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Blades: Trends and Research Update

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Sandia National Laboratories
2008 Sandia Blade Workshop
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Welcome

- Trends in Utility-Scale Wind Turbines Production
- Trends in Blade Fabrication
- Research in Blade Technologies at Sandia and Other Institutions
- Future Research Needs

Industry Trends

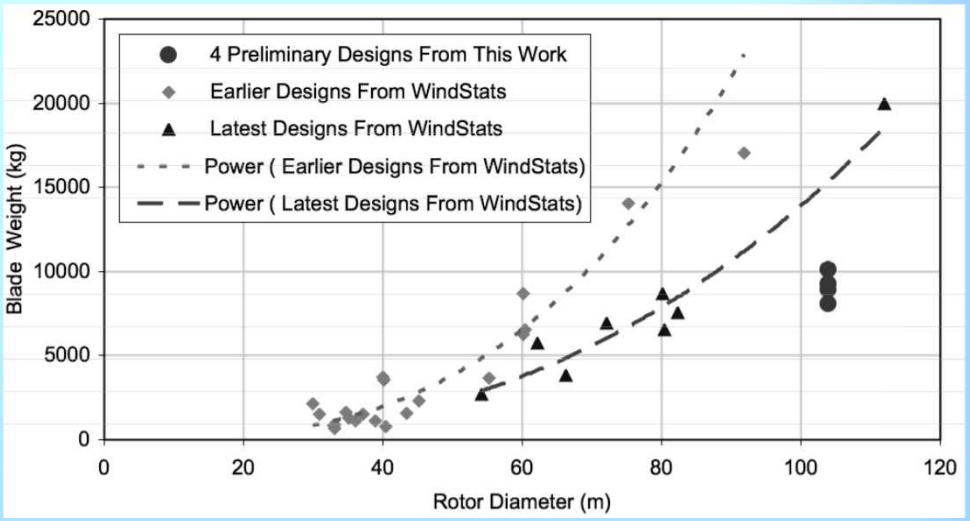
- Most significant trend in market place is the tight supply situation
  - Seller's Market - prices for wind turbines have increased and delivery time is longer.
  - Component suppliers costs are rising. Installed Cost Now – $1600-2200/kW
  - $1000 used to be the goal only a few years ago
- Trend of 20% increase in world-wide installation continued in 2007
- U.S. production tax cuts expire at end of 2008
  - China is 2nd in installed capacity (2007)
- Offshore installations - 2008 forecasts significantly lowered, but expected to grow to 4.7% by 2012

Industry Trends

- US has largest number of turbines worldwide (25,667) and second in 2007 installed capacity (16,879 MW v. Germany=22,277)
- Average turbine size delivered in 2007 was 1.492 MW about 70kW above 2006
- 1.5-2.5MW turned into “Main Stream” position – 48% of 2007 capacity – perhaps less larger models on market
- Two of top ten turbine suppliers are now Chinese
- Smaller turbines preferred in Asian markets
- 90% of turbine use pitch as the control feature – 10% use active stall
- Amount of Materials Required to Support Blade Production Growing Bigtime

Blade Growth Constraints

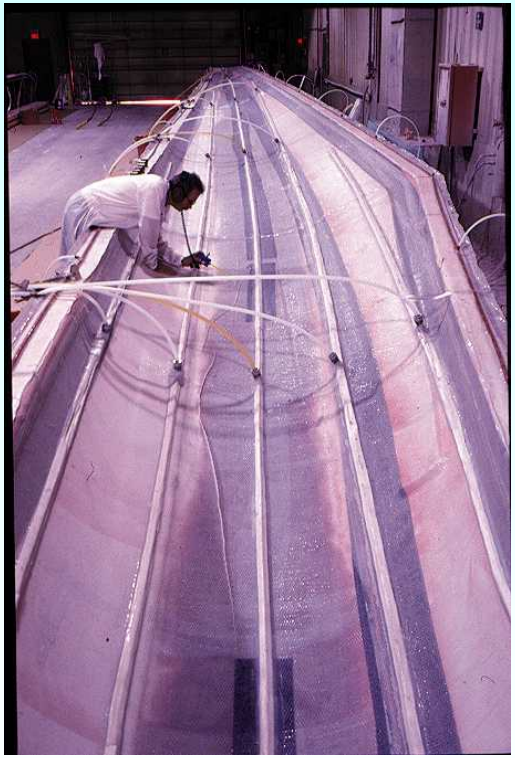
- Gravity Loads
- Transportation
- Large Crane Availability



