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Strengthening
University-Industry
Partnerships

The National Science Foundation
Industry University Cooperative Research Center Webinar
Program

The Center for Wind Energy, Science, Technology and Research
(WindSTAR) and the Center for GRid-connected Advanced
Power Electronic Systems (GRAPES)





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



*Wind-Energy Science, Technology, and Research
Industry/University Cooperative Research Center*



Christopher Niezrecki
Center Director



Mario A. Rotea
Site Director

I/UCRC Webinar Series
December 12, 2018



Our goals are to:

- Conduct research that **benefits our industry members**
- Bring together **university and industry** researchers to conduct basic and applied research on wind energy
- Combine **state-of-the-art capabilities and knowledge** to execute projects relevant 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**
- Help to make wind energy widespread by **lowering the LCOE**: through increases in performance, improved reliability, material components, and modeling capabilities, as well as reduced capital/operating expenditures of wind turbine systems.



General info

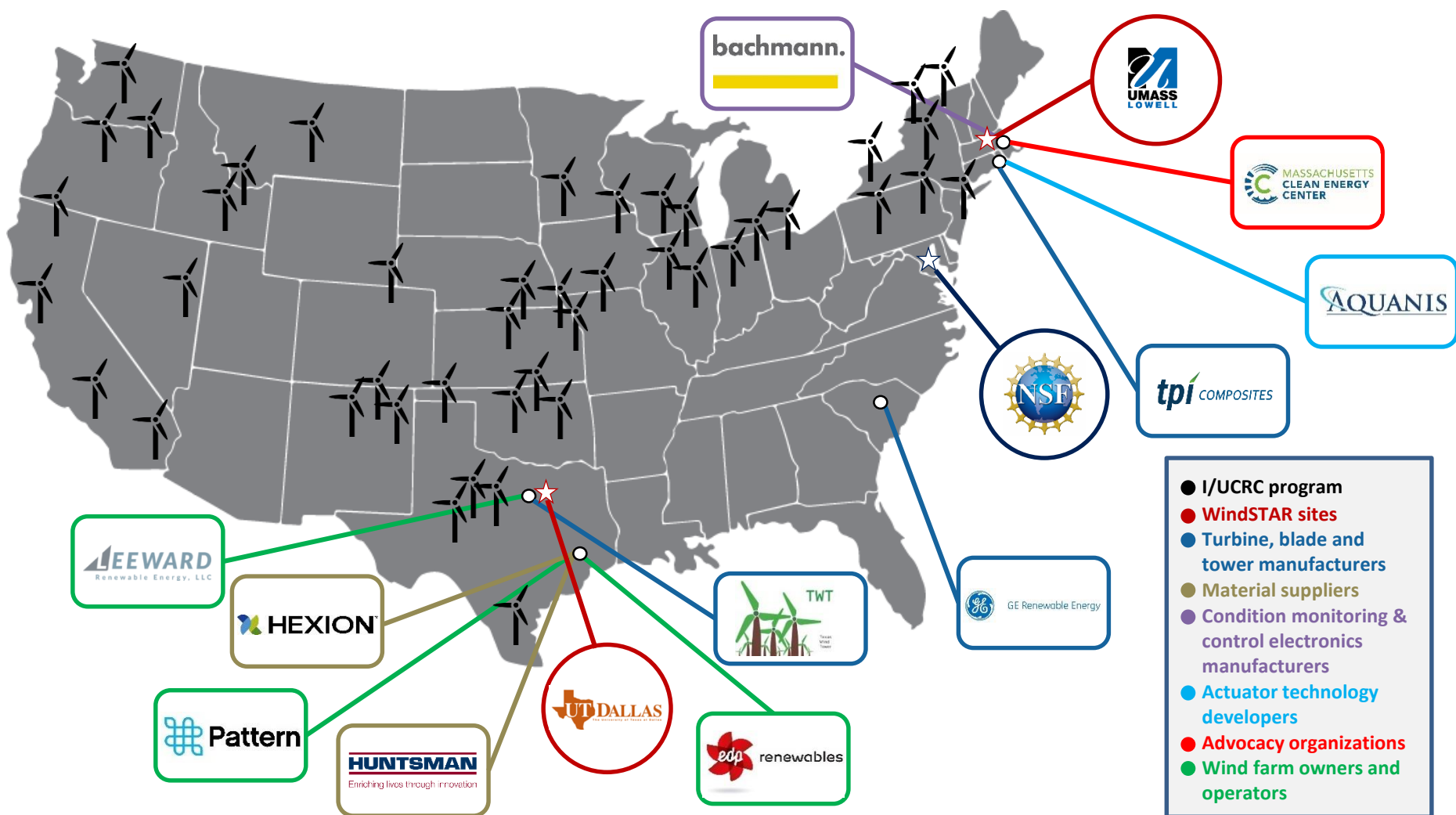
- Established in 2014
 - Completing NSF I/UCRC Phase I in 2019
 - Planning NSF I/UCRC Phase II for 2019 - 2024
- Major Annual Meetings/Events
 - June Industrial Advisory Board (IAB) Meeting (typically in Massachusetts)
 - January IAB Meeting (typically in Texas)
 - September WindSTAR Day (online webinars for final project presentations)
- Research projects
 - Project year – September 1 through August 31 (typically 1-year duration)
 - To Date, the Center has completed 22 research projects
 - Center has 9 additional research projects underway



www.uml.edu/WindSTAR



Participation





Center Leadership



Directors:



Center Director:

Christopher Nierecki, Ph.D.
University of Massachusetts Lowell



Site Director:

Mario Rotea, Ph.D.
University of Texas at Dallas

Operations:



Assistant Director for Operations:

Patrick Drane
University of Massachusetts Lowell

IAB Chairs:



IAB Chair:

Nicholas Althoff
GE - Senior Engr. Manager, Wind Advanced Technologies



IAB Co-Chair:

Neal Fine
Aquanis - CEO



IAB Past Chairs:

Stephen C. Nolet (2014-15)
TPI Composites, Inc.



Justin Johnson (2015-16)
EDP Renewables



Stephen Johnson (2016-17)
GE Renewable Energy



Ben Rice (2017-18)
Pattern Operators





Resources

- Leverage of the resources of two public research universities
 - **UMass Lowell** focuses on projects that advance the **materials, manufacturing, reliability, testing, modeling and monitoring** of turbines as well as **energy storage and transmission**.
 - **UT Dallas** focuses on **high-fidelity simulations** of wind power systems and components, **LiDAR measurements** and **analysis** of wind fields for diagnostics and model validation, Boundary layer and subsonic **wind tunnel testing, control system design** for wind turbines and farms, **large rotor design, grid integration** and **energy storage**.

Together 35+ faculty bring tremendous expertise to the Center:

- Composites, Mechanics, and Materials (8)
- Control Systems & Optimization (5)
- Fluid Mechanics (6)
- Geotechnical Engineering (3)
- Software Engineering (1)
- Structural Health Monitoring, Vibration, Acoustics, and Inspection (6)
- Other Engineering and Business (6)



Facilities and Laboratories



- Structural Dynamics and Acoustics Systems Laboratory (UML)
- Advanced Composites Materials and Textile Research Laboratory (UML)
- Control Systems Laboratory (UTD)
- Test Bed for Dynamic Visualization of Wind Farms (UTD)
- Access to the NREL/MassCEC - Wind Technology Testing Center
- Wind, Fluids, and eXperiments (WindFLuX) Lab (UTD)
- Boundary Layer and Subsonic (BLAST) Wind Tunnel (UTD)
- High-Performance Computing Centers (UTD & UML)
- Other:
 - Renewable Energy and Vehicular Technology Laboratory (UTD)
 - Security Analysis and Information Assurance Lab (UTD)
 - Renewable Energy Laboratory (UML)
 - Wet Chemistry Laboratory (UML)
 - Thermal Analysis Laboratory (UML)
 - Materials Characterization Laboratory (UML)
 - Processing Laboratories (UML)
 - Composites Engineering Research Laboratory (MCA)





