2014 WIND POWER PROGRAM PEER REVIEW

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

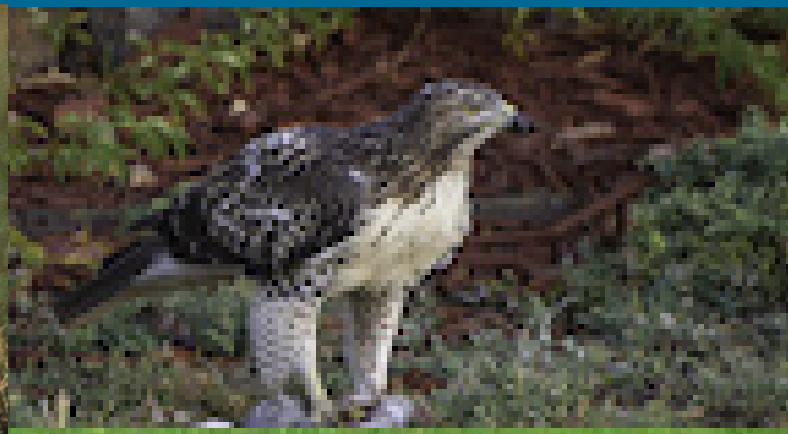

# Market Barrier Mitigation

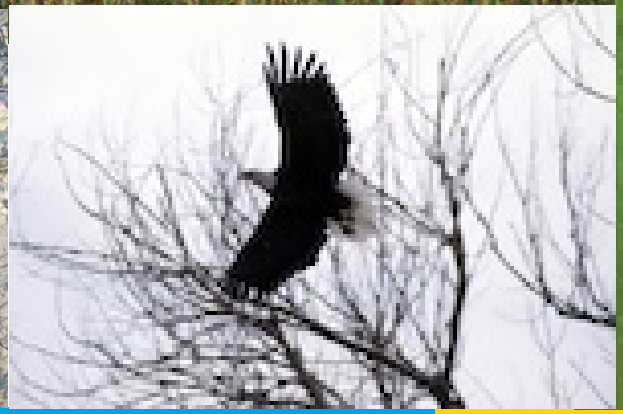
March 6-27, 2014

## Wind Energy Technologies

# Contents

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy





# Siting, Environmental and Permitting

**Karin Sinclair**

NREL

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March 25, 2014

# Budget, Purpose, & Objectives

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Total DOE Budget[1]: $1.701M

Total Cost-Share[1]:$4.305M

Problem Statement: Concerns for wildlife impacts from wind energy can—and do—create a barrier to deployment. Limited availability of scientifically robust research for a wide range of species and ecosystems makes it difficult to provide information to decision makers to facilitate lower-cost and more expeditious wind-project deployment.

Impact of Project: Scientifically based, peer-reviewed research results fostered through collaborative efforts contribute to achieving national wind deployment goals while avoiding, minimizing, and/or mitigating wildlife impacts.

This project aligns with the following DOE Program objectives and priorities:

- **Mitigate Market Barriers:** Reduce market barriers to preserve or expand access to quality wind resources

[1] ***Budget/Cost-Share for Period of Performance FY2012 – FY2013***

# Technical Approach



- Provide technical expertise on wildlife research activities and to key national and international collaboratives
- Support development of unbiased, scientifically rigorous research to facilitate widespread wind development, including in areas where species or habitat challenges exist
- Conduct analyses to allow for prioritization of issues requiring further research and support
- Facilitate access to wind wildlife data and literature

# Technical Approach



**Key issues currently being addressed:**

- Assessing impacts to sage grouse from wind energy
- Reducing bat fatalities at wind plants
- Improving coordination among international community on land and offshore wind/wildlife issues
- Mitigating golden eagle fatalities from wind energy
- Detecting birds and bats at offshore wind facilities

A majority of the work is conducted through collaboratives.

# Accomplishments and Progress



- Completed Wildlife Impacts Analysis, which identified key species concerns as related to the 20% scenario
- Continued Sage Grouse Collaborative field research
- Continued research to assess viability of operational curtailment to reduce bat fatalities at wind facilities (through the Bats and Wind Energy Cooperative)
- Started American Wind Wildlife Institute work to develop an eagle framework
- Provided technical support for Oregon State University to develop remote sensor array for offshore application

# Accomplishments and Progress



- IEA Wind Task 34—an international collaborative focused on land-based and onshore environmental issues
- Enhanced Wind-Wildlife Impacts Literature Database (WILD) and moved to Drupal platform

Location: Smøla, Norway. Photo Credit: Espen Lie Dahl

# Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

| Summary | |
|---|---|
| WBS Number or Agreement Number | 10.1.1 |
| Project Number | WE111005 |
| Agreement Number | 22719 |

| Legend | |
|---|---|
| | Work completed |
| | Active Task |
| | Milestones & Deliverables (Original Plan) |
| | Milestones & Deliverables (Actual) |

| Task / Event | FY2012 Q1 (Oct-Dec) | FY2012 Q2 (Jan-Mar) | FY2012 Q3 (Apr-Jun) | FY2012 Q4 (Jul-Sep) | FY2013 Q1 (Oct-Dec) | FY2013 Q2 (Jan-Mar) | FY2013 Q3 (Apr-Jun) | FY2013 Q4 (Jul-Sep) | FY2014 Q1 (Oct-Dec) | FY2014 Q2 (Jan-Mar) | FY2014 Q3 (Apr-Jun) | FY2014 Q4 (Jul-Sep) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Project Name: Environmental Siting & Permitting** | | | | | | | | | | | | |
| Q1 Milestone: Award NWCC facilitation subcontract | | | | | | | | | | | | |
| Q2 Milestone: BWEC Science Meeting report on research priorities | | | | | | | | | | | | |
| Q3 Milestone: SGC annual reports completed | | | | | | | | | | | | |
| Q4 Milestone: AWWI RIS User Requirements Document completed | | | | | | | | | | | | |
| Q1 Milestone: Complete preliminary impacts analysis (Regions 2 and 6) | | | | | | | | | | | | |
| Q2 Milestone: Complete preliminary impacts analysis (Regions 3 and 5, plus NC) | | | | | | | | | | | | |
| Q3 Milestone: Submit Draft Final Wildlife Impacts Analysis to DOE for review | | | | | | | | | | | | |
| Q4 Milestone: Submit Revised Draft Final Wildlife Impacts Analysis to DOE | | | | | | | | | | | | |
| Q1 Milestone: Provide OSU wind turbine vibration data | | | | | | | | | | | | |
| Q1 Milestone: BCI to complete analyses for synthesis reporting | | | | | | | | | | | | |
| Q1 Milestone: Compnlete Final Impacts Analysis report | | | | | | | | | | | | |
| Q2 Milestone: AWWI to complete draft miltigation workshop report | | | | | | | | | | | | |
| Q3 Milestone: BCI synthesis reports | | | | | | | | | | | | |
| Q3 Milestone: Report on outcome of SGC researcher's meeting | | | | | | | | | | | | |
| Q3 Milestone: BCI 2012 Annual Report | | | | | | | | | | | | |
| Q3 Milestone: White paper summarizing KSU PC research | | | | | | | | | | | | |
| Q3 Milestone: NREL to provide OSU technical support; document in memo to DOE | | | | | | | | | | | | |
| Q4 Milestone: AWWI to complete development of research framework | | | | | | | | | | | | |
| Q4 Milestone: AWWI to develop conceptual mitiation model for eagle take | | | | | | | | | | | | |

# Project Plan & Schedule (cont.)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

| Summary | |
|---|---|
| WBS Number or Agreement Number | 10.1.1 |
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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Project Name: Environmental Siting and Permitting** | | | | | | | | | | | | |
| Q1 Milestone: Organize and facilitate US strategy meeting for IEA Wind Task 34 | | | | | | | | | | | | |
| Q1 Milestone: Hold IEA Wind Task 34 kickoff meeting | | | | | | | | | | | | |
| Q2 Milestone: Hold SGC researcher's meeting | | | | | | | | | | | | |
| Q2 Milestone: Attend OSU Advisory Panel meeting | | | | | | | | | | | | |
| Q2 Milestone: Letter report summarizing SGC researcher's meeting | | | | | | | | | | | | |
| Q3 Milestone: Revised IEA Wind Task 34 work packages, et al | | | | | | | | | | | | |
| Q3 Milestone: Preliminary agenda for BWEC Science Meeting | | | | | | | | | | | | |
| Q4 Milestone: Literature Review - biological mechanisms for bird/bat deterrence | | | | | | | | | | | | |
| Q4 Milestone: IEA Wind Task 34 Hub portal and document/data collection | | | | | | | | | | | | |
| Q4 Milestone: Draft Final agenda for NWCC Research Meeting | | | | | | | | | | | | |
| **Current work and future research** | | | | | | | | | | | | |
| Develop revised documents for IEA Wind Task 34; plan for next meeting | | | | | | | | | | | | |
| Execute subcontract with BCI to support deterrent research and other BWEC activities | | | | | | | | | | | | |
| Support OSU and prepare to test sensor array at NWTC | | | | | | | | | | | | |
| Support BWEC and NWCC upcoming meetings | | | | | | | | | | | | |

- Wildlife research activities have been ongoing since 2005
- Project planned completion date is TBD

# Research Integration & Collaboration

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Partners, Subcontractors, and Collaborators: PNNL, USFWS, USGS, BOEM, NOAA, American Wind Wildlife Institute, National Wind Coordinating Collaborative, Sage Grouse Collaborative, University of Missouri, Kansas State University, Bat Conservation International, Bats and Wind Energy Cooperative, Oregon State University, Western EcoSystems Technology, Normandeau, TetraTech, IEA Wind Task 34

IEA Wind Task 34 meeting in Norway. Representatives from participating countries (Germany, Norway, Netherlands, Sweden, Switzerland, and the United States). Photo credit: Karin Sinclair

# Research Integration & Collaboration

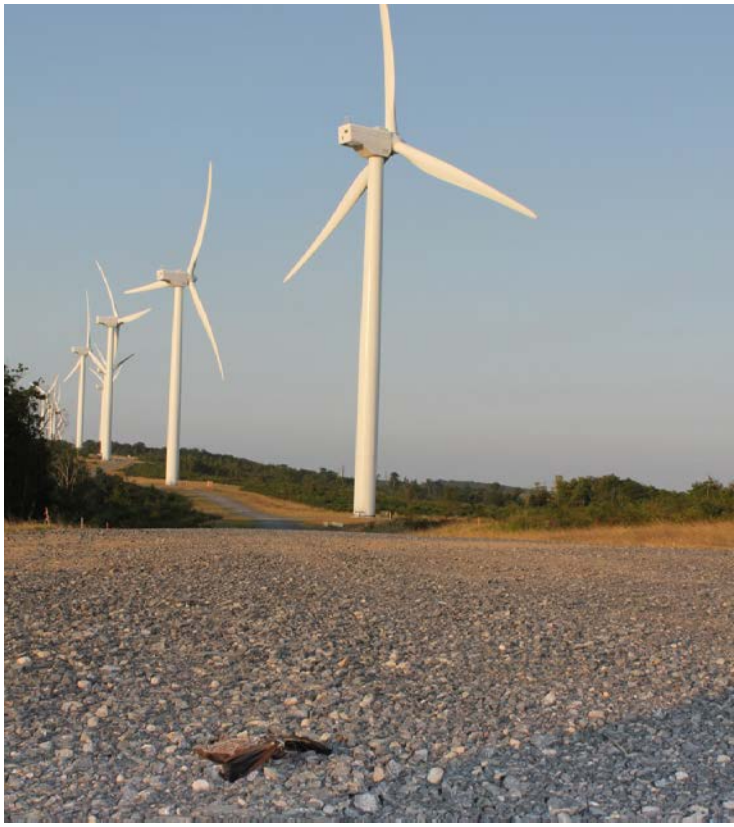


## Communications and Technology Transfer

Selected **bats and wind energy cooperative** publications:

- Relating Pre-Construction Bat Activity and Post-Construction Bat Fatality to Predict Risk at Wind Energy Facilities: A Synthesis http://www.batsandwind.org/pdf/Pre-%20Post-construction%20Synthesis_FINAL%20REPORT.pdf

- A Synthesis of Operational Mitigation Studies to Reduce Bat Fatalities at Wind Energy Facilities in North America (2013) http://www.batsandwind.org/pdf/Operational%20Mitigation%20Synthesis%20FINAL%20REPORT%20UPDATED.pdf



Source: BCI synthesis report

# Research Integration & Collaboration

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

## Communications and Technology Transfer

Selected **prairie chicken collaborative** publications:

- Winder, V.L., L.B. McNew, A.J. Gregory, L.M. Hunt, S.M. Wisely, and B.K. Sandercock. Effects of wind energy development on the survival of Greater Prairie-Chickens. *Journal of Applied Ecology*, in press.
- McNew, L.B., L.M. Hunt, A.J. Gregory, S.M. Wisely, and B.K. Sandercock. Wind energy development does not impact the nesting ecology of an obligate grassland bird in a fragmented landscape. *Conservation Biology*, submitted April 2013.

Photo credit: Lance McNew

## Communications and Technology Transfer

Recent **sage grouse collaborative** publications:

- Effects of Wind Power Development on the Population Biology of Greater Prairie-Chickens in Kansas (Research Brief, NWCC, 2013) http://nationalwind.org/wp-content/uploads/assets/gs3/Greater_Prairie-Chicken_Wind_Power_Research_Brief_May_2013_Final.pdf

- Environmental Impacts of Wind Power Development on the Population Biology of Greater Prairie-Chickens (Final report, 2013) http://www.osti.gov/scitech/servlets/purl/1080446

## Communications and Technology Transfer

Other

- Reducing Bat Fatalities From Interactions with Operating Wind Turbines (Factsheet, 2013) http://www.nrel.gov/docs/fy14osti/60427.pdf
- Collaboratives for Wildlife-Wind Turbine Interaction Research: Fostering Multistakeholder Involvement (poster—AWEA Windpower 2013) http://www.nrel.gov/docs/fy13osti/58241.pdf
- NREL's WILD database (https://wild.nrel.gov/)

Hoary Bat. Photo Credit: Michael Durham/Minden Pictures, BCI (in factsheet)

# Next Steps and Future Research



FY14/Current research: Completion of sage grouse field research and development of final reports; development of robust bat deterrent suitable for harsh environments and other BWEC activities; support for OSU sensor array development; support for AWWI eagle workshops; operating agent activities for IEA Wind Task 34 and development of related deliverables; support for National Wind Coordinating Collaborative.

Upcoming milestones/deliverables include:

- Revised IEA Wind Task 34 work package and associated materials
- BCI contract to continue development of bat deterrent
- Testing OSU's sensor array at NWTC
- Planning for NWCC research meeting and BWEC science meeting

Field testing of deterrent. BCI

# Next Steps and Future Research



Proposed Future Research: Focus on development of mitigation strategies for key species, including bats, eagles, and grouse. To facilitate wind energy deployment where there is either a real or perceived potential impact to sensitive species, proven mitigation strategies must be available options; therefore, these types of R&D efforts are critical activities going forward. This will be the case for both land-based as well as offshore deployments.

# Developing high-resolution spatial data of migration corridors for avian species of concern in regions of high potential wind development

**Todd Katzner**

West Virginia University

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25 March 2014

# Budget, Purpose, & Objectives



Total DOE Budget [1,2]: $0.00M

Total Cost-Share[1]:$.000M

Problem Statement: Wildlife conflict holds back wind energy development. We model risk to golden eagles from wind energy, to predict areas safe for development.

Impact of Project: Models of risk to eagles are important for wildlife-friendly energy development. We produce maps showing areas of high & low risk to eagles from turbines.

This project aligns with the following DOE Program objectives and priorities:

- **Mitigate Market Barriers:** Reduce market barriers to preserve or expand access to quality wind resources

[1] *Budget/Cost-Share for Period of Performance FY2012 – FY2013*
[2] *Project remained active using DOE funds received prior to FY2012*

# Budget, Purpose, & Objectives

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- PROJECT OBJECTIVES

- Model & understand eagle migration in areas important for wind energy development
- Analyze existing data to characterize eagle flight behavior
- Integrate data & models to predict behavior & risk to eagles from turbine development

# Technical Approach

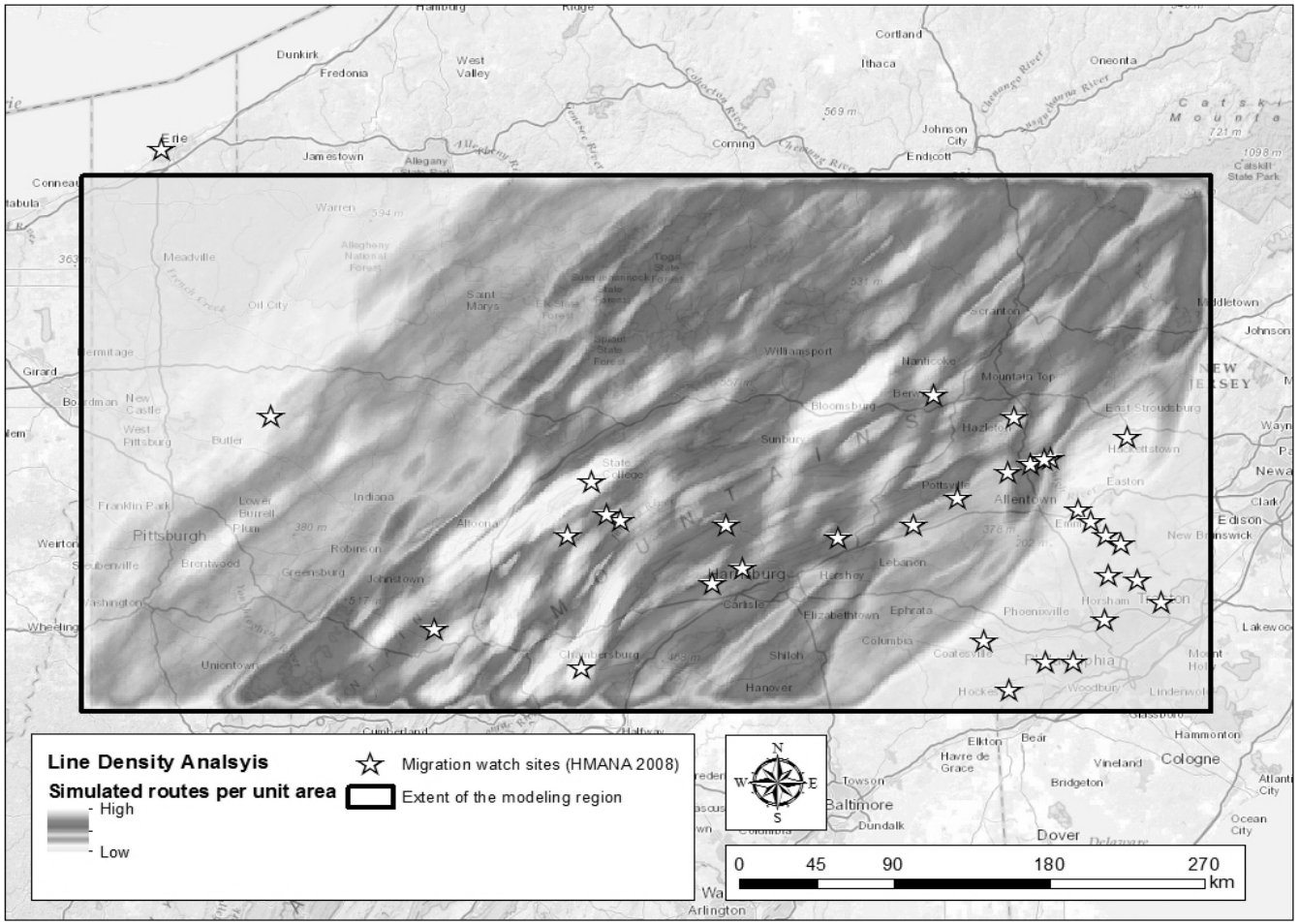


- Telemetry & modeling to understand eagle response potential to climate, topography, habitat & turbines
  - Goal - predictive maps of region showing risk
  - Two types of telemetry – hourly and 30-second data

- 2 step process
  1. Telemetry data analysis
  2. Modeling movement & risk

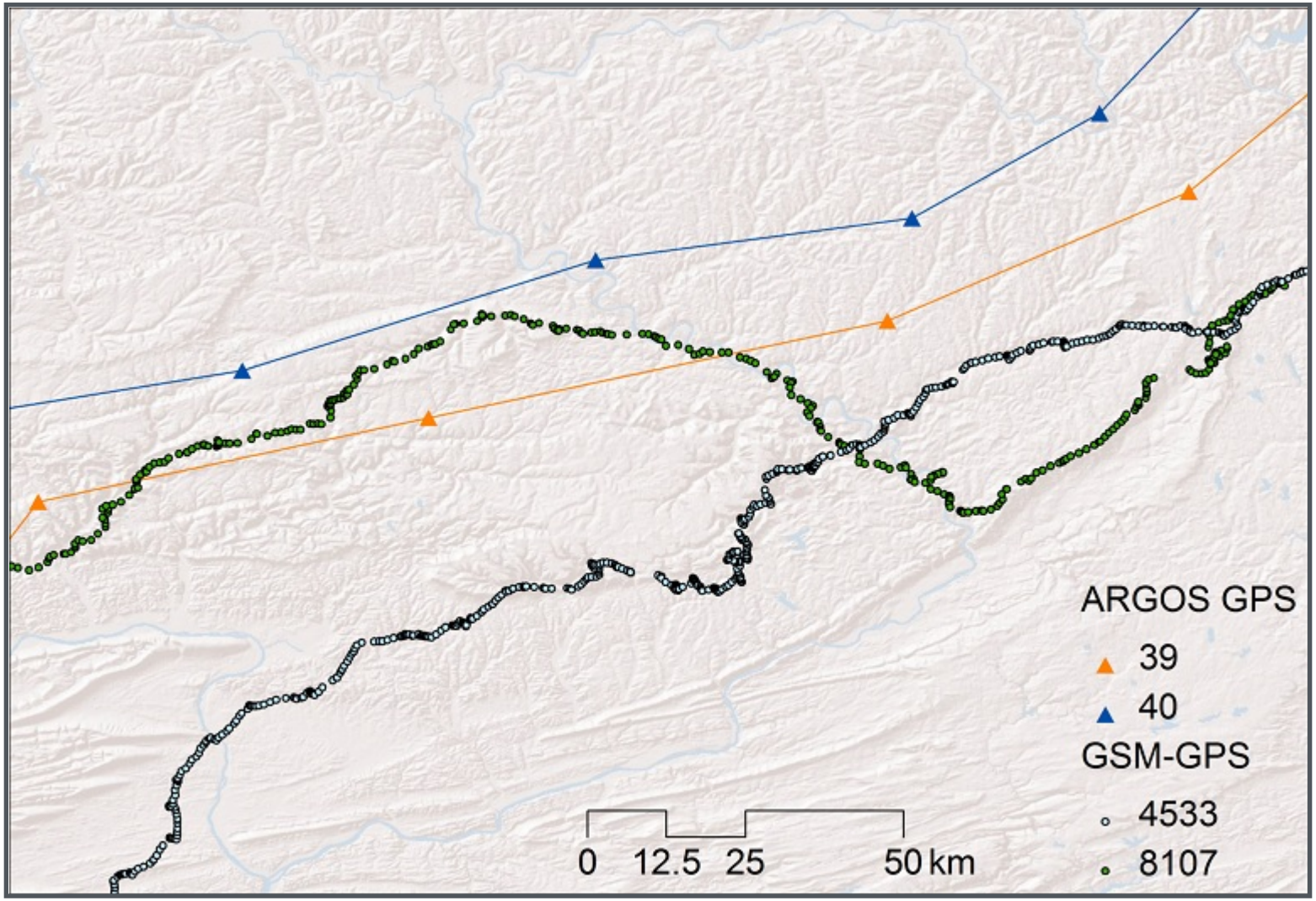
# Technical Approach

## Modeling eagle migration to understand general patterns in movement & risk



# Technical Approach





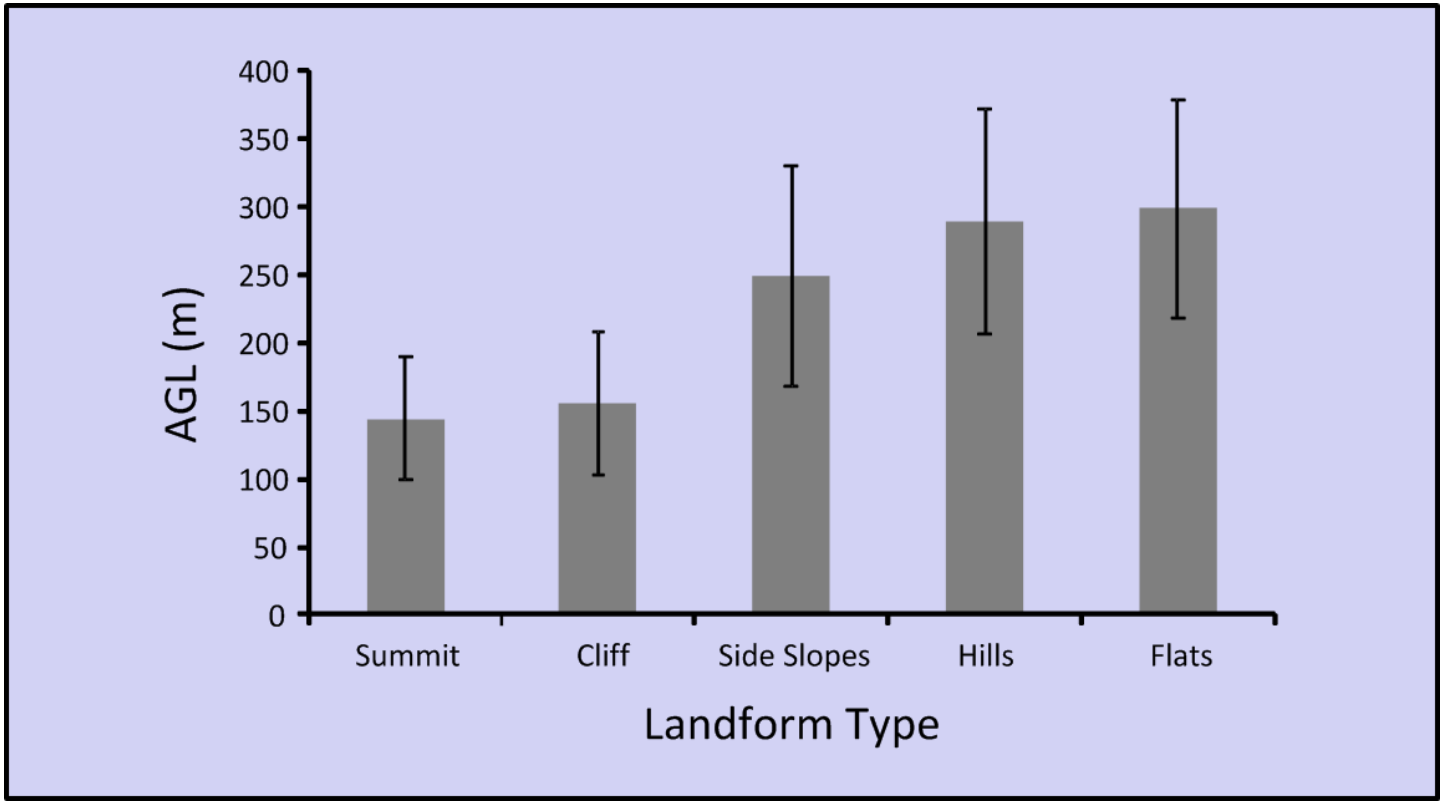
## Analysis – flight behavior (AGL & weather)

Measured several parameters related to AGL

- response to landform over which eagles fly
- expect flight behavior response to weather variation
- evaluated flight altitude by landform and wind speed
- used satellite telemetry (AGL) & GPS-GSM (weather)

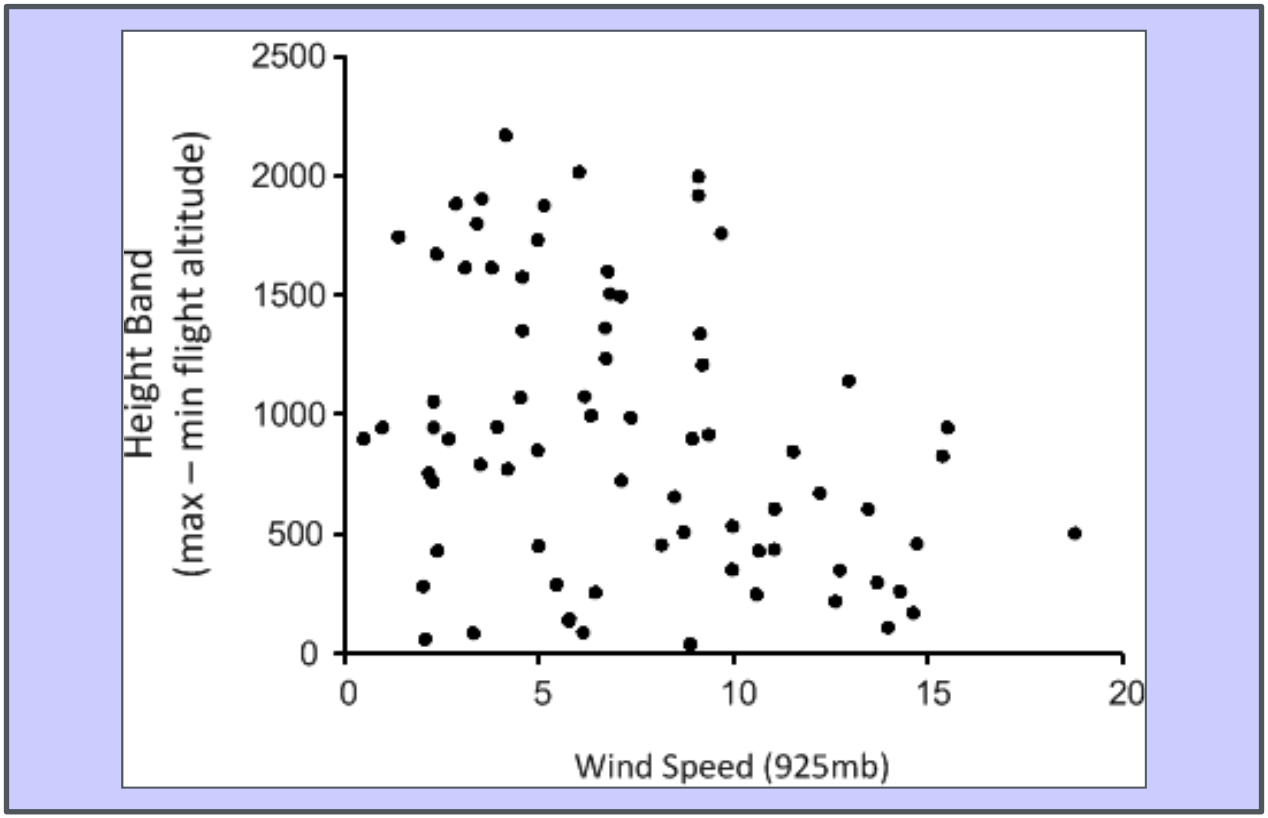
## Analysis – flight behavior (AGL & weather)

- Flight altitude linked to the landform they are over
- Lowest flight altitude over ridgetops and cliffs



## Analysis – flight behavior (AGL & weather)

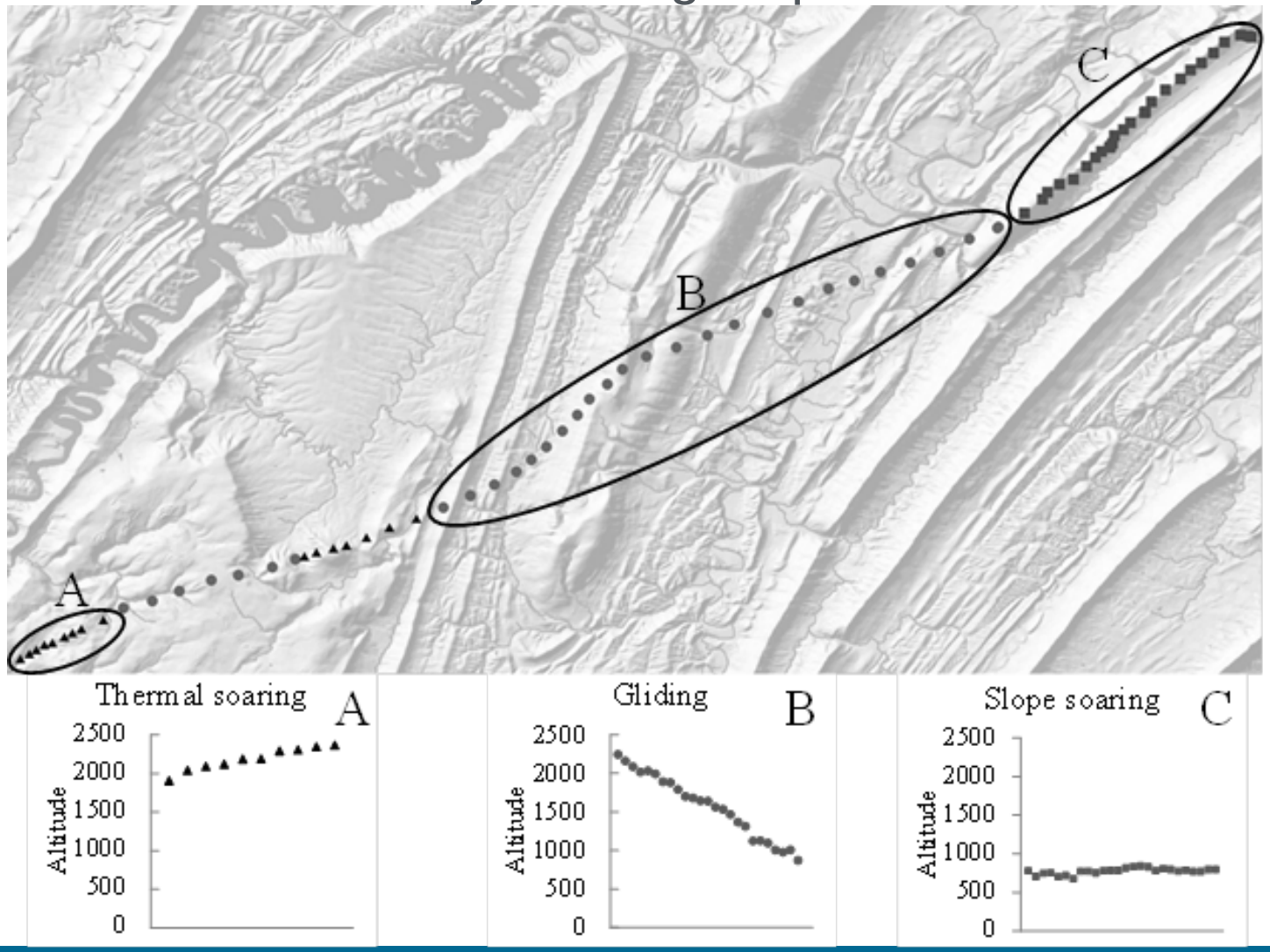
- As wind speed increases, eagles change altitude less
  - For each 1ms wind, -27 m lower altitude ($F_{(1,68)}$ = 5:04; $p$ = 0:0281)



