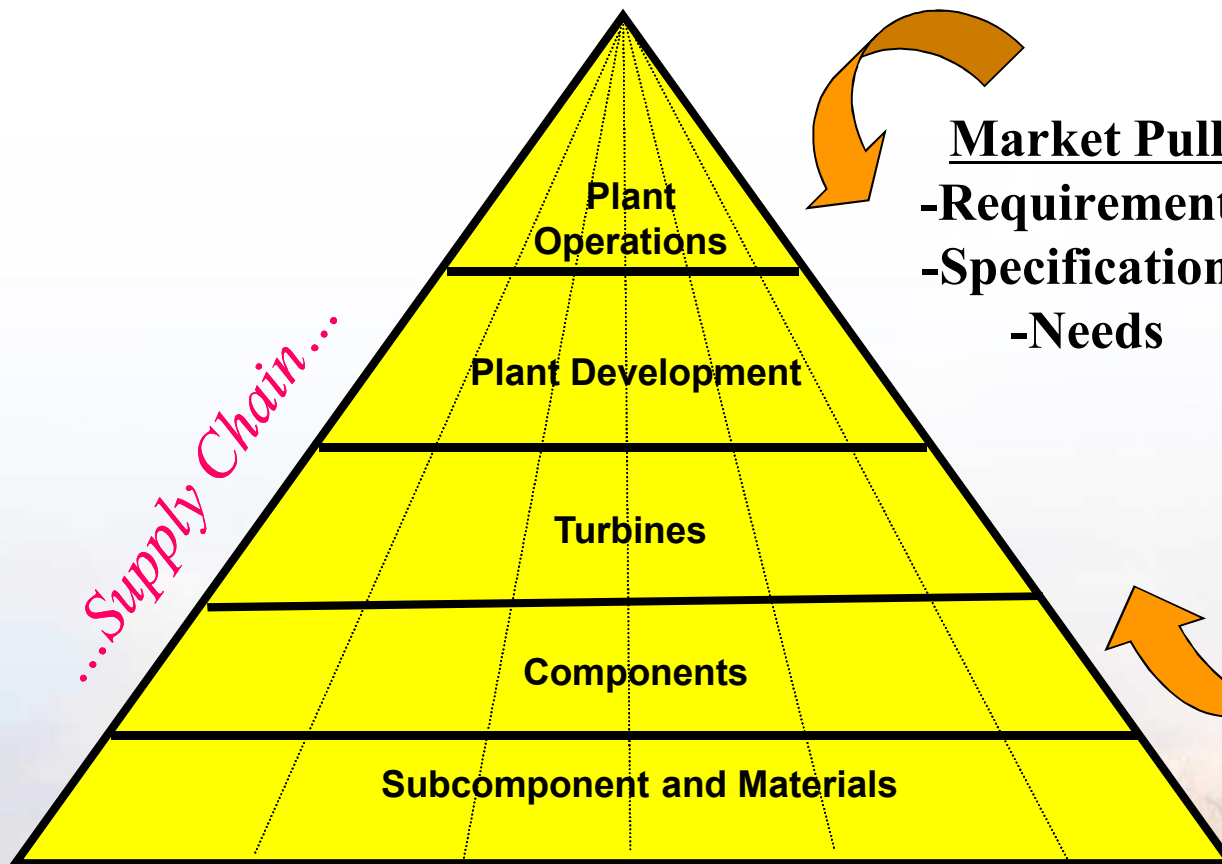
■ System Integration & Outreach



Wind Turbine Supply Chain Model

Utilities, Ratepayers,
Taxpayers, Social Benefits

...Supply Chain...



