National Science Foundation Industry/University Cooperative Research Center (I/UCRC)

WindSTAR

Wind-Energy Science, Technology, and Research Industry/University Cooperative Research Center
1. What is an I/UCRC?
The Industry/University Cooperative Research Centers (I/UCRC) Program

Mission:
- To contribute to the nation’s research infrastructure base by developing long-term partnerships among industry, academe and government
- To leverage NSF funds with industry to support graduate students performing industrially relevant research

Vision:
- To expand the innovation capacity of our nation’s competitive workforce through partnerships between industries and universities

Cooperatively Defined and Shared, Sector Precompetitive Research

1980’s 1990’s 2000’s 2010’s

40 years of fostering and growing long-term partnerships among industry and academe based on shared value
I/UCRC Fast Facts – FY14 Snapshot
52 ENG Funded Centers 25 CISE Funded Centers

6 International Sites:
Belgium, China, Finland, Germany, India, Russia

Program Funding
- $20M in Program Funding (ENG, CISE)
- 6:1 Leveraging of NSF funds

Students
- Over 2000 students engaged
- 649 graduated in 2014, nearly 30% hired by members

Sustainability
- Over 40 Graduated I/UCRCs remain in operation true to model
WindSTAR’s I/UCRC Nucleus: A Cooperatively Defined & Funded Shared Research Portfolio

Industry
Industry Advisory Board (IAB)

Shared Project Portfolio
- Cooperatively defined, selected
- Governed by NSF I/UCRC Agreement
  - Royalty free nonexclusive access to IP by members

Research Projects

Pooled Member $’s
Addresses precompetitive needs shared by IAB
Leverages & builds university strengths

Investment of Indirects

Center Sites
Universities

Value derived from portfolio

Requires trust be built in the model, and between all partners in the center.
2. What is WindSTAR?
WindSTAR Vision Statement

Our vision is to become the premier research Center in the area of wind energy in the USA.

- Bring together university and industry researchers to conduct basic and applied research on wind energy
- Combine state-of-the-art capabilities and knowledge to advance projects relevant and of mutual interest to industry partners
- Train students in the advanced technologies that are important to industry partners and to have a pipeline of state-of-the-art talent flowing from academia to industry
- Foster a community for networking, interactions, and collaboration
- Conduct research that benefits our industry members
Thrust Areas

Composites and Blade Manufacturing
- Design and methods
- Next generation materials

Structural Health Monitoring and NDI
- Damage detection and prognosis
- Life cycle management

Wind Plant Modeling and Measurements
- Simulation of power production, power fluctuations and loads
- LiDAR for performance diagnostic and model validation

Control Systems Wind Turbines and Wind Plants
- Optimization of energy capture and load mitigation
- Wake management

Energy Storage and Grid Integration
- Solutions for more reliable, dispatchable and grid-friendly wind energy systems

Foundation and Towers
- Modeling and costing for higher towers
- Improved ground/soil assessment

3 Projects
7 faculty members
4 graduate students

2 Projects
5 faculty
4 graduate students
3. How does it work?
WindSTAR I/UCRC - Annual Schedule

Faculty and LAB members and associate members work together to define project topics

Summer Meeting
Student presentations
Evaluations
Project re-direction

Projects defined

Students identified

Projects Initiated/continued

Progress reported at semi-annual meetings

New topics and opportunities defined

Industrial Members

University Members

Winter Meeting
Student presentations
Evaluations
Project re-direction
WindSTAR - Membership

- Company joins as **WindStar Member** - $40,000/year membership fee, or a **Small Business Member** - $15,000/year (NSF supplements may decrease SB fee to $5,000)
  
  - **Financial Benefits:**
    1. Enjoy 10% overhead rates on project funds
    2. Pooling money improves return on investment in new technology with a 15:1 leveraging of membership fee (~$670k invested in the first year)
    3. Enables IAB members to team on other research projects supported by NSF and DOE
  