## Analysis – flight speed

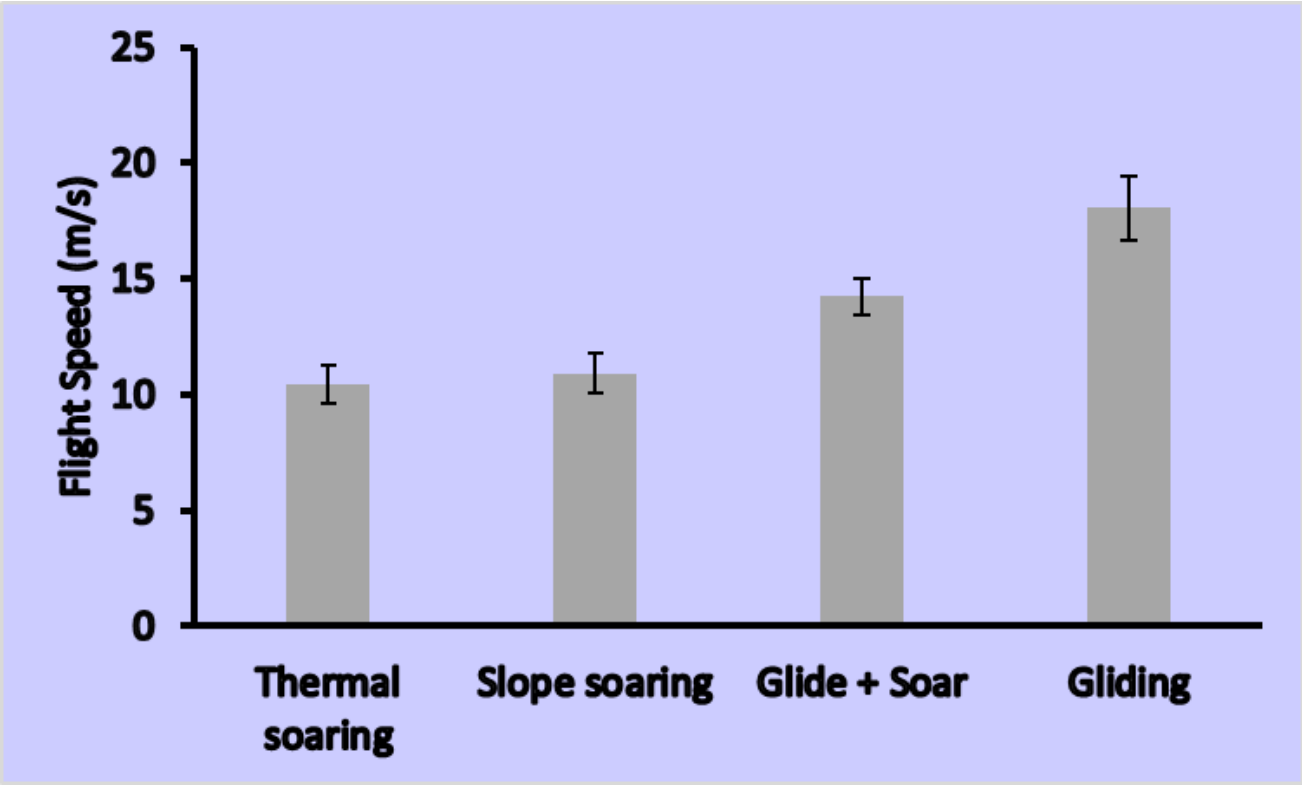
- Expect animals to maximize flight speed & minimize energetic expenditure – fitness consequences
- Lift – soaring/gliding (thermals) & orographic (ridge)
- Riding ridges = assumed faster because uninterrupted
- We tested this prediction, using GPS-GSM telemetry

## Analysis – flight speed



## Analysis – flight speed

- Ground speed of northbound migrating golden eagles
  - mean ± SE; n = 5 eagles

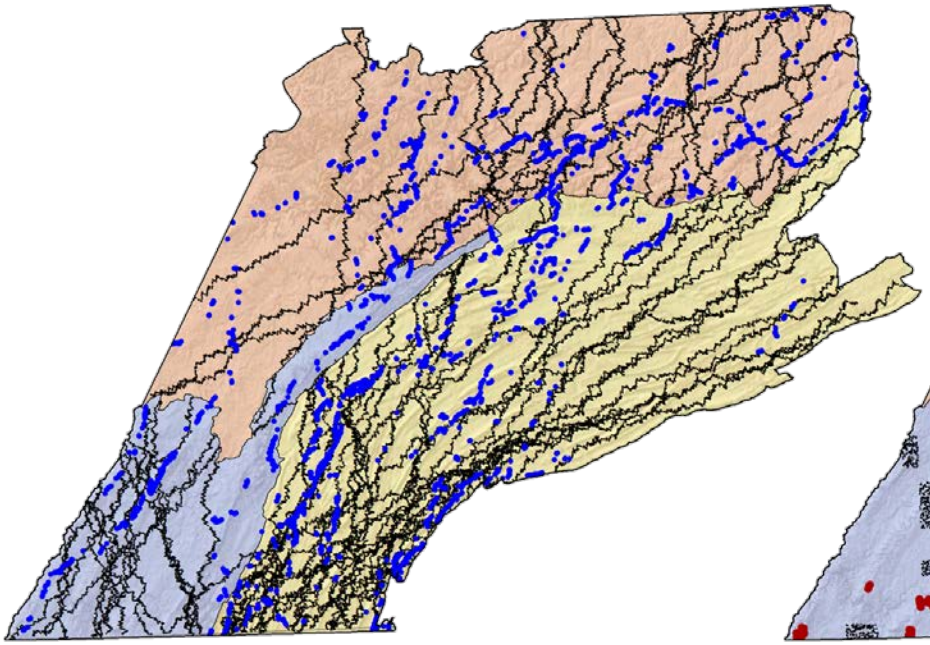


## Risk Models

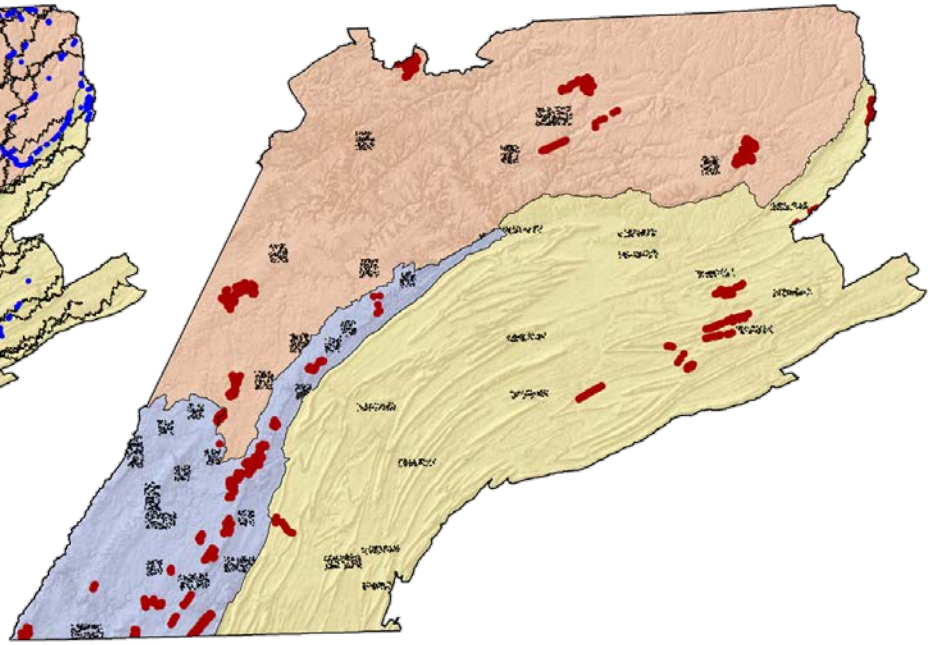
- Understanding of eagle flight to predict risk
- Modeled & overlaid resource use of turbines & of eagles

INPUT

Eagles (<150m) & random tracks

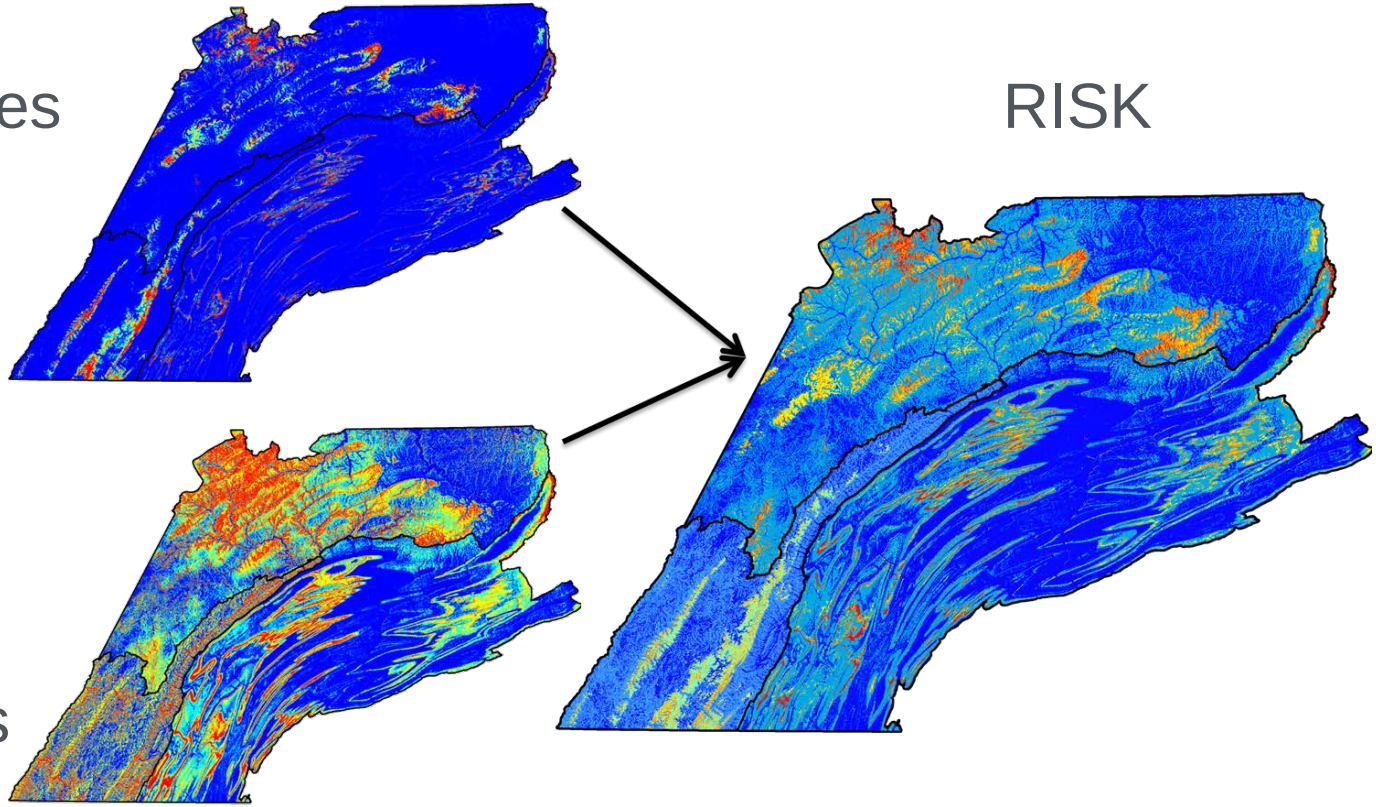


Turbines & no turbines



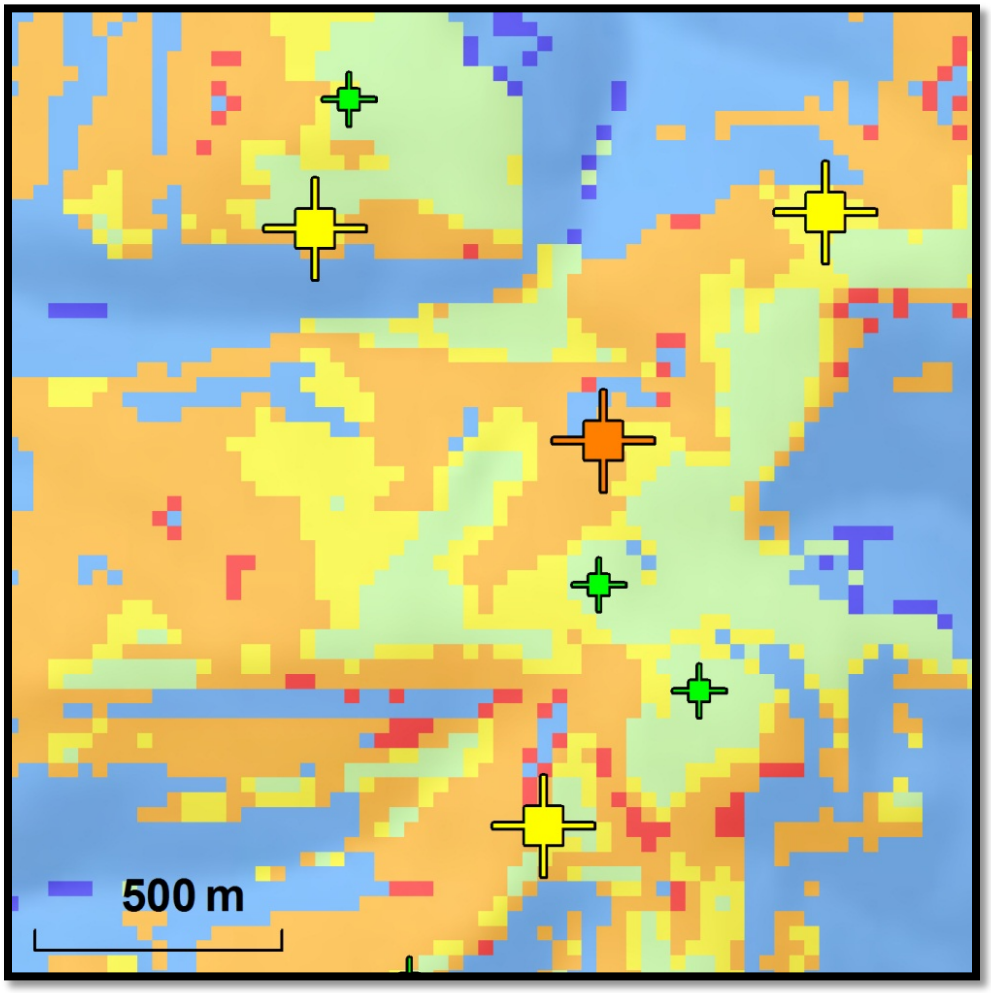
## Risk Models

- Resource Selection Functions (RSFs)
- Turbines
- Eagles



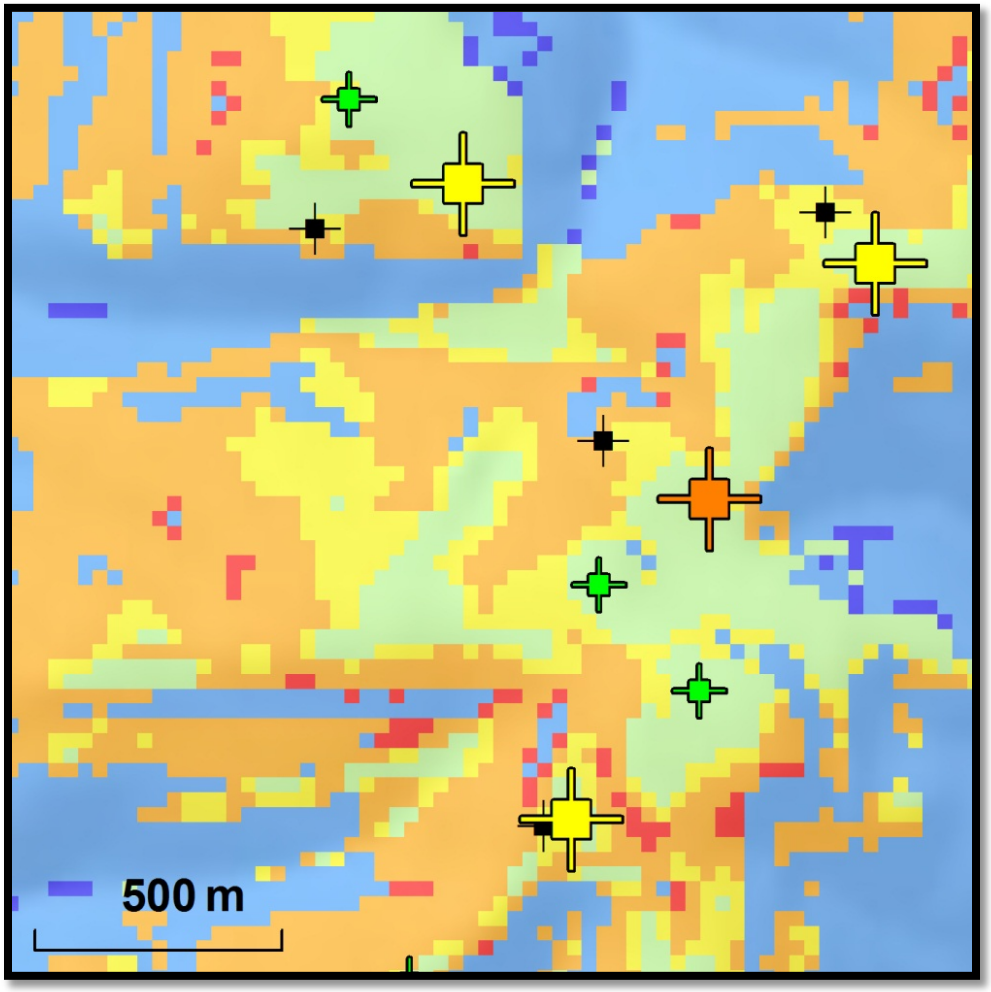
## Risk Models

- Scaled down to pixels
- Map shows a planned facility in PA
- Green = safe
- Yellow = moderate risk
- Orange = high risk



## Risk Models

- Scaled down to pixels
- Map shows a planned facility in PA
- Green = safe
- Yellow = moderate risk
- Orange = high risk
- Turbines can be moved to mitigate risk and maintain power generation capacity
- black = original location



# Purpose & Objectives



- PROJECT OBJECTIVES

✓ Model & understand eagle migration in areas important for wind energy development (Dec 2013)

✓ Analyze existing data to characterize eagle flight behavior (Dec 2013)

✓ Integrate data & models to predict behavior & risk to eagles from turbine development (Dec 2013)

# Research Integration & Collaboration



## Partners, Subcontractors, and Collaborators:

- West Virginia University
  - Todd Katzner, Philip Turk, Adam Duerr, Tricia Miller
- Lafayette College
  - David Brandes
- Cellular Tracking Technologies, LLC
  - Michael Lanzone

## Communications and Technology Transfer:

- 9 peer-reviewed publications on eagles & risk
- > 20 presentations at scientific conferences
- > 10 invited presentations at universities & community groups

# Next Steps and Future Research



FY14/Current research: This project closed 31 Dec 2013

Proposed future research:

- Expand modeling to other regions of the country where eagles and turbines interact (e.g., DRECP, Wyoming)
- Expand modeling to include other high-risk species
- Test predictive capacity of risk models in PA and elsewhere

# Wind Power & Bats Offshore — What Are the Risks? A Current Understanding of Offshore Bat Activity

DE-EE0005378

## Deepwater Offshore Bat Monitoring Program

**Steven K Pelletier, CWB**

Stantec Consulting Services, Inc.

steve.pelletier@stantec.com

March 25, 2014

# Budget, Purpose, & Objectives



**Total DOE Budget[1]: $0.399M**

**Total Cost-Share[1]:$0.192M**

- Bats occur offshore

*Information Synthesis on the Potential for Bat Interactions with Offshore Wind Facilities – Final Report* (Stantec 2013)

http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5289.pdf

- Are bats at risk from offshore wind projects?
  - How often are bats offshore?
  - How far do bats occur from shore?
  - Which species are most common?
  - When and where does activity occur?
  - Are there predictable activity patterns?

[1] ***Budget/Cost-Share for Period of Performance FY2012 – FY2013***

# Budget, Purpose, & Objectives



Knowledge gained from this study will:

- Help clarify risk to bat species and regional populations by providing developers, agencies, and stakeholders with key baseline information regarding siting, operations, and mitigation decisions;
- Help minimize project delays by providing comparative, regional baseline data sets, allowing a more efficient, timely, and cost-effective permitting review;
- Contribute to supporting more efficient and streamlined federal/state permitting procedures; and
- Support development of a bat migration model to inform future siting and management decisions for offshore wind energy development.

# Budget, Purpose, & Objectives



This project aligns with the following DOE Program objectives and priorities:

- **Mitigate Market Barriers:** Reduce market barriers to preserve or expand access to quality wind resources; and
- **Modeling & Analysis:** Conduct wind techno-economic and life-cycle assessments to help program focus its technology development priorities and identify key drivers and hurdles for wind energy technology commercialization


# Technical Approach

## Offshore Acoustic Bat Surveys

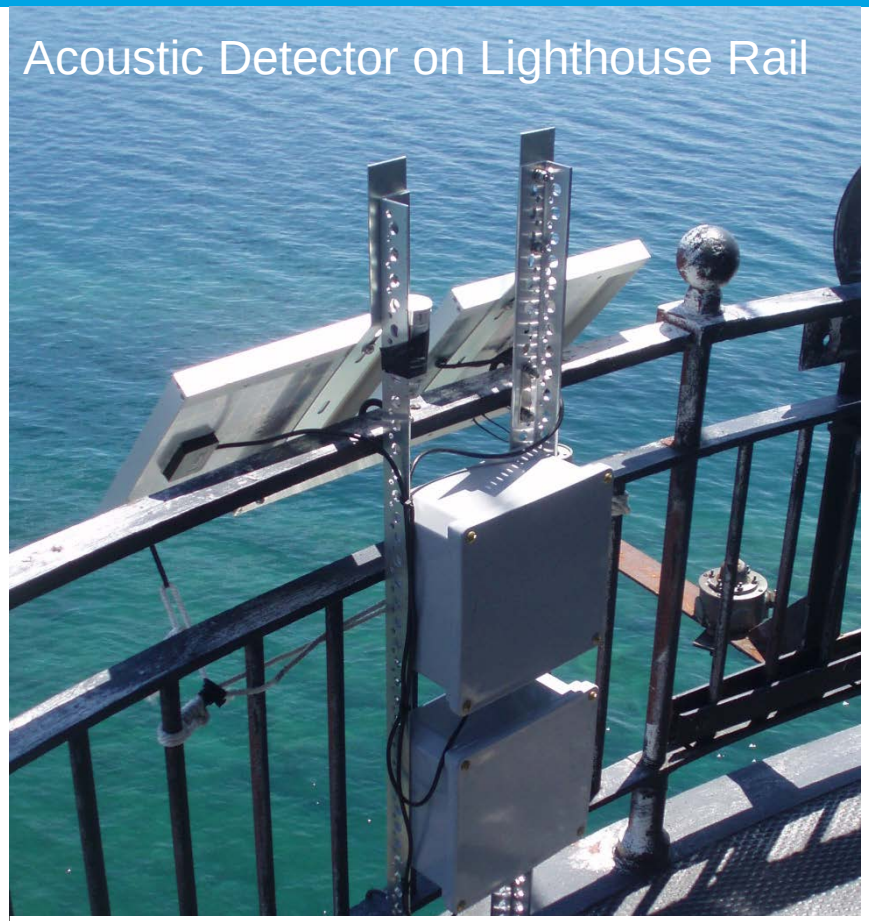
- Long-term, passive remote acoustic monitoring
- 2009–2011 pilot study
- 2012–2014 DOE study
- Lighthouses, towers, buoys, NOAA ships, coastline locations



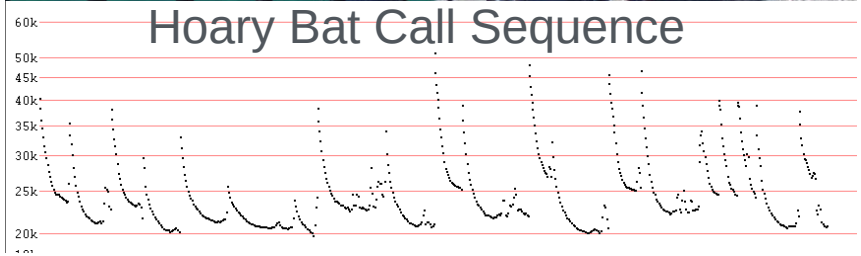
# Technical Approach



## Acoustic Detector on Lighthouse Rail



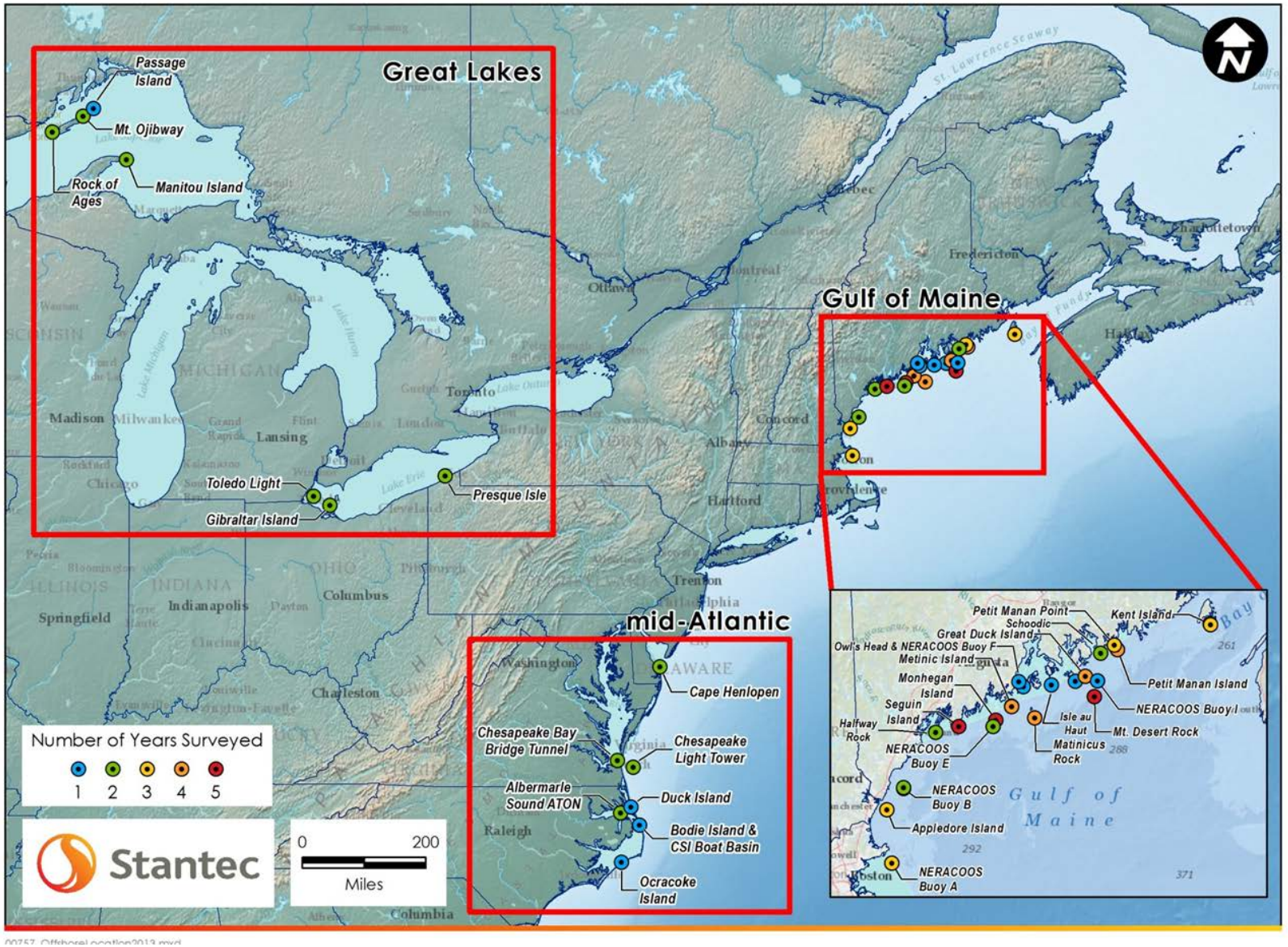
## Hoary Bat Call Sequence




## Rock of Ages Lighthouse, Lake Superior

# Technical Approach





# Accomplishments and Progress



| Year | 2009 | 2010 | 2011 | 2012 | 2013 | Total |
|---|---|---|---|---|---|---|
| Sites | 12 | 9 | 6 | 21 | 34 | 82 (40) |
| Geographic Area | Gulf of Maine (GOM) | GOM | GOM | GOM, mid-Atlantic, Great Lakes | GOM, mid-Atlantic, Great Lakes | n/a |
| Survey Period | 7/28 – 12/31 | 1/1-2/24; 7/15 – 12/31 | 1/1-12/31 | 4/11- 12/31 | 1/1– 12/31 | n/a |
| Survey Nights | 1,037 | 931 | 857 | 3,672 | ~3805 | ~10,302 |
| Calendar Nights | 157 | 225 | 365 | 265 | 365 | 1,377 |
| # Calls | 26,187 | 27,423 | 35,827 | 160,090 | TBD | 249,527 |

Technical survey results to date:

- Acoustic detectors capable of long term remote deployments in offshore marine settings;
- Study sites expanded from 16 (proposed) to 34 (82 total deployment seasons);
- Geographic area expanded beyond original proposed range; and
- Deployments extended to NOAA R/V surveys.

Biological survey results to date:

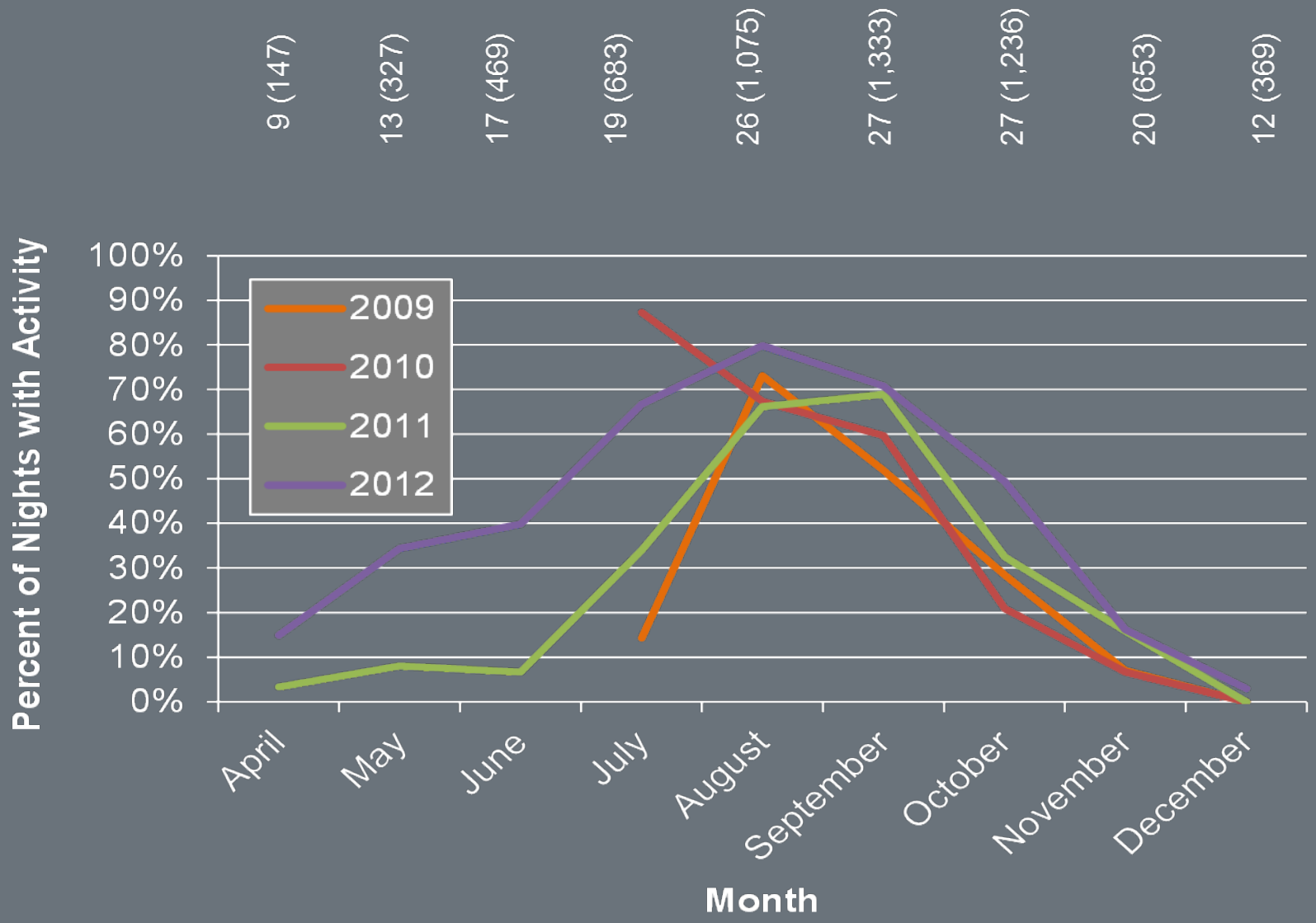
- Bats detected at all sites;
- Activity during 63% of monitoring nights between 15 July and 15 October (n=3,277);
- Activity levels highly variable among sites;
- Bats consistently most active and likely to be detected in August; and
- Seasonal timing and overall activity patterns similar to terrestrial surveys

Biological Survey results to date (continued):

- Eastern red bats most commonly identified species and present at every site;
- Silver-haired and hoary bats sporadically common;
- *Myotis* species also present at all but 3 of 27 sites; and
- Species composition highly variable among sites.