Market Pull
-Requirements
-Specifications
-Needs

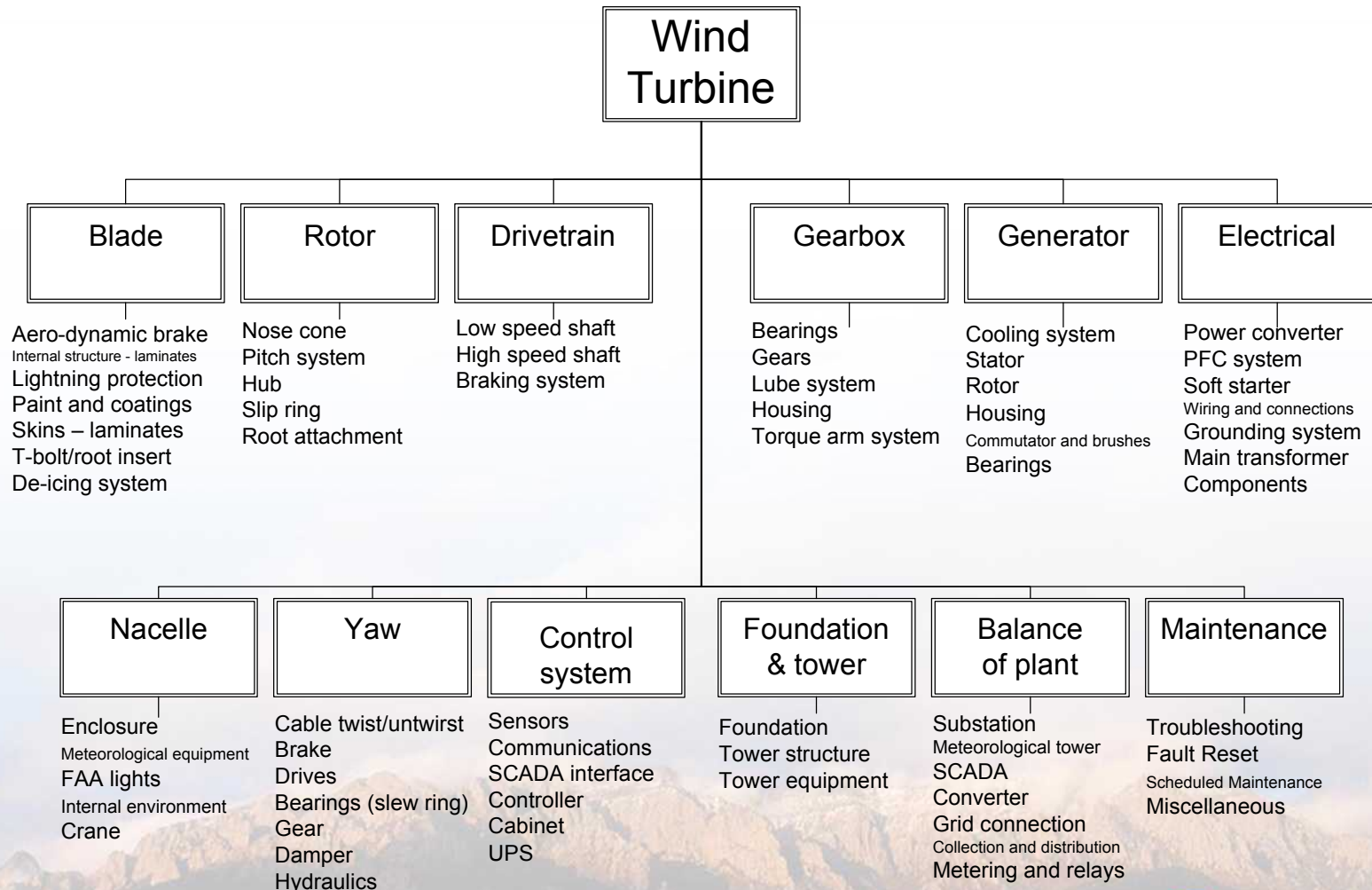
Technology Push
-Products
-Services
-Innovation