  - **Members Benefits:**
    1. Invited to attend semi-annual center meeting, guide project execution, and provide input and guidance to faculty and students (Cast 8 votes as an Industrial Member, 3 votes as an SB member)
    2. Work with faculty to identify topics of interest and propose new research topics
    3. Receive copies of semi-annual project reports
    4. Receive non-exclusive rights to all IP generated across the center
    5. Can also provide additional funds for special projects with exclusive rights to IP that is generated
    6. Receive copies of manuscripts generated by faculty and students prior to publication
    7. Receive annual resume book of participating students
    8. Receive access to network with other members and affiliates
Funds for the Center for Year 1

- Total Fund: $634,024 ($495,349 real dollars)
- Leveraging of $40k Membership = 14.9:1 (11.4:1 real dollars)
- In-kind Contribution (UML + UTD): $229,592
### Funds Required to Support a Student

<table>
<thead>
<tr>
<th></th>
<th>STUDENT ONLY</th>
<th>TYPICAL PROJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirect Costs</td>
<td>10% 53%</td>
<td>10% 53%</td>
</tr>
<tr>
<td>Faculty Salary</td>
<td>0 0</td>
<td>5,000 5,000</td>
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<tr>
<td>TOTAL SENIOR PERSONNEL</td>
<td>0 0</td>
<td>5,000 5,000</td>
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<tr>
<td>Number of Graduate Students</td>
<td>1 1</td>
<td>1 1</td>
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<tr>
<td>Graduate Students (academic)</td>
<td>17,005 17,005</td>
<td>17,005 17,005</td>
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<tr>
<td>Graduate Students (summer)</td>
<td>12,996 12,996</td>
<td>12,996 12,996</td>
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<tr>
<td>Total Salaries &amp; Wages</td>
<td>30,002 30,002</td>
<td>35,002 35,002</td>
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<tr>
<td>Fringe Benefits</td>
<td>2,411 2,411</td>
<td>2,482 2,482</td>
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<tr>
<td>Total Salaries, Wages &amp; Fringe</td>
<td>32,413 32,413</td>
<td>37,484 37,484</td>
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<tr>
<td>Equipment</td>
<td>0 0</td>
<td>500 500</td>
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<tr>
<td>Travel - Domestic</td>
<td>0 0</td>
<td>1,500 1,500</td>
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<tr>
<td>Materials &amp; Supplies</td>
<td>0 0</td>
<td>3,000 3,000</td>
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<td>25% Tuition - RA Fees ($5,000/RA)</td>
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<td>5,000 5,000</td>
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<tr>
<td>Total Other Direct Costs</td>
<td>5,000 5,000</td>
<td>8,000 8,000</td>
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<tr>
<td>Total Direct Costs</td>
<td>37,413 37,413</td>
<td>47,484 47,484</td>
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<tr>
<td>MTDC</td>
<td>32,413 32,413</td>
<td>41,984 41,984</td>
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<tr>
<td>Indirect Costs</td>
<td>3,241 17,179</td>
<td>4,198 22,252</td>
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<td>Total Direct &amp; Indirect Costs</td>
<td><strong>$40,654</strong></td>
<td><strong>$54,592</strong></td>
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<table>
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<th>STUDENT ONLY</th>
<th>TYPICAL PROJECT</th>
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<tr>
<td>I/UCRC BENEFIT (University Contribution)</td>
<td>$13,938</td>
<td>$18,053</td>
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- Center Savings in Year 1: **$138,675**
Projects in Year 1 and New Projects

- E2-14: Extremun Seeking Control for Wind Turbine Power Maximization
- D1-14: Large Area Turbine Blade Inspection
- A3-14: Failure Prevention via Self-healing Materials
- A1-14: Design for Composite Wind Turbine Blade Manufacturing
- E3-14: Two-layer Optimization for Maximizing Wind Farm Power Output
- A1-15 Enhancing Epoxy Infusion in Carbon Fiber Composites
- A2-15 Evaluation of Leading Edge Erosion Protection Systems and Their Effects on Wind Turbine Power Production
- B1-15 Low-Cost Wind Turbine Blade Structural Health Monitoring
Failure Prevention via Self-healing Materials