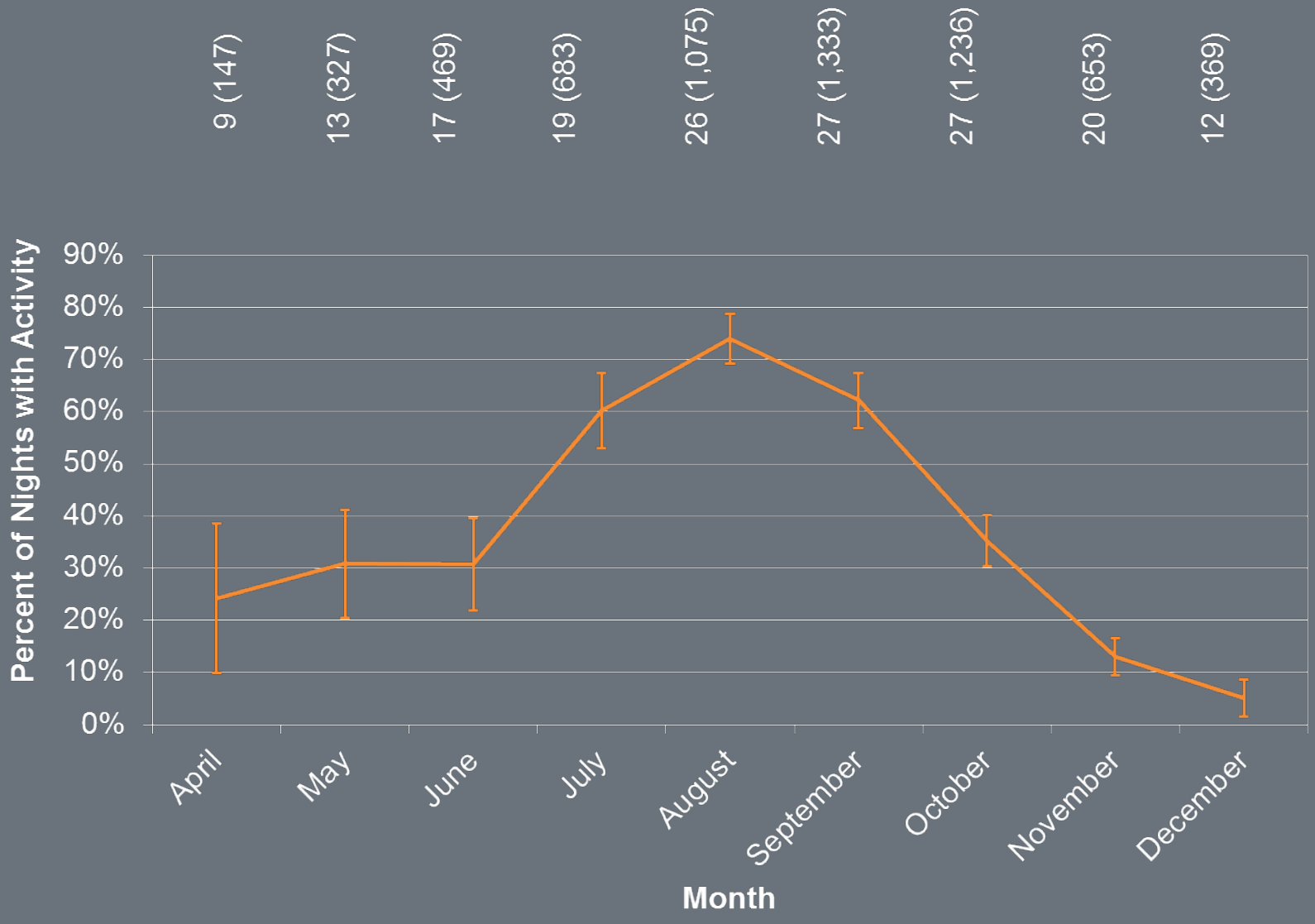
# Accomplishments and Progress





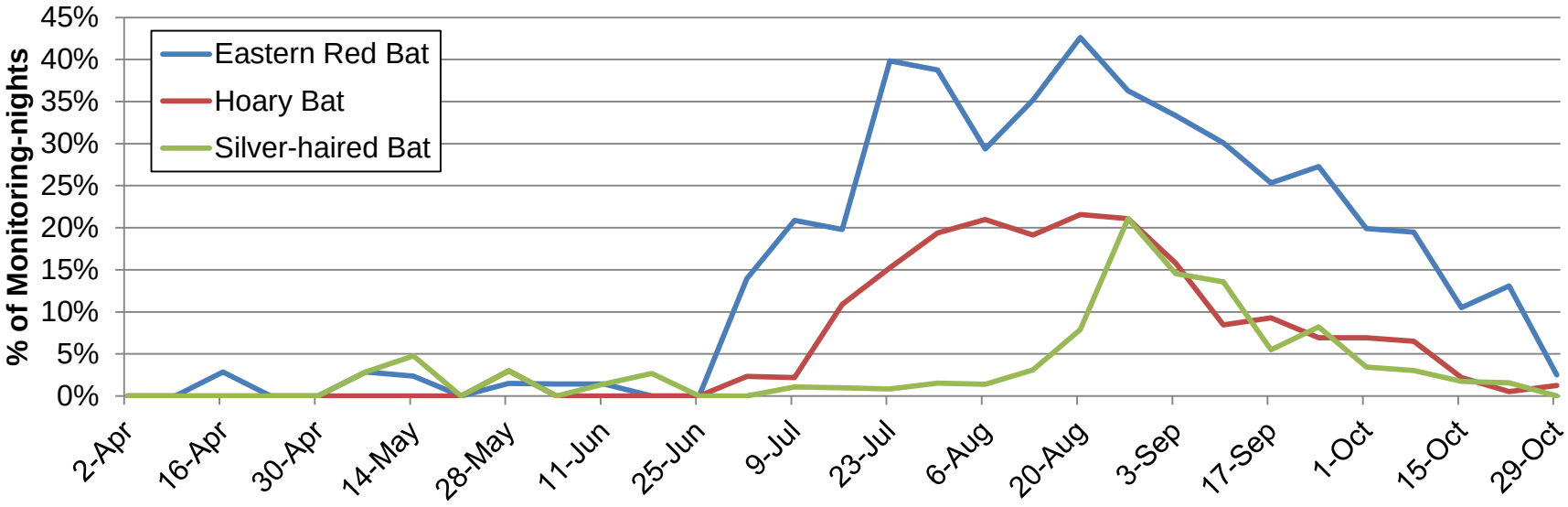
# Accomplishments and Progress



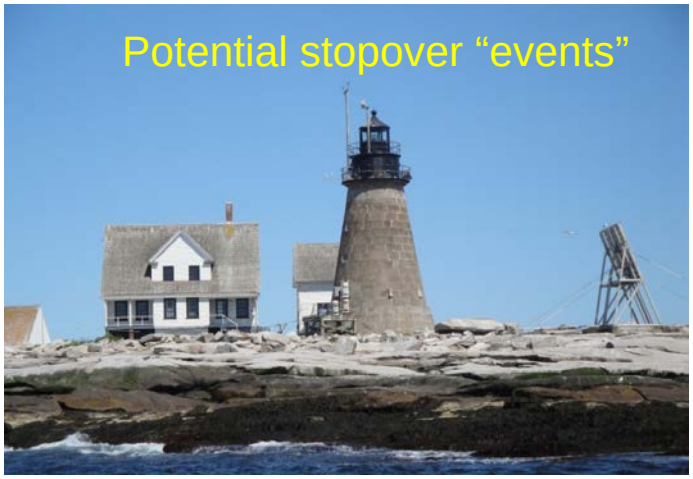


# Accomplishments and Progress






- Weekly presence of migratory species in Gulf of Maine (n=16 sites)




# Summary



What we know

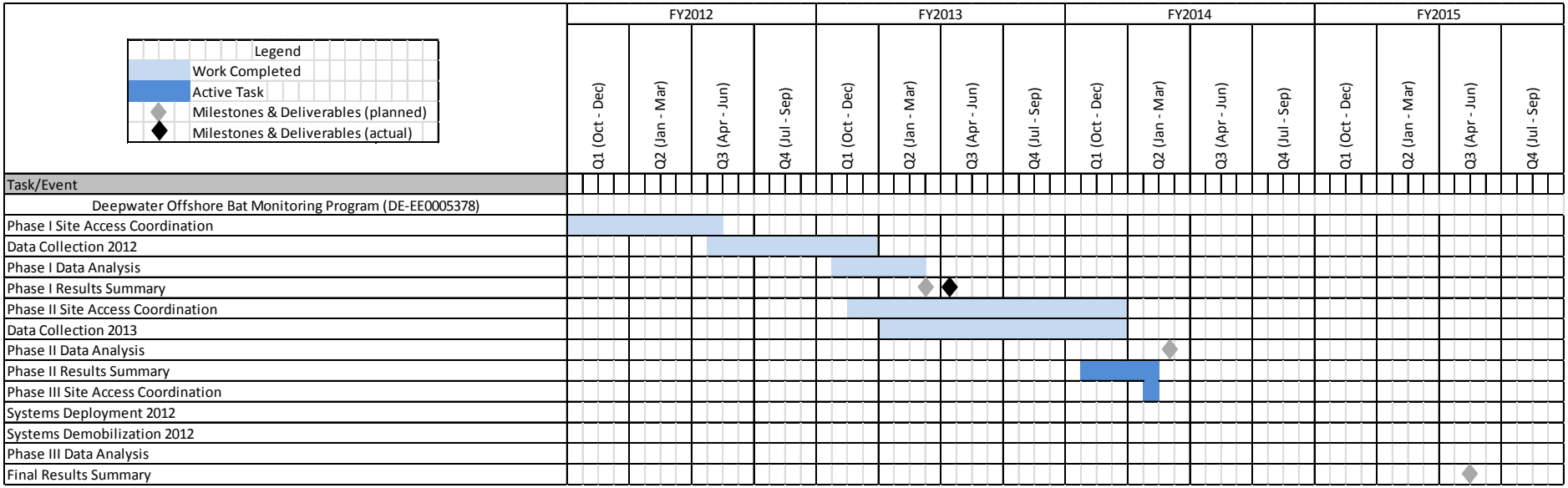
- Bats frequently occur offshore;
- Activity is seasonally predictable;
- Primarily migratory species but also non-migrants;
- Bats roost opportunistically on offshore ships and other structures including wind turbines

What next?

- Quantitative regional analysis of 2009 – 2014 bat activity and weather variables;
- Radio-tracking individual bats offshore using nanotags

# Project Plan & Schedule






## Comments

- Project milestones have been exceeded to date (34 vs. 16 projected sites);
- Project remains within budget and on schedule;
- Offshore surveys to be completed in late fall 2014; and
- Final Report to be submitted May 2015.

## Thanks to the following Partners and Collaborators:

- American Lighthouse Foundation
- Acadia National Park
- Bowdoin College
- Cape Hatteras National Park
- Cape Henlopen State Park
- Chesapeake Bay Bridge Tunnel Comm.
- College of the Atlantic
- Cornell University
- Delaware Division of Parks and Recreation
- Department of Energy
- East Carolina University
- Friends of Keweenaw
- Friends of Seguin Island
- Isle Royale National Park
- Monhegan Lighthouse Museum Assoc.
- National Oceanic & Atmospheric Administration
- NE Regional Assoc. of Coastal and Ocean Observing Systems
- NOAA R/V Henry Bigelow
- NOAA R/V Pisces
- NOAA R/V Gordon Guntar
- Shoals Marine Laboratory
- Stone Laboratory
- University of Maine
- University of New Hampshire
- University of North Carolina
- US Coast Guard
- US Fish & Wildlife Service

# Research Integration & Collaboration



Project data/information regarding the DOE funded offshore survey efforts have been presented to date at:

- AWEA Windpower 2012; Atlanta GA (June 2012)
- AWEA Offshore 2012; Virginia Beach, VA (October 2012)
- Department of Energy Webinar (April 2013)
- Energy Ocean 2012; Boston, MA (June 2012)
- Energy Ocean International; Providence RI (October 2013)
- Friends of Sequin Lighthouse; Bath, ME (June 2013)
- Friends of Merry Meeting Bay; Brunswick, ME (January 2013)
- Great Lakes Wind Collaborative Webinar (May 2013)
- Kennebec Land Trust Lyceum; Augusta, ME (July 2013)
- Maine Ocean and Wind Energy Initiative Webinar (August 2013)
- Monhegan Island Lighthouse Association; Monhegan, ME (August 2013)
- National Wind Wildlife Coordinating Collaborative (NWCC); Denver, CO, November 2012
- New England Bat Working Group (NEBWG); Carlisle, PA (January 2012)
- NEBWG; Albany NY (January 2013)
- NEBWG; Clinton, NJ (January 2014)
- Northeast Regional Migration Monitoring Network; Orono, ME (March 2012)
- Northeast Regional Migration Monitoring Network; Orono, ME (March 2013)
- Northeast Regional Migration Monitoring Network; Orono, ME (*scheduled* March 2014)

# Next Steps and Future Research



Proposed future research:

- Continued, regional expansion of acoustic studies to include Gulf of Mexico and Pacific coastlines;
- Regionally coordinated acoustic/nano-tag surveys of summer/ fall bat activities to assess extent and timing of resident/migrational movements; and
- Testing of coordinated acoustic/IR surveys to assess bat flight elevations.

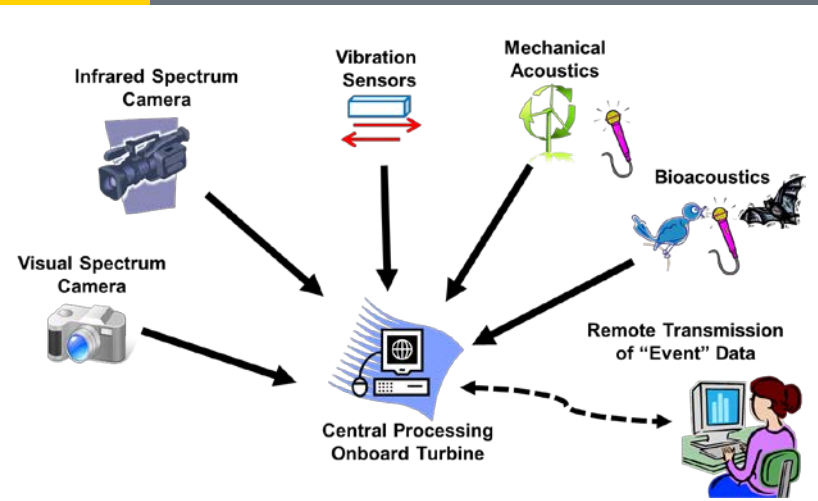
# Thank You



**Questions:**

**Steve Pelletier, CWB**
**steve.pelletier@stantec.com**

**Stantec Consulting**




Oregon State University OSU

UNIVERSITY of WASHINGTON

NNMREC Northwest National Marine Renewable Energy Center

# A Synchronized Sensor Array for Remote Monitoring of Avian and Bat Interactions with Offshore Renewable Energy Facilities

**Robert M. Suryan, Ph.D.**

Oregon State University

rob.suryan@oregonstate.edu, 541-867-0223

March 25, 2014

# Budget, Purpose, & Objectives



Total DOE Budget[1]: $0.399M

Total Cost-Share[1]:$0.162M

Problem Statement: (1) A major environmental concern (barrier) for offshore wind development is the potential impact on bird and bat populations through collision mortality. (2) Carcass surveys, the standard for terrestrial impact monitoring, is not possible in the marine environment.

Impact of Project: (1) Monitoring collision impact to meet regulatory compliance. (2) Wind turbine structure and system diagnostics.

This project aligns with the following DOE Program objectives and priorities

- **Mitigate Market Barriers:** Reduce market barriers to preserve or expand access to quality wind resources

[1] ***Budget/Cost-Share for Period of Performance FY2012 – FY2013***

# Technical Approach

**Project:**

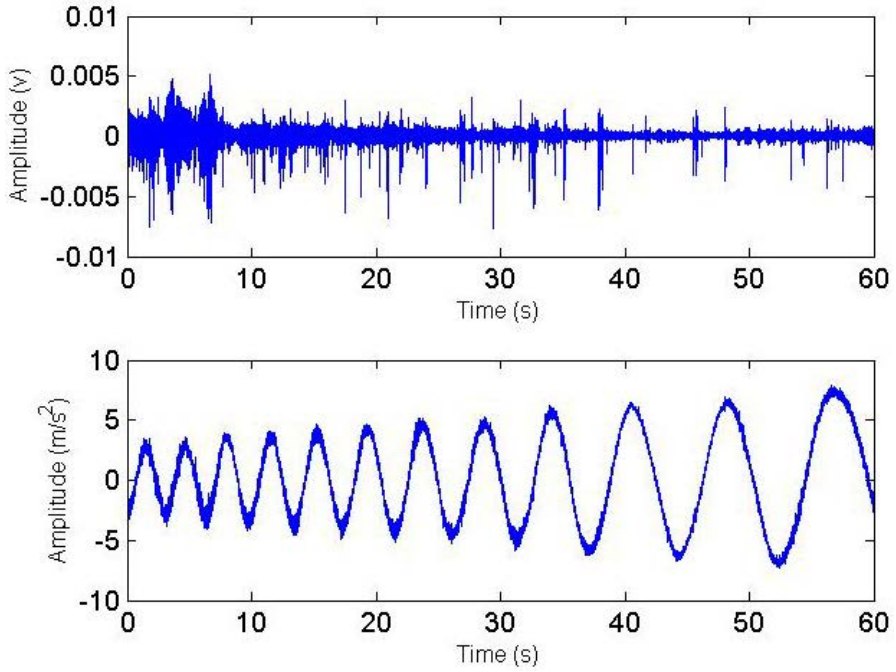
Design and experimentally test an integrated sensor array including accelerometers, contact microphones, visual and infrared spectrum cameras, and bioacoustic recorders that will continuously monitor avian and bat interactions (including impacts) on the blades, nacelle, and tower of wind turbines.

**Ours is the first effort to:**

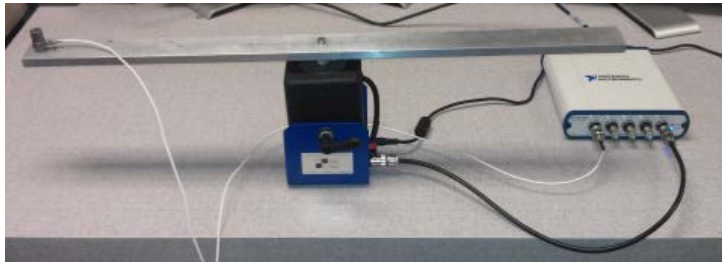
1. Incorporate all sensors into an integrated array
2. Develop real-time event detection algorithms that trigger remote data transmission of event data
3. Experimentally test with controlled impacts on operating research turbines

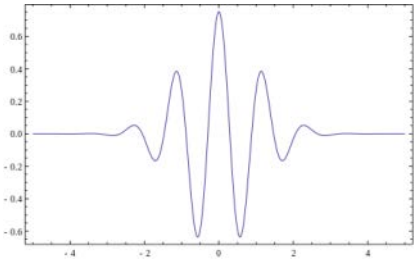
## Components:

1. Accelerometers - LORD MicroStrain G-Link LXRS with wireless 104-LXRS base station, 512 Hz
2. Contact Microphones - Sun-Mechatronics USK-40 with wireless UZ-10 UHF receiver, 1000 Hz

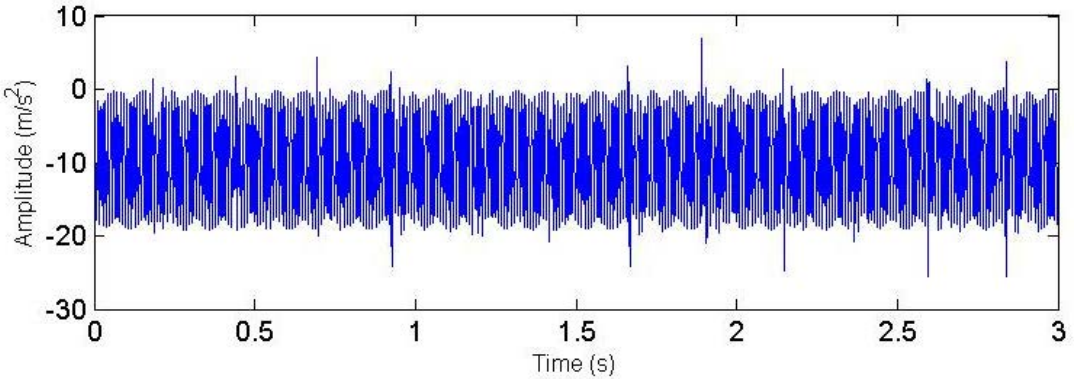



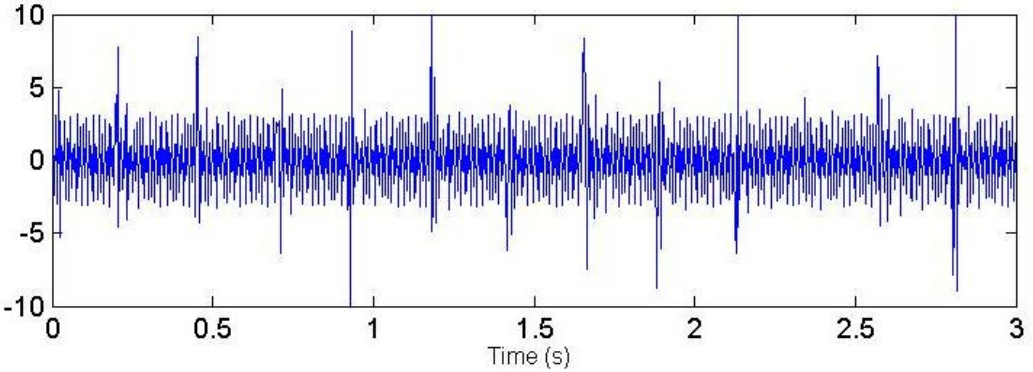
# LabTesting of Accelerometers and Detection Algorithm





Wavelet Transfomation

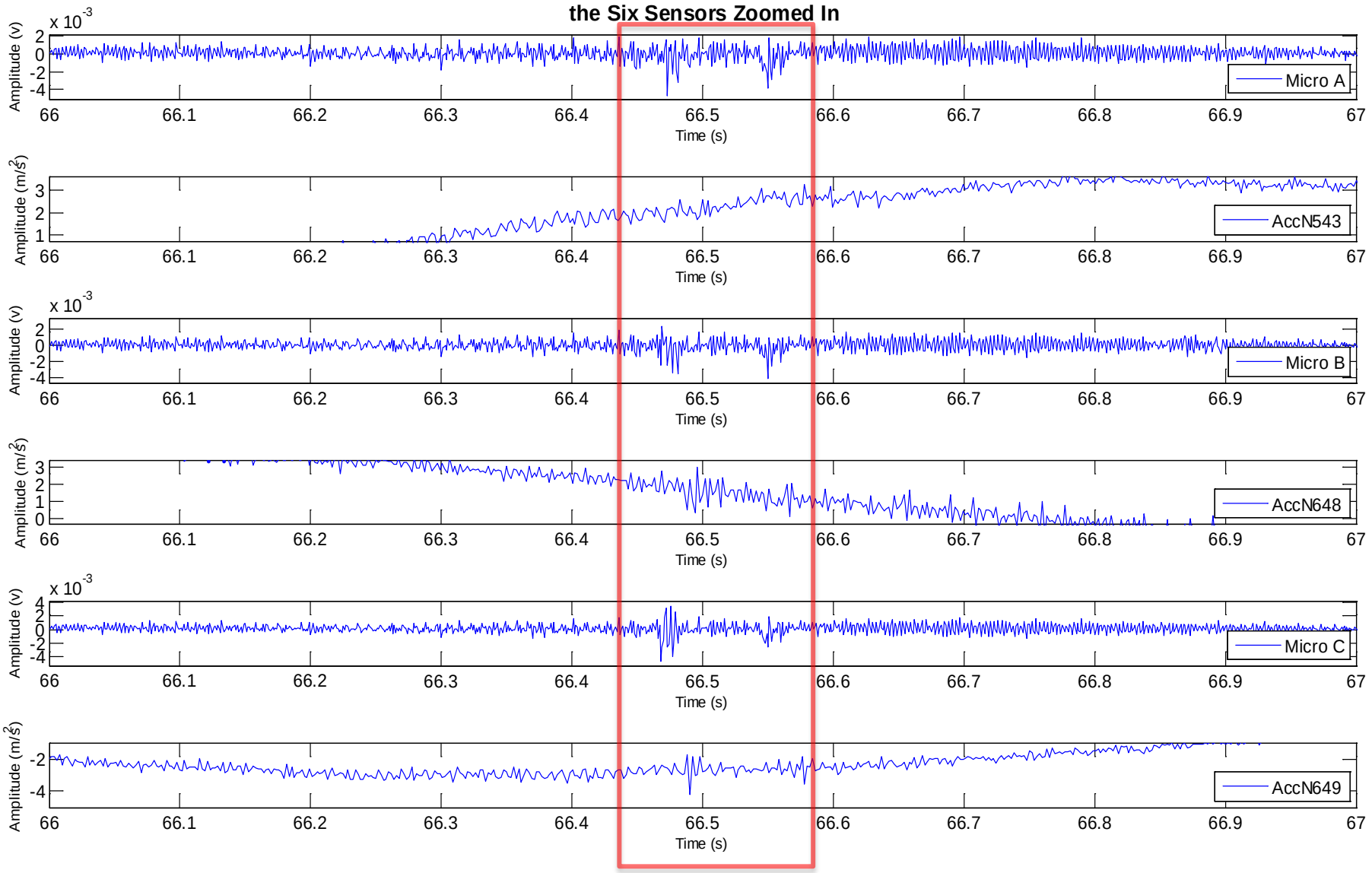


# Operational Testing of Impact Detection by Accelerometers and Contact Microphones


# Accomplishments and Progress





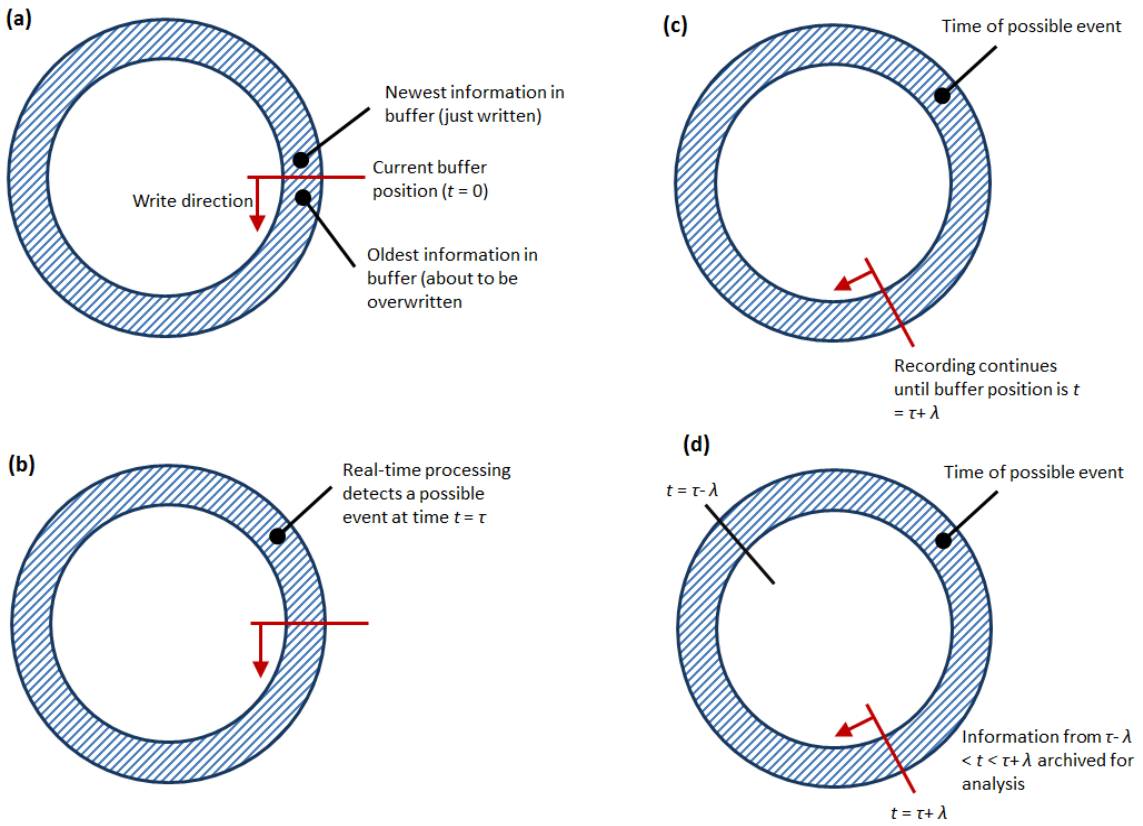
## Automated IR Camera Target Detection

Recorded image (x marks target)

Image with mean removed

Binary thresholded image

# Ring Buffer Architecture



# Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

| Summary | |
|---|---|
| WBS Number or Agreement Number | |
| Project Number | DE-EE0005363 |
| Agreement Number | |

| Legend | |
|---|---|
| | Work completed |
| | Active Task |
| | Milestones & Deliverables (Original Plan) |
| | Milestones & Deliverables (Actual) |

| Task / Event | FY2012 | | | | FY2013 | | | | FY2014 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q1 (Octt-Dec) | Q2 (Jan-Mar) | Q3 (Apr-Jun) | Q4 (Jul-Sep) | Q1 (Octt-Dec) | Q2 (Jan-Mar) | Q3 (Apr-Jun) | Q4 (Jul-Sep) | Q1 (Octt-Dec) | Q2 (Jan-Mar) | Q3 (Apr-Jun) | Q4 (Jul-Sep) |
| **Project Name: Wind Energy Forecasting Methods and Validation for Tall Turbine Resource Assessment** | | | | | | | | | | | | |
| Advisory Group Meeting #1 | | | | ◆ | | | | | | | | ◆ |
| Laboratory Testing | | | | | | | | | | | | |
| Target Detection and Taxonomic Grouping | | | | | | ◆ | | | | | | |
| Field Testing - NREL #1 | | | | | | ◆ | | | | | | |
| Collision Event Detection - Mesaland CC | | | | | | | | | ◆ | | | |
| **Current work and future research** | | | | | | | | | | | | |
| Advisory Group Meeting #2 | | | | | | | | | | ◆ | | |
| Compoenent Field Testing - NREL #2 | | | | | | | | | | | ◆ | |
| Advisory Group Meeting #3 | | | | | | | | | | | | ◆ |
| Full Array Field Testing - NREL #3 (final) | | | | | | | | | | | | ◆ |

## Comments

- Project period: October 1, 2011 – September 30, 2015
- Slipped schedule: Delayed establishment of contract and subawards
- Go/no-go FY12-13: Advisory panel approval, initial lab and field demonstration of sensors and event detection algorithms

# Research Integration & Collaboration

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

## Partners, Subcontractors, and Collaborators:

***Subcontracts:***

(1) University of Washington, Dr. Brian Polagye (Co-Principal Investigator)

(2) ABR, Inc. – Environmental Research & Services, Dr. Jon Plissner, Mr. Brian Cooper,

(3) HT Harvey and Associates, Dr. Judd Howell, Dr. Sharon Kramer

***Collaborators:*** (1) National Renewable Energy Lab, (2) Mesalands Community College, (3) Pacific Northwest National Lab, (4) Bat Conservation International, (5) U.S. Geological Survey, (6) Northwest National Marine Renewable Energy Center

***Advisory:*** (1) Floating Power Plant A/S, (2) Floating Power Inc., (3) Principal Power, (4) Leidos Maritime Solutions, (5) Iberdrola Renewables, (6) Coastal Community Action Program, (7) U.S. Fish and Wildlife Service

## Communications and Technology Transfer:

***Manuscript in Review:*** Flowers, J., R. Albertani, T. Harrison, B. Polagye, R. Suryan. Remote Monitoring of Avian and Bat Interactions with Offshore Wind Energy Facilities. Proceedings of the 2nd Annual Marine Energy Technology Symposium, Seattle, WA, April 15-17, 2014

***Presentations:*** Pacific Seabird Group Meeting 2012, Hatfield Marine Science Center 2012, Oregon State University 2013, Oregon Marine Renewable Energy Conference 2013, Ocean Sciences Meeting 2014, Global Marine Energy Conference, 2014

# Next Steps and Future Research



## FY14/Current research:

- 2nd advisory panel meeting, March 13, 2014
- Processing vibration and impact data collected at Mesalands Community College
- Refining target and signal detection algorithms
- Continue software programming for system integration
- 2nd & 3rd (final) tests at NREL

# Next Steps and Future Research



## Proposed future research:

- Marinization of exterior components
- Extended full scale deployment on a shore-based, grid connected turbine in area of high bird/bat passage rate (incl. component upgrades and radar monitoring)
- Deployment on offshore turbines at WindFloat Pacific site (if approved and mobilized)
- Possible technology transfer to business start-up if there looks to be high demand for the system from onshore and offshore industries
- Avian and bat deterrents?

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

TETHYS

# Offshore Wind Environmental Research and Support

**Andrea Copping**

Pacific Northwest National Laboratory

Andrea.Copping@pnnl.gov

March 20, 2014

# Budget, Purpose, & Objectives

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Total DOE Budget[1]: $1.026M

Total Cost-Share[1]:$0.00M

Problem Statement: Complex environmental siting and permitting processes, coupled with uncertainty surrounding potential environmental effects of Offshore Wind (OSW) development, has slowed development of the OSW industry in the US.

Impact of Project: By enhancing the accessibility and level of scientific understanding of OSW environmental effects, this project will accelerate permitting processes and assist in advancing the offshore wind industry in the US.

This project aligns with the following DOE Program objectives and priorities:

**Mitigate Market Barriers:** Reduce market barriers to preserve or expand access to quality wind resources.

[1] ***Budget/Cost-Share for Period of Performance FY2012 – FY2013***

# Technical Approach – Critical Tasks for OSW Research and Support



**Systematically evaluate and develop targeted solutions to potential environmental effects of installation, operation, maintenance, and decommissioning of OSW turbines, including:**

- **North Atlantic Right Whales** – Understand risk to NARWs from installation of OSW, optimize acoustic monitoring systems for detection of NARW, measure and mitigate risk
- **Automated Detection for Birds & Bats**– Develop monitoring solutions for birds and bats at OSW sites through automated processing of thermal imagery
- ***Tethys* Database** – Expand access to OSW environmental effects research through expansion of Tethys knowledge management system
- **IEA Wind Task 34 –** Collaborate Internationally to expand understanding of OSW research and best practices

# Technical Approach - North Atlantic Right Whales

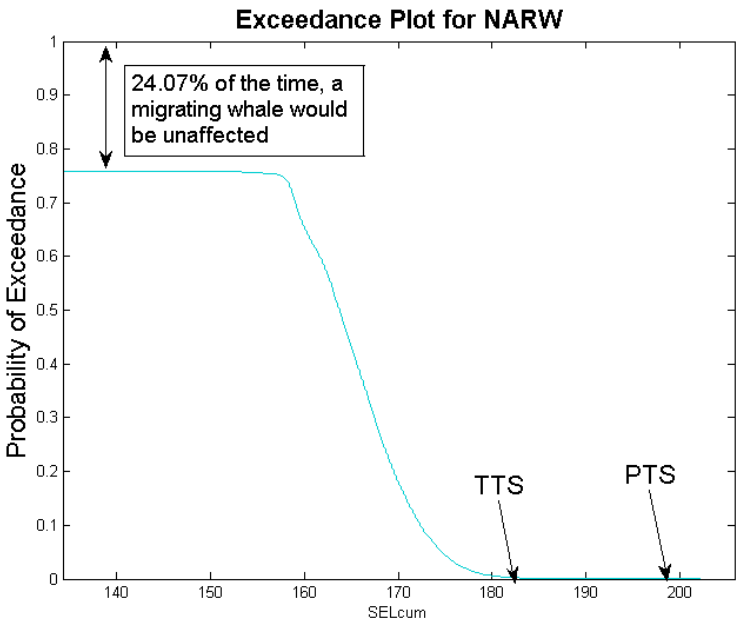


- Examine risk to migrating North Atlantic Right Whales (NARW) from the sound of pile driving for OSW installation.
- Engage with OSW industry to understand tolerance for alterations and delays in construction schedules.
- Gather existing data on NARW behavior, population, and migratory routes along the Atlantic coast.
- Model sound sources and NARW movements stochastically.
- Engage stakeholders, including OSW developers, to obtain feedback on risk assessment and modeling efforts, and potential mitigation measures.

# Accomplishment and Progress - North Atlantic Right Whale



- Probabilistic sound exposure model developed, measured potential for hearing damage (temporary or permanent hearing shift) to NARW.
- Determined that incomplete NARW data drives uncertainty in use of sound exposure model for risk to NARW.
- Incorporated pile driving construction workflow into model to determine effects of different potential mitigation practices.




Exceedance plot developed from stochastic model. Temporary Threshold Shift (TTS) and Permanent Threshold Shift (PTS) are shown.