UTD Mobile Research Facility



Mobile Research Van

- Dodge RAM 2500 Promaster Cargo commercial van
- Long wheelbase, extra height interior
- Set up for towing, e.g., LiDAR trailer

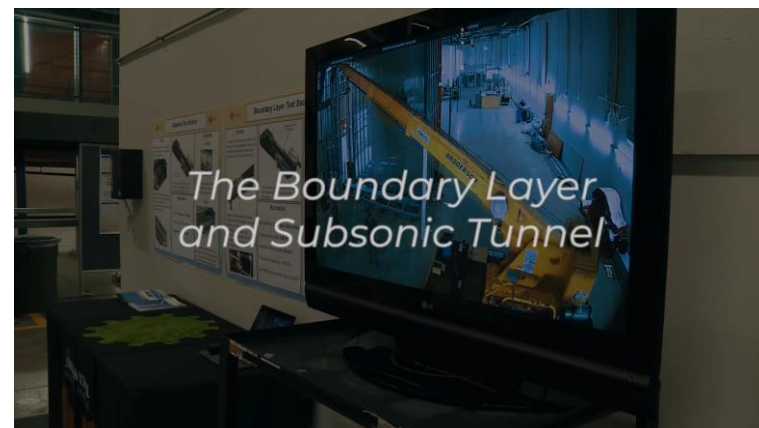
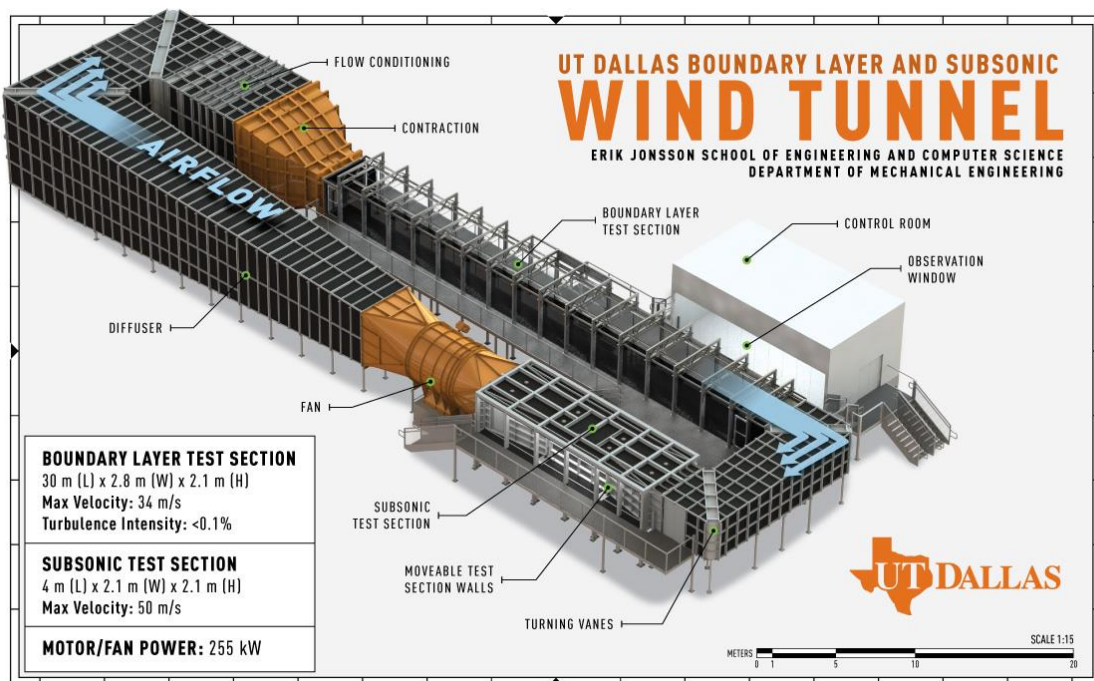
LiDAR Trailer

- 14', extra-height trailer providing safe transport and storage of LiDAR instrument and associated gear
- Carry 4KW power generation capability, tools, support equipment





UTD BLAST Wind Tunnel





Research Thrust Areas



Composites and Blade Manufacturing

- Design and methods
- Next generation materials



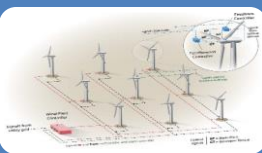
Structural Health Monitoring and NDI

- 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

Snapshot of projects completed in 2018:

6 Projects
10 faculty members
8 graduate students
2 undergraduates

2 Projects
5 faculty
4 graduate students

1 Projects
1 faculty
4 undergrad students



Major Outcomes

- 22 Final Project Reports and Presentations to our Members
- 5 Software
- 1 Patent Filing
- 3 Hardware Developments
- 9 Journal Publications
- 2 Masters Theses
- 3 Doctoral Dissertations
- 21 Conference Publications
- IACMI Project Funding
- ARPA-E – \$3.5M Funding

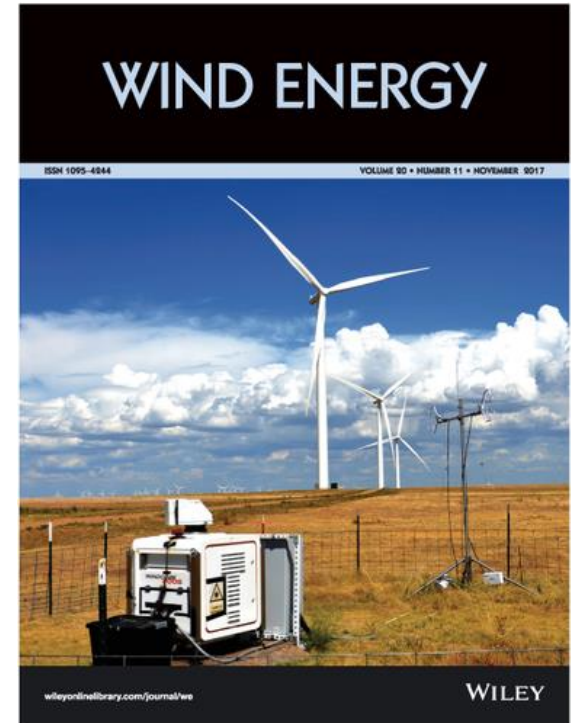


Photo of the deployment of the UT Dallas mobile LiDAR station on the cover of *Wind Energy*, Vol 20, Issue 11, Nov 2017.

Wind Farm Model - LiDAR data

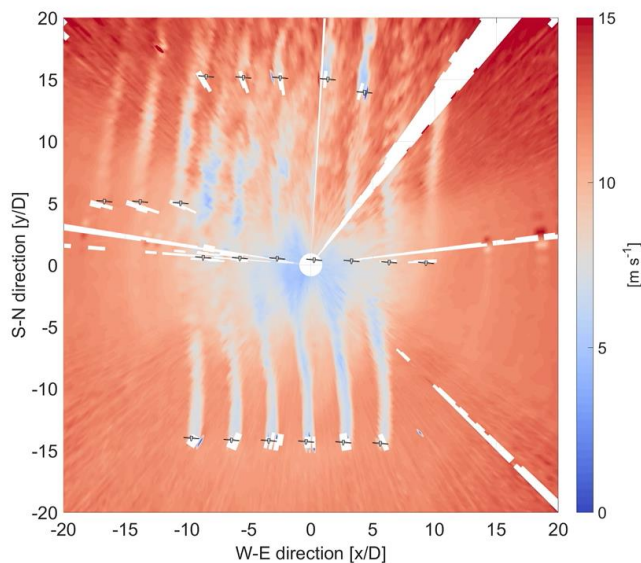


PI: G. Valerio Iungo
Valerio.iungo@utdallas.edu

Objective: Develop a reduced order model to predict wind turbine wakes and power capture

- Characterization of wind farm performance through SCADA, meteorological and LiDAR data
- Probing wind turbine wakes through LiDAR measurements for different atmospheric conditions and turbine settings
- Capability to predict power production from individual wind turbines, wake interactions and turbine power capture with low computational costs.