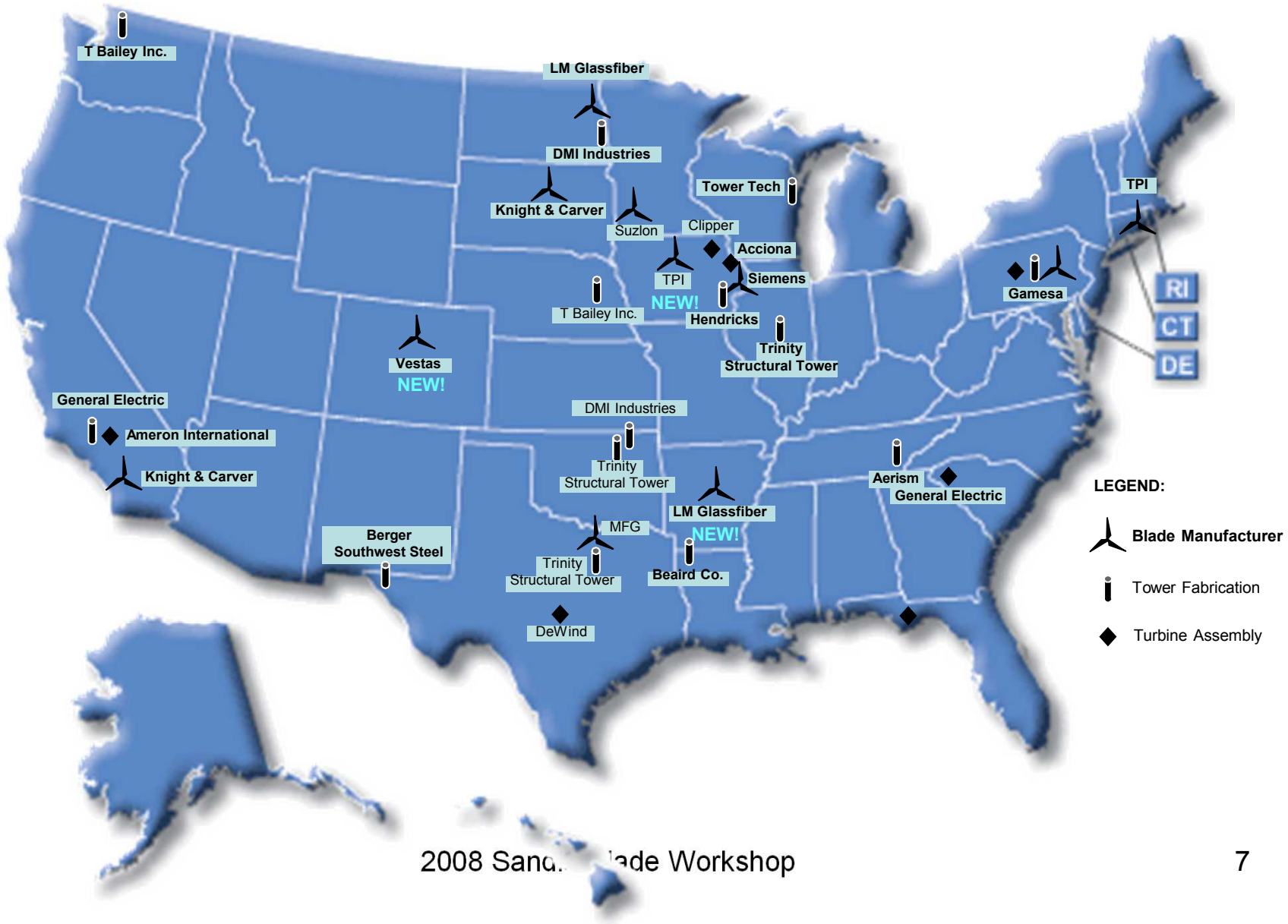
LM 61.5m
Blade for 5MW
Offshore

Blade Manufacturing Processes

- Infusion – TPI, LM, Siemens, GE
- One shot Infusion - Siemens
- Pre-preg – Vestas, Gamesa
- Wet lay-up – GE, K&C