# Project Plan & Schedule – North Atlantic Right Whale

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

| Summary | |
|---|---|
| WBS Number or Agreement Number | 5.1.5 |
| Project Number | |
| Agreement Number | 22531 |
| | |

| Legend | |
|---|---|
| | Work completed |
| | Active Task |
| | Milestones & Deliverables (Original Plan) |
| | Milestones & Deliverables (Actual) |

| Task / Event | FY2012 Q1 (Oct-Dec) | FY2012 Q2 (Jan-Mar) | FY2012 Q3 (Apr-Jun) | FY2012 Q4 (Jul-Sep) | FY2013 Q1 (Oct-Dec) | FY2013 Q2 (Jan-Mar) | FY2013 Q3 (Apr-Jun) | FY2013 Q4 (Jul-Sep) | FY2014 Q1 (Oct-Dec) | FY2014 Q2 (Jan-Mar) | FY2014 Q3 (Apr-Jun) | FY2014 Q4 (Jul-Sep) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Project Name: North Atlantic Right Whale** | | | | | | | | | | | | |
| Q2 Milestone: Summary of interactions with offshore wind and pile driving industry | | | | | | | | | | | | |
| Q3 Milestone: Report providing review and assessment of systems to detect NARW | | | | | | | | | | | | |
| Q4 Milestone: Monitoring/mitigation plan for installation of offshore wind turbines | | | | | | | | | | | | |
| Q1 Milestone: Analysis of source levels to which NARWs are likely to be exposed | | | | | | | | | | | | |
| Q2 Milestone: Model for detection of NARW; report on interactions of OSW | | | | | | | | | | | | |
| Q3 Milestone: Probabilistic NARW risk model; Monitoring/mitigation into workflow | | | | | | | | | | | | |
| Q4 Milestone: Report on workshop with OSW developers/progress on outreach | | | | | | | | | | | | |
| **Current work and future research** | | | | | | | | | | | | |
| Reach out to NARW Experts | | | | | | | | | | | | |
| Integration of construction into modeling effort | | | | | | | | | | | | |

## Comments

- FY13 report delayed due to delay in timing of FY13 funding

# Technical Approach - Detecting Birds and Bats



- Support efficient and objective remote monitoring and automated processing of thermal images of birds and bats in offshore environments, reducing need for human observers at sea.
- Developed general algorithms for processing thermal infrared (IR) video to automatically detect and characterize tracks of animals passing through the camera field of view.
- Developed methods for post-processing track statistics to quantify the number of birds and bats, and to classify the species.


# Accomplishments and Progress - Detecting Birds and Bats



- Collected and annotated video clips with multiple bird species in the marine environment to support algorithm development.
- Algorithms developed and implemented, and software has been demonstrated, made available to collaborators.
- Annotated dataset generated with recordings made during day and night, in different weather conditions, containing examples of bats, passerines and seabirds, and examples of false targets.
- The software evaluated using the annotated dataset: the detection rate found to be greater than 93%.

# Project Plan & Schedule – Detecting Birds & Bats

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

| Summary | |
|---|---|
| WBS Number or Agreement Number | 5.1.2 |
| Project Number | |
| Agreement Number | 22531 |

| Legend | |
|---|---|
| | Work completed |
| | Active Task |
| | Milestones & Deliverables (Original Plan) |
| | Milestones & Deliverables (Actual) |

| Task / Event | FY2012 Q1 (Oct-Dec) | FY2012 Q2 (Jan-Mar) | FY2012 Q3 (Apr-Jun) | FY2012 Q4 (Jul-Sep) | FY2013 Q1 (Oct-Dec) | FY2013 Q2 (Jan-Mar) | FY2013 Q3 (Apr-Jun) | FY2013 Q4 (Jul-Sep) | FY2014 Q1 (Oct-Dec) | FY2014 Q2 (Jan-Mar) | FY2014 Q3 (Apr-Jun) | FY2014 Q4 (Jul-Sep) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Project Name: Technology Assessment** | | | | | | | | | | | | |
| Q1 Milestone: Acquire annotated dataset and implement framework for analysis | | | | | | | | | | | | |
| Q2 Milestone: Implement feature extraction and classification algorithm. | | | | | | | | | | | | |
| Q3 Milestone: Gather validation dataset of flying objects on IR video. | | | | | | | | | | | | |
| Q4 Milestone: Analyze data extraction efficiency/develop classification algorithm | | | | | | | | | | | | |
| Q1 Milestone: Dataset of statistically validated target track detections | | | | | | | | | | | | |
| Q2 Milestone: Complete track identification/attribute extraction from 2012 library | | | | | | | | | | | | |
| Q3 Milestone: Complete decision tree classification; draft software prototype | | | | | | | | | | | | |
| Q4 Milestone: Beta software version as a platform-independent application | | | | | | | | | | | | |
| **Current work and future research** | | | | | | | | | | | | |
| Further Develop Software | | | | | | | | | | | | |
| Groundtruth Algorithms | | | | | | | | | | | | |

## Comments

- Some delay in progress due to delay in timing of FY13 funding

# Technical Approach - *Tethys*



- *Tethys* is web-based knowledge management system designed to organize research on environmental effects of ocean energy development. OSW content added in FY12.
- Functionality of *Tethys* enhanced to serve OSW (as well as MHK).
- OSW environmental effects literature and information gathered worldwide.
- Specific metrics for expansion and use of OSW *Tethys* established, annual peer review conducted for content and functionality.
- As content grows, *Tethys* will enhance cumulative understanding of effects, support efficient siting and permitting of OSW in US.

# Accomplishments and Progress - *Tethys*




- Functionality of *Tethys* enhanced to house both MHK and OSW content in the same searchable database.
- Key performance metrics developed in FY12 to monitor and improve content and performance of *Tethys;* quarterly metrics met throughout FY13.
- Content expanded from 91 to 1200 media in 2 years; 400 documents added that pertain specifically to OSW.
- Increased unique visitors by 19% in FY13.
- Peer review process carried out in FY12; enhancements made based on feedback.
- Recognized as Wiki of the Month in April 2013
  - Highlights the success of the technical infrastructure

# Project Plan & Schedule – *Tethys*

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

| Summary | |
|---|---|
| WBS Number or Agreement Number | 5.1.2 |
| Project Number | |
| Agreement Number | 22531 |

| Legend | |
|---|---|
| | Work completed |
| | Active Task |
| | Milestones & Deliverables (Original Plan) |
| | Milestones & Deliverables (Actual) |

| Task / Event | FY2012 Q1 (Oct-Dec) | FY2012 Q2 (Jan-Mar) | FY2012 Q3 (Apr-Jun) | FY2012 Q4 (Jul-Sep) | FY2013 Q1 (Oct-Dec) | FY2013 Q2 (Jan-Mar) | FY2013 Q3 (Apr-Jun) | FY2013 Q4 (Jul-Sep) | FY2014 Q1 (Oct-Dec) | FY2014 Q2 (Jan-Mar) | FY2014 Q3 (Apr-Jun) | FY2014 Q4 (Jul-Sep) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Project Name: Tethys** | | | | | | | | | | | | |
| Q1 Milestone: Establish Tethys Editorial Board | | | | | | | | | | | | |
| Q2 Milestone: Knowledge Management System fully operational | | | | | | | | | | | | |
| Q3 Milestone: Delivery of curation and collection plan for Tethys | | | | | | | | | | | | |
| Q4 Milestone: OSW portion of Tethys populated; Report Tethys metrics and | | | | | | | | | | | | |
| Q1 Milestone: Increase of 40 OSW Documents on Tethys | | | | | | | | | | | | |
| Q2 Milestone: Initial integration of OSW geospatial documents in Map Viewer | | | | | | | | | | | | |
| Q3 Milestone: Annual peer review of Tethys completed, showing satisfaction level | | | | | | | | | | | | |
| Q4 Milestone: 10% increase in total user sessions of Tethys | | | | | | | | | | | | |
| **Current work and future research** | | | | | | | | | | | | |
| Tethys Migrated to New Platform | | | | | | | | | | | | |
| Collection of OSW will continue | | | | | | | | | | | | |

## Comments

- Some delays in milestones, due to delay in timing of FY13 funding, also delay in peer review to fit Annex IV (MHK) schedule

# Technical Approach - International Energy Agency Wind Task 34



- International collaborative project under IEA Wind
  - 7 member nations currently participating.
- Collaboratively examine information on environmental effects of land-based and OSW development worldwide.
- Focus on effective monitoring practices and mitigation strategies.
- Make environmental effects material widely accessible and available to researchers, regulators and developers.
- Led by US: DOE WWPTO; PNNL – OSW; NREL – land based wind
- Develop IT-enabled hub to facilitate collaboration:
  - Expand current state of knowledge and understanding worldwide
  - Accelerate development of OSW industry in US

iea Energy Technology Network

# Accomplishments and Progress – IEA Wind Task 34



- Introductory webinars for member nations
  - Shared project goals and objectives
  - Reviewed existing data portals/ for environmental effects of wind
  - Surveyed nations on topics of interest
- Kickoff meeting in Norway, Dec 2013
  - Participation from Netherlands, Norway, Germany, Switzerland, Sweden, US
- Developed products:
  - Summary of Task 34 project
  - Survey for stakeholders in participating nations
  - Conceptual hub for IT and collaboration

# Project Plan & Schedule – IEA Wind Task 34

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

| Summary | |
|---|---|
| WBS Number or Agreement Number | 5.1.6 |
| Project Number | |
| Agreement Number | 22531 |
| | |

| Legend | |
|---|---|
| | Work completed |
| | Active Task |
| | Milestones & Deliverables (Original Plan) |
| | Milestones & Deliverables (Actual) |

| | FY2012 | | | | FY2013 | | | | FY2014 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Task / Event | Q1 (Oct-Dec) | Q2 (Jan-Mar) | Q3 (Apr-Jun) | Q4 (Jul-Sep) | Q1 (Oct-Dec) | Q2 (Jan-Mar) | Q3 (Apr-Jun) | Q4 (Jul-Sep) | Q1 (Oct-Dec) | Q2 (Jan-Mar) | Q3 (Apr-Jun) | Q4 (Jul-Sep) |
| **Project Name: IEA Wind Task 34** | | | | | | | | | | | | |
| Q3 Milestone: Refine the scope of the IEA offshore wind task for work plan | | | | | | | | | | | | |
| Q4 Milestone: Create a collection plan for offshore wind information | | | | | | | | | | | | |
| **Current work and future research** | | | | | | | | | | | | |
| Continue refining work plan | | | | | | | | | | | | |
| Engage with IEA Nations | | | | | | | | | | | | |
| Collection of Metadata | | | | | | | | | | | | |
| Plan for State of the Science Report | | | | | | | | | | | | |

## Comments

- Progress lags on FY13 milestones as specific work program still under development in cooperation with WWPTO staff & member countries.

## Partners, Subcontractors, and Collaborators:

- **NARW**
  - Collaboration with OSW developers, marine construction industry, NOAA, marine mammal observers.
- **Detecting Birds & Bats**
  - Partnered with Northwest National Marine Renewable Energy Center (NNMREC)
- ***Tethys***
  - Collaboration with OSW researchers for content collection, peer review of *Tethys*
- **IEA Wind Task 34**
  - Collaborative initiative with seven member nations, partnered with DOE WWPTO and NREL

## Communications and Technology Transfer:

- **NARW**
  - Webinar with Atlantic coast NGOs to share outcomes
- **Detecting Birds & Bats**
  - Presentation at NWWC conference, provided computer code to NNMREC
- ***Tethys***
  - Peer-reviewed papers on *Tethys*: one published, two in review
  - Presentations at national, international conferences (GMREC, EWTEC, AWEA)
- **IEA Wind Task 34**
  - Webinars and in person meeting with member nations

# Next Steps and Future Research



## FY14/Current research:

- **NARW**
  - Work with regulators and NARW experts to incorporate new NOAA guidance on sound risk for marine mammals into NARW risk models
- **Detecting Birds & Bats**
  - Publish findings in *Tethys*; adapt software for real-time data collection in marine environment
- ***Tethys***
  - Migrate to new platform
  - Complete OSW information collection
- **IEA Wind Task 34**
  - Survey stakeholders in participating nations
  - Develop white papers on topics of concern
  - Develop IT hub and community

# Mid-Atlantic Baseline Studies of Wildlife Densities and Habitat Use

Principle Investigator: Kate Williams, Biodiversity Research Institute (BRI)

Co-PIs: Evan Adams, David Evers, Andrew Gilbert, and Iain Stenhouse, BRI
Ari Friedlaender, Oregon State University
Beth Gardner, North Carolina State University
David Johnston, Duke University
Richard Veit, City University of New York

## Mid-Atlantic Baseline Studies

Modeling Wildlife Densities and Habitat Use Across Temporal and Spatial Scales on the Mid-Atlantic Continental Shelf

**Dr. Iain Stenhouse**

Biodiversity Research Institute
Iain.stenhouse@briloon.org; 207-839-7600

25 March 2014

# Budget, Purpose, & Objectives

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Total DOE Budget[1]: $3.000M

Total Cost-Share[1]:$0.038M

Problem Statement: There are relatively sparse data on wildlife distributions and movements on the Atlantic Outer Continental Shelf. This data gap, particularly for listed species, presents a barrier to offshore wind development during environmental permitting processes.

Impact of Project: This study provides natural resource data for siting and permitting of offshore wind energy development in the mid-Atlantic and will aid in avoiding and minimizing effects of development on wildlife.

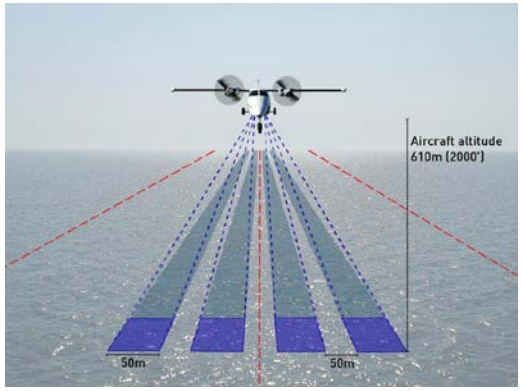
This project aligns with the following DOE Program objectives and priorities:

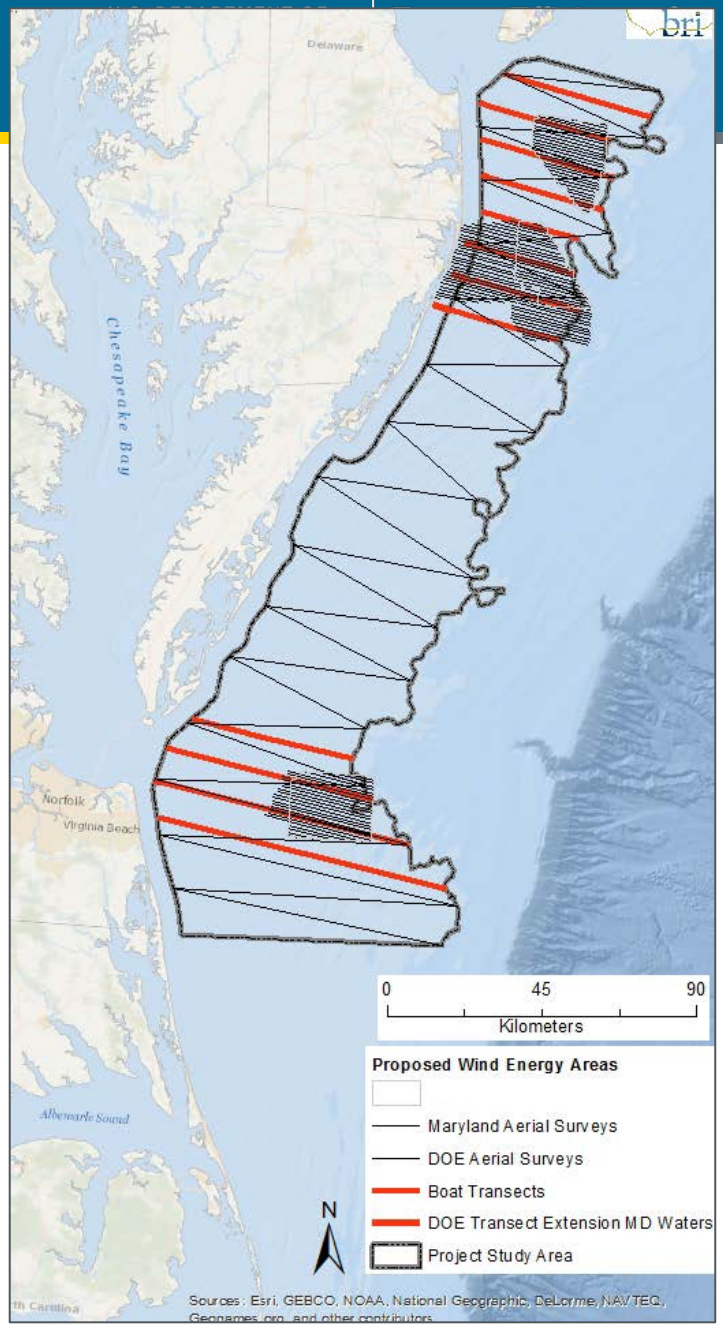
**Mitigate Market Barriers:** Reduce market barriers to preserve or expand access to quality wind resources.

[1] ***Budget/Cost-Share for Period of Performance FY2012 – FY2013***

# Technical Approach

- **Boat and high definition video aerial surveys** to quantify wildlife densities and distributions.
- **Comparison** of high definition video aerial and boat-based survey data, and publication of results for U.S. waters.
- Contribution of data and analyses to help **overcome the market barrier associated with NEPA, MMPA, ESA, and MBTA** requirements.

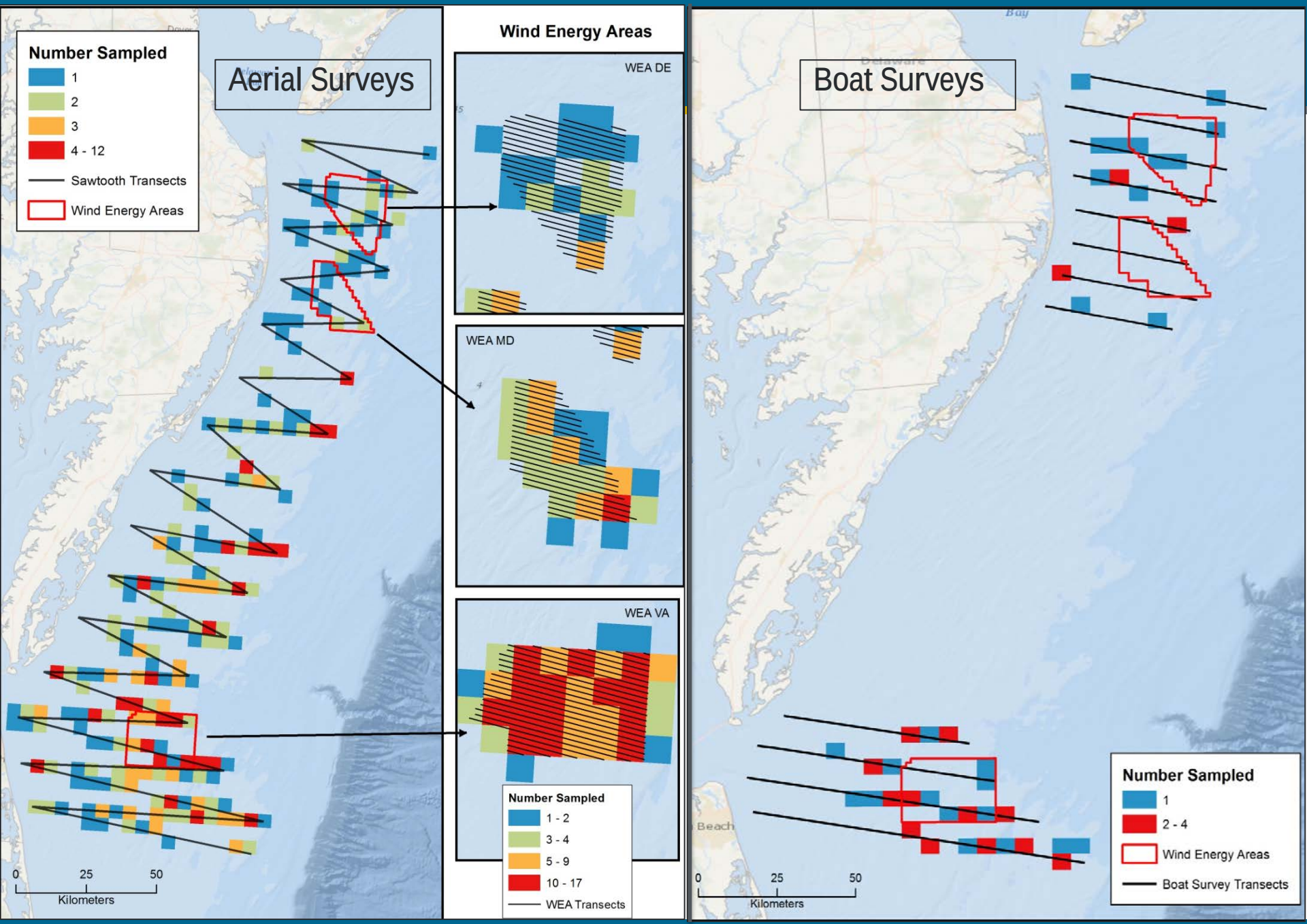


# Boat Surveys vs. Aerial Surveys



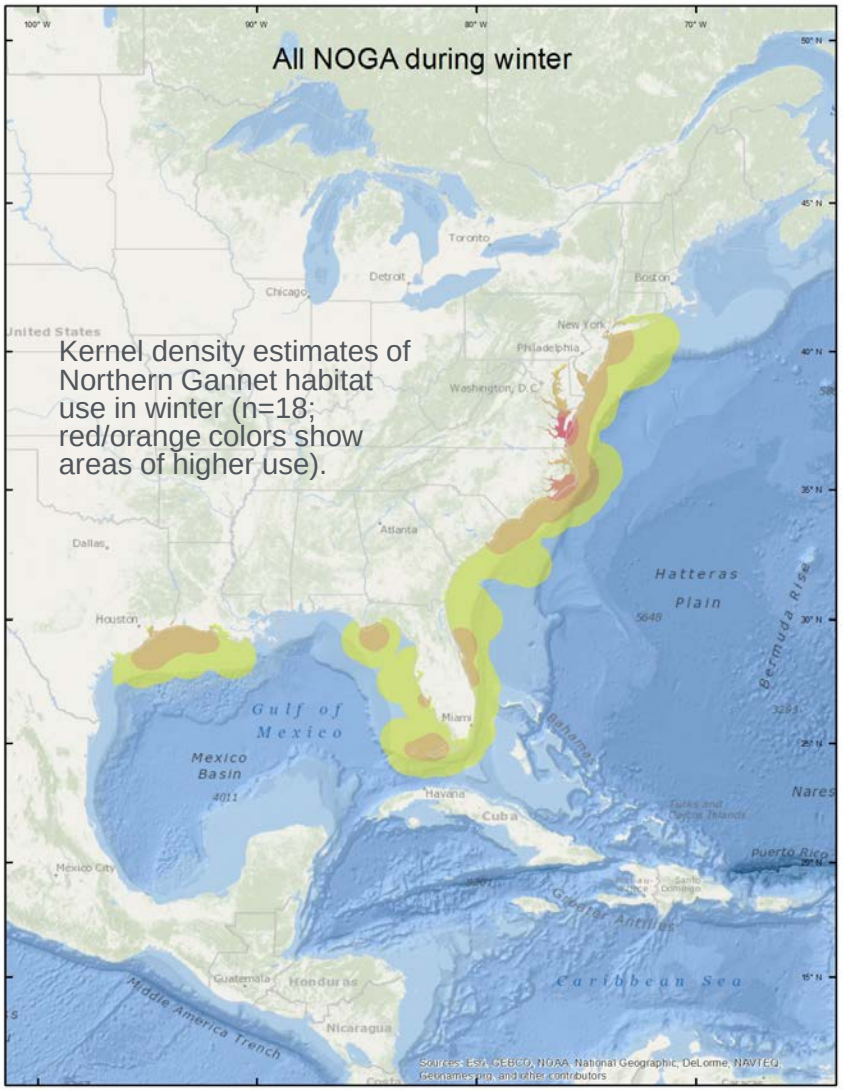
| | Advantages | Challenges |
|---|---|---|
| Boat Surveys | • Can record both in and outside strip width<br>• Behavioral details<br>• Species ID rates<br>• Comparable with historic datasets | • Disturbance/displacement<br>• Detection varies with distance, weather, and other factors<br>• Slow survey pace<br>• Observer biases<br>• No opportunity for audits<br>• No permanent record |
| Aerial Surveys | • Efficient<br>• Less biased in some ways<br>• Repeatable pre- and post-construction<br>• Archivable<br>• Auditable | • Relatively narrow strip width<br>• Detection of small dark species<br>• Identification rates<br>• Weather effects on image quality |


Aerial Surveys
Number Sampled
1
2
3
4 - 12
Sawtooth Transects
Wind Energy Areas
Wind Energy Areas
WEA DE
WEA MD
WEA VA
Number Sampled
1 - 2
3 - 4
5 - 9
10 - 17
WEA Transects
0
25
50
Kilometers
Boat Surveys
Number Sampled
1
2 - 4
Wind Energy Areas
Boat Survey Transects
0
25
50
Kilometers

# Technical Approach



- **Individual tracking** to determine seabird movements and habitat use.
- Exploration of methods for monitoring **nocturnal avian migration** in the offshore environment (passive acoustics, NEXRAD weather radar).
- **Statistical analyses** of environmental covariates and spatial and temporal patterns in wildlife distributions.
- **Identification of species at potential risk** of interaction with wind development in the mid-Atlantic.
- **Disseminate project data** to stakeholders and regulators through technical and summary reports, geospatial map layers, scientific manuscripts, and in-person briefings.



# Technical Approach

## Current efforts:

- Completion of boat and aerial surveys by May 2014
  - *Unique approach:* First broad-scale use of high definition video aerial surveys in North America
  - *Unique approach:* Direct comparison of high definition video aerial surveys and observational boat surveys (the methods of choice in Europe)
- Analysis of survey data: seasonal patterns and density maps
  - *Unique approach:* Community distance sampling model for boat survey data allows for prediction of distributions of rare species.
  - *Unique approach:* Hierarchical modeling combines survey data and environmental covariates to understand underlying causes of wildlife distributions and predict future occurrence

# Accomplishments and Progress



- Milestones (through April 2014):
  - 75% of planned boat and aerial surveys completed in each budget period
  - Comparison of aerial and boat-based survey techniques
  - Annual progress and technical reports
- Status in relation to milestones:
  - Completion of 85% of the planned aerial surveys and 93% of the planned boat surveys for the project
  - Completion of a field comparison of boat and aerial survey techniques *(March 2013)*
  - Submission of annual progress reports *(Jan. '13, Jan. '14)*
  - Submission of annual technical reports with preliminary analyses *(Jan. '13, Jan. '14)*

# Accomplishments and Progress

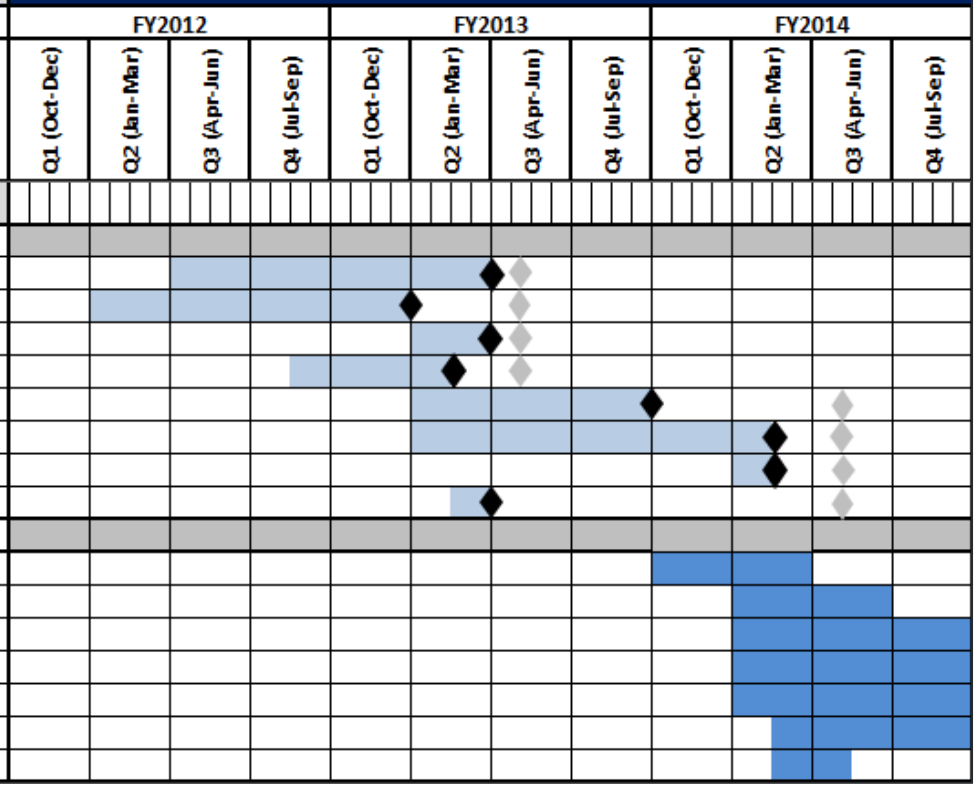


- **Field:**
  - Individual tracking data for 149 individuals from four focal bird species
  - Expansion of project scope and funding in FY13 through collaboration with the state of Maryland
- **Analysis:**
  - Development of data management and quality assurance/quality control procedures for boat and aerial survey data
  - Determination of the utility of weather radar data for examining nocturnal migratory movements offshore
  - Coordination with other ongoing wildlife studies
  - Publication of a scientific manuscript that describes high definition video aerial survey methodologies
- **Awards:**
  - Best Poster in the Project Development/Permitting Category at AWEA Offshore Expo 2013: “Offshore Observations of Eastern Red Bats in the Mid-Atlantic US Using Multiple Survey Methods”

# Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

| Summary | Legend | | | |
|---|---|---|---|---|
| WBS Number or Agreement Number | | Work completed | | Milestones & Deliverables (Original Plan) |
| Project Number | | Active Task | | Milestones & Deliverables (Actual) |
| Agreement Number DE-EE0005362 | | | | |




| Task / Event |
|---|
| **Project Name: Mid-Atlantic Baseline Studies** |
| Completion of 75% of planned boat surveys for first budget period |
| Completion of 75% of planned aerial surveys for first budget period |
| Submission of annual progress and technical reports with preliminary analyses |
| Begin to compare aerial and boat-based survey techniques |
| Completion of 75% of planned boat surveys for second budget period |
| Completion of 75% of planned aerial surveys for second budget period |
| Submission of annual progress and technical reports with preliminary analyses |
| Conduct boat-aerial comparison |
| **Current work and future research** |
| Complete boat surveys |
| Complete aerial surveys |
| Continue modeling efforts |
| Continue analyses of satellite tracking data |
| Continue data collection and management for nocturnal migration monitoring data |
| Develop boat-aerial comparison manuscript for publication |
| Develop detailed plan for project administration/deliverables for 2014-2015 |

## Comments

- Project Duration: Sept. 30, 2011 – April 30, 2015
- Go/no-go decision point: April 2013

# Research Integration & Collaboration



## Communications & Technology Transfer (Conference activities):

**Presentation Forums:**

- Platform presentations: Workshops (1), Conferences (9), Webinars (6)
- Posters: Conferences (3)

**Workshop/conference outcomes:**

- Brown-Saracino et al. 2013. Mid-Atlantic Marine Wildlife Surveys, Modeling, and Data: Workshop to Establish Coordination & Communication. DOE Workshop, Silver Spring, Maryland.
- Marine Bird Cooperative Newsletters 2012, 2013

**Communications:**

- Taylor. 2012. Offshore wind: Wildlife studies in mid-Atlantic seen as crucial to industry's future. Greenwire, Oct. 11, 2012.
- Project flyers

# Research Integration & Collaboration

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

## Communications and Technology Transfer (Reports and Publications):

**Reports:**

- Two annual technical reports to the DOE EERE Wind & Water Power Program (Reports BRI 2013-10, BRI 2014-15).

**Scientific Publications:**

- Hatch et al. 2013. Offshore observations of Eastern Red Bats (*Lasiurus borealis*) in the Mid-Atlantic United States Using Multiple Survey Methods. PLoS ONE 8(12): e83803.

**Non-technical Publications:**

- Hatch et al. In press. Offshore observations of Eastern Red Bats…. ECO Magazine.

**Project website:** www.briloon.org/MABS.

# Research Integration & Collaboration



## Partners, Subcontractors, and Collaborators:

*Private companies:* HiDef Aerial Surveying Ltd.; Brian Patteson Inc.

*Federal collaborators:* Bureau of Ocean Energy Management; U.S. Fish and Wildlife Service Division of Migratory Birds; U.S. Geological Survey; Sea Duck Joint Venture

*State collaborators:* Maryland Dept. of Natural Resources; Maryland Energy Administration

*Nonprofit collaborators:* Biodiversity Research Institute

*Academic collaborators:* College of Staten Island; Duke University; University of Oklahoma; Oregon State University; Memorial University of Newfoundland; North Carolina State University

# Next Steps and Future Research



## FY14/Current research:

- Complete remainder of project surveys (May 2014)
- Finalize survey data (October 2014)
- Analyze boat-aerial survey comparison data
- Continue model development for survey data and begin developing predictive density maps
- Continue analysis of individual tracking data of bird movements
- Continue analysis of weather radar data to determine offshore patterns of nocturnal migration
- Continue data sharing and dissemination of project results

# Next Steps and Future Research

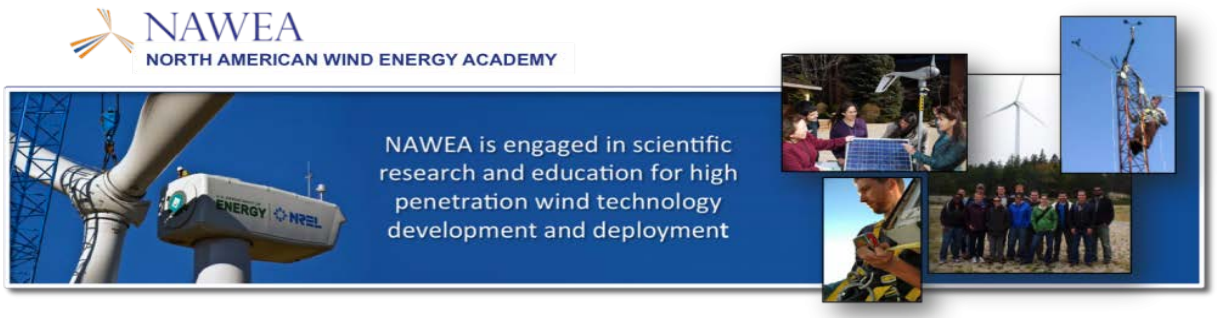


## Potential future research:

- Conduct comprehensive baseline surveys in other regions along U.S. coasts (South Atlantic, Gulf of Maine)
- Expand individual tracking studies to other species
- Expand pilot passive acoustic study to examine species composition of offshore avian migrants
- Continue examination of weather radar data for predicting offshore migration activity

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy






# Workforce Development

Market Acceleration and Deployment

**Ian Baring-Gould**

National Renewable Energy Laboratory

Ian.baring.gould@nrel.gov – (303) 384-7021

March 26, 2014

# Budget, Purpose, & Objectives

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

**Total DOE Budget[1]: $1.919M**

**Total Cost-Share[1]:$1.460M**

**Problem Statement:** The development of a skilled and trained workforce was one of the principle challenges outlined in the 20% report and has impacts on costs, not only in deployment but also design and system reliability.