LiDAR Measurements



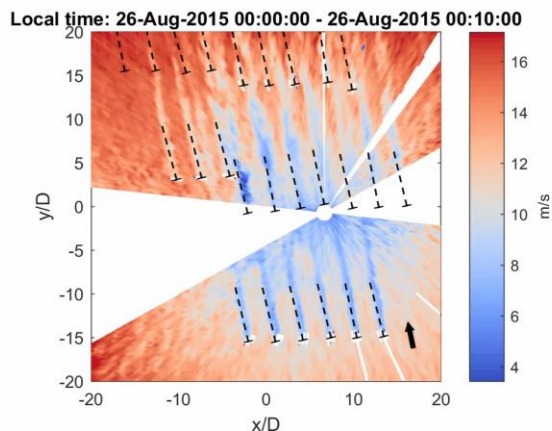
UTD mobile
LiDAR station



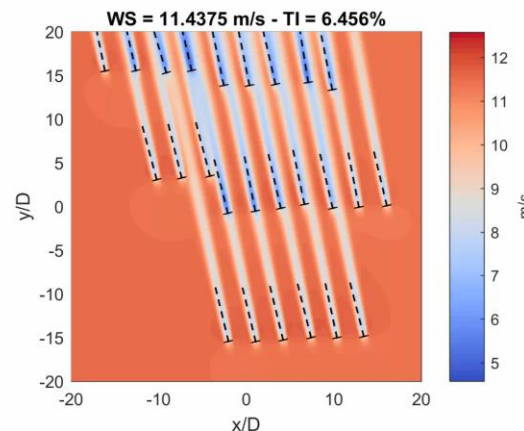


Accuracy Quantification

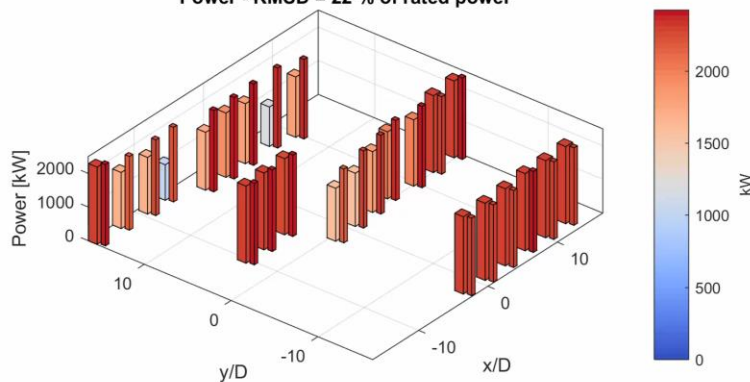
LiDAR



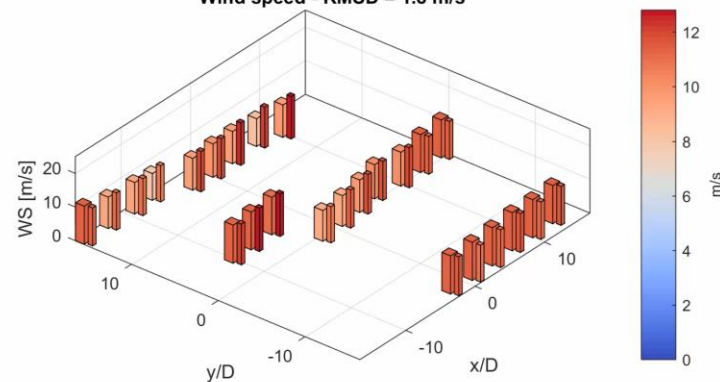
RANS



Power - RMSD = 22 % of rated power



Wind speed - RMSD = 1.8 m/s



SCADA vs RANS: power

SCADA vs RANS: wind speed



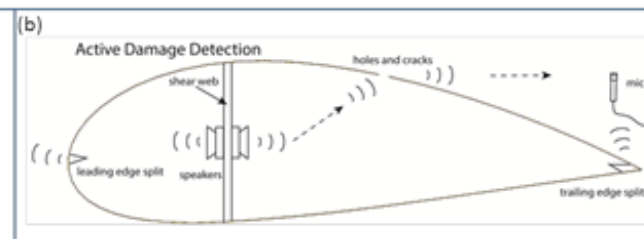
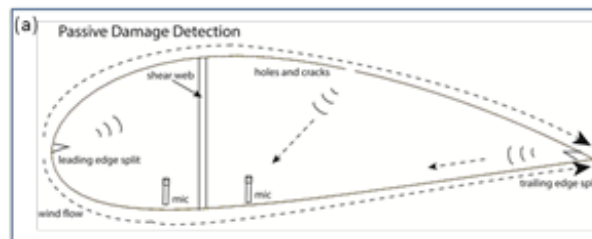
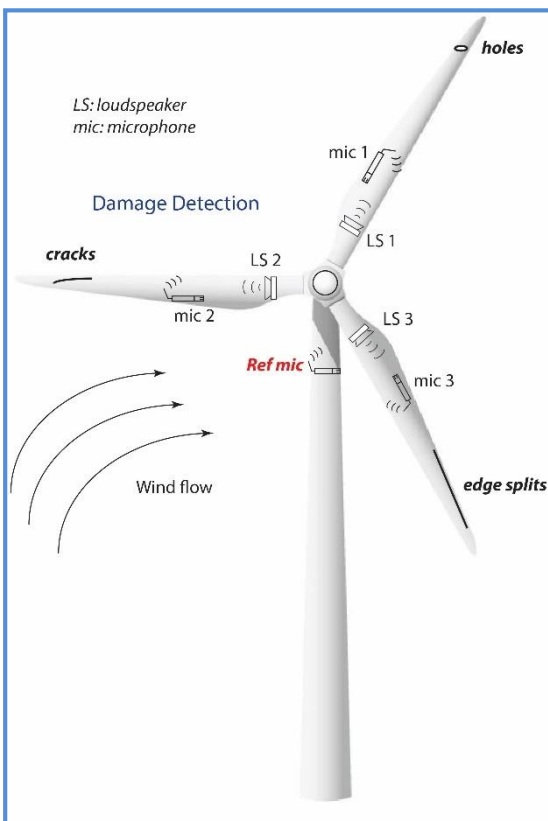
Low-cost Acoustics-based Blade Monitoring



PI: Murat Inalpolat
Murat_Inalpolat@uml.edu

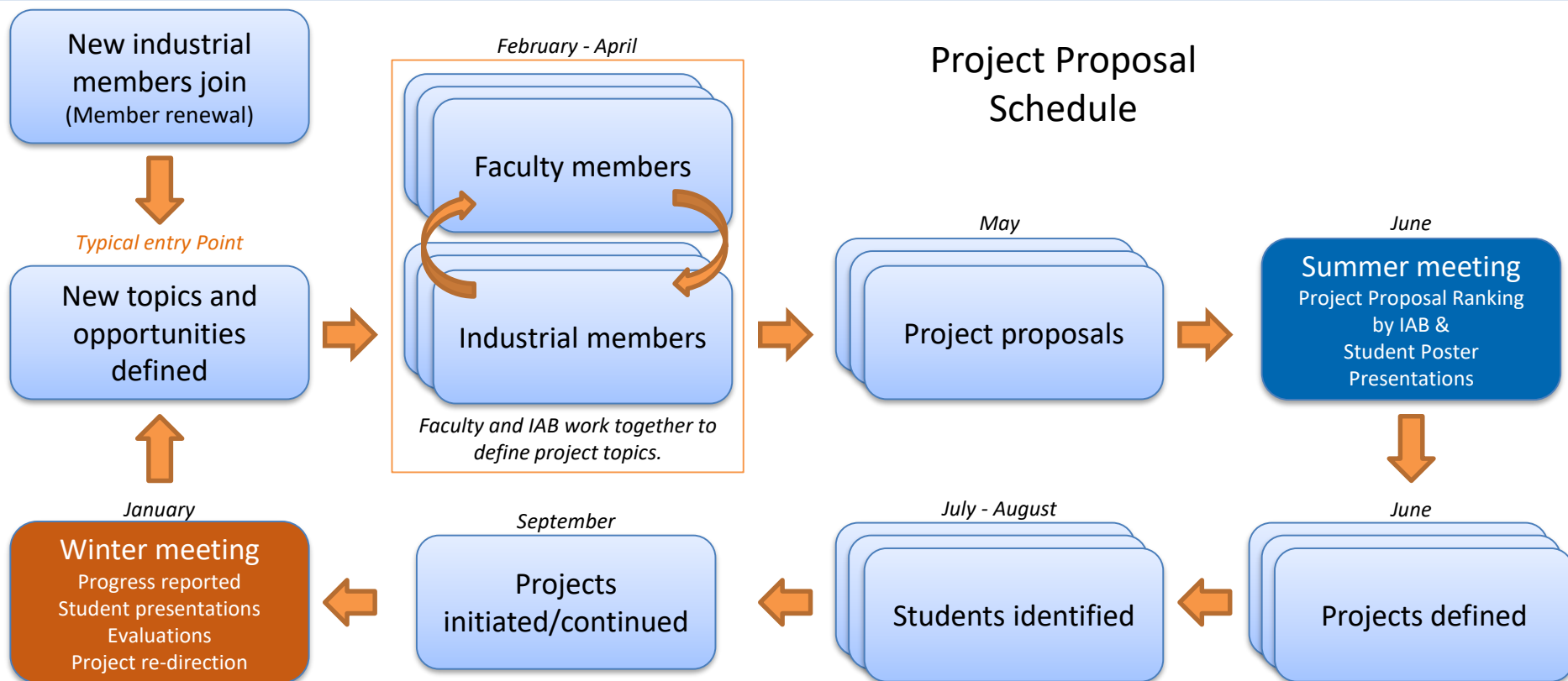
Objective: Develop a low-cost monitoring blade monitoring solution that will help reduce O&M costs