Employment, Taxes, Social Benefits



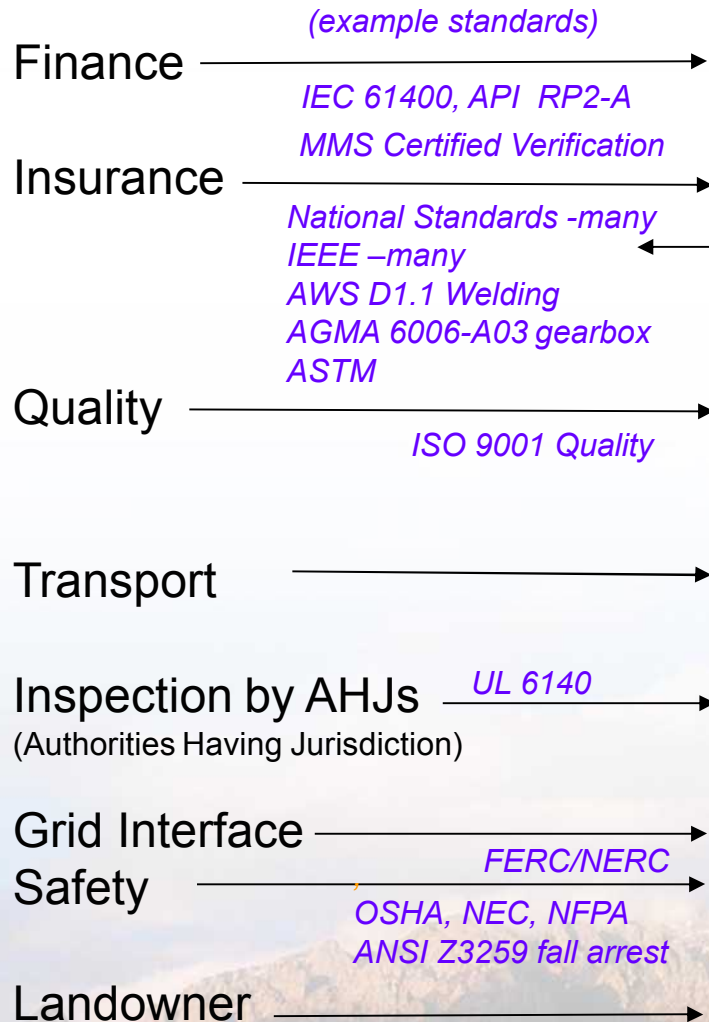
Taxonomy of a Wind Plant

Over 8,000 individual components in a single wind turbine

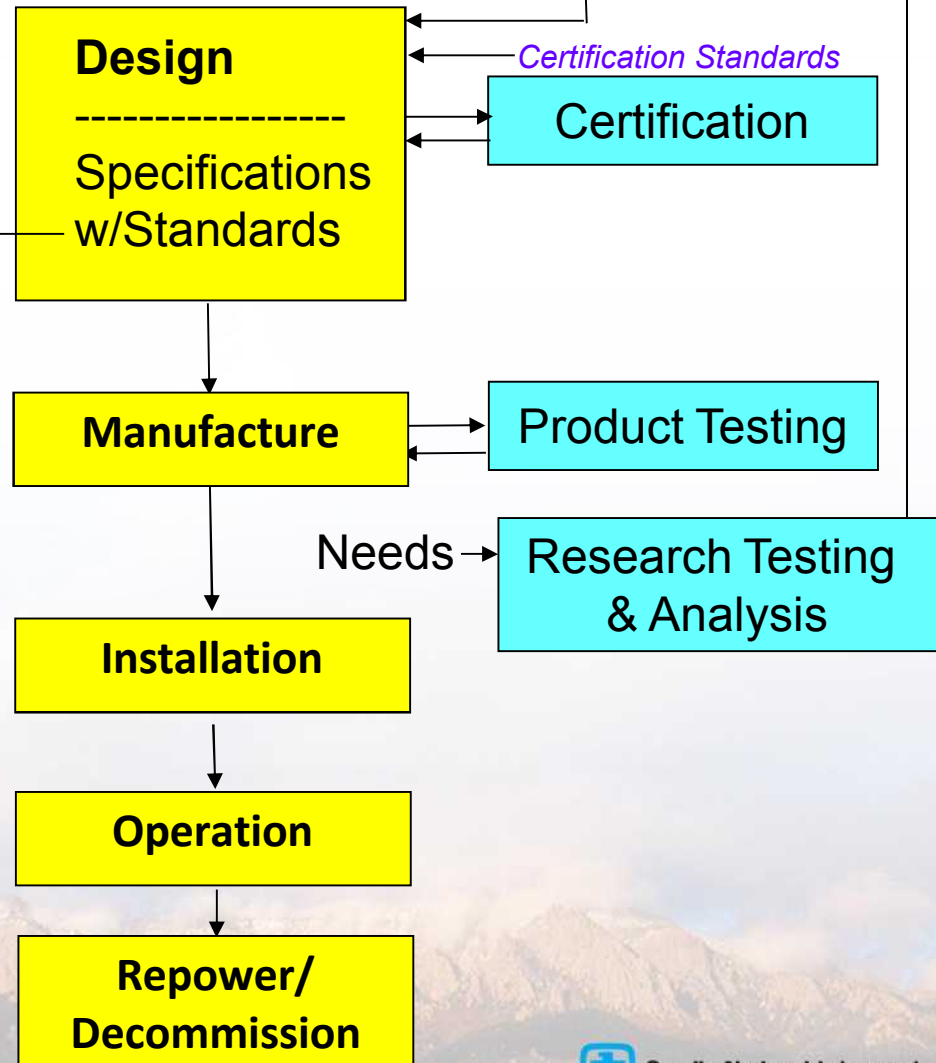


Another Perspective with Adjacent R&D Space

Functional Requirements



IEC Design Standards



Sandia Manufacturing Efforts

- **Manufacturing R&D**
- **Advanced Manufacturing Initiative, AMI-Blades**
- **Component Demonstration Platform**
- **Blade Reliability Cooperative**
 - survey of issues and problems
 - various size blades
 - various manufacturing approaches/processes
 - identification of underlying causes of defects
- **Sensor Blades, Smart Blades**





Core Manufacturing R&D

Core Manufacturing R&D

- **Manufacturing Sensors** (Collaboration with MSU – Prof. Doug Cairns)
 - improve manufacturing throughput
 - minimize scrap rate
 - minimize rework