Current U.S. Manufacturing



Ongoing Blade Research

Many countries have ongoing research in labs, universities

Wind industry performing more & more independent research

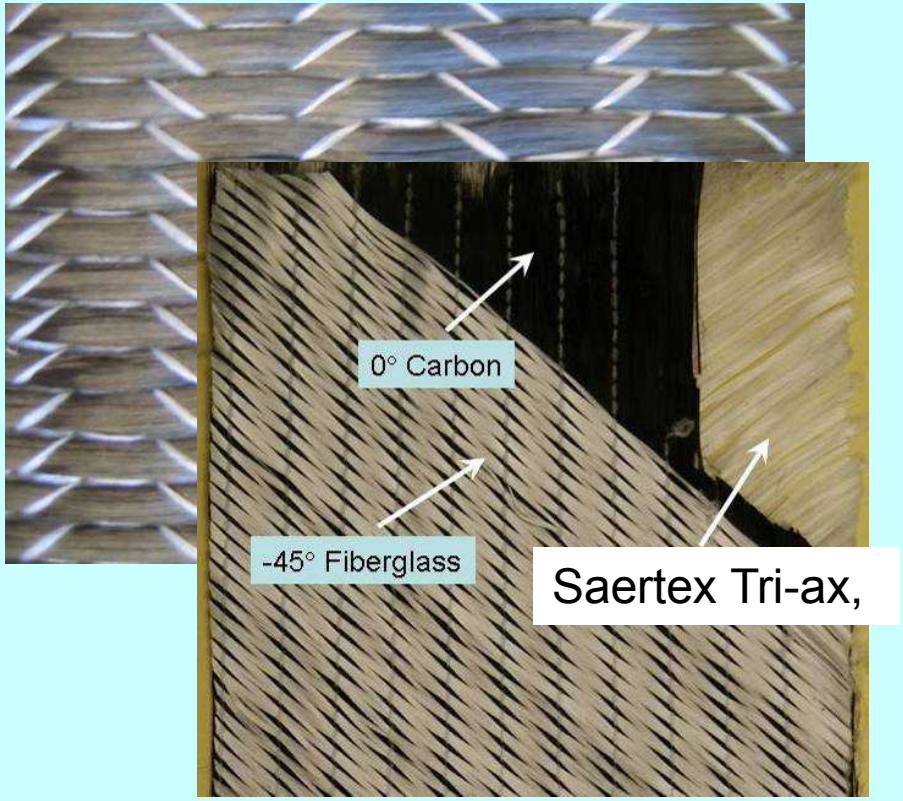
- U.S. NREL, SNL
- Denmark
  - Risoe (DTU)
- Netherlands
  - TUDelft
  - WMC/ECN
- Universities
- Industry

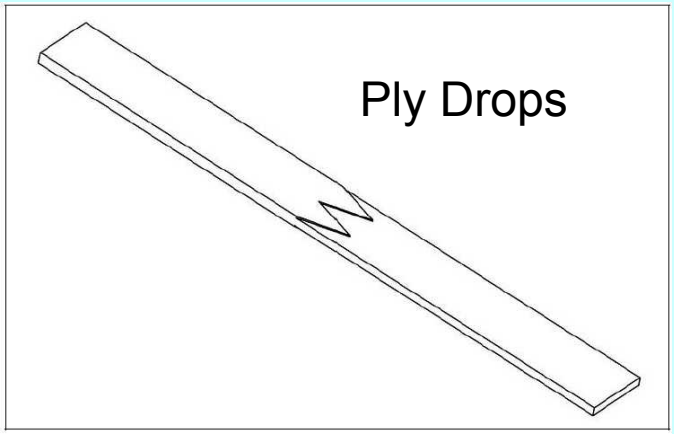
LM Glasfiber Blade Testing in Lunderskov, Denmark.