**Impact of Project:** Support the understanding and development of wind energy education infrastructure, largely in K-20, through program development, curricula support, and organized outreach, leading to education of students, teachers, and communities about wind technologies. In addition, assess the current workforce to determine how DOE can best support the training and education of the future workforce.

**This project aligns with the following DOE Program objectives and priorities:**

- **Optimize Wind Plant Performance:** Reduce Wind Plant Levelized Cost of Energy (LCOE)
- **Accelerate Technology Transfer:** Lead the way for new high-tech U.S. industries
- **Mitigate Market Barriers:** Reduce market barriers to preserve or expand access to quality wind resources
- **Modeling & Analysis:** Conduct wind techno-economic and life-cycle assessments to help program focus its technology development priorities and identify key drivers and hurdles for wind energy technology commercialization

[1] ***Budget/Cost-Share for Period of Performance FY2012 – FY2013***

# Educational Challenge



## Limited Infrastructure

- Mineral extraction-focused schools have been in place for many years. The state-supported Colorado School of Mines started in 1866.
- The U.S. doesn't often develop new energy education systems.
- Wind has a limited and under-supported existing educational infrastructure.

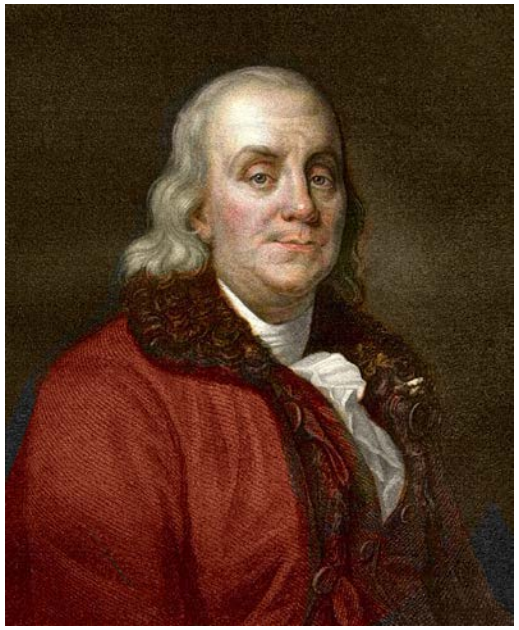
## Large need – smaller pool

- Men make up most of the engineers in the power sector, but the rate of men going into higher education has leveled off or is decreasing.
- Women and minorities are increasingly graduating from universities, but are being turned off by sciences, engineering, and other technical fields.
- Industry faces an ongoing shortage of trained technicians. Many of them leave programs before they are completed to enter the workforce.
- K-12 education in STEM areas is still lacking and needs community inspiration.

# Technical Approach



- Collaborate with existing activities and organizations
- Provide seed funding so that organizations can build larger initiatives or do the little extra that makes a huge impact
- Build off of successful models
- Use experience-based approaches and standards-based curricula
- Expand use of OpenEI as a portal for information exchange
- Look at the whole educational infrastructure as a system
- Assess the current state of the wind workforce and perform a gap analysis for future education and training needs.

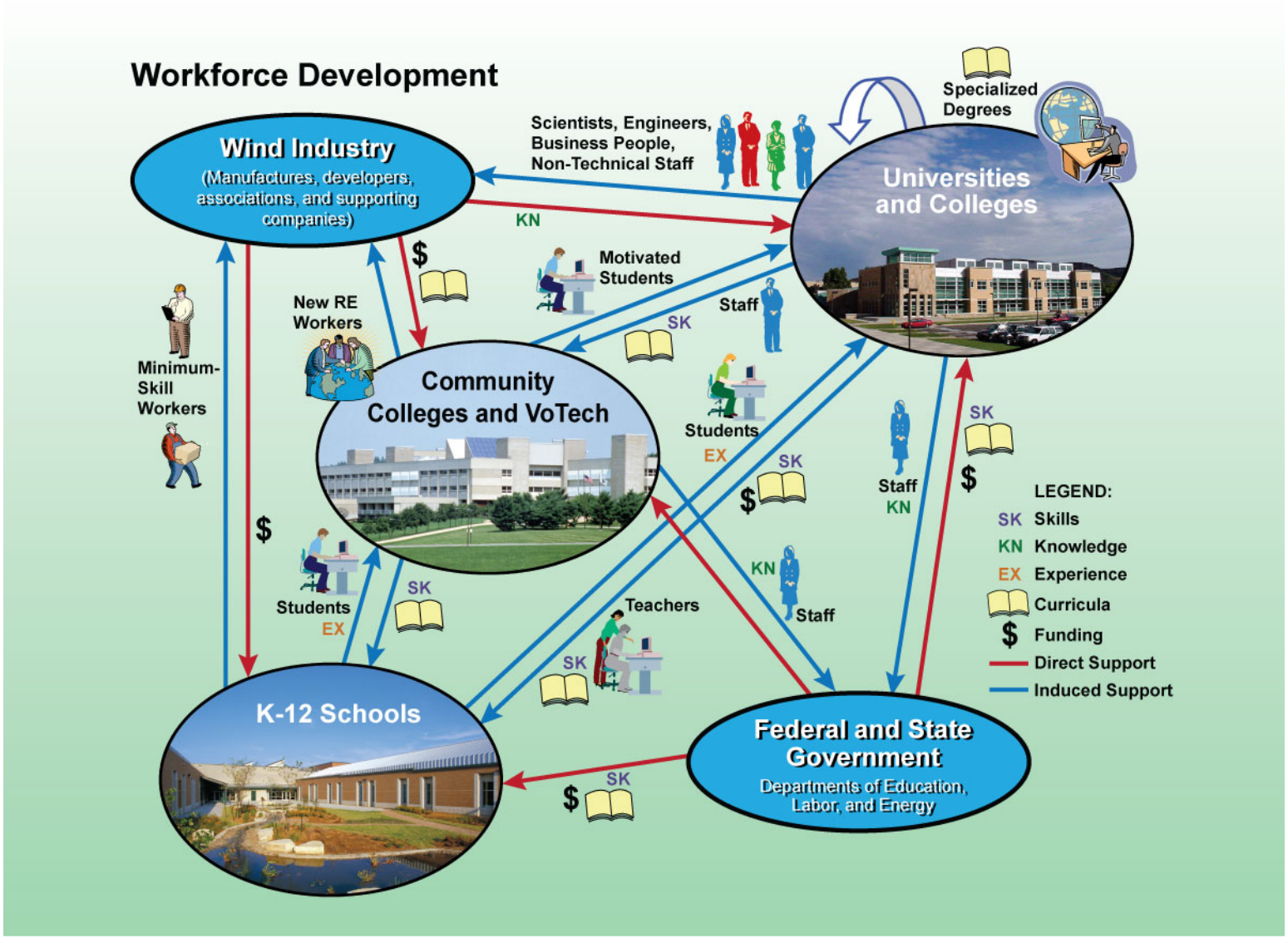


"Tell me and I forget. Teach me and I remember. Involve me and I learn."

*Benjamin Franklin*

# Educational System





# Primary Technical Activities

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

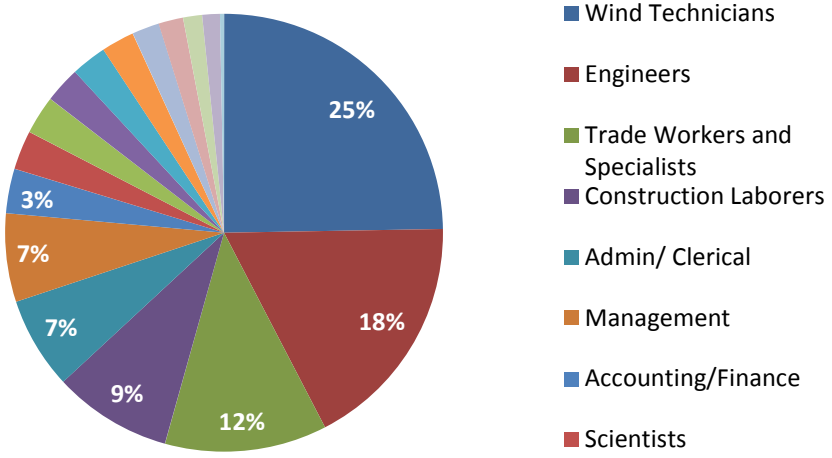
- Develop a Wind Workforce Framework / Road mapping efforts (Vision)
- Work with the wind industry to expand the understanding of the labor needs and appropriate skill sets. (National Skills Assessment outreach)
- Provide platforms to engage university students in hands-on learning about the wind industry (Collegiate Wind Competition)
- Support the development of programs at universities while engaging K-12 education (Wind for Schools)
- Supporting the development of a University Consortia (NAWEA)
- Provide a location to collect and disseminate information about wind programs (OpenEI Portal)
- Technical Needs Assessment for technical workers (Offshore Wind Technician requirements analysis)


Self identified wind educational programs

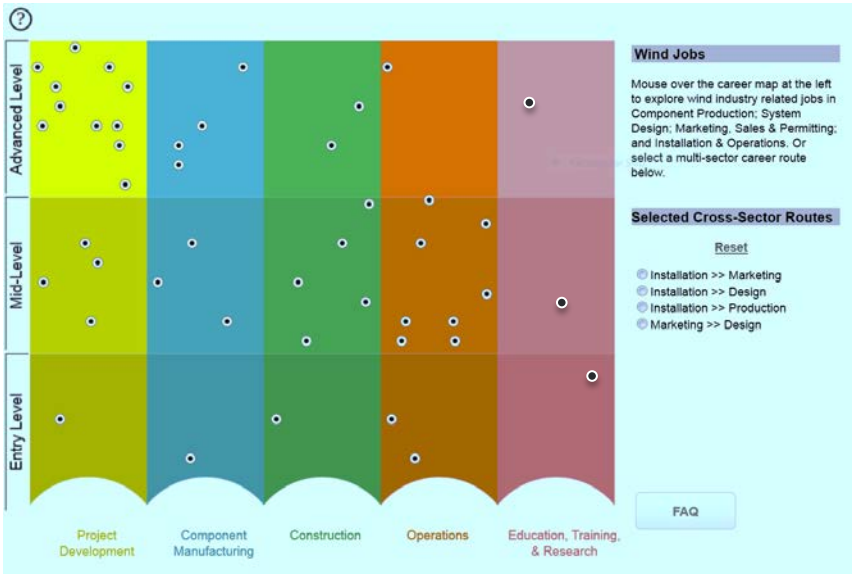
# Wind Workforce Analysis and Career Map

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

**_Subset_ of the Workforce Captured in our Survey**
(~46,000 Workers)




~25% of jobs are involved with the wind power supply chain




*Draft* Web-based Wind Power Career Map
(mock up based on Solar Career Map)

## Published the first-of-its-kind *National Wind Energy Skills Assessment* report

- Included information from 418 wind companies focused on utility-scale market
- 95 specific roles covering 15 different wind market segments (e.g., turbine design, turbine installation, etc.) and 35 specific job functions (e.g., engineer, manager)
- Surveyed employers about educational needs and the preference for applicants with wind experience
- Surveyed wind-focused university and community college programs
- Performed initial extrapolation to worker and educational institution needs based on the 20% report.

## FY14 - drafting a wind career lattice modeled after SunShot's Solar Career Map

# DOE Collegiate Wind Competition



Stimulate student interest and industry awareness of an elite next-gen workforce and new institutions launching wind programs.

- Experience designing, building, and testing a wind turbine to perform according to a customized market, data-derived business plan
- Investigate and develop innovative wind energy concepts
- Increase knowledge of market drivers and deployment acceleration opportunities affecting the wind industry
- Collect detailed metrics for both students and the competition
- Build cross-disciplinary teams to address a challenge, mirroring the wind industry.


Colorado School of Mines team of diverse majors – engineers, business, & marketing

2014 Inaugural Competition

- This year's theme is to design, construct, and develop a business case for a lightweight, transportable wind turbine that can be used to power small electronic devices.
- 10 undergraduate university teams selected through a competitive solicitation.
- A 3-day event to be held in conjunction with WINDPOWER 2014

COLLEGIATE WIND COMPETITION
U.S. DEPARTMENT OF ENERGY

- Build and test a wind turbine
- Present on wind energy topics
- Deliver a cohesive business plan

# Wind for Schools

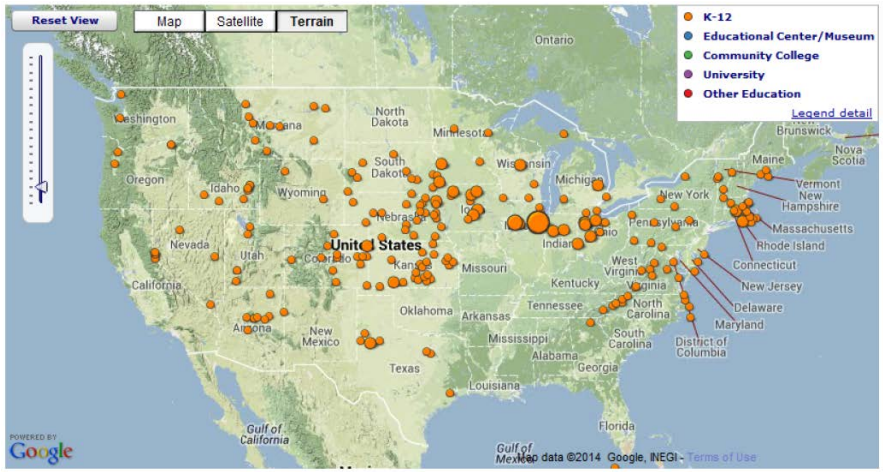
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Raise awareness about the benefits of wind energy while simultaneously developing a wind energy knowledge base to educate future leaders of our communities, states, and nation

- **Project Objectives:**
- *Engage rural America in the concept that wind offers an alternative energy and economic future for rural America*
- *Engage rural school teachers and students in energy education, specifically wind*
- *Equip college juniors and seniors in wind energy applications and education to provide the growing U.S. wind industry with interested and equipped engineers*

*Through the Wind Application Centers develop state based centers of excellence for wind energy information*

**Wind turbine at Sanborn Central School in Forestburg, South Dakota. PIX # 16032**
**Photo credit: East River Electric Power Cooperative**




**Locations of Wind projects at Schools (Alaska projects not shown)**

**Project Approach:** Develop and then work though a Wind Application Center started at a state university to install small wind turbines and implement educational programs at K-12 schools using university students interested in a career in the wind industry.

**Results to Date:**

- Active programs in 12 states originally with most states currently operating with no new DOE funds
- Hundreds of undergraduate students graduating with wind energy experience
- 134 turbines installed at K-12 schools with no DOE funding ( over $2.6M project leverage)
- K-12 Teacher training programs in every state impacting ten's of thousands of students.

Project Status: Project currently being wrapped down at the direction of the Office of Management and budget

# Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

| Summary | |
|---|---|
| WBS Number or Agreement Number | WE 6.1.1; WE 11.1.1; WE11.1.3 |
| Project Number | |
| Agreement Number | |
| | |

| Legend | |
|---|---|
| | Work completed |
| | Active Task |
| | Milestones & Deliverables (Original Plan) |
| | Milestones & Deliverables (Actual) |

| Task / Event | FY2012 Q1 (Oct-Dec) | FY2012 Q2 (Jan-Mar) | FY2012 Q3 (Apr-Jun) | FY2012 Q4 (Jul-Sep) | FY2013 Q1 (Oct-Dec) | FY2013 Q2 (Jan-Mar) | FY2013 Q3 (Apr-Jun) | FY2013 Q4 (Jul-Sep) | FY2014 Q1 (Oct-Dec) | FY2014 Q2 (Jan-Mar) | FY2014 Q3 (Apr-Jun) | FY2014 Q4 (Jul-Sep) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Project Name: Workforce Development** | | | | | | | | | | | | |
| Wind Workforce Development | | | | | | | | | | | | |
| NAWEA Support | | | | | | | | | | | | |
| Wind Educational Framework | | | | | | | | | | | | |
| Wind for Schools | | | | | | | | | | | | |
| National Skills Assessment | | | | | | | | | | | | |
| National Carrier Ladder Development | | | | | | | | | | | | |
| Collegiate Wind Competition - Development | | | | | | | | | | | | |
| Collegiate Wind Competition - Event Preparation | | | | | | | | | | | | |
| Collegiate Wind Competition - Second Event Development | | | | | | | | | | | | |

## Comments

- Workforce development projects are ongoing although specific activities may have defined timelines
- Only very limited Wind for Schools work is ongoing

# Research Integration & Collaboration

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

**Partners, Subcontractors, and Collaborators:** We work closely with many educational institutions including more than 20 universities. Project team members also include the NEED project, KidWind, and WindWise that support K-12 curricula development. The activity also works closely with AWEA and other industry partners not only in project development, but also to obtain funding support for activities. Outside project funding comes from a host of organizations, private and public.

**Communications and Technology Transfer:** Expansive outreach activities include fact sheets, webinars, and technical documents including technical and project reports. Extensive use of Web-focused content, both static and through OpenEI (http://en.openei.org/wiki/Wind_for_Schools_Portal). Most products developed to allow external branded usage through external partners such as NEED project, KidWind, and WindWise. University partners also have explicit outreach actives.

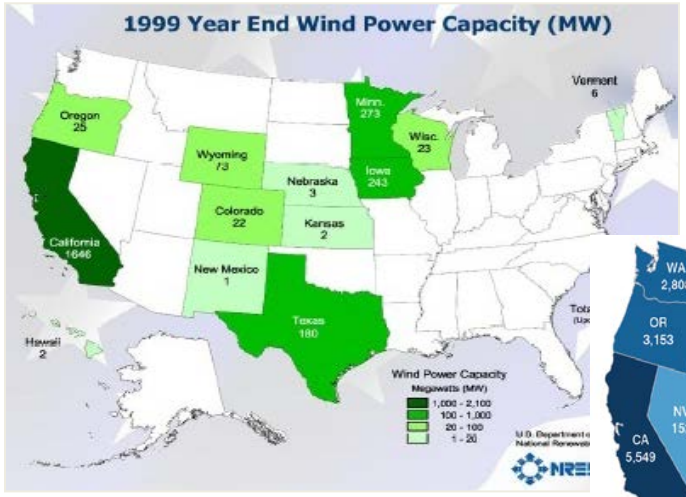
# Next Steps and Future Research

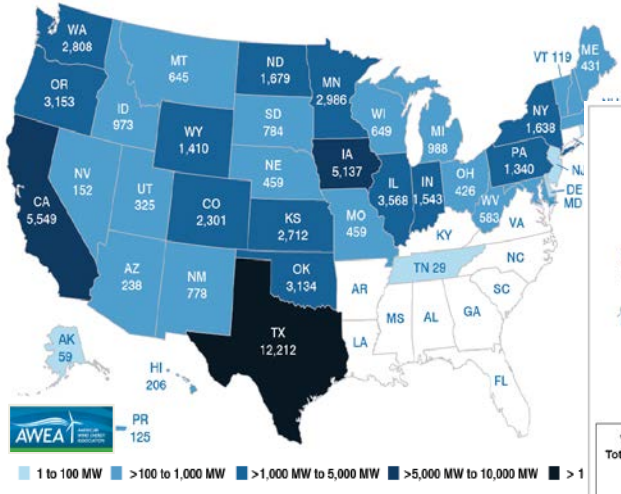


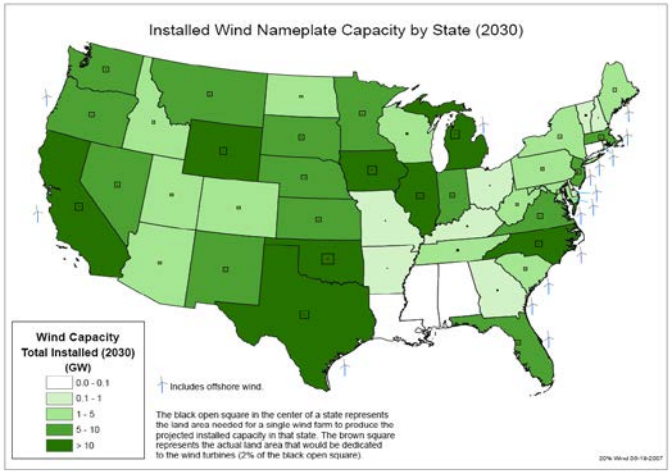
**FY14/Current research:** Current activities focused around the implementation of the inaugural Collegiate Wind Competition, development of the Wind Career Map, and closing down the Wind for Schools initiative. All activities working to assess education and training infrastructure needs are currently in support of the Wind Vision. All other activities significantly reduced or stopped.

**Proposed future research:** A great deal of work areas have been proposed through the National Wind Workforce Framework and Wind Vision Roadmap. Specific near-term actions could include:

- Re-engage with Wind for Schools (with OMB approval)
- Continue to support the formation of the NAWEA
- Expand workforce and educational system assessments
- Implement an activity consolidating continuing education/professional development to strengthen and improve the existing workforce
- Perform curricula consolidation and review.




# Stakeholder Engagement & Outreach

Market Acceleration and Deployment

**Ian Baring-Gould**

National Renewable Energy Laboratory

Ian.baring.gould@nrel.gov – (303) 384-7021

March 6, 2014

# Budget, Purpose, & Objectives

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

**Total DOE Budget[1]: $2.100M**

**Total Cost-Share[1]:$0.110M**

**Problem Statement:** Wind project developments are being stopped and/or contested, increasing the total cost and deployment times for wind projects. Although wind has broad conceptual support, key issues and misconceptions remain. This condition will continue to get worse as wind expands into areas with increasing conflicts.

**Impact of Project:** This activity makes available unbiased information to a wide range of stakeholders, allowing decision makers to make scientifically supported decisions. This allows expanded wind deployment and continued access to the best sites while reducing costs for overall deployment and potential unneeded mitigation. Better information also reduces deployment times and increases the likelihood that proposed projects will result in development.

## This project aligns with the following DOE Program objectives and priorities

**Mitigate Market Barriers:** Reduce market barriers to preserve or expand access to quality wind resources

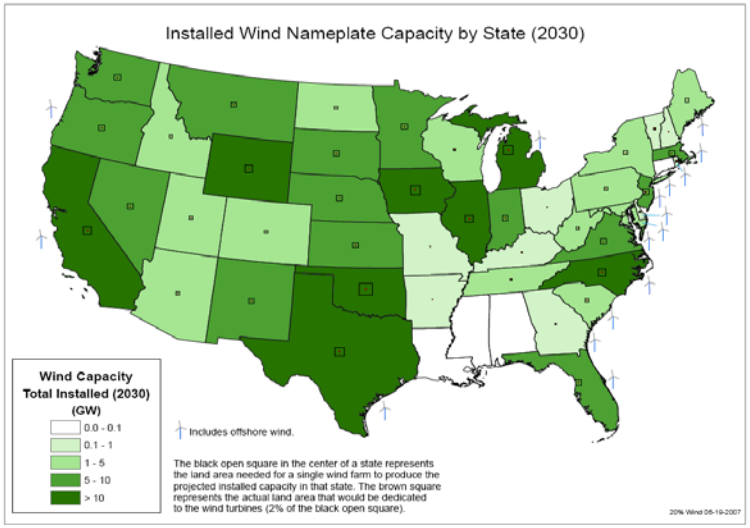
[1] ***Budget/Cost-Share for Period of Performance FY2012 – FY2013***

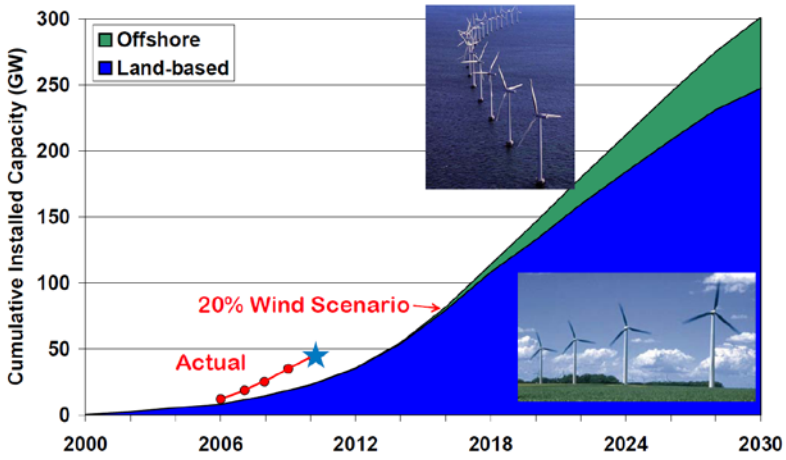
# Technical Approach

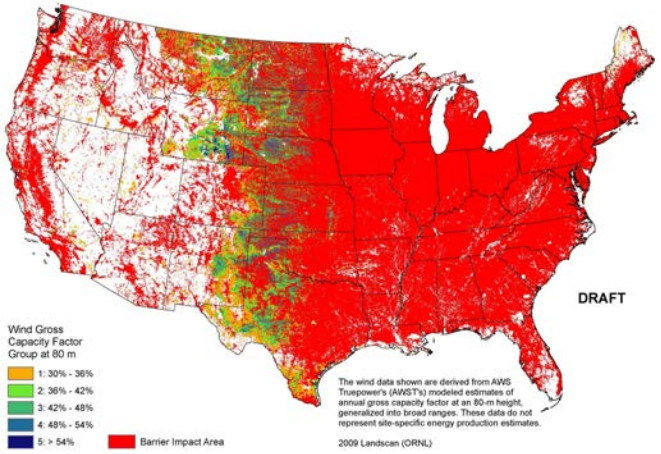


## What is the problem?

- As wind technology deployment becomes more wide spread, a defined opposition is forming brought on by fear of change and competing energy technologies
- As with access to good wind resources, as the easy-to-deploy sites are developed, the costs of developing at sites facing increased deployment barriers will increase, raising the total cost of power



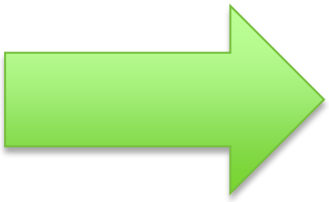

The dialog is shifting – but extreme permitting scenarios demonstrate the potential impact

# Catching up with a Change in Scope



## Wind Powering America was incredibly successful

- 34 states with more than 100 MW of installed wind capacity
- 15 states with more than 1,000 MW of installed wind capacity
- With a total DOE investment of $27M; 3,375 MW of wind were deployed via WPA Wind Working Group activities from 1999 to 2010(1) - 250:1 ROI or $8k/MW


## However…

- Original focus was to introduce a technology that had become mainstream in other parts of the world to an American energy market that had little experience – Bringing Wind Power to America.
- The changing federal role to inject fact-based information into wind deployment discussions warranted a change in the initiative's name to a new one focused on providing information – A Wind Energy Information Network…

(1) "Impact and Process Evaluation of the U.S. Department of Energy's Wind Powering America Initiative," Navigant Consulting, Inc., Publication DOE/EE-0897, May 2013

# Guiding Principles



- Listen so that we can understand the issues that are facing the industry and wind development, typically on a regional and state level
- Development products and tools providing unbiased information, allowing stakeholders to make educated decisions
- Work actively to get that information in the hands of people who can use it to impact project development and good decision making
- Develop and implement collaborative partnerships to engage and leverage existing stakeholder networks
- Conduct and disseminate the results of market analyses
- Engage and leverage existing educational infrastructure
- Engage current state of the art in marketing metrics development
- Shift to web based content
- Become more of a portal, less of a generator


Updated WindExchange website

Annual All States Summit

# Technical Approach



- Transition to regional approach
  - Wrap up all previous state Wind Working Groups (WWG) contracts
  - Continue bridge funding to defined regional partners
  - Work with DOE to develop a new competitive solicitation for regional centers (expected FY13)
- Maintain efforts to work in problem areas where other support does not exist, moving out of that space when the infrastructure is in place
- Develop innovative, metrics-based implementation plan
- Use new and innovative communication tools – lower cost, expanded outreach
- Work in all technology areas
- Expand work with the federal sector, including training and tech. assistance
- Work to develop / articulate deployment links to cost of energy & deployment
- Leverage appropriate state, GO, lab and university skills
- Collaborate in appropriate IEA tasks

Annual All-States Summit

# Regional Resource Centers

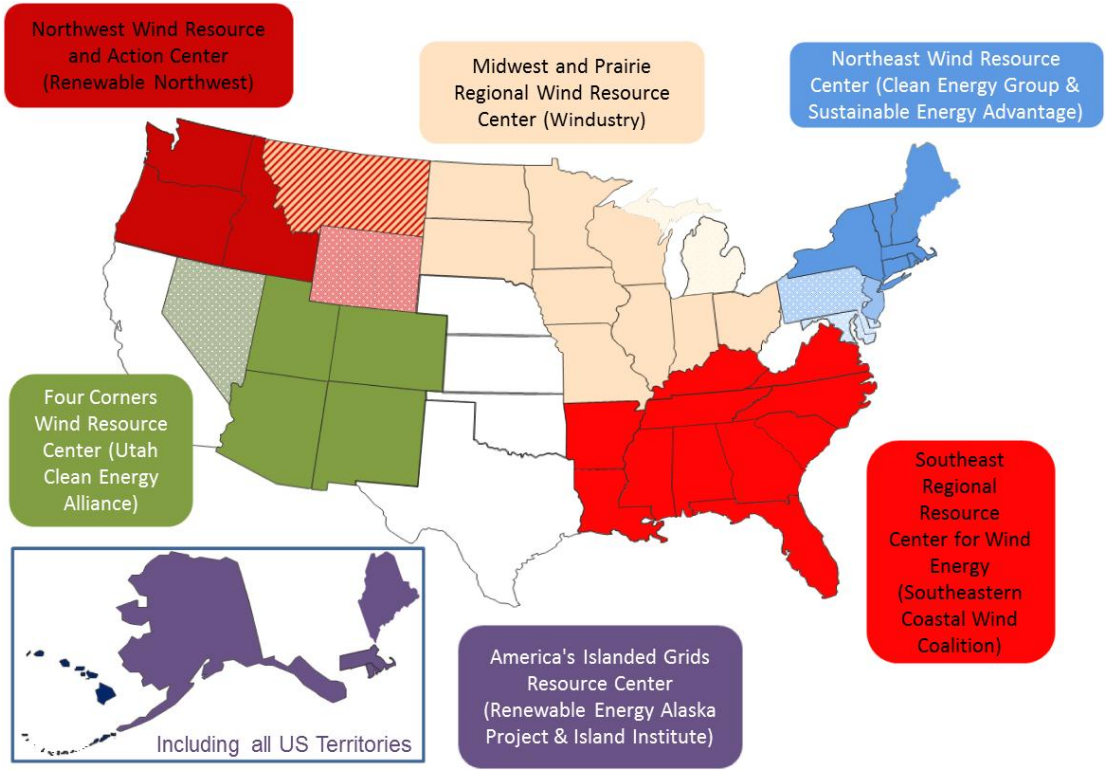


RRCs will prioritize activities to those promising the largest impact and build off the successful Wind Working Group model:

- Maximize the local implementation of national outreach priorities.
- Expand outreach of local experts by hosting meetings and trainings.
- Identify and engage appropriate regulators and decision makers.
- Form working groups on relevant issues
- Provide technical expertise and tools.
- Educate communities about development impact.

RRC leadership will also:

- Provide guidance on issues and regional priorities.
- Repackage relevant content to be provided nationally.
- Become self sufficient
- Monitor performance through defined metrics



# Support of Federal Agencies



Executive mandates are requiring expanded acceptance/consideration of RE technologies although many Federal entities are not sure how to implement wind projects, which will be required to meet any goals.

DOE supports educational workshops and outreach to Federal entities:

- Workshop at GovEnergy in August 2012, GovEnergy was canceled at the last minute
- Participation and presentation at initial F&WS Guidelines training in September 2012
- Federal WEATS – Three day training activity in October, 2012
  - 78 Attendees from 13 states, representing 16 federal agencies and 13 companies
- Participated and presented at three BOEM Offshore Energy Workshops
  - Workshops in OR, CA, and HI over the spring and summer of 2013 with over 230 attendees
- Presentation at several governmental forms, trainings, and conferences, providing information about wind energy technologies and deployment
- Federal Sequester has made it harder for Fed's to engage, especially for trainings that are not core to their job focus

# Communications Accomplishments

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Expand Web-based outreach for Stakeholder Engagement – becoming a portal for wind information and maximizing visibility of products, still understanding importance of active engagement:

- Bi-weekly e-newsletter with 10,000 subscribers
- Website is one of the most visited of all EERE sites for multiple years running
- More than 100 success stories, lessons learned, and case studies produced
- Monthly webinar series with more than 80 recorded, each capturing between 70 and 150 people
- Reduce printed material to control costs
- Information portal developed on OpenEI with a growing number of wiki-based community-supported documents
- Efforts underway to develop a referenced myth-busters through Wind Vision project
- All-States Summit and partner engagement
- Implementation of Regional Resource Centers to support outreach and feedback


U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

**Stakeholder Engagement & Outreach Newsletter**

**Issue #80: November 4-15, 2013**

The Wind Program Stakeholder Engagement and Outreach Newsletter is issued twice a month to inform program partners and interested individuals of wind energy events, webinars, financial opportunities, new publications, state success stories, and other wind-related activities. If you have news items and success stories to share, please submit them to Ruth Baranowski.

**News**

- DOE's NREL Releases Regional Wind Deployment Resource Centers RFP
- IEA Publishes Recommended Practices for Wind Integration Studies
- NREL Publishes Transmission Line JEDI Model User Reference Guide
- Report Shows Trend toward Larger Offshore Wind Systems, with 11 Advanced-Stage Projects Proposed in U.S. Waters
- Rural Communities Benefit from Wind Energy's Continued Success
- North Charleston Proclaims Support for Offshore Wind Energy
- ACORE Publishes Renewable Energy Report for the Midwestern Region

**Webinars**

- Stakeholder Engagement & Outreach November Webinar: Jobs and Economic Development Impacts of Offshore Wind
- Bureau of Ocean Energy Management Webinar: Offshore Renewable Energy Program Update

**Events**

- AWEA Wind Energy Fall Symposiu
- 6th Annual Nebraska Wind Confere
- AWEA Wind Resource & Project En
- Distributed Wind 2014
- AWEA Wind Energy Regional Sumr

**Wind Energy Stakeholder Engagement & Outreach Portal**

The U.S. Department of Energy uses OpenEI to host these stakeholder engagement and outreach tools:

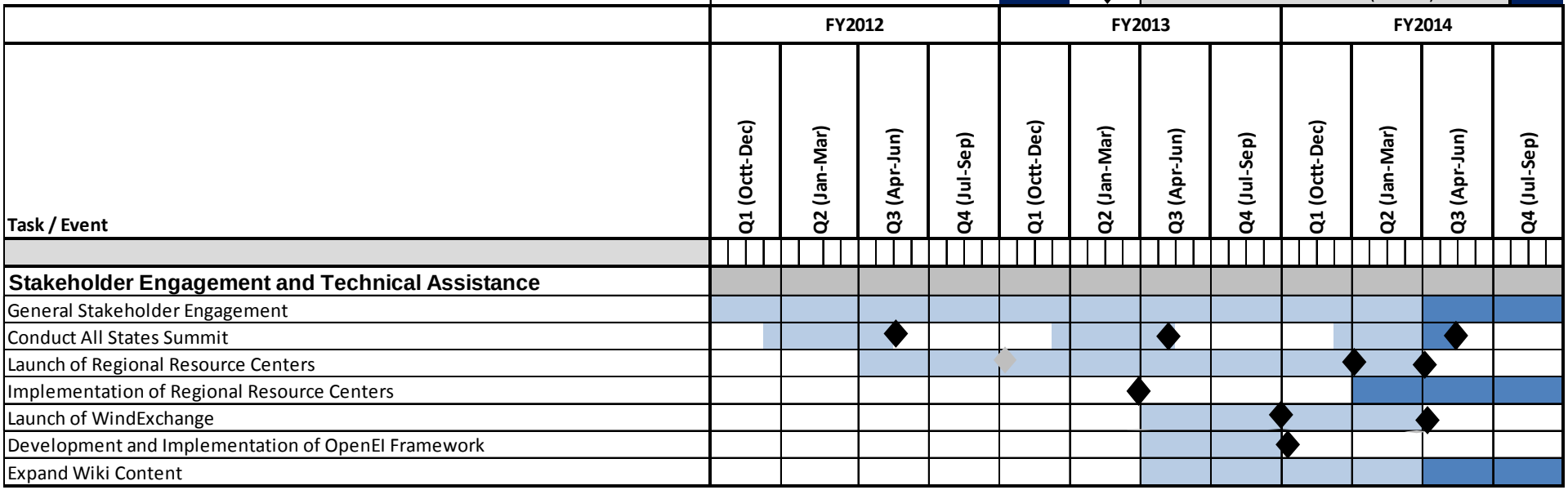
- Small Wind Guidebook
- Wind for Schools Portal
- Wind Working Group Toolkit (under development)
- Community Wind Handbook (under development)

# Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

| Summary | |
|---|---|
| WBS Number or Agreement Number | WE 11.1.2 |
| Project Number | |
| Agreement Number | |
| | |

| Legend | |
|---|---|
| | Work completed |
| | Active Task |
| | Milestones & Deliverables (Original Plan) |
| | Milestones & Deliverables (Actual) |




## Comments

- Most product outputs are ongoing, such as bi-weekly e-newsletters
- RRC concept development and rollout has been a long and ongoing project
- Development and launch of the WindExchange has been equally challenging

# Research Integration & Collaboration



**Partners, Subcontractors, and Collaborators:** State energy offices, energy-focused NGOs, academia, regional wind-focused organizations (GLWC, SACE, NEWF), and federal agencies. The WindExchange also works directly with other national organizations addressing issues around wind deployment, including AWEA, DWEA, NWCC, AWWI, and UWIG.