 - potential condition monitoring
 - Sensors cannot compromise blade
 - ◆ Static
 - ◆ Fatigue
 - Support Blade Reliability Collaborative



Advanced Manufacturing Initiative (AMI)



Statement of Problem

Challenge: High cost of labor in U.S. makes it difficult to manufacture blades economically

Goal: Improve labor productivity (and leverage transportation advantage) to make U.S. manufacture for U.S. market economically viable



Approach

Three-way Manufacturing Research Collaboration

- ♦ 3-year duration (Aug 2009 start)
- ♦ Equal funding
 - DOE
 - Iowa OEI
 - TPI



PI – Steve Nolet



PI – Daniel Laird



PI – Frank Peters



Challenges:

- Collaborating at “industry speed”
- Intellectual Property
- Disseminating Results



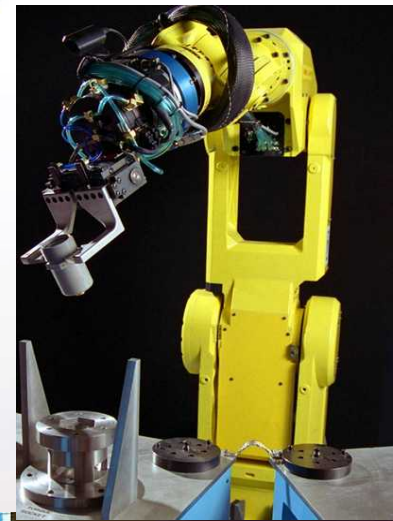
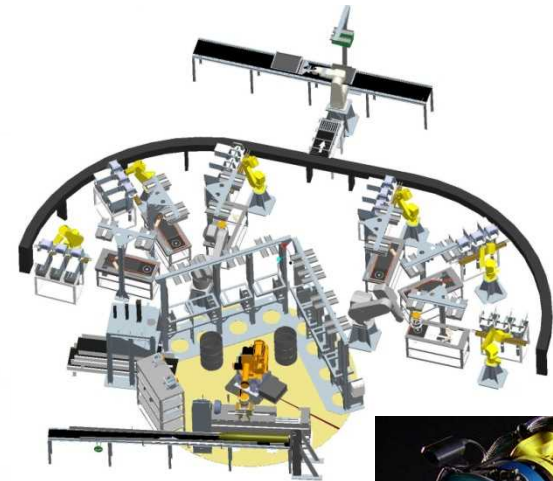
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Approach