- Reduce the need for total blade replacement by identifying issues before they become significant or catastrophic.
- Reduce the need for unscheduled maintenance.
- Improve turbine availability and reduce repair costs.
- Can be used on new and existing turbines (retrofit).
- Can be used both on on-shore and off-shore turbines.
- Costs less than existing monitoring methods.





Annual Schedule



Project Schedule





Membership



- Company joins as a *Full Member* - \$42,400/year membership fee, or a *Small Business Associate Member* - \$15,900/year
 - NSF supplements may decrease SB fee to \$5,000 if member has NSF SBIR
- Pooling money improves **return on investment** in new technology with a ~16:1 leveraging of membership fee and only 10% overhead rate (~60% is typical)
- Industry **members direct** the selection and execution of **research** topics across a broad range of researchers and facilities at multiple universities
- **Sharing risk** at an early stage in research is a good business strategy
- **Royalty-free licenses** to technology generated through the Center and **pre-publication access** to research results
- The Center allows us to pursue other sources of **funding**
- **Student engagement** - resume book and access to graduates who are well trained in the field of wind energy
- **Strategic networking** and synergistic cooperation opportunities with complementary *and* competitor companies



Member Statements



*“EDPR benefits from the knowledge established within the consortium and shared with the participants. This is **invaluable in assessing and proposing potential improvement initiatives** within the company.”*

– Brian Hayes
Executive Vice President
EDP Renewables

*“The center has the **resources** needed to create the right environment for successful research that **benefits the industry**.”*

– Nicholas Althoff
Sr. Adv. Mfg. Engineer
GE Renewable Energy

*“They have done a remarkable job in recruiting a cadre of **highly qualified and motivated students** that carry out the **projects essential to driving forward technologies** in the design, manufacturing, inspection and life-time management of critical components for energy generated by wind power.”*

– Stephen Nolet
Senior Director
TPI Composites

*“Through the relationships that we have built through WindSTAR, we were able to put together a successful bid for an extremely competitive ARPA-E award. The team, led by Aquanis and supported by UTD, WindSTAR member TPI Composites, and potential member Sandia National Labs, will receive **\$3.5M in funding** to develop and test an active load control solution for wind turbines.”*

– Neal Fine, PhD
CEO, Aquanis



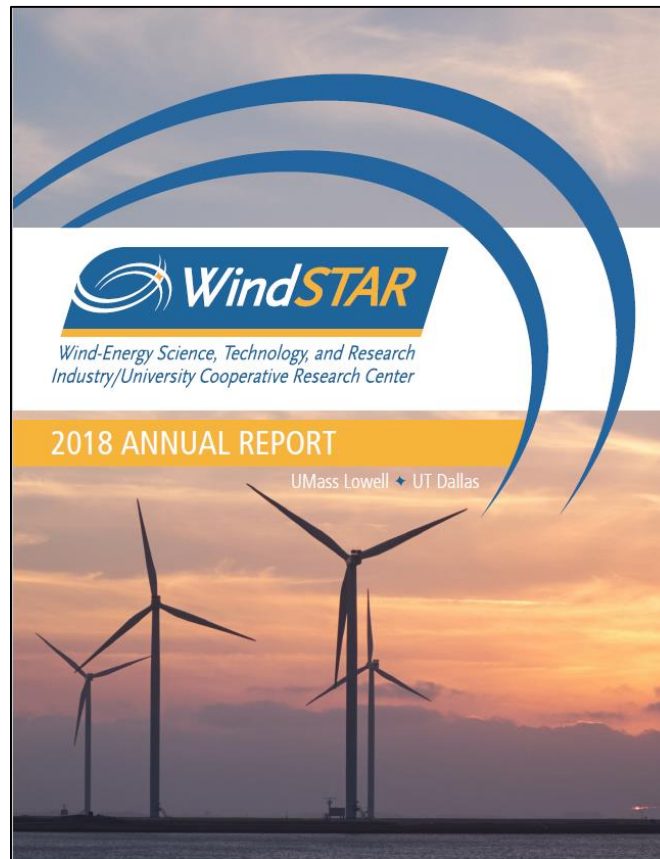
Timeline for Joining

- Membership Year Begins in June
 - Mid-year Joining of Center can be negotiated at a prorated Fee under special circumstances.
- Prospective members are invited to attend the next **WindSTAR Center IAB Meeting as a guest (single time) to learn about our Center and its operation.**
 - Winter at the University of Texas Dallas
 - Summer at UMass Lowell
 - All Guests are required to sign and NDA
- **Decide** whether becoming a member makes sense for your company and provide a **membership fee** and sign the **membership agreement**.
- WindSTAR I/UCRC will execute its **next set** of research projects starting September 2019.





For More Information



www.uml.edu/WindSTAR



www.uml.edu/WindSTAR



For more information, contact:

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For a WindSTAR reference, contact:

Industrial Advisory Board Chair:

Nicholas Althoff
GE - Senior Engr. Manager, Wind Advanced Technologies
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Phone: 608-451-5740



Industrial Advisory Board Member

Adam Johs
EDP Renewables - Performance Management
E-mail: Adam.Johs@edpr.com
Phone: 361-920-1325



Industrial Advisory Board Member:

Ben Rice
Manager, Operations Engineering
E-mail: Benjamin.Rice@patternenergy.com
Phone: 713-308-4212



Industrial Advisory Board Member:

Stephen C. Nolet
TPI Composites, Inc. - Principal Engineer, Senior Director
E-mail: snolet@tpicomposites.com
Phone: 401-247-4009



QUESTIONS?