**Communications and Technology Transfer:** As articulated previously, most of the work done through this activity is focused on communications and stakeholder engagement. Key focuses will continue to include the program website http://wind.energy.gov/WindExchange.gov and OpenEI http://en.openei.org/wiki/Gateway:Wind though more direct outreach is expected through wider engagement of the RRC's and through the Wind Vision.

# Next Steps and Future Research



**FY14/Current research:** Beyond continued long-standing activities such as newsletters, outreach products, major focuses for the year include the revamping of the website to more accurately reflect WindExchange mission and the implementation of the Regional Resource Center Model. Continued, though limited, engagement with the Federal sector through distance outreach. The rollout of the Wind Vision will also be a focal point of activities, largely in Q4.

**Proposed future research:** The Wind Vision lays out a host of important engagement options that must be addressed and discussed in order to allow the levels of deployment required by the industry.

- There remain many misconceptions about winds relevance
- Expanded work understanding and documenting public acceptance issues is needed: Acoustics, lighting, local impact assessment
- Public acceptance and community impact for offshore wind development will become a key issue going forwards
- Expanded engagement with the Utility sector on Integrated Resource Planning and outreach
- Expanded Engagement with the Federal sector on deployment and permitting

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# Market Analysis and Resource Assessment

Wind and Water Power Market Acceleration and Deployment

**Suzanne Tegen**

NREL

suzanne.tegen@nrel.gov, 303 384 6939

March 27, 2014

# Budget, Purpose, & Objectives

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

**Total DOE Budget[1]: $0.340M**

**Total Cost-Share[1]:$0.030M**

## Problem Statement

- Decision-makers lack reliable, peer reviewed, inexpensive data on wind jobs and economic effects to their communities
- Jobs and other economic effects are often quantified with varying degrees of reliability. This causes problems during siting and the public engagement process.
- Without a public source of basic information, it's hard for anyone other than large companies to understand their wind resource potential. Wind resource analysis is essential so that people understand the amount of energy wind could provide to their locality.

## This project aligns with the following DOE Program objectives and priorities

- **Mitigate Market Barriers:** Reduce market barriers to preserve or expand access to quality wind resources
- **Modeling and Analysis:** Conduct wind techno-economic and lifecycle assessments to help program focus its technology-development priorities and identify key drivers and hurdles for wind-energy technology commercialization.

[1] ***Budget/Cost-Share for Period of Performance FY2012 – FY2013***

# Budget, Purpose, & Objectives



## Impact of Project

This work provides reliable data, maps, and analysis to DOE, local and state decision-makers, industry, academia, and other wind-power stakeholders in two crucial areas:

1) Jobs and other economic impacts from wind power
2) Wind resource maps for land-based and offshore wind so that all parties can make informed decisions

NREL creates and maintains Jobs and Economic Development Impacts (JEDI) models for land-based and offshore wind so that developers, project owners, and others can relay economic estimates to local and state officials, and the local community, during the siting and permitting processes.

## Impact of Project

- Why it's important
  - One vital factor in the deployment and operation of a wind-power system is the ability to assess and characterize available wind resources
  - Our reliable, validated, free wind resource maps save both time and money for county commissioners and other decision-makers, developers, and potential project owners requiring wind resource data.

Note: when there is increased interest in wind resource assessments necessitating more detailed data, NREL encourages interested parties to work with industry to obtain high-quality, site-specific wind resource data.

# Technical Approach
## *Modeling and Economic Analysis*

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- NREL creates and maintains the land-based and offshore wind JEDI models to perform economic analyses
  - Gathers cost and local share data
  - Creates the models
  - Performs model testing
  - Validates models through external peer reviews
  - Publishes models on line
  - Maintains models
  - Conducts analysis

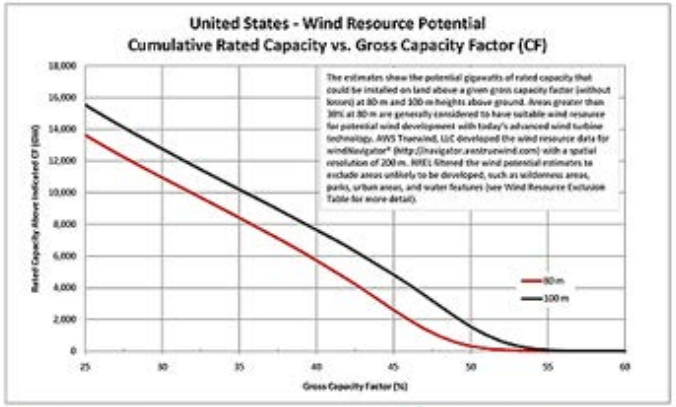

- On an annual basis, models are updated with current basic industry cost information (primarily from the DOE Wind Technologies Market Report). We provide technical assistance to model users as funding permits.
- NREL researches, validates, and provides the manufacturing facilities map for the annual DOE Wind Technologies Market Report.

# Technical Approach
## *Wind Resource Assessment*



- NREL wind resource assessment experts and GIS team, working with AWS Truepower, have expanded and updated wind resource maps of the United States to address different stakeholder needs (distributed, utility-scale, and offshore) and document the impact of technology improvements on market potential.
- Wind resource maps are among the most popular downloads across all EERE.

Capacity curves displayed on our website with wind resource maps



# Accomplishments and Progress

## Economic Analysis

- Created the transmission JEDI model and user guide (co-funded)
- Created and published the offshore wind JEDI model and user guide
- Presented the JEDI models to:
  - The National Academy of Sciences group interested in future mining workforce
  - North American Wind Energy Academy, at WINDPOWER
  - Others
- Researched potential deployment scenarios for fixed-bottom offshore wind in four regions of the country

## Publications

- The Jobs and Economic Development Impacts from the first 1000 MW of Wind in Iowa
- User guides for offshore and transmission JEDI models
- Regional Offshore Wind Fact Sheets
- Ex post analysis of economic impacts from wind power development in U.S. counties with USDA and LBNL

# Accomplishments and Progress
## *Economic Analysis*



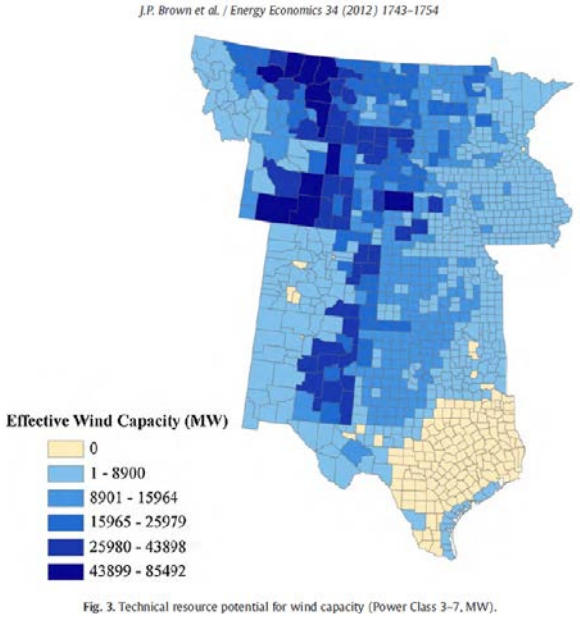



Fig. 3. Technical resource potential for wind capacity (Power Class 3–7, MW).

**A joint research effort by USDA, LBNL, and NREL published in the journal *Energy Economics*, validated JEDI model outputs.**

*Results showed approximately $36,000 per megawatt increase in county-level personal income resulting from wind power installations between 2000 and 2008.*

We used the fixed-bottom offshore wind JEDI model to run potential OSW scenarios in four regions of the country.

Fact sheets for U.S. regions:

- Great Lakes
- Mid-Atlantic
- Southeast
- Gulf Coast

## Results from the Analysis of the Mid-Atlantic Region's OSW Potential


U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

ECONOMIC IMPACTS OF OFFSHORE WIND

**Potential Economic Impacts from Offshore Wind in the Mid-Atlantic Region**

Offshore wind is a clean, renewable source of energy and can be an economic driver in the United States. To better understand the employment opportunities and other potential regional economic impacts from offshore wind development, the U.S. Department of Energy (DOE) funded research that focuses on four regions of the country. The studies use multiple scenarios with various local job and domestic manufacturing content assumptions. Each regional study uses the new offshore wind Jobs and Economic Development Impacts (JEDI) model, developed by the National Renewable Energy Laboratory. This fact sheet summarizes the potential economic impacts for the

(IMPLAN) accounting software and state data files. Sources include the Bureau of Labor Statistics, Bureau of Economic Analysis, and the U.S. Census.

**Table 2. 2030 Local Content of Select Expenditures**

| Deployment Scenario | Blades and Towers | Nacelles and Drivetrains | Erection Installation Services | Converter and Substation |
|---|---|---|---|---|
| Low | 71% | 66% | 60% | 20% |
| Moderate | 95% | 95% | 85% | 71% |
| High | 95% | 100% | 100% | 87% |

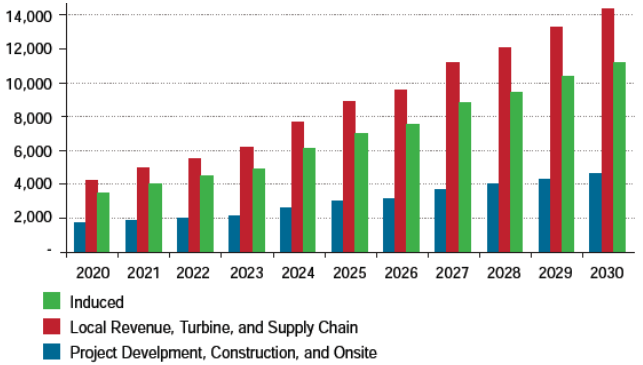
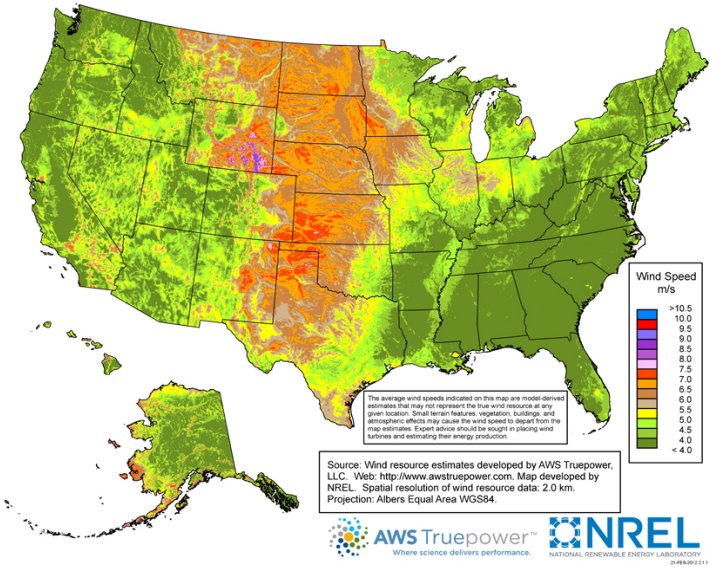
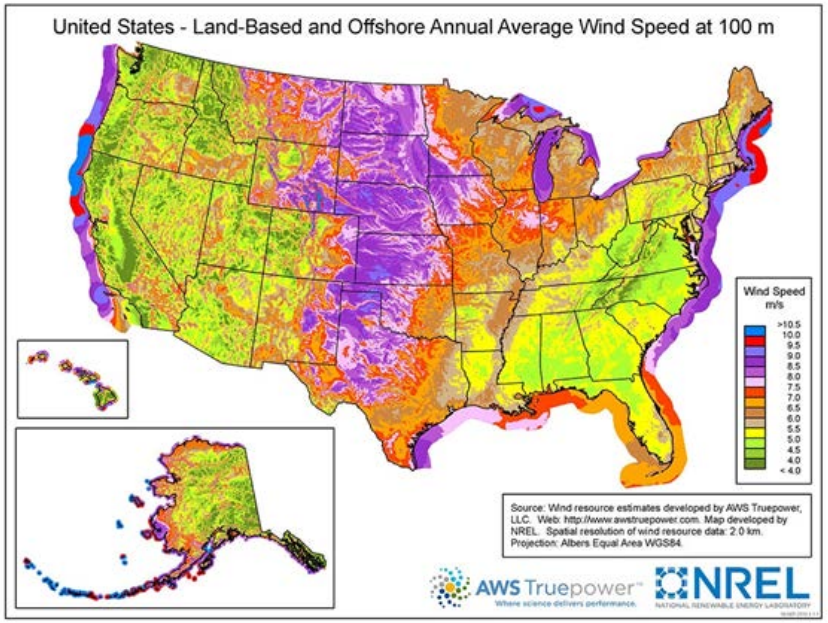



*Figure 1. Estimated number of construction and O&M jobs supported by offshore wind deployment from 2020 to 2030 (moderate scenario)*

## Wind Resource Assessment and Mapping




NREL

- Created a new, national 30 m map (above left)
- Created a new, national 100 m map
- Combined offshore and land-based state maps at 100 m (above right)

# Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

| Summary | |
|---|---|
| WBS Number or Agreement Number | |
| Project Number | |
| Agreement Number | |

Legend: Work completed; Active Task; Milestones & Deliverables (Original Plan); Milestones & Deliverables (Actual)

| Task / Event | FY2012 Q1 (Oct-Dec) | FY2012 Q2 (Jan-Mar) | FY2012 Q3 (Apr-Jun) | FY2012 Q4 (Jul-Sep) | FY2013 Q1 (Oct-Dec) | FY2013 Q2 (Jan-Mar) | FY2013 Q3 (Apr-Jun) | FY2013 Q4 (Jul-Sep) | FY2014 Q1 (Oct-Dec) | FY2014 Q2 (Jan-Mar) | FY2014 Q3 (Apr-Jun) | FY2014 Q4 (Jul-Sep) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Project Name: Wind Energy Forecasting Methods and Validation for Tall Turbine Resource Assessment** | | | | | | | | | | | | |
| Q3 Milestone: Update coal, natural gas, and wind JEDI models | | | ◆ | | | | | | | | | |
| Q4 Milestone: Draft regional offshore wind facts sheets | | | | ◆ | | | | | | | | |
| Q1 Milestone: Publish two offshore wind regional fact sheets | | | | | ◆ | | | | | | | |
| Q2 Milestone: Complete 30m wind resource maps | | | | | | ◆ | | | | | | |
| Q3 Milestone: Publish technical report on Iowa's first 1000MW of wind | | | | | | | ◆ | | | | | |
| Colloborate with Wind Vision Team so they have the latest data on wind resource assessment and current technologies | | | | | | | | ◆ | | | | |
| **Current work and future research** | | | | | | | | | | | | |
| Q1 Milestone: Publish two offshore wind JEDI fact sheets | | | | | | | | ◆ | ◆ | | | |
| Q2 Milestone: Offshore wind JEDI report with four regional case studies | | | | | | | | | | ◆ | | |
| Q3 Milestone: Provide domestic wind industry manufacturing map and related jobs to LBNL | | | | | | | | | | | ◆ | |
| Continue to support the Wind Vision, RRCs, and others with current wind resource maps | | | | | | | | | | | | ◆ |

- There were delays in the offshore wind fact sheets due to DOE Product Governance Team decisions.

# Research Integration & Collaboration

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

## Partners, Subcontractors, and Collaborators:

- Partners/Collaborators
  - LBNL, the American Wind Energy Association, Great Lakes Wind Network, Illinois State University, James Madison University
- Subcontractors
  - MRG & Associates, AWS Truepower

## Communications and Technology Transfer

- In FY12 and FY13, work has been presented by webinar and Web downloads as there has been limited opportunity for conference attendance. NREL also produced postcards with economic analysis and resource information.

JEDI Models are available at www.nrel.gov/analysis/jedi
Wind Maps are at www.energy.gov/eere/wind/wind-resource-assessment-and-characterization

# Next Steps and Future Research



## FY14/Current research

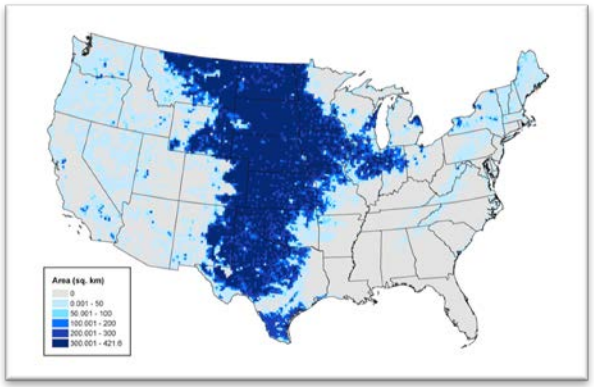
- Offshore wind JEDI technical report with four regional case studies
- Technical report on economic impacts from the first 1000 MW of wind in Indiana
- Support of the Wind Vision
- Support of Regional Resource Centers
- JEDI model validation and updates
- JEDI analyses

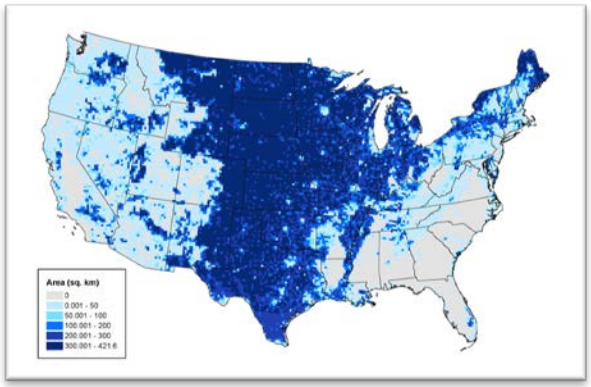
Barriers: if conference attendance is limited, NREL staff have fewer opportunities to gather data in person, which is crucial for validating JEDI models and gathering supply-chain information.

# Next Steps
## *Wind Resource*

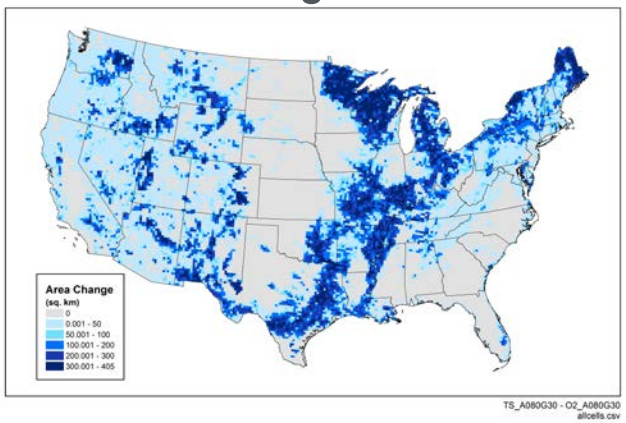


Current turbine technology has greatly expanded the possible deployable wind area resulting from modern turbine technology. Results show significant increases in raw area that may be suitable for deployment. The difference can be seen below.





Area Change



# Future Research

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

## Future research

- States and regions have requested JEDI analysis—both land-based and offshore.

*"If we could get this JEDI analysis, it would have a significant impact on decision-making."*

— State Energy Official

- Analyze other U.S. offshore regions
- Create floating offshore wind JEDI model
- Continue mapping updates and analysis based on the most current turbine technology, in collaboration with manufacturing efforts and other labs
- Publish report that synthesizes new data on logistical barriers, technology trends, and resource maps
- Outreach to utilities and other stakeholders around new maps and analysis—wind power is possible in the Southeast!
- Collaborate with, and support of, the Regional Resource Centers and Wind Vision on wind resource issues

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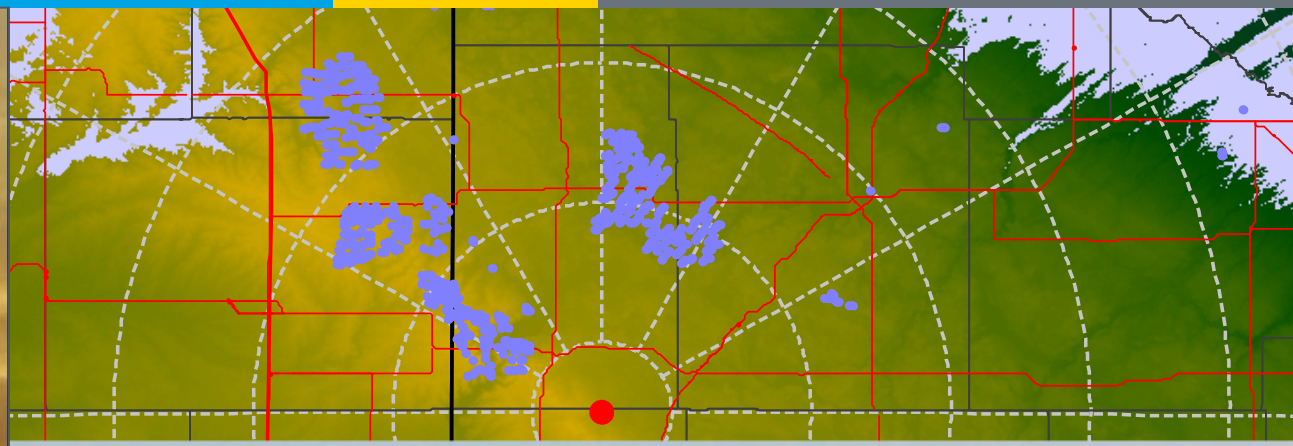


# Siting – Radar: Wind Turbine RCS Mitigation

Wind Turbine Blade Cross Section Reduction
Interagency Field Test & Evaluation
Tool for Siting and Encroachment Analysis for Renewables

**Benjamin Karlson, P.E.**

Sandia National Laboratories
Benjamin.Karlson@sandia.gov
(505) 377-3774

March 27, 2014

# Budget, Purpose, & Objectives



Total DOE Budget[1]: $2.447M

Total Cost-Share[1]:$0.000M

## Problem Statement:

Wind turbines have grown in size and number. When these machines are installed within the line-of-sight of a radar system, they can cause significant interference, detrimentally impacting radar performance.

This effort is divided into 3 projects:

1. Wind Turbine Blade Radar Cross Section (RCS) Reduction
2. The Interagency Field Test and Evaluation (IFT&E) Program
3. The Tool for Siting, Planning and Encroachment Analysis for Renewables (TSPEAR)

## Impact of Project:

- Investigate materials and techniques to reduce the RCS of a wind turbine blade
- Characterize the impact of wind turbines on current air surveillance radars, assess new technologies for near-term mitigation
- Develop a framework that allows users to analyze proposed wind projects on radar systems.

## This project aligns with the following DOE Program objectives and priorities

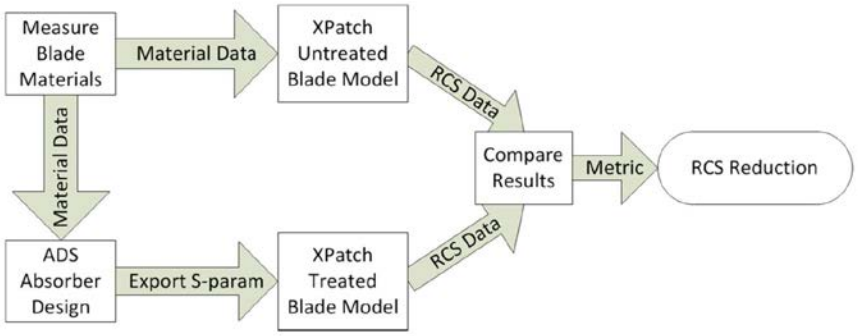
- **Mitigate Market Barriers**: Reduce market barriers to preserve or expand access to quality wind resources

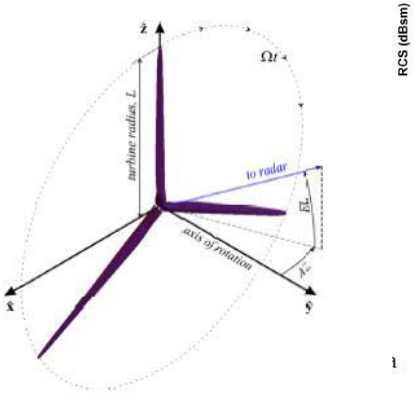
[1] ***Budget/Cost-Share for Period of Performance FY2012 – FY2013***

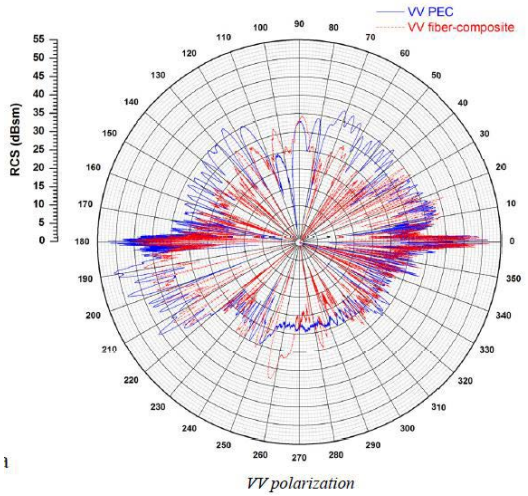
# Wind Turbine Blade RCS Reduction

JJ. McDonald, B.C. Brock, J.A. Paquette, S.E. Allen, E.D. Spoerke, J. Wheeler, D.A. Calkins, W.K. Miller, Paul G. Clem

- Developed integrated absorber design
  - Radar Absorbing Material (RAM) positions
  - RAM conductivity
  - Composite material properties
- Developed RAM for integration in blade fabrication
- Rotor Scattering Analysis
  - Modeled a 60 m blade set (diameter 126 m)
- Fabrication Approach
  - Vacuum assisted resin molding with no process modification
  - Verified at the coupon level
- Measured RCS
  - Anechoic chamber testing
- Cost Scaling
  - Preliminary analysis indicates turbine cost of 1-2%



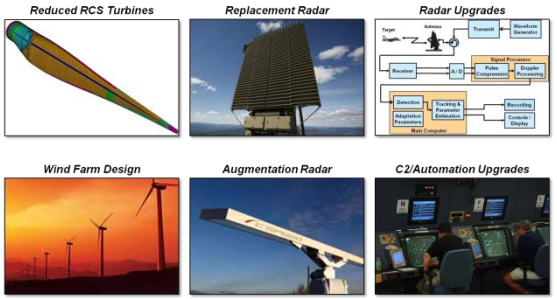



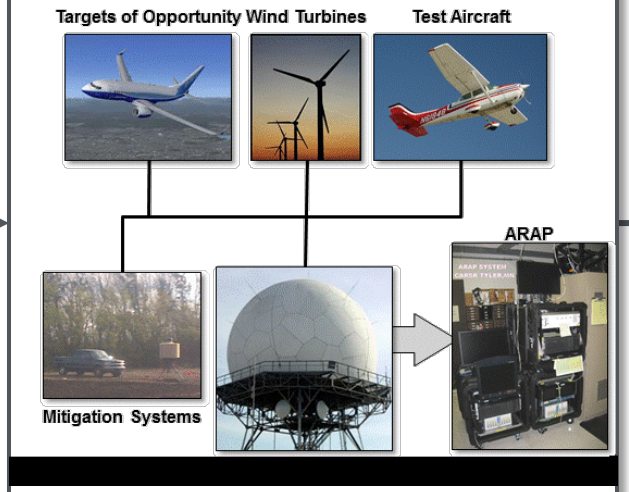

Identify a commercially viable solution to reduce RCS of a blade by 20 dB or greater with minimal cost impact.

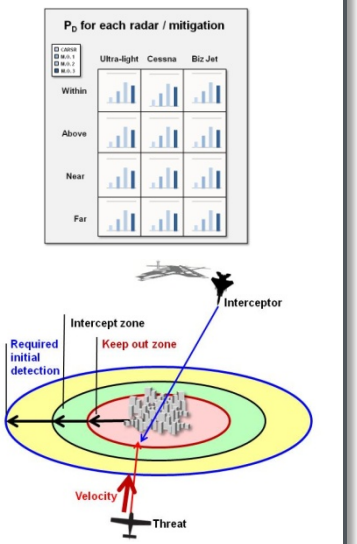
# Technical Approach

## Interagency Field Test & Evaluation (IFT&E)

### Steering Committee
DOE, DoD, DHS, FAA

### Industry Mitigations



### Flight Tests & Analysis



### System Analysis



- 2-year, jointly funded program
- 3 flight campaigns
  - Long-range radar (CARSR in Tyler, MN)
  - Short-range radar (ASR-11 in Abilene, TX)
  - Long-range radar (ARSR-4 in King Mountain, TX)
- Invited selected mitigations
  - 8 concepts were evaluated

### Interagency Field Test & Evaluation Products

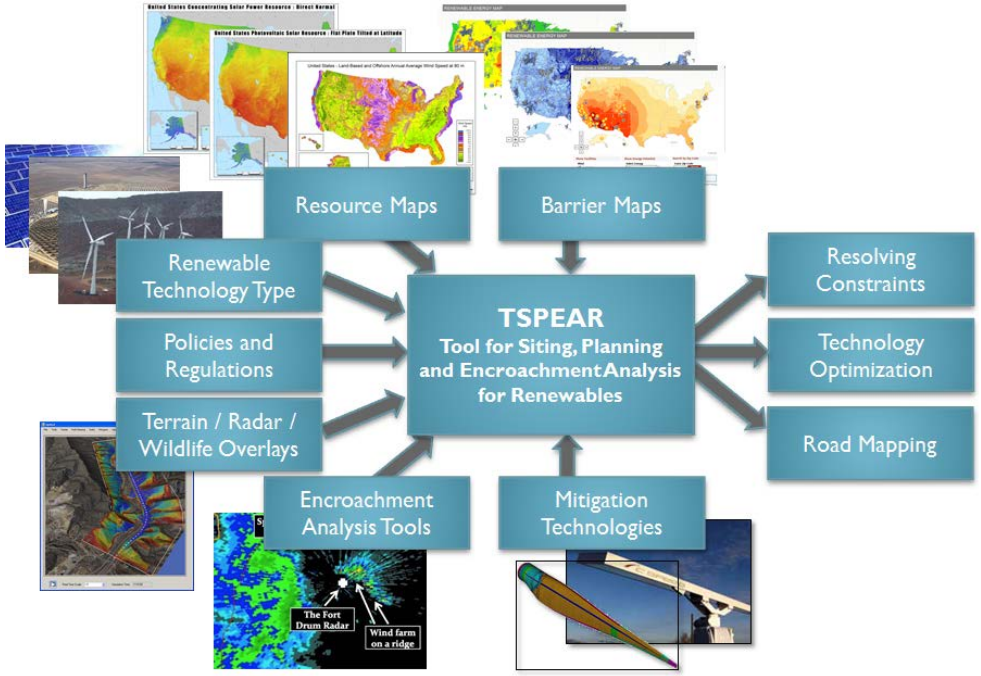


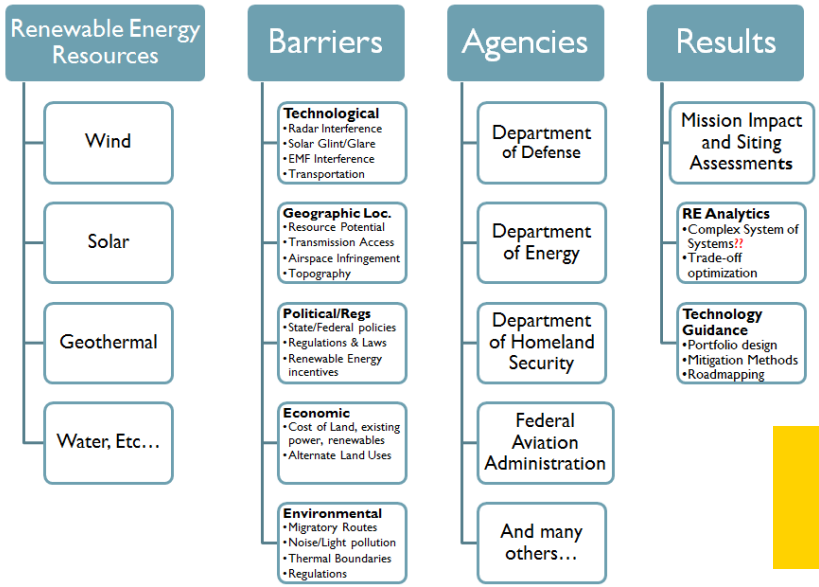
**Characterize Current Impact** | **Assess Proposed Mitigations** | **Data for Future R&D**

# Technical Approach

## Tool for Siting, Planning & Encroachment Analysis for Renewables (TSPEAR)

- A web-based siting, planning and assessment tool supporting RE deployment
- Quantitative analytical underpinnings to support decision makers
- Utilizes databases that already exist
  No new databases will be created



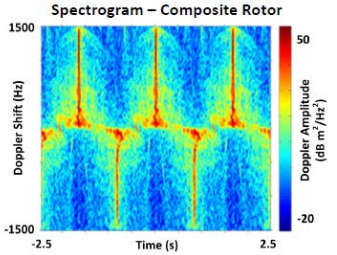

- Gov't agencies have specific assessment requirements and interests in wind energy which can be supported by TSPEAR

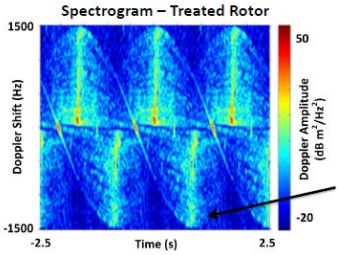
**Connecting industry inputs with gov't requirements in a web-based tool**