AMI - Blades

■ Research Areas Identified

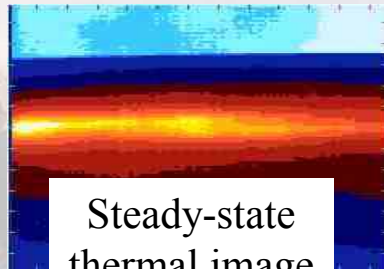
- Mold Layup Productivity
very labor intensive
- Non-destructive Evaluation
initial interest in shear web bondline integrity
- Virtual Factory Simulation
key to long-term optimization of manuf. processes
- Modular Automation
implementation of results from other areas



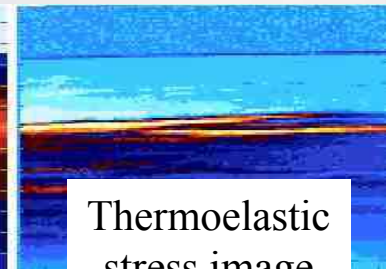
**Non-
Destructive
Inspection
Methods**



Visual photo



Steady-state
thermal image



Thermoelastic
stress image



Fluorescent
dye-penetrant

AMI-Blades Current Efforts

- **True 3D Laser Projection**
- **Edge Operations Study**
- **Non-Destructive Inspection Capabilities Evaluation**
- **Factory Logic/Process Flow Simulation**
- **Engineering Data Software Platform**
- **Spar Cap Assembly Fiber Placement**
- **Ply Nesting Optimization**



Component Demonstration Platform

Goal: Facilitate the entry of *new* U.S.-based blade manufacturers into the wind industry

Challenges:

- High entry costs
- Unfamiliar with materials used in wind turbine blades
- Unfamiliar with wind blade manufacturing processes

Approach:

- Make molds and baseline blade design available to industry (“library card” for blade molds)

Industry Impact:

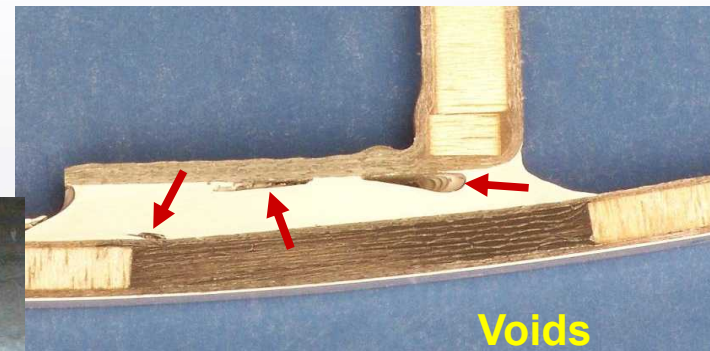
- Significantly reduce barriers for manufacturers considering an entry into the wind industry

Interested? dllaird@sandia.gov



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)**



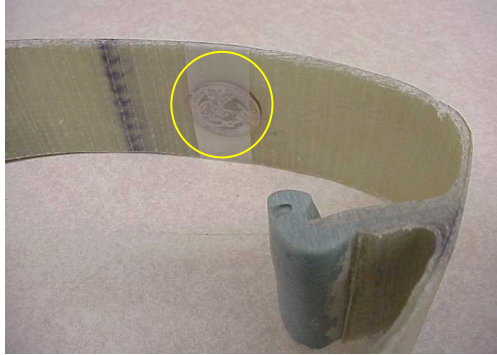
****Courtesy of Dennis Roach***



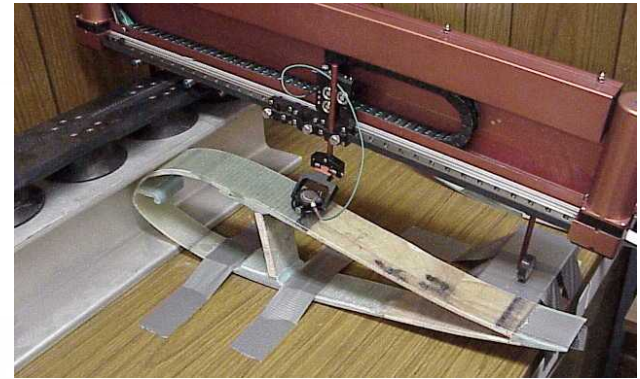
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Inspection of Wind Turbine Blades