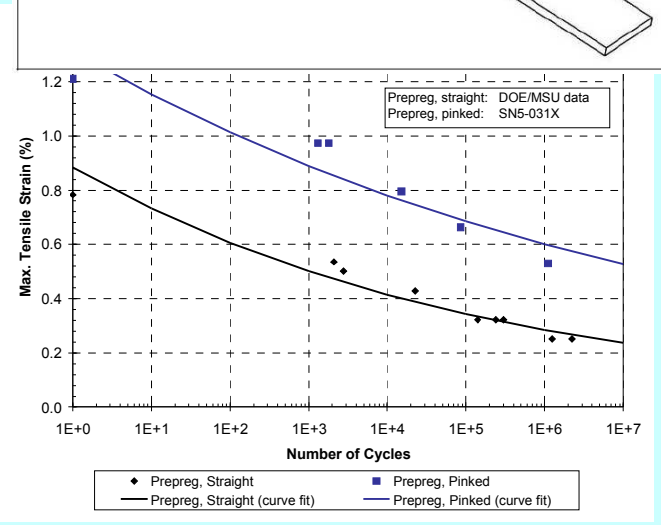
Research Items

- Materials & Manufacturing
- Load Control – Active & Passive
- Very Thick Airfoils, including Flatbacks
- Blunt trailing edges – noise, wind tunnel
- Innovations for Blade Enhancement
- Codes
  - Aerodynamic and Structural
  - NuMAD
  - CFD
- Sensors & Reliability

Materials Research







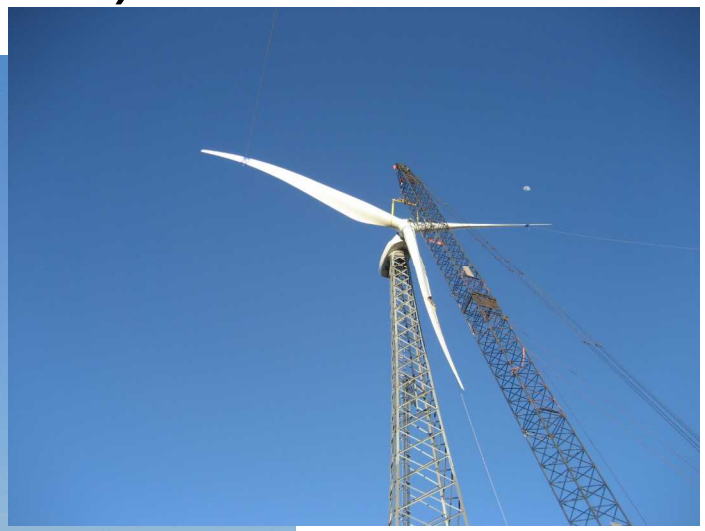
Ref:

T. D. Ashwill and J. Paquette, Composite Materials for Innovative Wind Turbine Blades

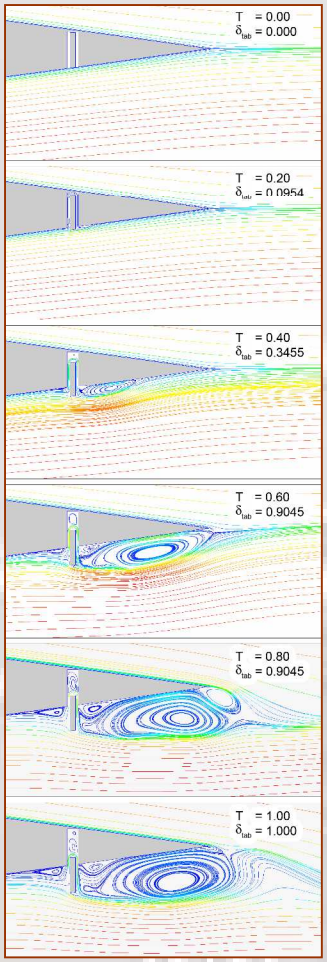
J. F. Mandell, D. D. Samborsky and P. Agastra, “Composite Materials Fatigue Issues in Wind Turbine Blade Construction,” SAMPE 2008, Los Angeles, CA.Fatigue coupons of typical blade materials,