Strengthening
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GRAPES

GRid-connected Advanced Power Electronic Systems

NSF Industry/University Cooperative Research Center

H. Alan Mantooth

Executive Director

21st Century Research Leadership Chair

Distinguished Professor of Electrical Engineering

mantooth@uark.edu; 479-575-4838

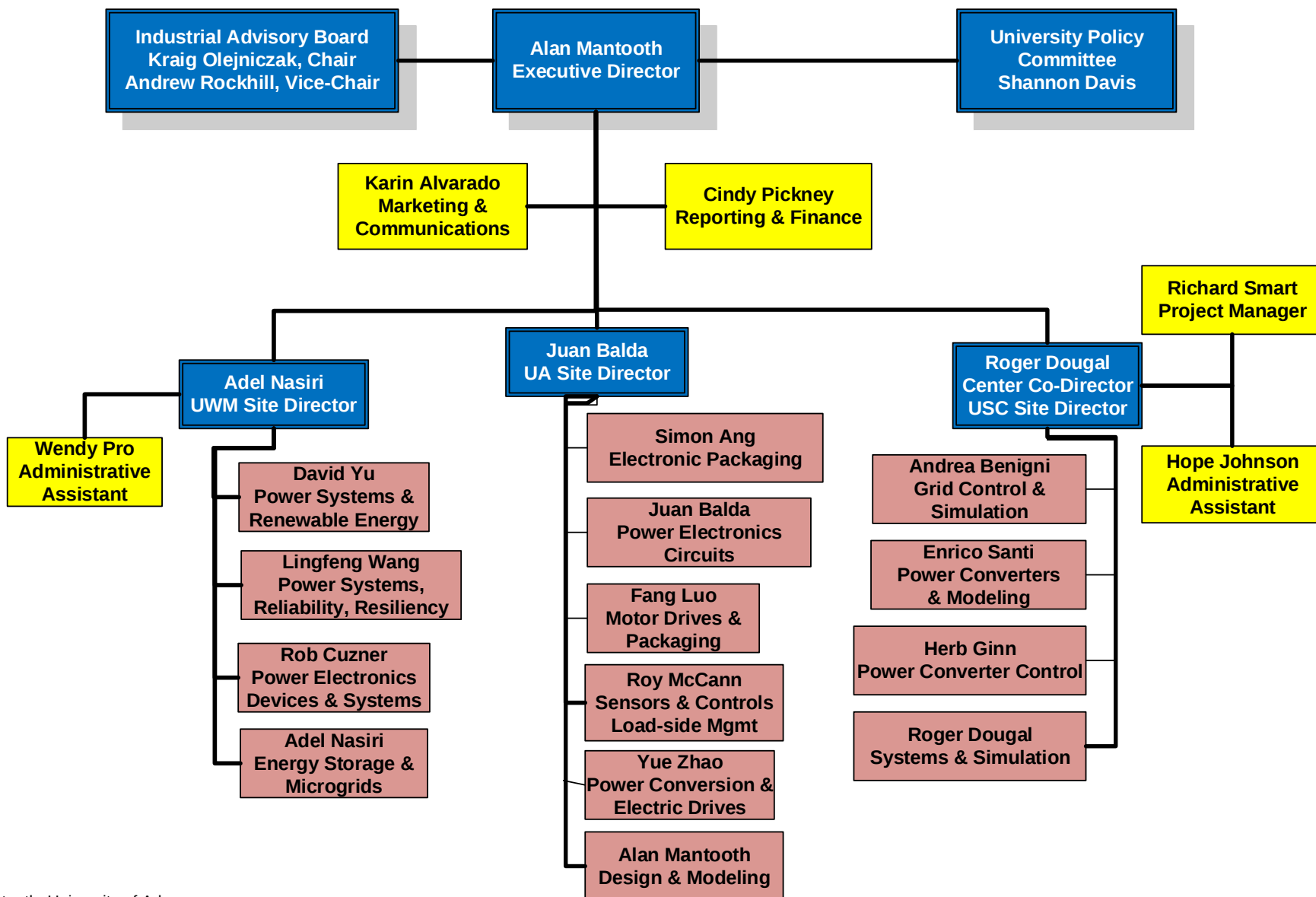
December 12, 2018

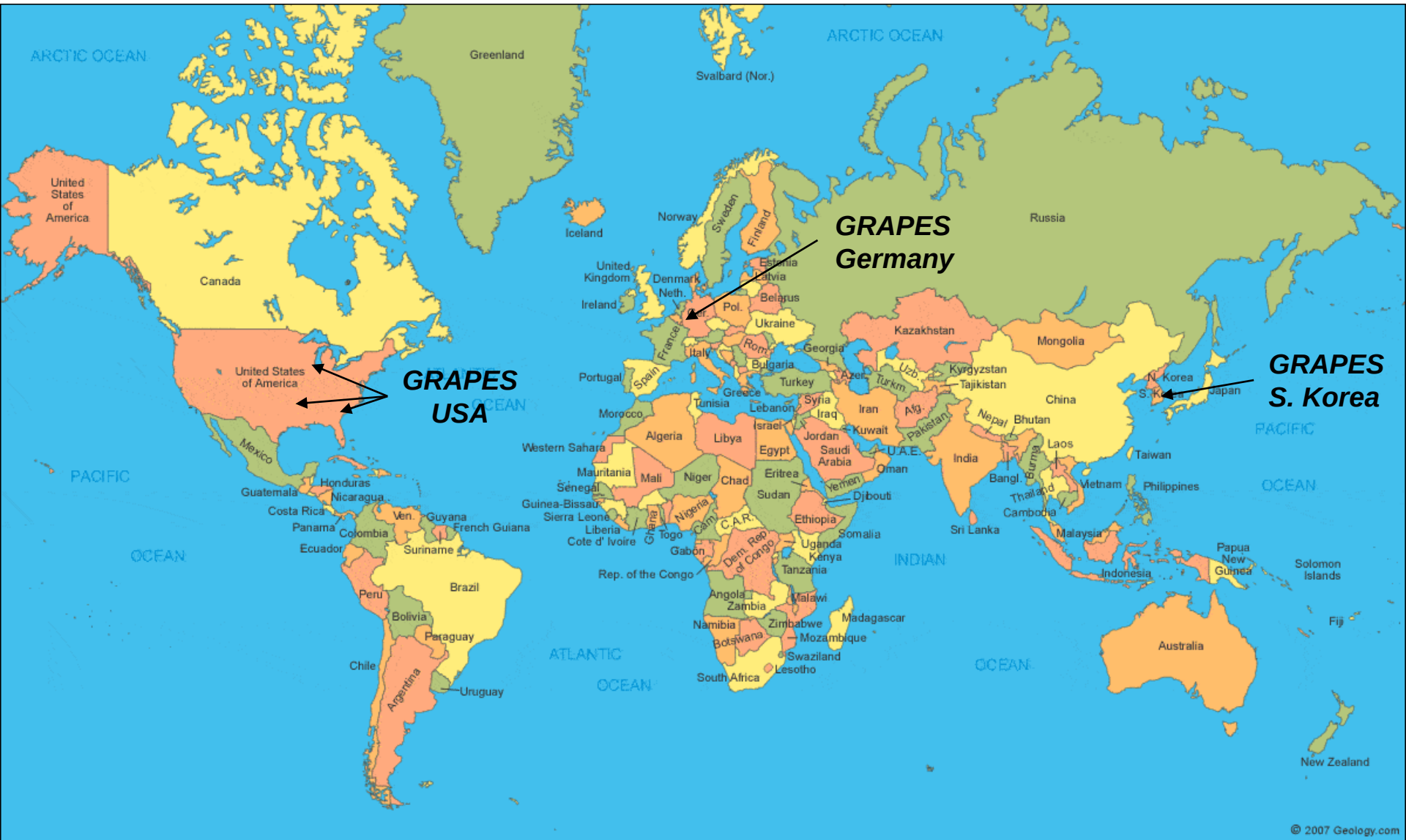
The mission of GRAPES is to:

- ✓ *create a smarter, more resilient electric power grid through power electronics technologies*
- ✓ *Create and encourage an **evolution to revolution!***

The GRAPES vision is:

- *To be a model industry-sponsored research center*
- *To provide member value through advanced technologies in grid-connected power electronic systems*





18 Member Companies

- *Members pay a \$40,000 annual fee*
- *Small businesses pay a \$5,000 annual fee*