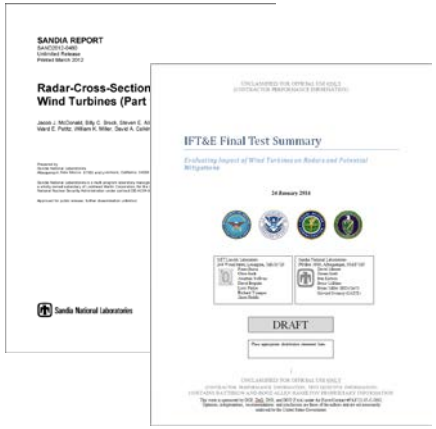
# Accomplishments and Progress



- Modeled RCS of a 60 m blade set (dia 126 m)
- Models identify key areas requiring Radar Absorbing Material (RAM) treatment
- 20 dB or greater RCS reduction achieved in testing
- RCS Reduction of Wind Turbines Reports
- 2+ years, three test campaigns evaluating three NAS radars and eight mitigation technologies. 450+ flight hours

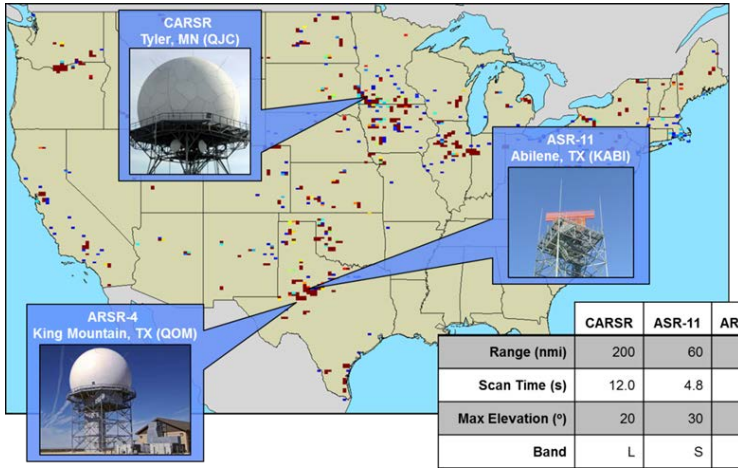



Treating shear web and spar cap with perfect absorber reduces Doppler component

Demonstrated 20 dB reduction through modeling and testing at coupon level

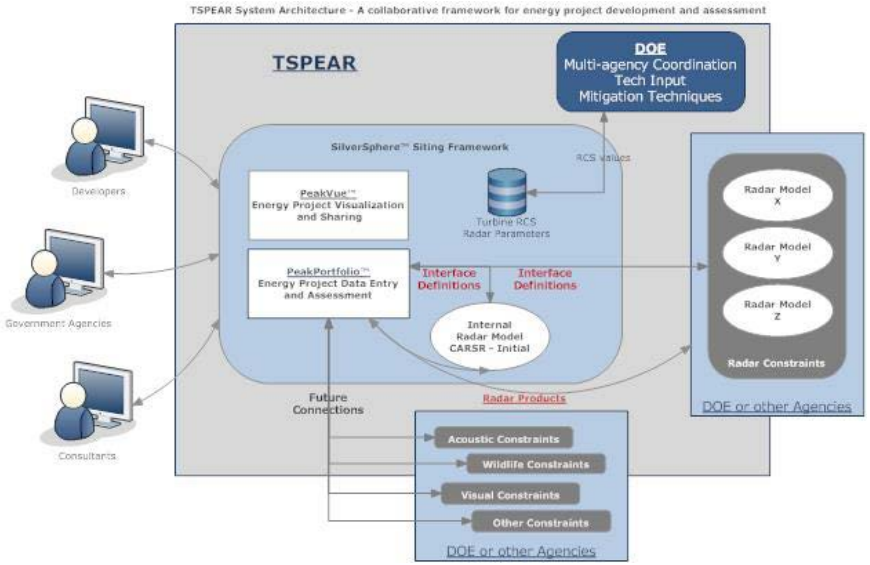


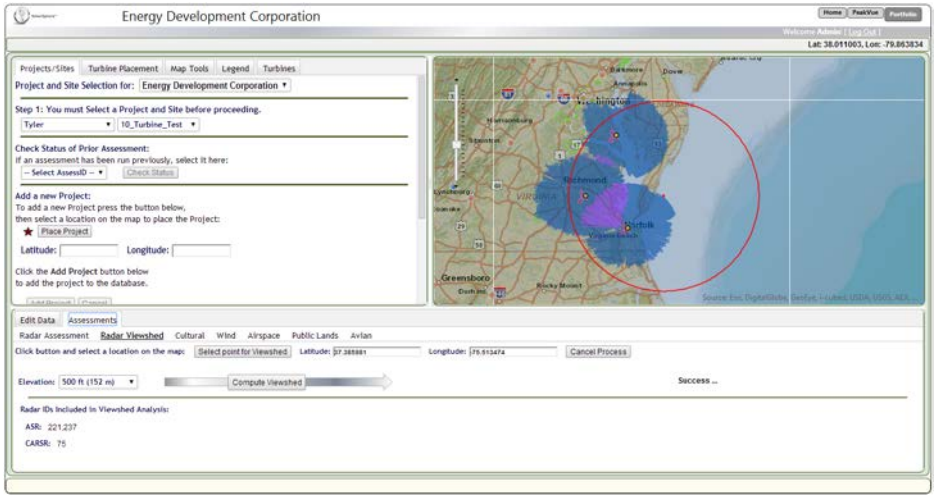

| | CARSR | ASR-11 | ARSR-4 |
|---|---|---|---|
| Range (nmi) | 200 | 60 | 250 |
| Scan Time (s) | 12.0 | 4.8 | 12.0 |
| Max Elevation (°) | 20 | 30 | 30 |
| Band | L | S | L |

- Characterized impact to current air surveillance radars
- Investigated near-term mitigation technologies
- Gov't only OUO Final Report
- Public IFT&E Industry Report
- Pilot Mitigation Project to move forward and continue to evaluate near-term mitigation technologies
- Contributed to a National Strategy for Wind Turbine-Radar Interference Mitigation

# Tool for Siting, Planning & Encroachment Analysis for Renewables (TSPEAR)

- Defined initial framework design/architecture
- Developed portal for initial capability to combine a commercial planning/management tool with an existing radar model
  - Radar model mirrors parameters utilized in the various government models currently used for wind turbine/radar interference analysis
  - Outputs 126 specific data points for each turbine evaluated related to Pd, Pfa, shadowing, and blade flash
- Added Line-of-Sight (LOS) tool and modified it to analyze CARSR effects
- Developed CARSR view sheds



# Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

| Summary | |
|---|---|
| WBS Number or Agreement Number | 4.1.1 |
| Project Number | |
| Agreement Number | 22530 |

| Legend | |
|---|---|
| | Work completed |
| | Active Task |
| | Milestones & Deliverables (Original Plan) |
| | Milestones & Deliverables (Actual) |

| Task / Event | FY2012 Q1 (Oct-Dec) | FY2012 Q2 (Jan-Mar) | FY2012 Q3 (Apr-Jun) | FY2012 Q4 (Jul-Sep) | FY2013 Q1 (Oct-Dec) | FY2013 Q2 (Jan-Mar) | FY2013 Q3 (Apr-Jun) | FY2013 Q4 (Jul-Sep) | FY2014 Q1 (Oct-Dec) | FY2014 Q2 (Jan-Mar) | FY2014 Q3 (Apr-Jun) | FY2014 Q4 (Jul-Sep) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Project Name: Wind Energy Forecasting Methods and Validation for Tall Turbine Resource Assessment** | | | | | | | | | | | | |
| Q1 Milestone: Develop IFT&E Test Collaborators & Wind Farm Participants | | | | | | | | | | | | |
| Q2 Milestone: Contribute to IFT&E Test Plan and Turbine Modeling | | | | | | | | | | | | |
| Q3 Milestone: Support Field Test and Contribute to Analysis of IFT&E #1 | | | | | | | | | | | | |
| Q4 Milestone: Support IFT&E #2 and Develop Recommendations for Follow-on T&E | | | | | | | | | | | | |
| Q1 Complete Field Work for IFT&E #2 at Abilene, TX | | | | | | | | | | | | |
| Q2 Contribute to Analysis of IFT&E #2 and Prepare for IFT&E #3 | | | | | | | | | | | | |
| Q3 Complete IFT&E #3 and Present Preliminary Findings | | | | | | | | | | | | |
| Q4 Contribute to Analysis of IFT&E #3 and Contribute to Final Report | | | | | | | | | | | | |
| **Current work and future research** | | | | | | | | | | | | |
| Status Report for the CARSR Model in TSPEAR | | | | | | | | | | | | |
| IFT&E Publicly Releasable Industry Report | | | | | | | | | | | | |
| Whitepaper for Offshore Wind Turbine/Radar Interference Test | | | | | | | | | | | | |
| Incorporate new radar models into TSPEAR | | | | | | | | | | | | |
| Technical Report on TSPEAR model | | | | | | | | | | | | |

## Comments

- IFT&E program initiated FY11 and completed FY13
- TSPEAR program initiated FY12 and Phase II to be complete FY14
- WTRI Strategic Planning and Pilot Mitigation Project initiated in FY14 and on-going

# Research Integration & Collaboration

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

## Partners, Subcontractors, and Collaborators:

### IFT&E Program:

- Co-funded by:
  DOE, DOD, DHS, DOT (FAA)
- Partners:
  - MIT Lincoln Laboratory
- Subcontractors:
  - BEM Int'l
  - GAITS
- Collaborators:
  - Radar vendors
  - Wind Industry

### TSPEAR Program:

- Partners:
  - MIT Lincoln Laboratory
- Subcontractors:
  - BEM Int'l
- Collaborators:
  - NREL
  - FAA
  - NORAD

### Wind Turbine Blade RCS Reduction:

- Leveraged expertise within Sandia
- Synthetic Aperture Radar (SAR) Sensor Technology Department

## Communications and Technology Transfer:

IFT&E Program:

- AWEA webinar: October 2012
- AWEA WindPower Poster Session: May 2013
- AWEA WindPower IFT&E Listening Session: May 2013
- IFT&E Industry Day: August 2013
- FOUO Report: IFT&E Final Test Summary
- IFT&E Industry Report
- Pilot Mitigation Project – Aims to partner with a proposed wind development that has interference issues to use IFT&E results

TSPEAR Program:

- Demo of TSPEAR to DOD and DOE at AWEA Fall Symposium, September 2013
- DOD Technical Interchange Meeting (TIM) presentation: December 2013

RCS of Wind Turbine Blades:

- Radar-Cross-Section Reduction of Wind Turbines (Part 1-3), March 2012
- Non-provisional patent: US AppIn. No.: 13/834,541

# Next Steps and Future Research

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

## FY14/Current research:

- Offshore IFT&E Whitepaper:
  - Investigate the potential for an offshore test
  - Develop a list of organizations with a potential impact from an offshore development
  - Develop a suite of objectives and locations to test
  - Develop an estimate of costs to conduct the test
- TSPEAR Phase II:
  - "Phase A" RCS Studies
    - Get current DOE L-band RCS data and develop RCS size reduction / storage approaches
    - Evaluate resampled RCS values against CARSR performance. Find break point in RCS vs. radar performance
  - Addition of all contiguous U.S. ASR-9, ASR-11, and ARSR-4 radar systems

## Proposed future research:

- Gain access to NGO owned tools, databases, and guidelines prioritized by market need. Examples:
  - Western Governor's Association (WGA) – Crucial Habitat Assessment Tool (CHAT)
  - America Wind-Wildlife Institute (AWWI) – Landscape Assessment Tool (LAT)
  - Western Regional Partnership (WRP) – Web Mapping Application
- Complete encroachment analysis of remaining NAS and NOAA radars
- Model test mitigation technologies (replacement and infill radars, low-RCS blades, etc.)
- Design, develop, and demonstrate wind turbine blades that have a substantially lower RCS

# Wind Radar Interagency Field Test & Evaluation

**Franz Busse**

MIT Lincoln Laboratory

busse@ll.mit.edu, (781)981-7465

26 March 2012

# Budget, Purpose, & Objectives

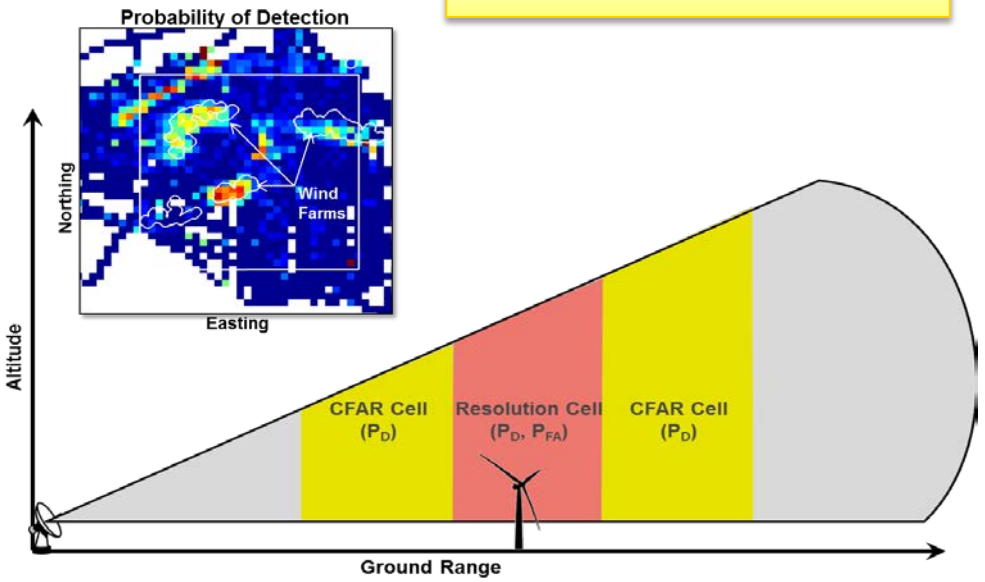
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Total DOE Budget[1]: $2.762M

Total Cost-Share[1]:$3.882M

Problem Statement:

- ***Wind turbines impact radars:***
  - ***Decrease sensitivity***
  - ***Increase false alarms***
  - ***Corrupt track quality***
- ***Concern for:***
  - ***Flight safety (FAA)***
  - ***Homeland security (DHS)***
  - ***Homeland defense (DOD)***




Impact of Project:

**This project will reduce barriers to wind farm deployments by:**

- **Guiding FAA, DHS, and DOD radar investments**
- **Supporting development of algorithms, tools, models, designs, and processes that expand wind development options**

This project aligns with the following DOE Program objectives and priorities

***XXX***

[1] ***Budget/Cost-Share for Period of Performance FY2012 – FY2013***

# Technical Approach

Evaluate Wind Turbine Impact on Radars and Mitigation Options

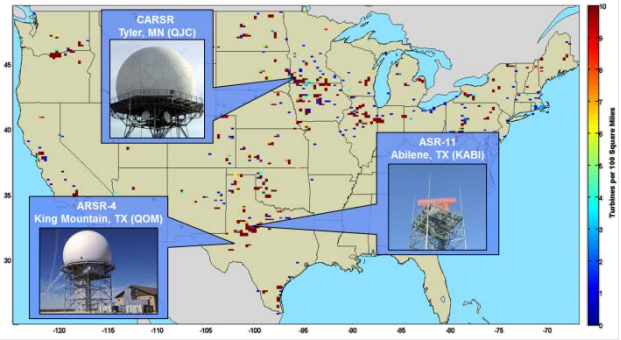
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

## Jointly Funded and Steered

**DOE, DoD, DHS, FAA**

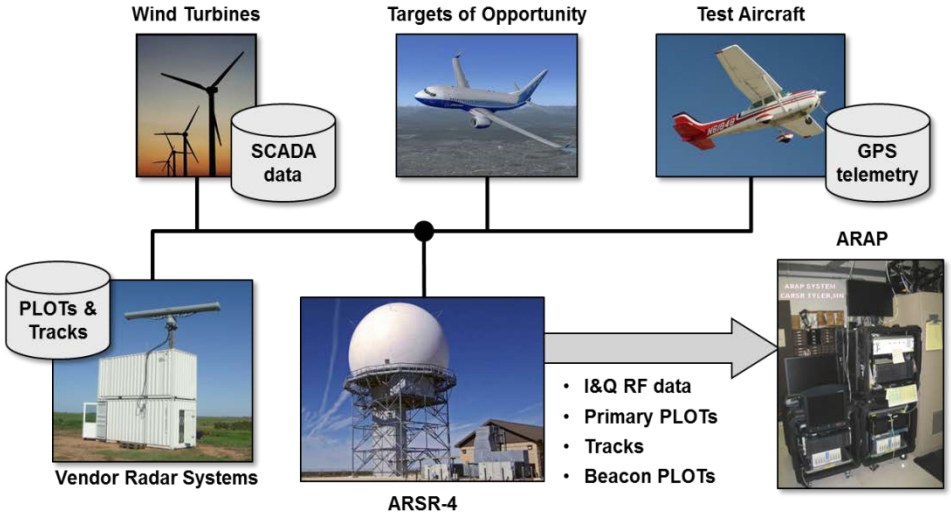
## 3 Flight Campaigns over 2 years

**(CARSR, ASR-11, ARSR-4)**

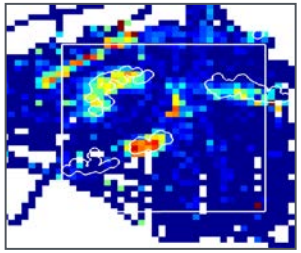



## 8 Industry Mitigations Tested

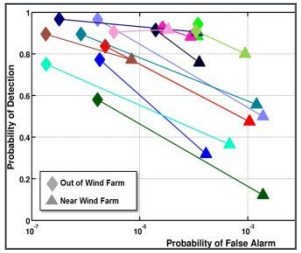
## Flight Tests & Analysis



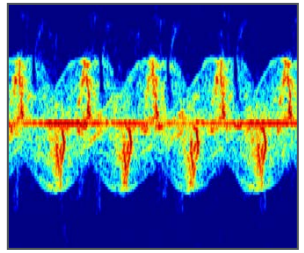

## Products



**Characterize Current Impact**



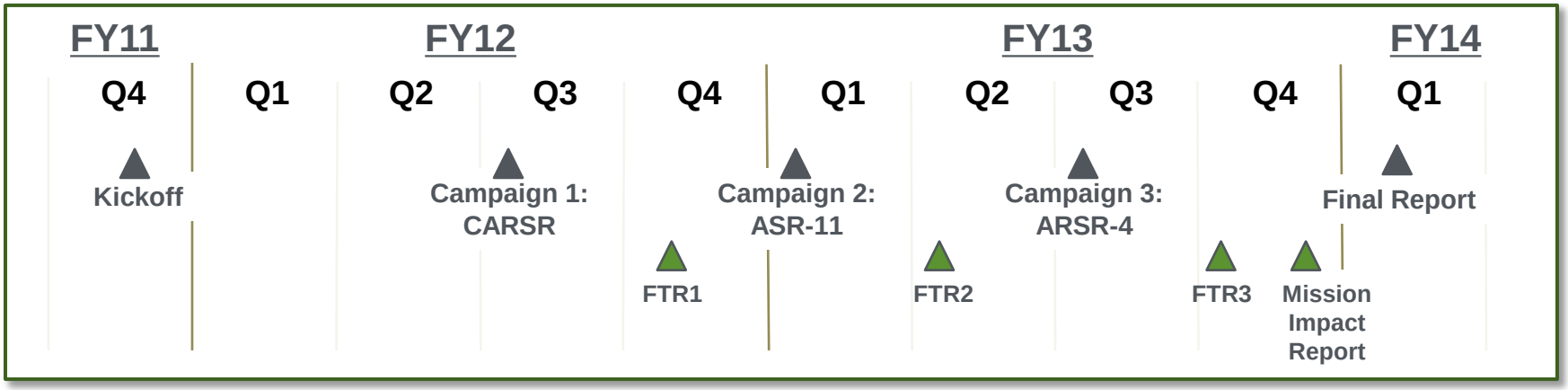

**Assess Proposed Mitigations**



**Data for Future R&D**

# Evaluation Participants



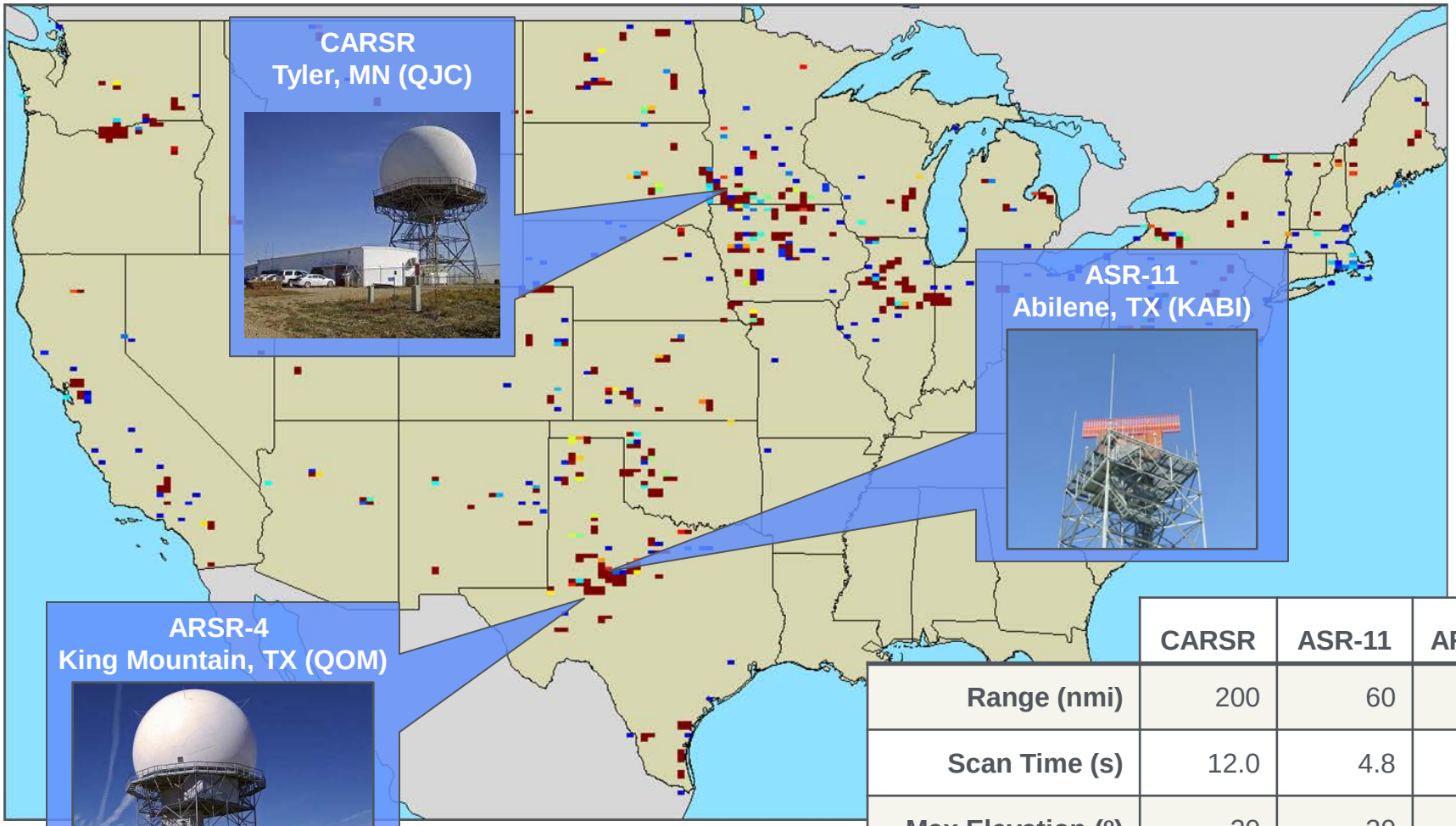



FTR = Field Test Report

| Campaign 1 | Campaign 2 | Campaign 3 |
|---|---|---|
| CARSR | ASR-11 | ARSR-4 |
| Tyler, MN | Abilene, TX | King Mountain, TX |
| 24 Apr – 04 May 2012 | 20 Oct – 28 Oct 2012 | 20 Apr – 28 Apr 2013 |
| • C Speed Lightwave<br>• SRC LSTAR(V)3<br>• Raytheon Processor Upgrades | • Terma Scanter 4002<br>• BAH RF Precision Nulling Device | • Lockheed TPS-77<br>• Aveillant Holographic Radar<br>• Raytheon X-band Radar |

# National Airspace System (NAS) Radars Evaluated in IFT&E



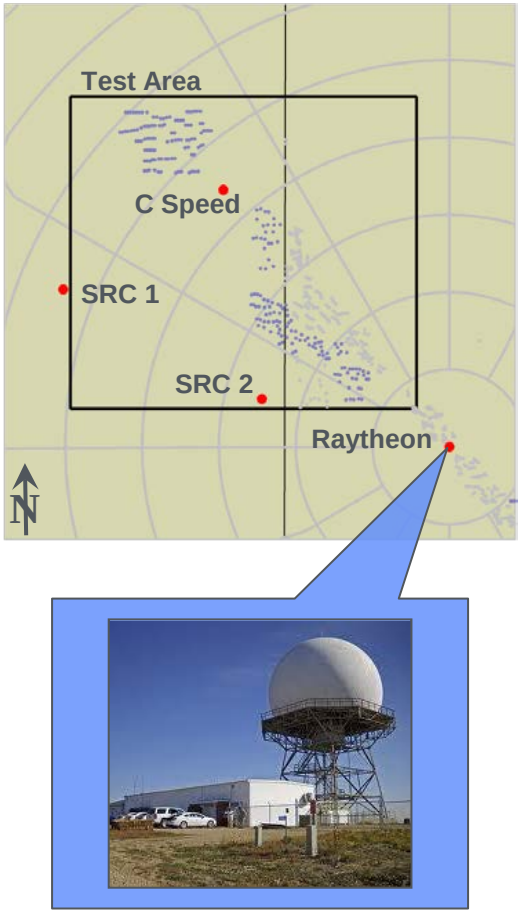



| | CARSR | ASR-11 | ARSR-4 |
|---|---|---|---|
| Range (nmi) | 200 | 60 | 250 |
| Scan Time (s) | 12.0 | 4.8 | 12.0 |
| Max Elevation (º) | 20 | 30 | 30 |
| Band | L | S | L |

# Flight Test Campaigns

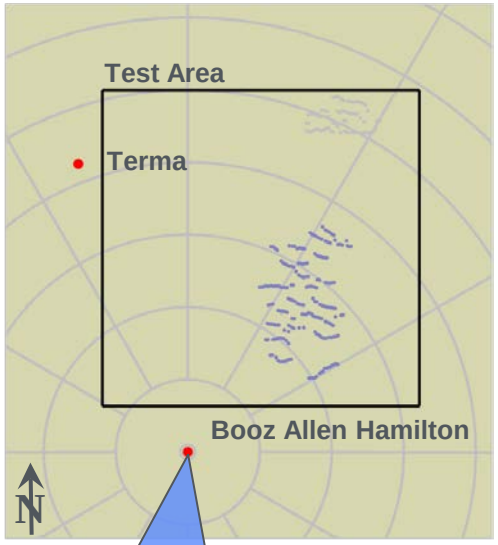
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

## CARSR
**(459 Turbines, 132 Flight Hours)**

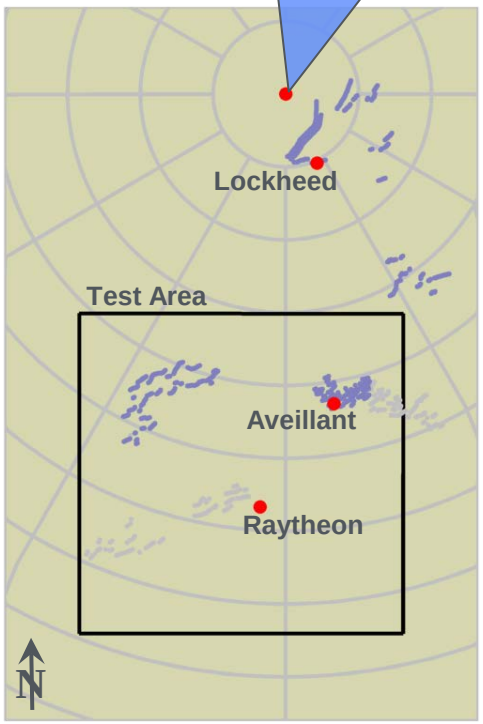





## ASR-11
**(272 Turbines, 166 Flight Hours)**



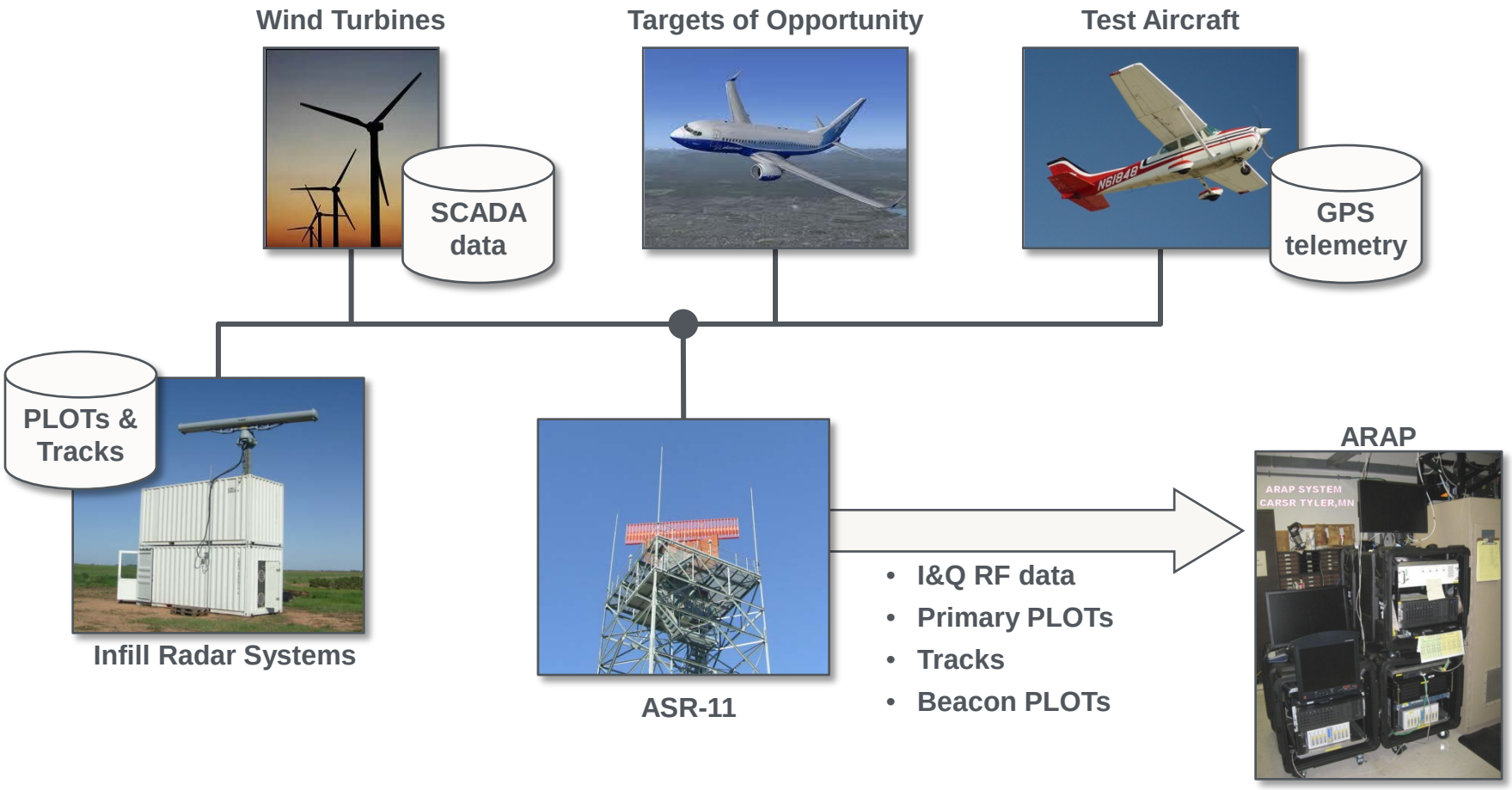

## ARSR-4
**(385 Turbines, 164 Flight Hours)**




**Test Area 22x22 nmi**

# Field Test Process

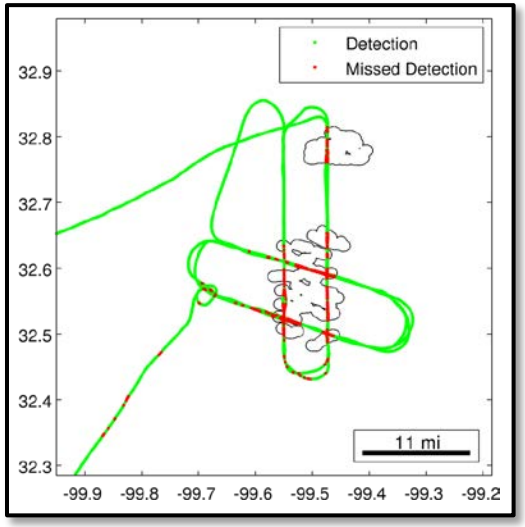




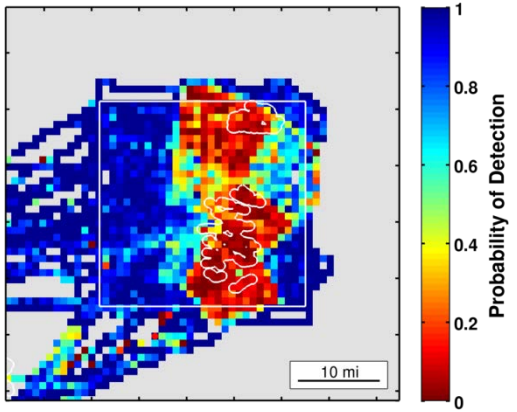
# Data Analysis



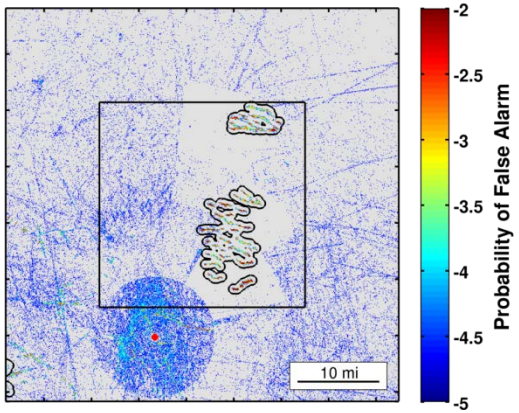
**Single Flight Maps** → **Cumulative Performance Maps** → **ROC* Curve Summary**