Passive Load Control – Bend-Twist Coupling Using Off-axis Material (TPI/SNL)

Bend-Twist Coupling Using Sweep (K&C/SNL)

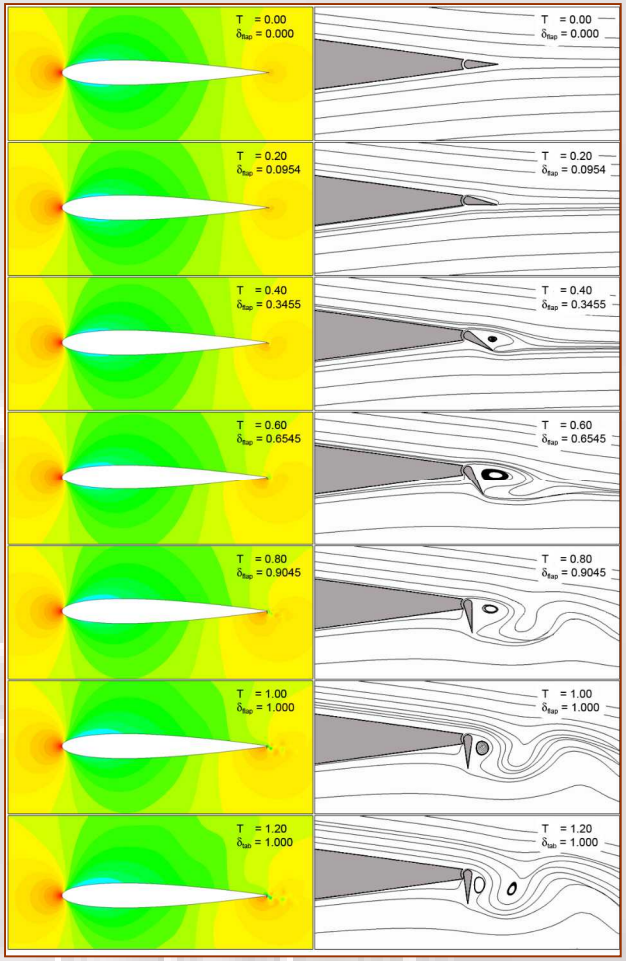


Active Load Control – Tabs & Flaps (UCDavis/SNL)