Schlumberger

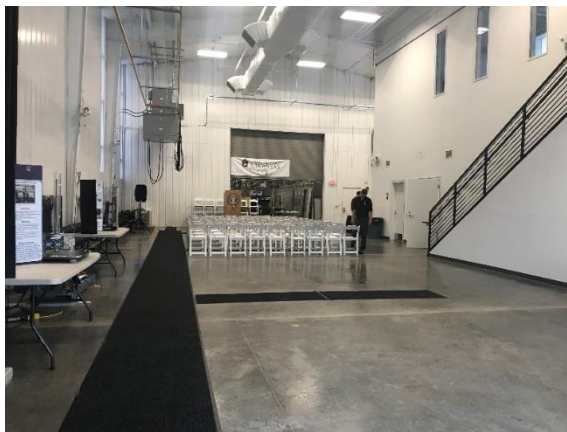


➤ Existing Building

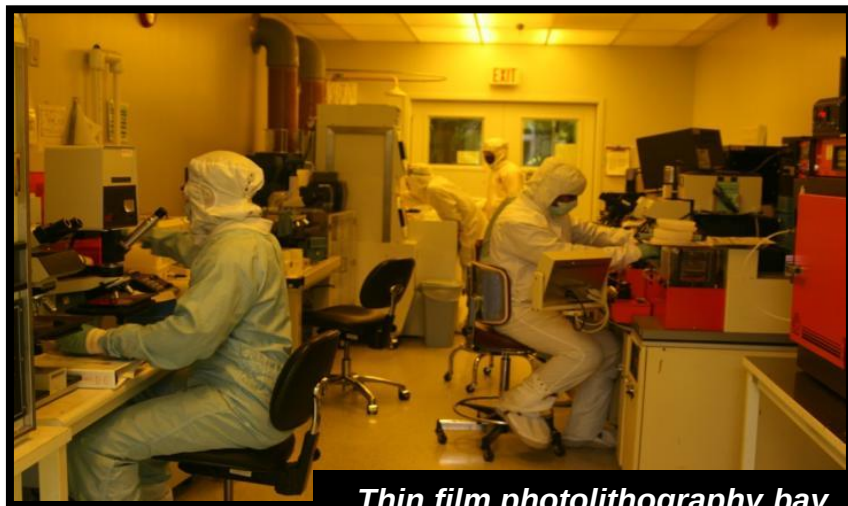
- 7,000 sq. ft.
- 120' x 50' + 20' x 50' (2nd)

➤ Expansion Project Additions

- Additional 4,800 sq. ft.
- 80' x 50' + 12' x 62' (2nd)
- 1500 V / 1500 A dc Bus
- 480 V / 1200 A ac Bus
- SCIF (Secret Rating) [400 sq. ft.]
- Office space for students/faculty
- Server/IT room to support Cyber research
- 120 ton chiller



Parameter	Rating
Power	up to 6 MVA (3 x 2 MVA Circuits)
Medium Voltage (ac)	13.8 kV or 4.16 kV (line-line) Variable from 0 V to 15.18 kV
Low Voltages (ac)	480 V (line-line), Variable from 0 V to 528 V
Frequency	40 Hz to 70 Hz Values outside this range (up to 400 Hz or down to 20 Hz) are possible, but require de-rating
Currents (ac)	300 A at 13.8 kV 1,000 A at 4.16 kV 2,500 A at 480 V
Loads	Active loads fully programmable; Test energy is recirculated 700 kW Resistive Load Bank Various Passive Components Available
Active Cooling	120 ton Chiller (420 kW Heat Rejection)
DC	2.25 MW (1500 Vdc / 1500 A) [Construction In Progress] 750 kW (660 Vdc / 1.1 kA)
Dynamometer	100 kW with Overload Capability 6,600 rpm @ 220 Nm



Thin film photolithography bay



Electronics assembly Lab



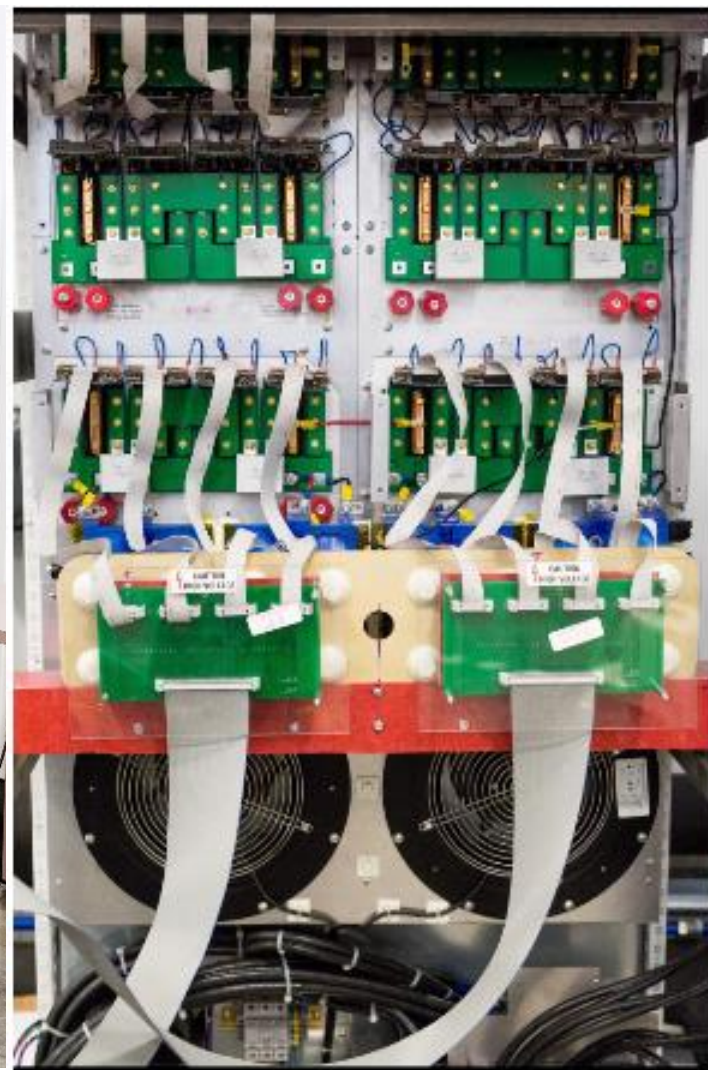
*Low temperature co-fired
ceramics lab*

- **Residential Power Router => Scalable to MW**
- **Transmission Load Flow**
- **Microgrid Research**
- **Wind Farm Power Quality**
- **Next Generation Electronics Technologies for PE**
- **Electric Vehicle Charging**
- **Energy Storage Electronics**
- **Grid Protection & Resiliency Devices**
- **Solar Inverters**
- **Additional projects funded by:**
 - **Army Research Lab**
 - **ARPAe**
 - **DoE**
 - **NSF**
 - **Industry directly**



Medium Voltage Cabinet Level Prototype

- Integrating a battery energy storage into a medium voltage distribution system (13.8 kV) without a bulk step-up 60 Hz transformer



Nine Level Cascaded H-Bridge

- Using ≥ 6.5 kV SiC modules for power electronics interface
- Minimizing the number of modules and complexity

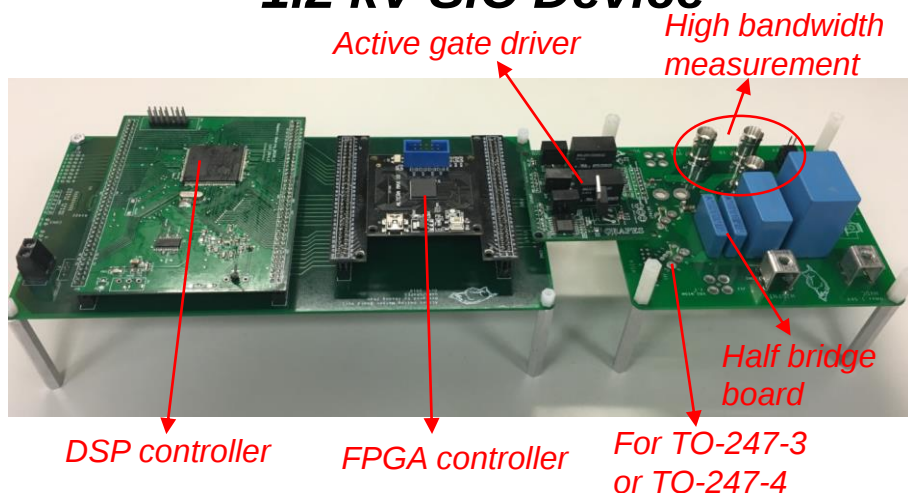
Background and Major Challenges

- Design an intelligent gate driver board for 1.2 kV and 10 kV SiC MOSFET
- Suppress the high EMI noise of SiC power device
- Provide isolation capability for the high voltage (1.2 kV and 10 kV).
- The protection of the SiC power MOSFET.