Depth of penetration in thick, attenuative laminates is key issue

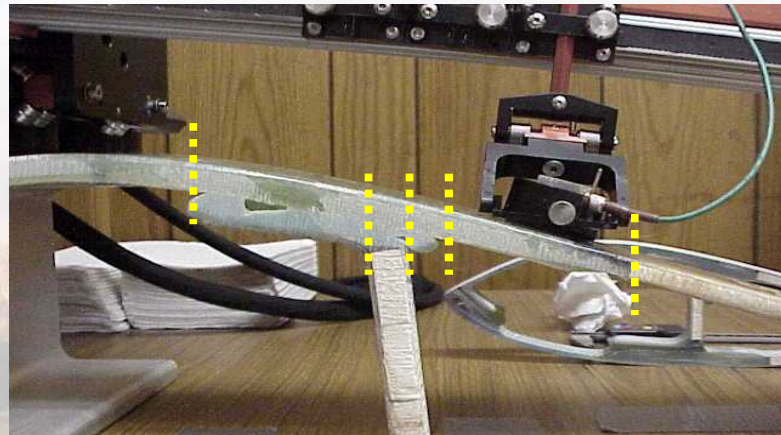
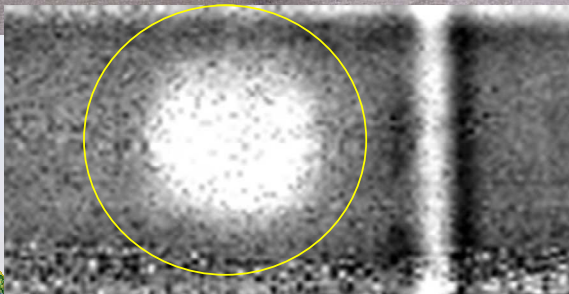
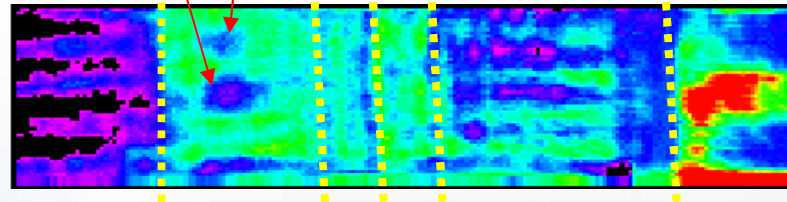


Thermography



Resonance Scan 152 kHz

Voids



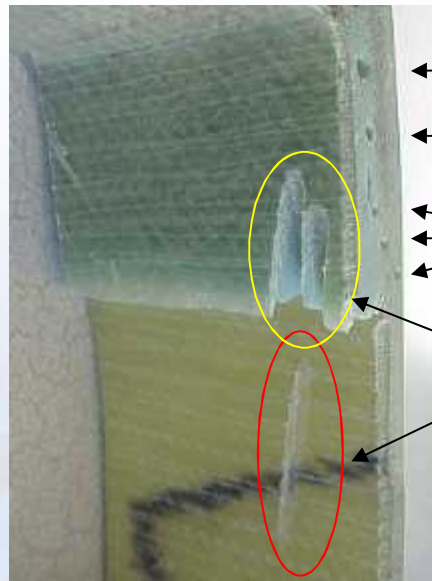
Quality Assurance for Turbine Blades

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)

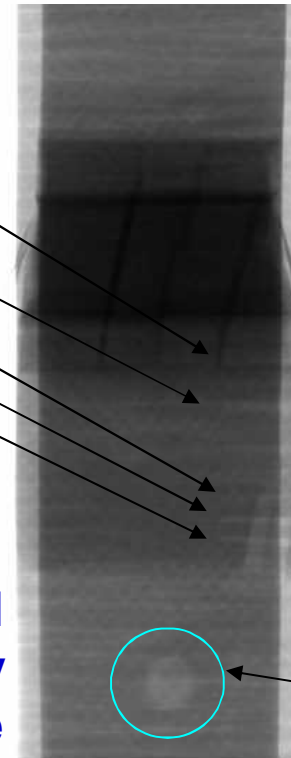
← #45 Drill (DIA 0.082, 0.75" Deep)

← #51 Drill (DIA 0.067, 0.75" Deep)

← Saw cuts caused by the creation of specimen?