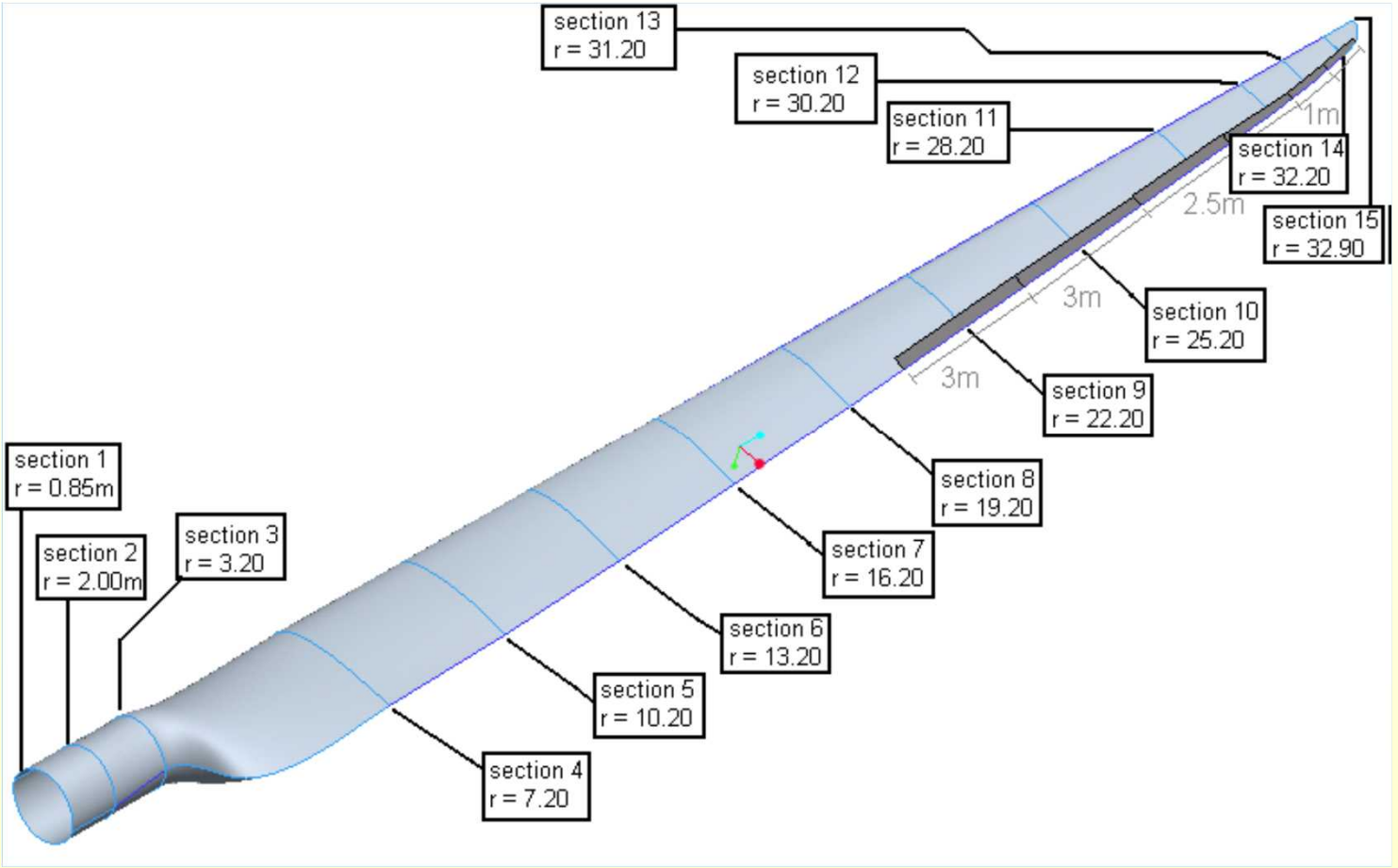


Aerodynamic lift, drag and moment during microtab deployment

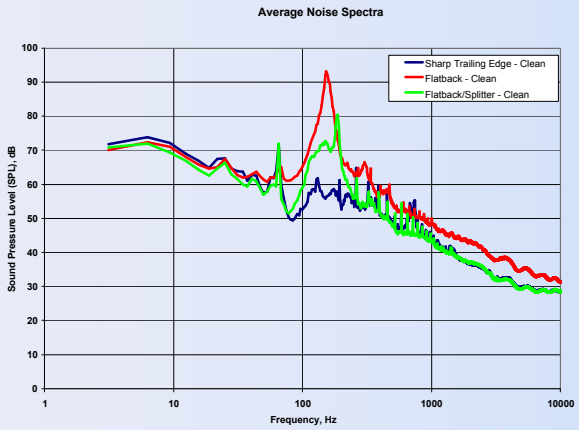
Pressure contours over the airfoil and instantan-eous streamlines over flap region during deployment



Risoe (Buhl and others)