**Scope:**
- Embed self-healing capsules for improved fatigue life in fiber-reinforced materials
- Increase turbine blade reliability and extend service life while minimizing manual inspection and intervention

**Specific Objectives:**
- Develop encapsulated self-healing solvent or epoxy-amine chemistries applicable to blade material systems
- Apply self-healing microcapsule based technology to composite specimens manufactured using VARTM
- Examine mechanical properties of manufactured samples using quasi-static fracture and fatigue tests and characterize healing efficiency
- Compute the scope for materials reduction based on material fatigue models

Shift to higher fatigue cycles

Compress effect of materials, processing variability

Could target self-healing to critical fatigue locations to further minimize cost
Problem Statement (2/5):

- Depending on the mechanical behavior of the fabric, i.e. in-plane shear stiffness and bending stiffness, localized defects in the form of in-plane waviness and out-of-plane wrinkling can occur.
Problem Statement (3/5):

- Both types of defects can compromise the load path through the structure and lead to reduced stiffness and reduced strength.

Zoomed-in view of double-bias fabric showing slight in-plane waviness of yarns.
Problem Statement

Problem Statement (4/5):

• Example failure mechanisms

Failure mechanism for (a) high and (b) low wave angle
Problem Statement (5/5):

• Need access to an easy-to-use virtual design tool
  • Considers the mechanical behavior of the fabric
  • Valuable tool to assist in the design of the blade manufacturing process
  • Reduce the potential for defects to develop during the manufacturing process
• If defects cannot be eliminated,
  • at least design the process to push the defects into an area of the blade that is of little importance to the structural health of the blade.
1. Pooling money improves return on investment in new technology with a ~15:1 leveraging of membership fee and only 10% overhead rate (50-100% is typical)

2. Industry members direct the selection and execution of research topics across a broad range of researchers and facilities at multiple universities

3. Sharing risk at an early stage in research is a good business strategy

4. Royalty-free licenses to technology generated through the Center and pre-publication access to research results

5. The Center allows us to pursue other sources of funding

6. Student engagement - resume book and access to graduates who are well trained in the field of wind energy

7. Strategic networking and synergistic cooperation opportunities with complementary and competitor companies
Timeline for Joining WindSTAR

1. Attend the next WindSTAR Center IAB Meeting to define research topics with all potential industry members.
   - January at University of Texas Dallas
   - June at UMass Lowell

2. Decide whether becoming a member makes sense for your company and provide a membership fee and sign the membership agreement.

3. WindSTAR I/UCRC will execute its next set of research projects starting September 2015.
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Phone: 401-247-4009
Facilitating Industry by Engineering, Roadmapping and Science for the Composites Industry

FLBERS
Facilitating Industry by Engineering, Roadmapping and Science Composites Industry Consortium

NIST
National Institute of Standards and Technology
U.S. Department of Commerce
# Industry Participation

Companies Providing Letters of Interest for Proposal

<table>
<thead>
<tr>
<th>ARKEMA</th>
<th>ATK</th>
<th>Aurora</th>
<th>Automated Dynamics</th>
<th>BOWMAN</th>
<th>Performance</th>
<th>CW Composites World</th>
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<tr>
<td>CYTEC</td>
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<td>M</td>
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<td>Texit</td>
<td>Thermo Scientific</td>
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<td>Vistex Composites</td>
<td>WARRIOR</td>
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<td>TSI</td>
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University / Non-Profit / Government Participation
Supply Chain and Life Cycle

Raw Materials
- Core Materials
- Fiber Production
- Resin Production

Conversion
- Braiding
- Coating
- Compounding
- Prepreging
- Weaving
- Winding

Manufacturing
- Autoclave
- Infusion
- Molding
- OoA
- Process Design
- Stamping
- Tooling

Applications
- Aerospace
- Automotive
- Energy
- Infrastructure
- Marine
- Military
- Sports

Recycling
Industry Sectors

Aerospace

Automotive

Military

Marine

Sports / Recreation

Architectural

Energy

Infrastructure

Rail

Other Piping / Rebar / Pressure Vessels