Main Approach

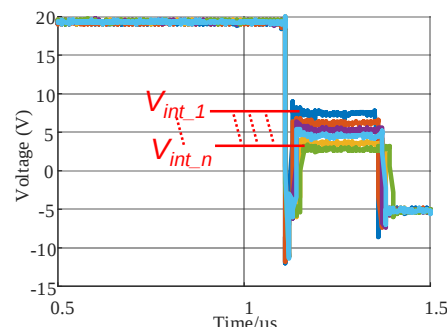
- A novel switching profile to suppress dv/dt and di/dt without increasing switching delay time
- Novel circuitry for multi-level active gate driver
- Model predictive control for the switching transient process

Prototype of Active Gate Driver for 1.2 kV SiC Device

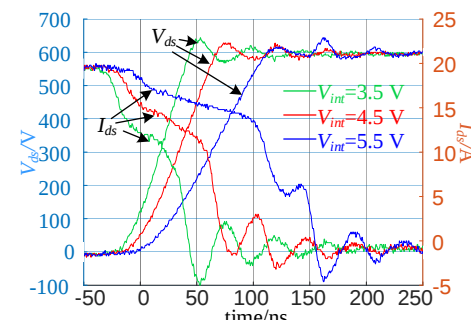


Experimental Results

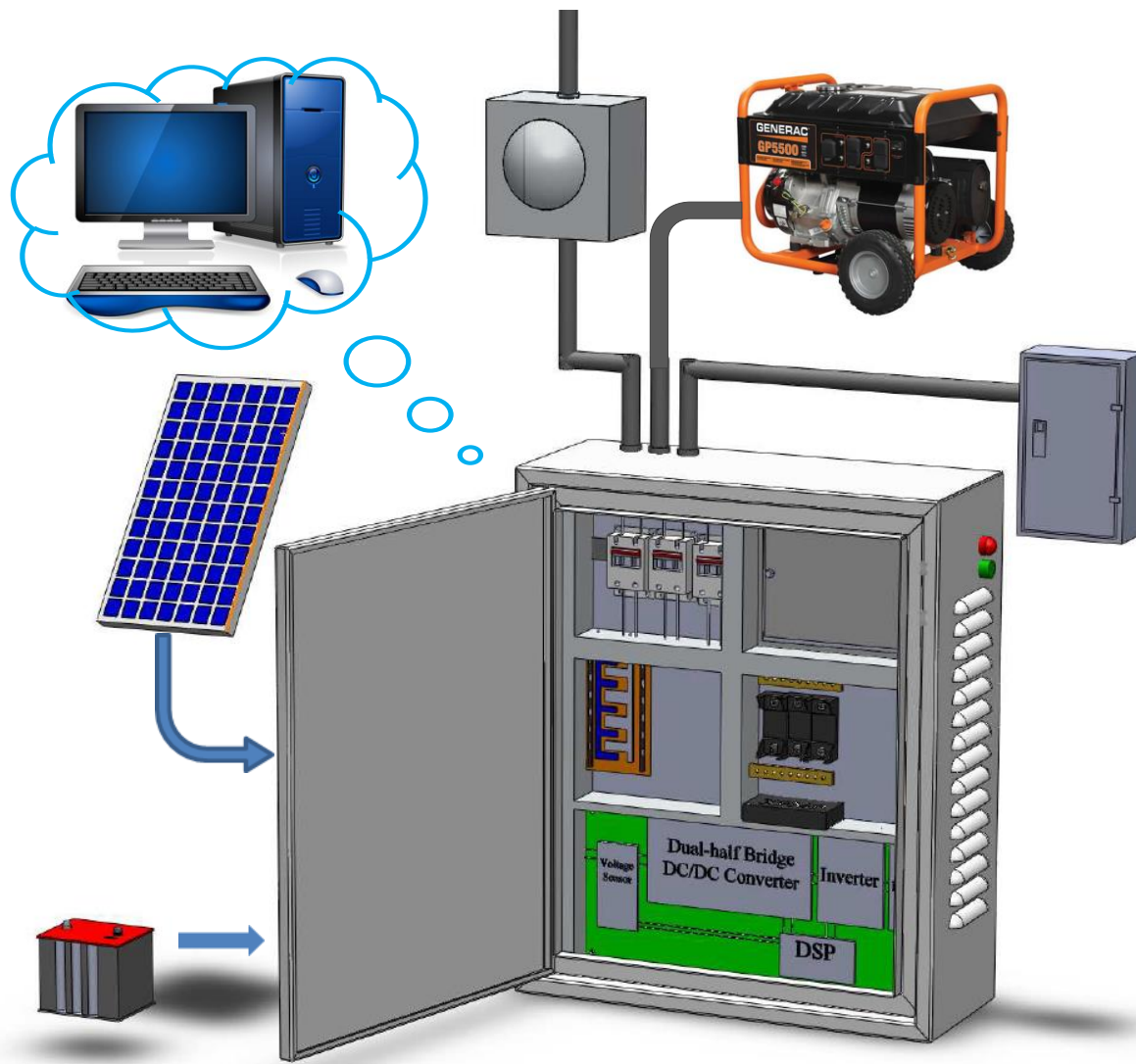
- ✓ Super accurate: 64 levels voltage adjustment.
- ✓ Super fast: 10 ns adjustment speed.
- ✓ Super smart: With switching process optimization to maximize the performance of SiC power devices



The output voltage of the gate driver at multi-level turn-off.



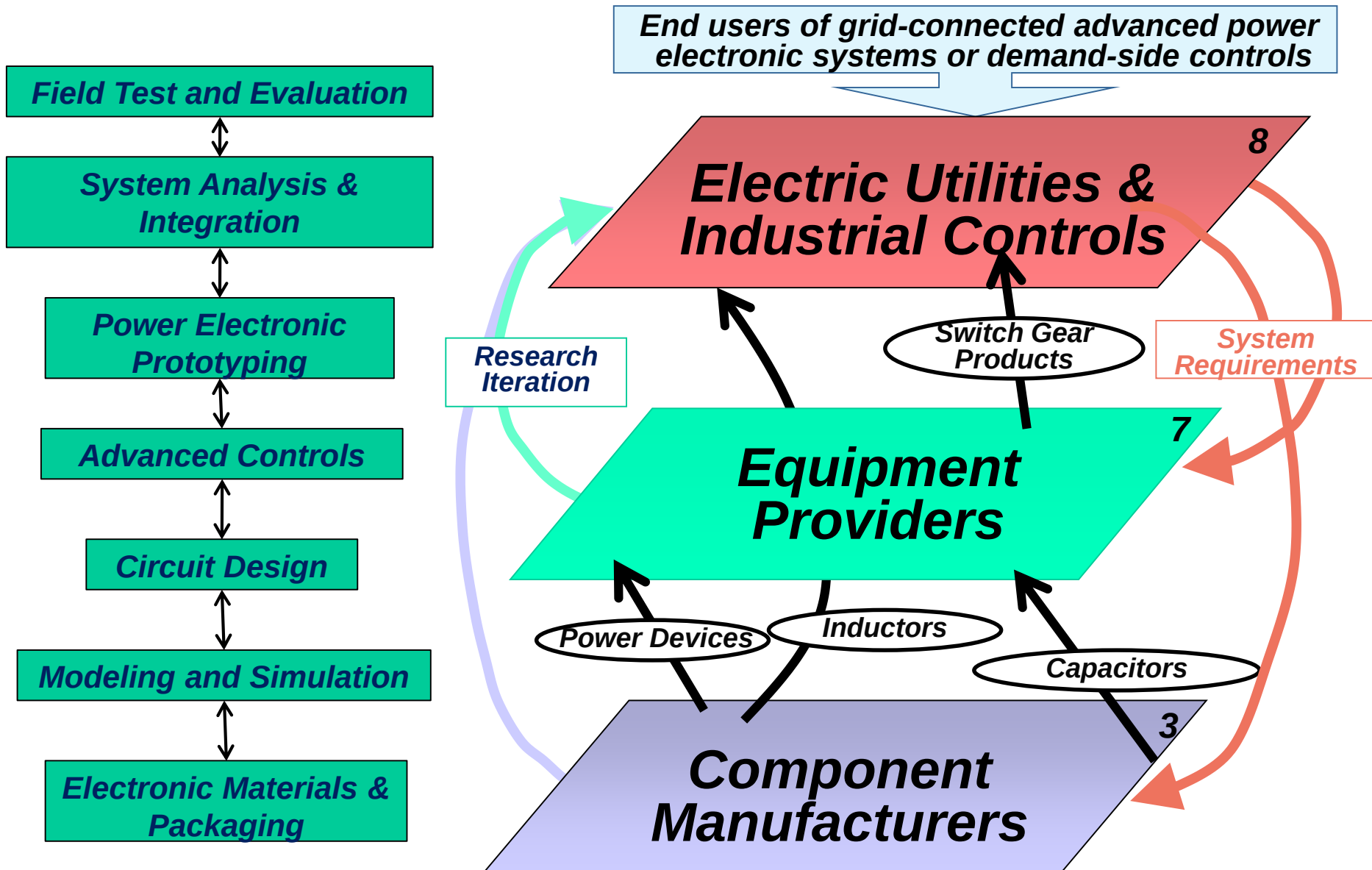
The turn-off waveform of SiC power MOSFET under different V_{int}