Flatback Noise & T.E. Treatment

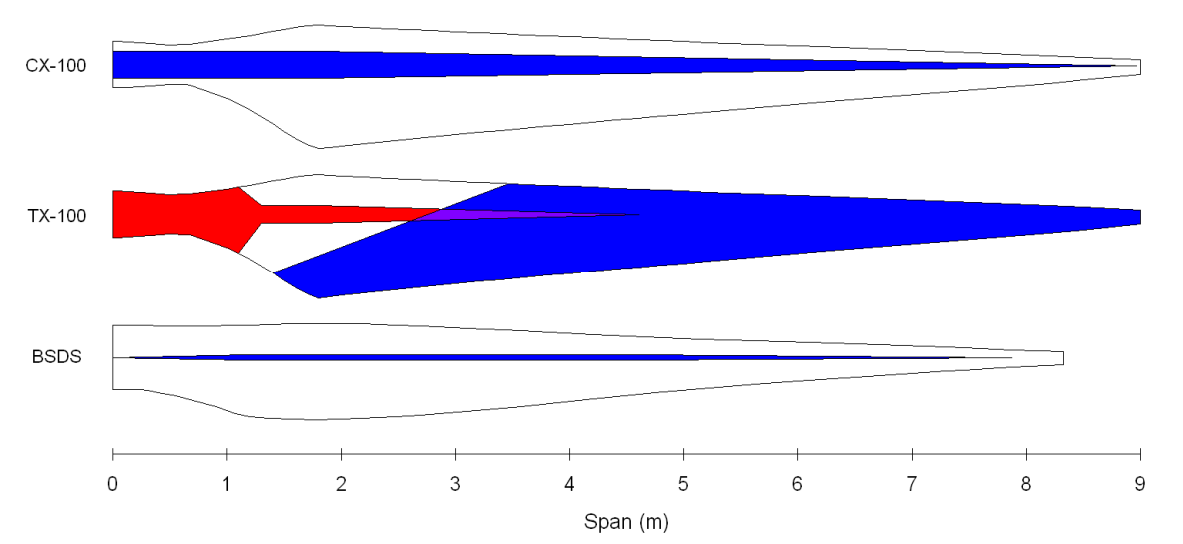


Reference:
Aerodynamic and Aeroacoustic Properties of Flatback Airfoils

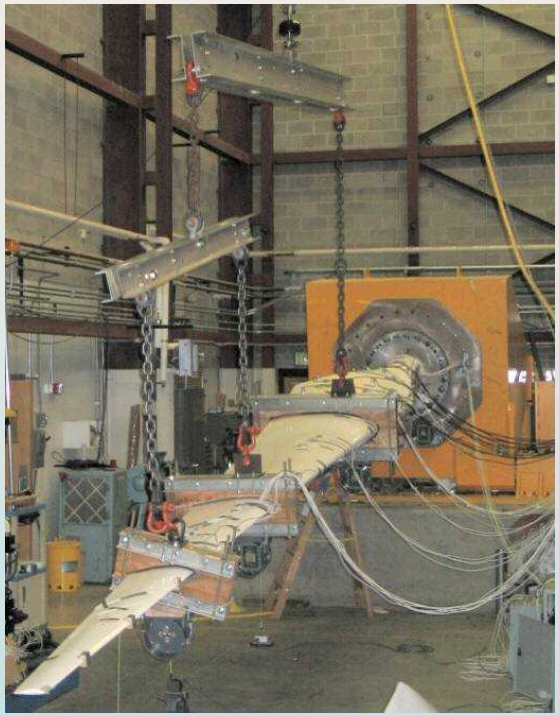
Dale E. Berg and Jose R. Zayas
Sandia National Laboratories
Albuquerque, NM 87185-1124 USA

Innovations in Research Blades

- Improved manufacturing processes & remote build demonstration
- Carbon as entire spar
- Bend-twist coupling in material using carbon placed 20 degrees off-axis
- Very thick airfoils (flatbacks), slenderized profile, constant thickness carbon spar cap, use of threaded rod (manufactured in place) for attachment