← Non engineered flaws!

Digital Radiography Image

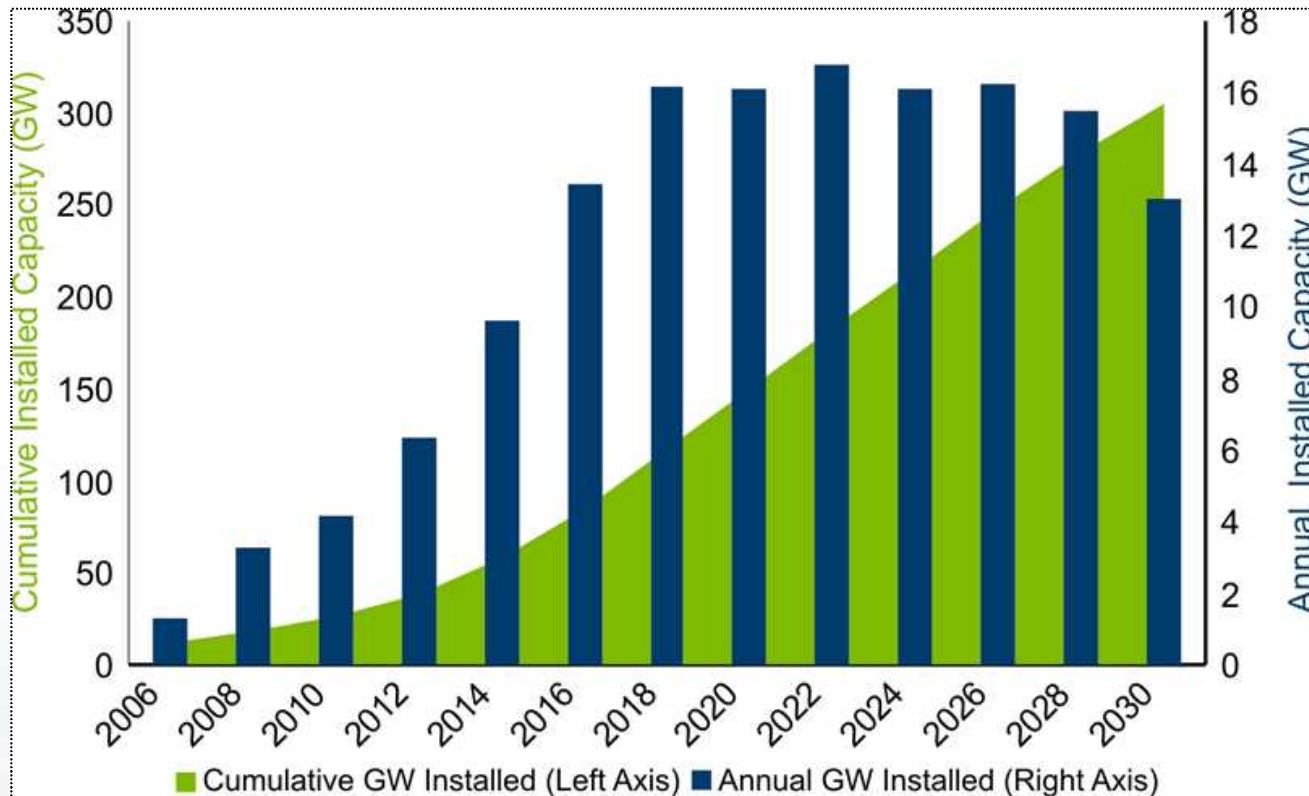


Semi Flat Bottom Hole:
0.4375 DIA and 0.0615 Deep

Bottom of Blade



Federal Support: DOE 20% by 2030 Report



20% Wind Energy by 2030

Increasing Wind Energy's Contribution to U.S. Electricity Supply, July 2008



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Technology Improvement Summary