Intelligent Power Router:

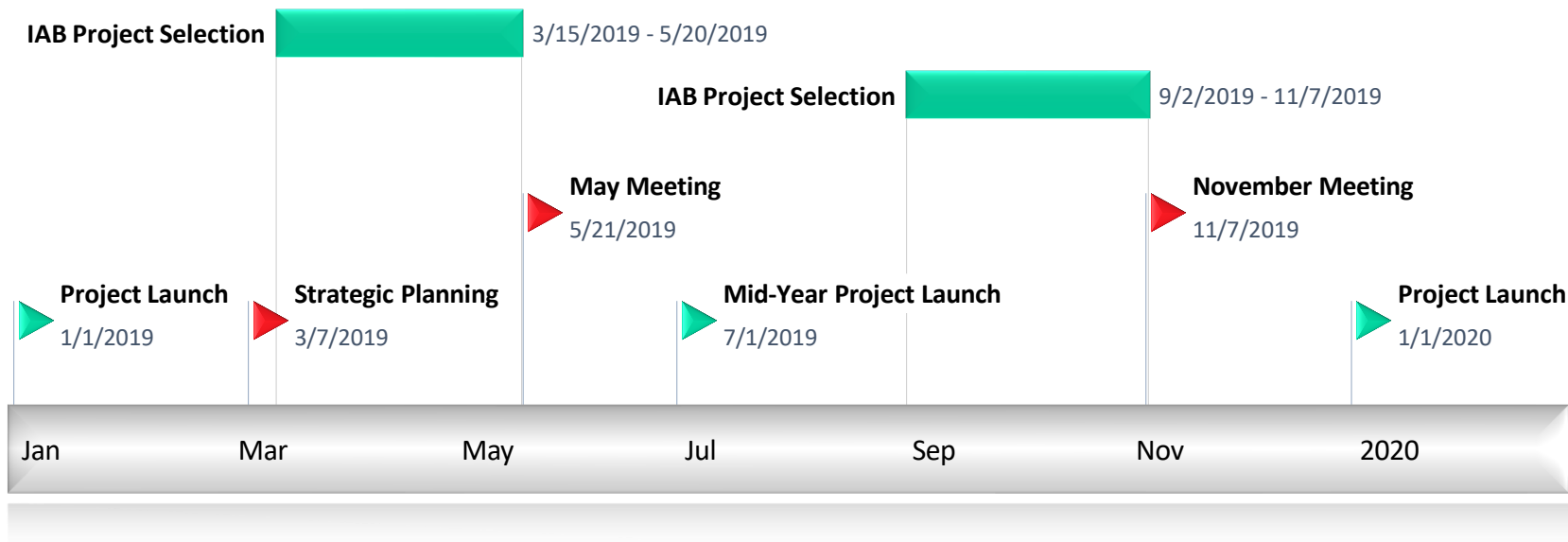
- ***Takes in weather and time of use pricing data***
- ***Directs power from grid or other assets such as solar, storage, generator***
- ***Sits between meter and breaker box***
- ***Operates in islanded or grid-connected mode***
- ***Prototyped and tested***
- ***Available for licensing***





- **Has voting and non-voting members**
- **Paying members have voting privileges for project selection and shared IP rights**
- **Reviews project proposals and recommends funding choices to Directors**
- **Monitors progress of projects => best way to ensure value to your company is to be involved in the projects! (webinar series, reports, strategic planning groups, nuggets)**
- **Advises Directors & Staff on Center Operations**

- 1. GRAPES faculty present project proposals at one of two semi-annual meetings**
- 2. Members vote on projects of interest (40 votes per full membership; 5 votes for small membership)**
- 3. Highest voted projects are discussed in the IAB against available budget to finalize recommendations to Directors**
- 4. Each project lead will submit a detailed budget and SOW to Center Directors within 21 days**
- 5. Directors will review, consolidate budgets, send to IAB for information by e-mail within 10 days**



2020



- **A graying workforce and evolving electric power grid needs well-educated talent**
- **GRAPES provides access to unique expertise**
- **GRAPES provides access to unique facilities**
- **Research is award-winning and widely recognized**
- **Research is industry-driven from concept to prototype**
- **Research is pre-competitive; shared IP model**
- **Center model customer-supplier oriented and collaborative**
- **Membership is cost-effective**

- **For a \$40,000 annual fee, members leverage a \$10-20 million dollar research institute!!**
- **GRAPES has received ~\$2 million in NSF funds; ~\$6 million in industry funds; ~\$10 million in university support**
- **GRAPES has or is leveraging a research agenda of over \$10-20 million per year in external funding domestically and another \$10-20 million through international sites!**
- **GRAPES began operation in Jan. 2010**
- **GRAPES is up for renewal in 2019; moving from Phase II to Phase III**

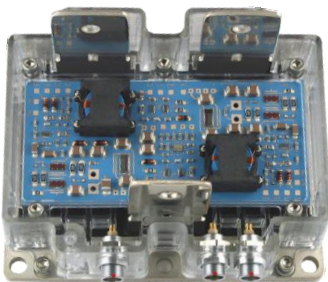
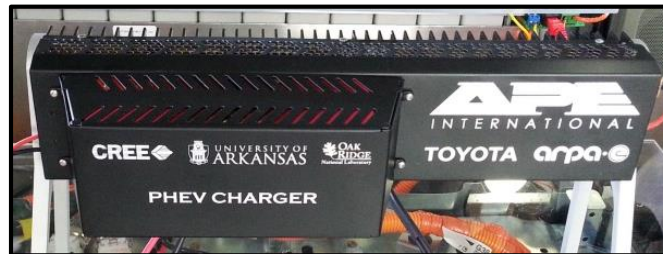
➤ Upcoming meetings:

- May 20-22, 2019 in Milwaukee, Wisconsin
- November 6-8, 2019 in Fayetteville, Arkansas

➤ NDA is required to attend as a guest

Join us as we transform the electric power grid!

- **3 R&D 100 Awards since 2009 – given for top 100 worldwide innovations that year**



**GRAPES**

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NSF Industry/University Cooperative Research Center***H. Alan Mantooth*****Executive Director****21st Century Research Leadership Chair****Distinguished Professor of Electrical Engineering****mantooth@uark.edu; 479-575-4838*****December 12, 2018***

QUESTIONS?



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Interested in university- industry partnerships?

Sign up for information about UIDP news,
webinars, projects, and more at
uidp.org/newsletter-signup.



Strengthening
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Partnerships

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