Testing of Research Blades – Laboratory & Field



Design Codes

Aeroelastics

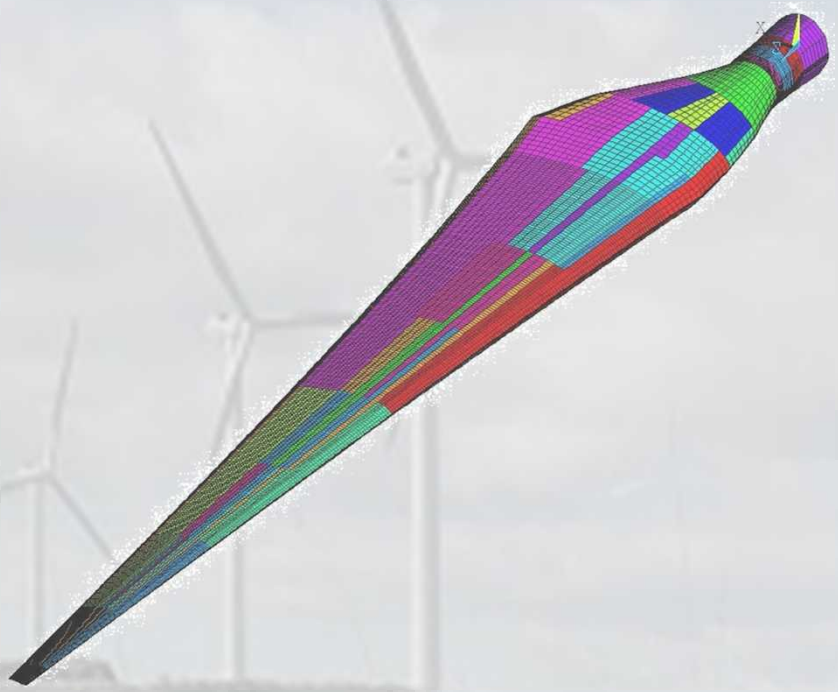
- FAST – NREL
- BLADED – commerical (GH)
- FLEX5 – DTU (Academic)
- ADAMS – commercial – (MSC)

Structural Analysis

- NuMAD/BPE (Sandia)
- Focus (WMC)
- Pre-Comp (NREL)

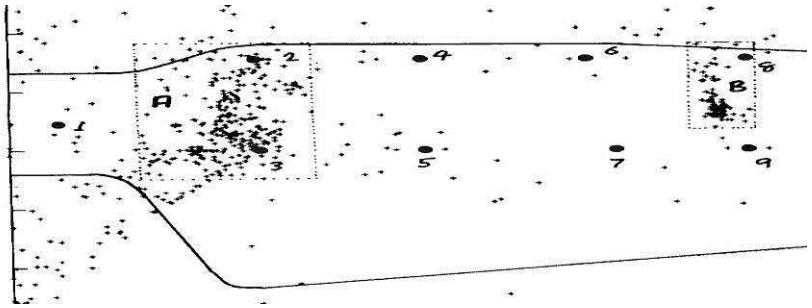
Aerodynamics

- AeroDyn (NREL)

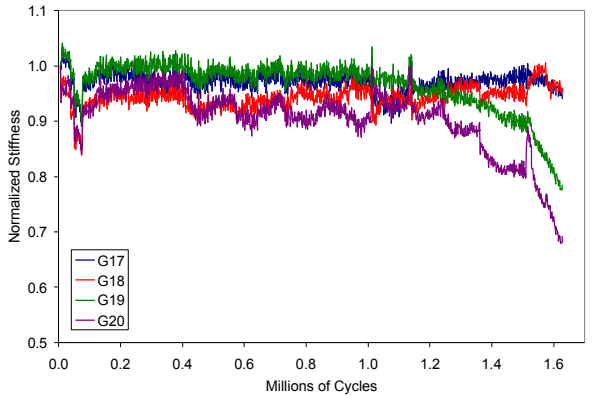


Sensors Applications for Lab and Field

Acoustic Emissions



Strain Gauges



Future Research Needs

- Reliability
- Materials
  - Coatings
  - Adhesives
  - Thick Laminates
  - Core
- Joints – TRANS BARRIER

- Lean Blade Manufacturing
  - Labor Reduction
  - Automation
- Load Control
- More Efficient Designs
  - Optimize material usage

Adios and Thank You