20% by 2030 Report

Subsystem	Description	Increased Energy	Capital Cost
Towers	Taller with new materials/self erecting	+11/+11/+11	+8/+12/+20
Rotors	Lighter & larger with smart structures	+35/+25/+10	-6/-3/+3
Site Energy	Improved reliability – less losses	+7/+5/0	0/0/0
Drive Train	Innovative designs – high reliability	+8/+4/0	-11/-6/+1
Manufacturing	Process evolution and automation	0/0/0	-27/-13/-3
Totals		+61/+45/+21	-36/-10/+21

20% Report, Table 2-1, page 41 (working from 2002 baseline)



Federal Support for Wind Manufacturing

- **Manufacturing Workshop**
- **ARRA Wind Manufacturing Projects (FOA)**
- **Massachusetts Wind Technology Testing Center**
- **Large Wind Turbine Drivetrain Testing Facility**
- **Advanced Manufacturing Initiative – Blades**
- **Manufacturing Tax Credit (48C)**

Wind Funding Opportunity Announcements (FOAs)

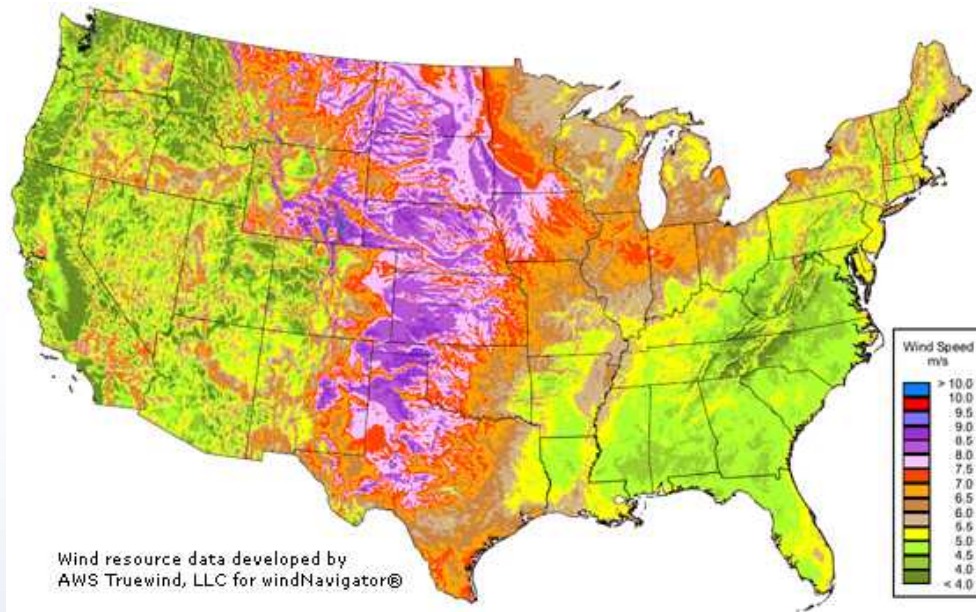
<http://www1.eere.energy.gov/windandhydro/>

(Hint: Google DOE wind power)

Click on financial opportunities



A Final Word on Economic Clusters



- Natural resources drive development of industries
- Geographic concentrations may develop specialized suppliers, service providers and associated institutions
- Clusters arise because they increase the productivity with which companies can compete

Publications@ sandia.gov/wind

Active Aero Control Design

Blades:

Adaptive

Aeroacoustics

Blade System Design

Study

Carbon Hybrid

Flutter

General

Testing

Computational Fluid

Dynamics

Control System Design:

Nonlinear Control Theory

**Wind Turbine Blade
Controls**

Data Acquisition and Field

Measurements

Fatigue and Reliability:

General

LIFE2

Loads

Probability of Failure

Health Monitoring

Manufacturing

Materials:

Aluminum

Bonded Joints

Composites

Material Testing and Fatigue

Property Determination

Modal Testing and Analysis

Non-destructive Testing

NuMAD

Partnerships:

Low Wind Speed Technology:

Knight & Carver

WindPACT

Supervisory Control And Data

Acquisition

Structural Dynamics

Turbine Systems

Turbulence Simulation

VAWT Archive

Wind Plant Reliability

Wind Powering America



Thank You

The “Eye” of the dollar bill has two

Latin phrases:

Annuit Coeptis

-Approves Our Endeavors

Novus Ordo Seclorum

-New Order of the Ages

Roger Hill

Principal member of Technical Staff

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