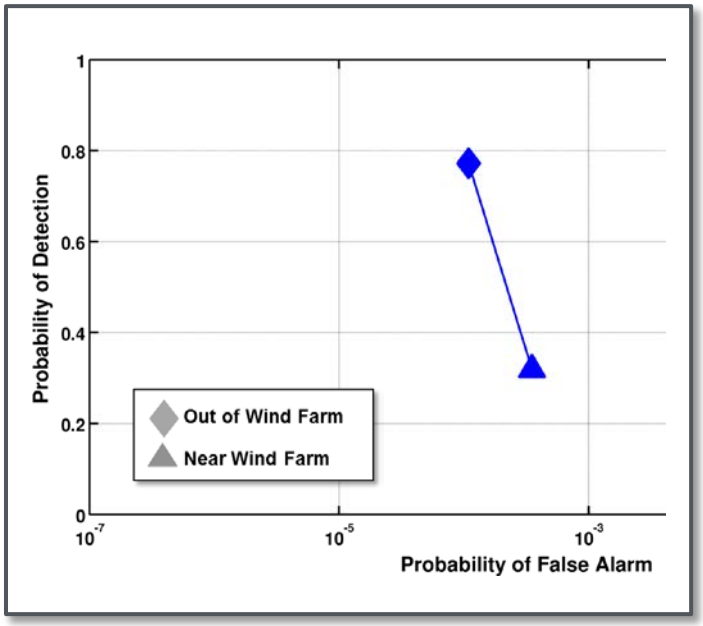



**Probability of Detection**




**Probability of False Alarm**



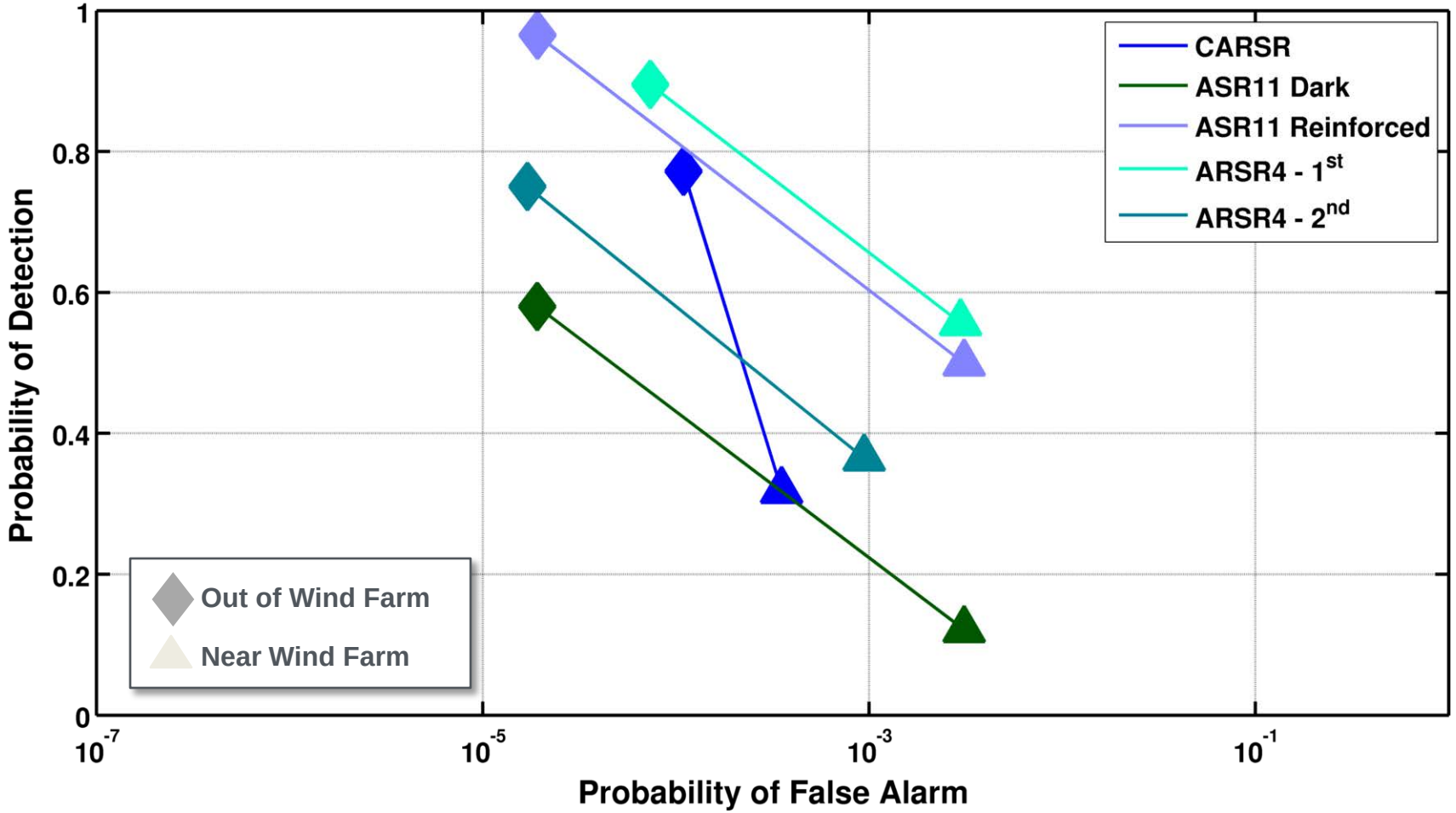




*Radio Operator Characteristic

# Characterize Impact on NAS Primary Radars



- Primary Test Area
- GA Aircraft
- Individual Fields of Regard

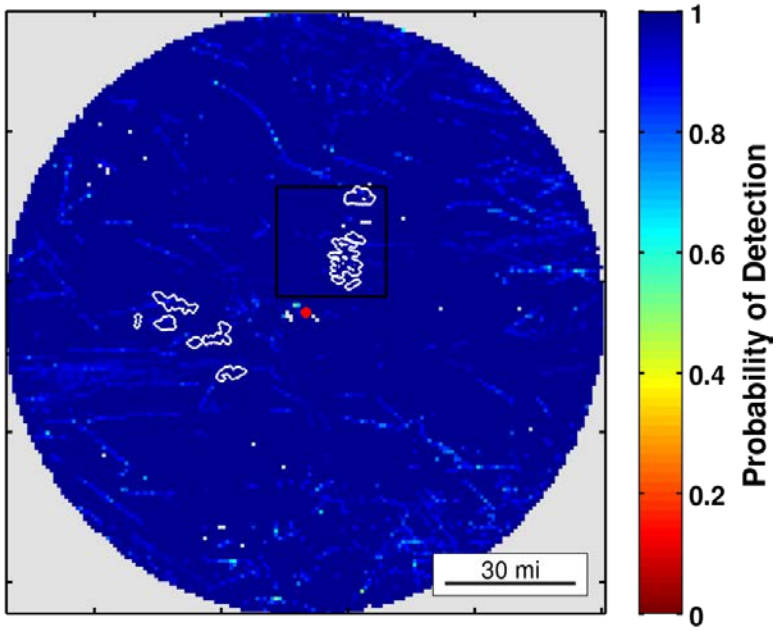



$P_D$ and $P_{FA}$ calculation method different than FAA method (see report for full description)

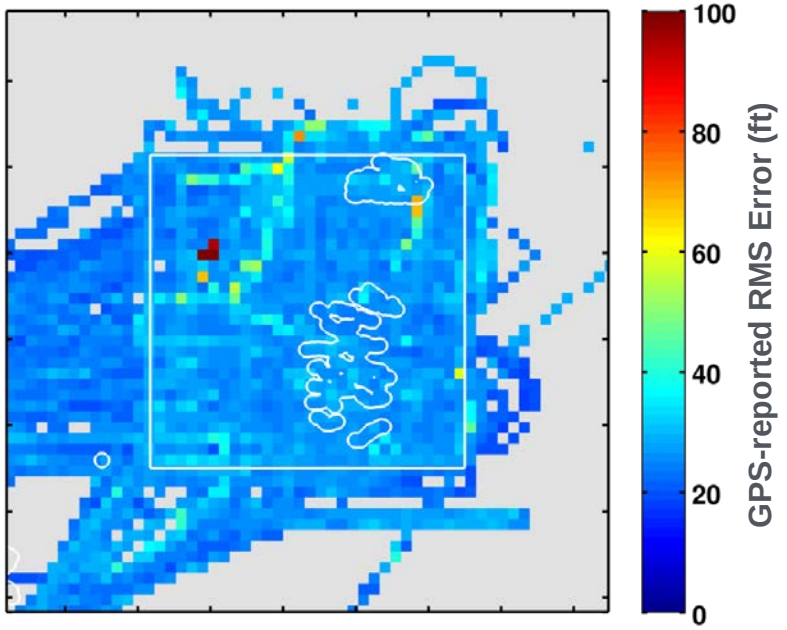
# Characterize Impact on Secondary Radar and GPS

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

**Example of SSR Performance (ASR-11)**




**Example of GPS Performance (during ASR-11)**

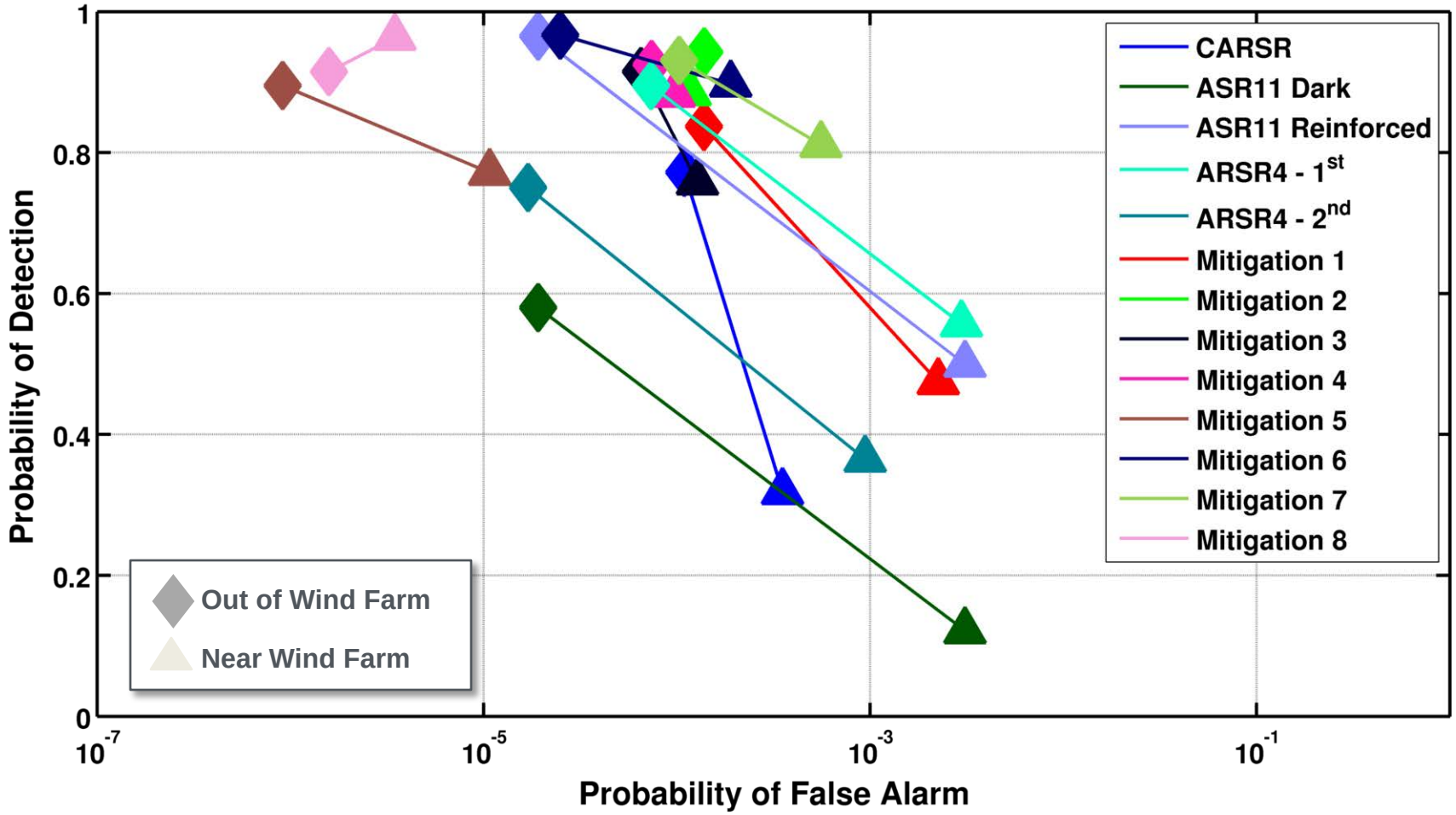



- Secondary Surveillance Radar (SSR) shows no impact from wind turbines
- GPS shows no impact from wind turbines
- No communications degradation observed during tests due to wind turbines
- Expect ADS-B to not be impacted by wind turbines

# Evaluated Mitigation Technologies

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- Primary Test Area
- GA Aircraft
- Individual Fields of Regard




$P_D$ and $P_{FA}$ calculation method different than FAA method (see report for full description)

# Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

| Summary | |
|---|---|
| WBS Number or Agreement Number | |
| Project Number | |
| Agreement Number | |

| Legend | |
|---|---|
| | Work completed |
| | Active Task |
| | Milestones & Deliverables (Original Plan) |
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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Wind Radar IFT&E Program** | | | | | | | | | | | | |
| Field Test 1: CARSR | | | | | | | | | | | | |
| Field Test 2: ASR-11 | | | | | | | | | | | | |
| Field Test 3: ARSR-4 | | | | | | | | | | | | |
| HAD Mission Impact Report | | | | | | | | | | | | |
| Test Summary Report | | | | | | | | | | | | |
| **Current work and future research** | | | | | | | | | | | | |
| Mitigation algorithm selection and development (MATLAB) | | | | | | | | | | | | |
| C2 Automation Analysis - AMOSS | | | | | | | | | | | | |
| Bench-test ARAP for real-time demonstration | | | | | | | | | | | | |

## Comments

- **Start: Aug 2011, funded through Aug 2014 (end TBD)**
- **Test Summary Report milestone slipped due to additional interagency review and re-scoping for different audiences**

# Project Budget



| Budget History ($K) | | | | | |
|---|---|---|---|---|---|
| FY2012 | | FY2013 | | FY2014 (to date) | |
| DOE | Cost-share | DOE | Cost-share | DOE | Cost-share |
| 1,431 | 1,750 | 1,331 | 105 | -- | 2,027 |

- **MIT LL has spent $1,874K of FY12-FY14 DOE funding (68%)***
  - **Expect additional $750K from DOE with additional tasking in FY14**
- **Spending is on track to meet budgets**
- **Cost share is provided by DOD, FAA, and DHS**
- **Radar and wind industry expenses for testing were the responsibility of the companies and are not included**

***As of 01 Feb 2014**

# Research Integration & Collaboration



## Partners, Subcontractors, and Collaborators:

- **Partnership between Sandia National Laboratory and MIT Lincoln Laboratory**
  - **Subcontractors: BEM International and GAITS**
- **Government partnership between DOE, DOD, DHS, FAA, and NOAA**
- **Industry collaboration with 9 different companies proposing mitigation technologies**
- **Wind industry providing data**
- **Several government agencies flying aircraft**

## Communications and Technology Transfer:

- **3 Field Test Reports**
- **1 Industry Guidance Report (SNL) & Industry Day (Nov 2013)**
- **Homeland Air Defense Mission Impact Report (SECRET)**
- **Test Summary Report & Mitigation Roadmap Report**
- **Multiple Conferences & DoD-sponsored TIMs**

# Next Steps and Future Research



## FY14/Current research:

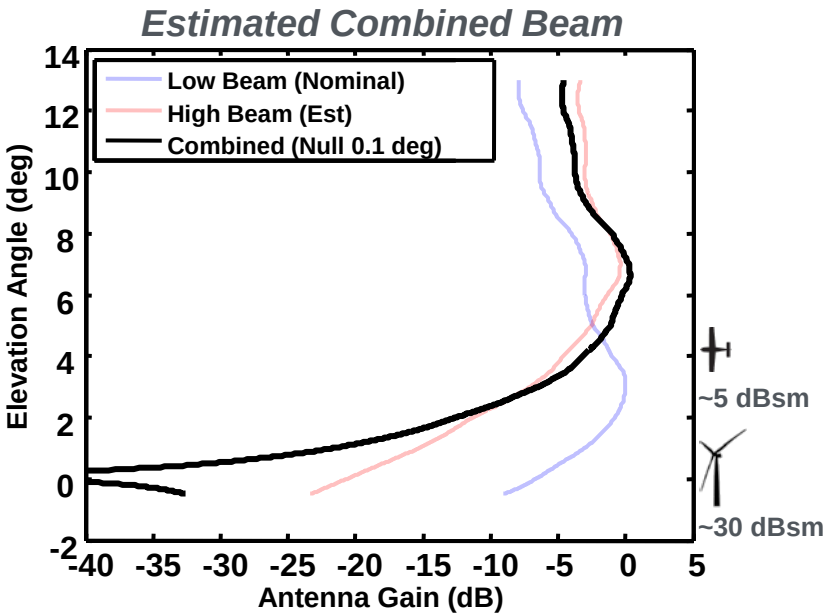
- **Switch from *study* to *solve***
- **Develop software mitigation algorithms for existing NAS radars**
- **Prepare testbed for real-time mitigation demonstrations**
- **Analyze impact on C2 Automation systems (e.g., AMOSS)**

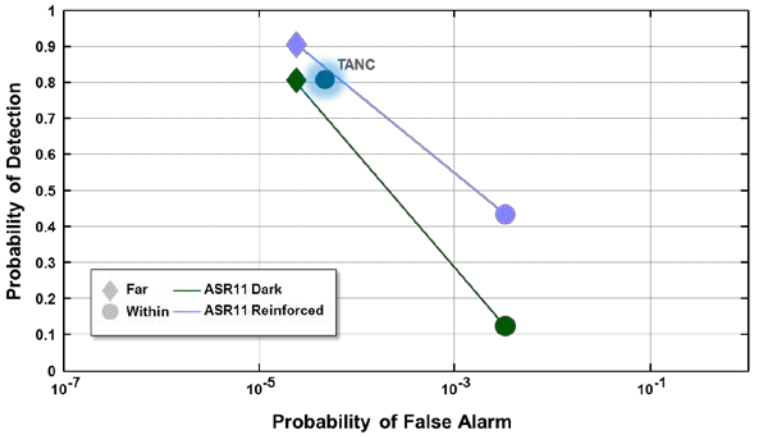
## Proposed future research:

- **Support infill radar integration**
- **Operator evaluations of mitigations**
- **Additional software mitigations for existing NAS radars and next-generation systems**
- **Off-shore test campaign**

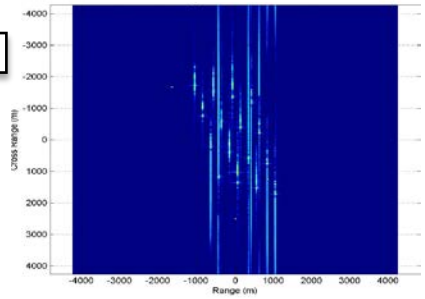
## Software Upgrade Mitigation Example

**"TANC" algorithm**

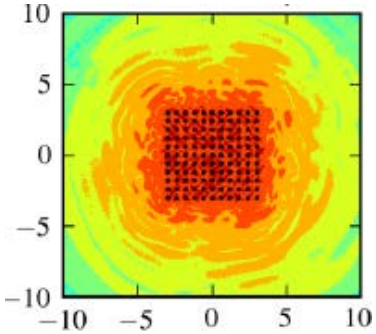


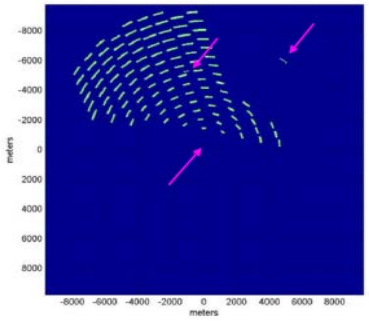
Airborne Radar



Sound Generation Underwater




Marine Navigation



# Assessment of Offshore Wind Farm Effects on Sea Surface, Subsurface and Airborne Electronic Systems

**Presenter: To be determined**

The University of Texas at Austin

ling@ece.utexas.edu, (512) 797-0926

March 26, 2014

# Budget, Purpose, & Objectives



Total DOE Budget [1,2]: $0.00M

Total Cost-Share[1]:$0.00M

Problem Statement: Provide a baseline assessment of potential impacts of offshore wind farms on electromagnetic and acoustic equipment (for surveillance, navigation and communications) operating in the marine environment.

Impact of Project: The findings from the study will help remove the uncertainties associated with offshore wind farm deployment, and in setting future guidelines for the permitting process.

This project aligns with the following DOE Program objectives and priorities:

- **Mitigate Market Barriers:** Reduce market barriers to preserve or expand access to quality wind resources

[1] *Budget/Cost-Share for Period of Performance FY2012 – FY2013*
[2] *Project remained active using DOE funds received prior to FY2012*

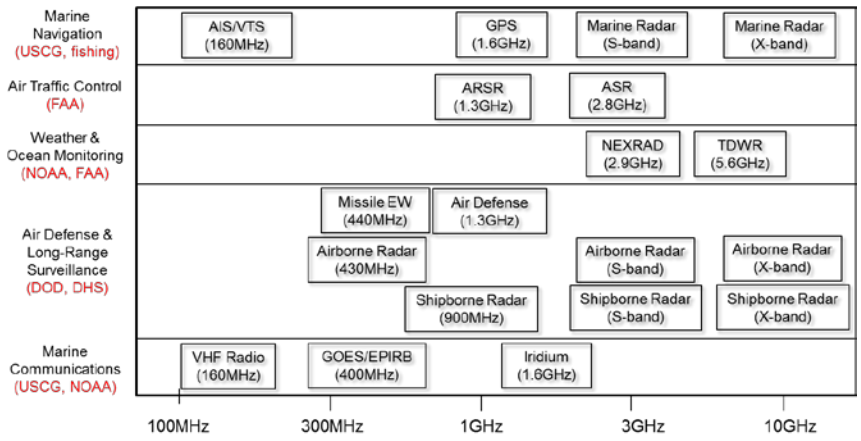
# Technical Approach

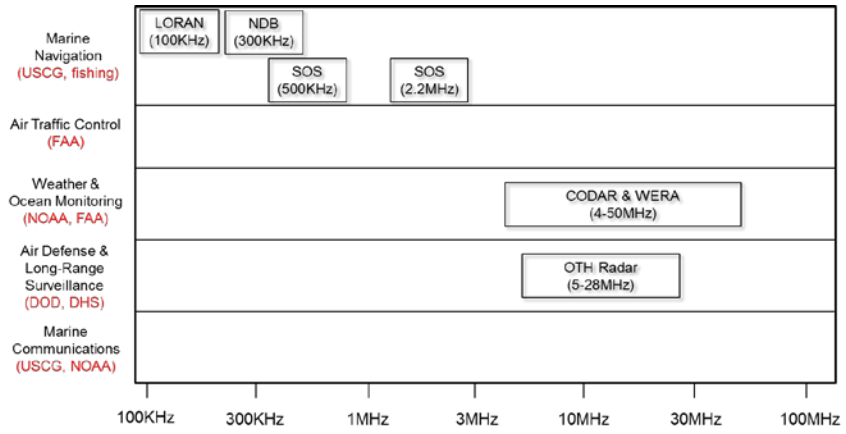


- **Task 1 and Task 3: Survey potential challenges**
  - Developed a list of systems vs. frequency and stakeholders
  - Compiled list of references including both US and non-US activities
- **Task 2: Engage stakeholders**
  - Formulated questionnaires for both EM and acoustics
  - Conducted in-depth interviews with stakeholders
- **Task 4: Modeling study**
  - Identified priority topics based on stakeholder interviews and carried out modeling studies in EM and acoustics
- **Task 5 and Task 6: Documentation and dissemination**

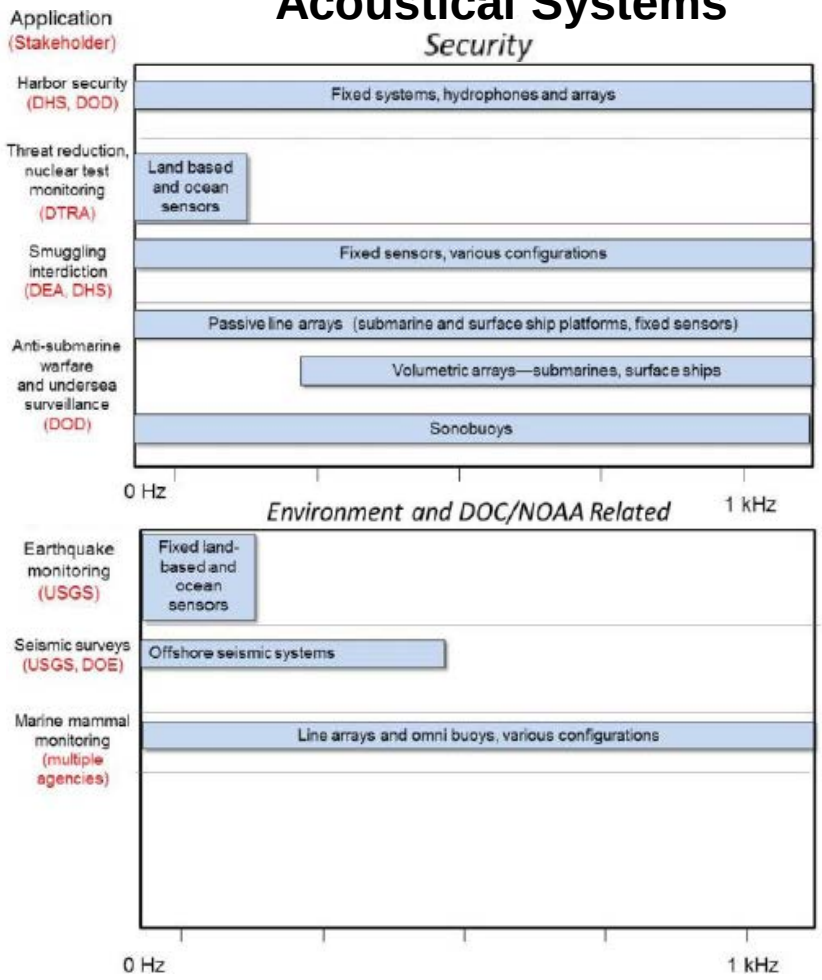
# Survey Potential Challenges

## Electromagnetic Systems




## Acoustical Systems



# Literature Review of US and Non-US Activities

- **Electromagnetics** (52)
  - **Marine Navigation** (9)
  - **Air Traffic Control** (6)
  - **Weather and Ocean Monitoring** (10)
  - **Air Defense and LR Surveillance** (9)
  - **Communications Systems** (11)
  - **Mitigation Techniques** (10)

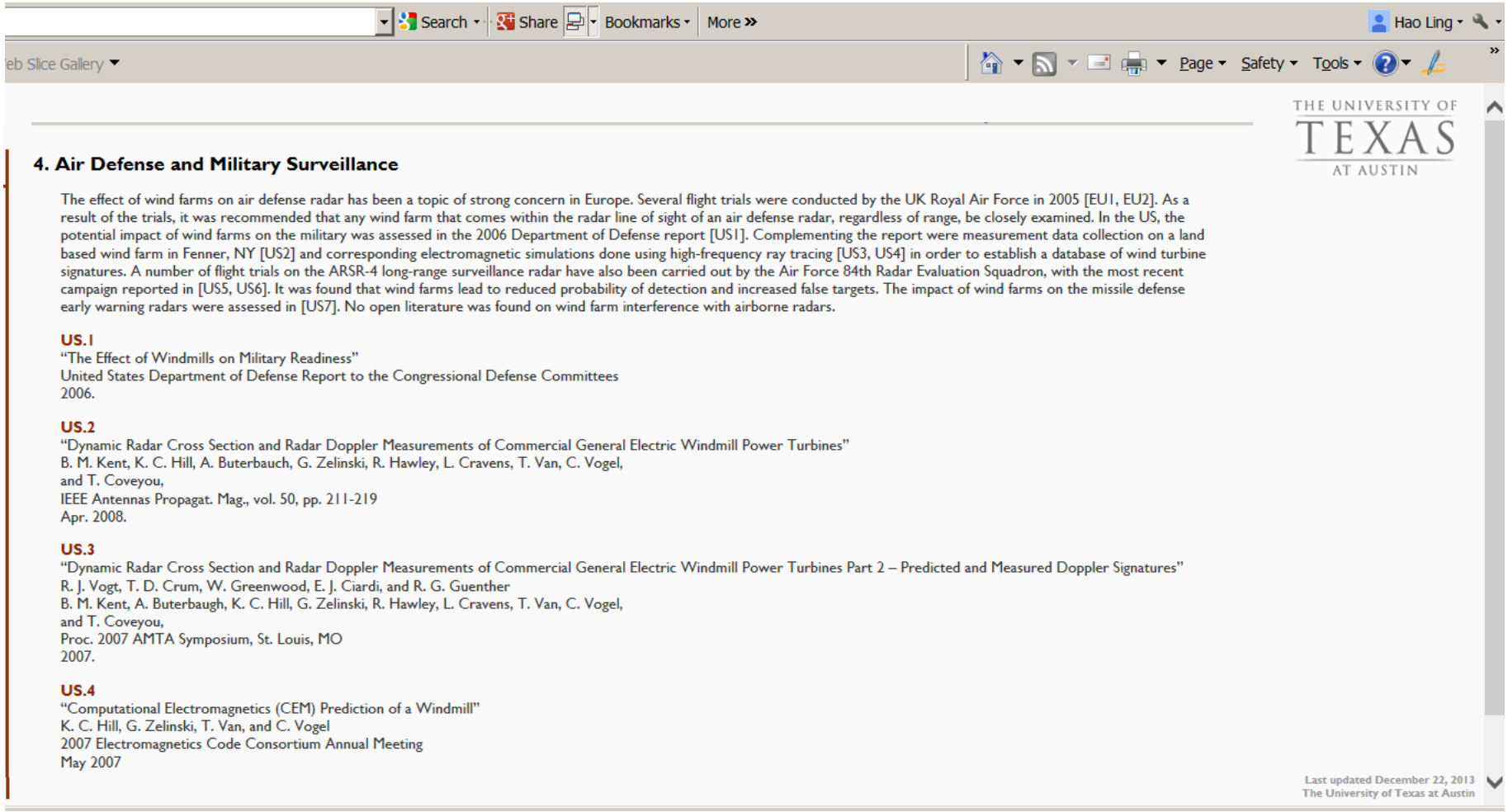
- In Europe, a number of systems have been characterized through in-situ measurements near offshore wind farms. In the US, significant efforts have taken place to address electromagnetic interference from land-based wind farms. For offshore wind farms, only limited modeling studies have been done.

- **Acoustics** (25)
  - **Noise Measurements** (6)
  - **Impact on Marine Mammals** (8)
  - **Impact on Fish/Fisheries** (3)
  - **Mitigation Techniques** (8)

- The vast majority of studies of underwater sound radiation by operational offshore wind farms have been performed in Europe and primarily to assess impact on marine mammals. No studies of how underwater sound affects acoustical equipment and systems were identified.

# Accomplishments and Progress

**Web access: http://users.ece.utexas.edu/~ling/WindFarms_2.html**



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THE UNIVERSITY OF TEXAS AT AUSTIN

## 4. Air Defense and Military Surveillance

The effect of wind farms on air defense radar has been a topic of strong concern in Europe. Several flight trials were conducted by the UK Royal Air Force in 2005 [EU1, EU2]. As a result of the trials, it was recommended that any wind farm that comes within the radar line of sight of an air defense radar, regardless of range, be closely examined. In the US, the potential impact of wind farms on the military was assessed in the 2006 Department of Defense report [US1]. Complementing the report were measurement data collection on a land based wind farm in Fenner, NY [US2] and corresponding electromagnetic simulations done using high-frequency ray tracing [US3, US4] in order to establish a database of wind turbine signatures. A number of flight trials on the ARSR-4 long-range surveillance radar have also been carried out by the Air Force 84th Radar Evaluation Squadron, with the most recent campaign reported in [US5, US6]. It was found that wind farms lead to reduced probability of detection and increased false targets. The impact of wind farms on the missile defense early warning radars were assessed in [US7]. No open literature was found on wind farm interference with airborne radars.

**US.1**
"The Effect of Windmills on Military Readiness"
United States Department of Defense Report to the Congressional Defense Committees
2006.

**US.2**
"Dynamic Radar Cross Section and Radar Doppler Measurements of Commercial General Electric Windmill Power Turbines"
B. M. Kent, K. C. Hill, A. Buterbauch, G. Zelinski, R. Hawley, L. Cravens, T. Van, C. Vogel,
and T. Coveyou,
IEEE Antennas Propagat. Mag., vol. 50, pp. 211-219
Apr. 2008.

**US.3**
"Dynamic Radar Cross Section and Radar Doppler Measurements of Commercial General Electric Windmill Power Turbines Part 2 – Predicted and Measured Doppler Signatures"
R. J. Vogt, T. D. Crum, W. Greenwood, E. J. Ciardi, and R. G. Guenther
B. M. Kent, A. Buterbaugh, K. C. Hill, G. Zelinski, R. Hawley, L. Cravens, T. Van, C. Vogel,
and T. Coveyou,
Proc. 2007 AMTA Symposium, St. Louis, MO
2007.

**US.4**
"Computational Electromagnetics (CEM) Prediction of a Windmill"
K. C. Hill, G. Zelinski, T. Van, and C. Vogel
2007 Electromagnetics Code Consortium Annual Meeting
May 2007

Last updated December 22, 2013
The University of Texas at Austin

# Engage Stakeholders

- **Goal:**

To engage key stakeholders in government and industry to identify concerns on interference from offshore wind farms.

- **Methodology:**

- In-depth personal interview was chosen as the research approach.
- A total of 22 participants in EM and 18 participants in acoustics were interviewed during the summer and fall of 2012. The list included DOD, FAA, USCG, NOAA, DHS, NTIA, commercial fisherman's association, and oil & gas industry.
- The interviews lasted 40 minutes on average. Immediately after each interview, key notes taken were summarized into written form.
- Stakeholders were asked to comment on the effect of existing land based wind farms on their systems (EM only), and the potential effect of future offshore wind farms on their systems.

## Key Findings

- A number of stakeholders believed that interference from future US offshore wind farms on land-based radar systems (weather, air traffic control, and long-range surveillance) can be dealt with using the existing approval mechanisms and technical solutions.
- However, offshore wind farms do raise some new concerns for other stakeholders. These new concerns include marine navigation and communications, airborne radar, and coastal HF radars.
- Noise radiated underwater exceeds background levels only below 1 kHz. This noise may cause interference with certain acoustical systems when placed in close proximity to a wind farm, or at longer ranges in certain acoustic environments.
- The Navy currently possesses no empirical data to suggest that their systems have been affected in the past, but there may be interference from future wind farms in U.S. coastal waters. Commercial fish-finding sonar operates at frequencies much too high to experience interference.

# Modeling Studies

- **Goal:**

To carry out first-principle modeling studies and to provide quantitative assessment of the effects.

- **Electromagnetics:**

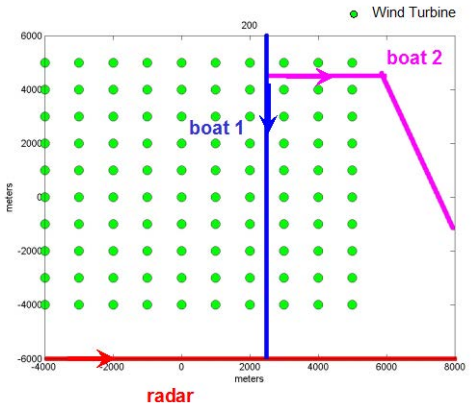
1. Marine radar.
2. Airborne radar.
3. Coastal HF radar.
4. Communications systems.

- **Acoustics:**

1. Noise propagation over different seabed compositions investigated.
2. Bathymetries of several proposed wind farm sites incorporated.
3. Propagation off continental shelf into open ocean simulated.

# Marine Radar Study

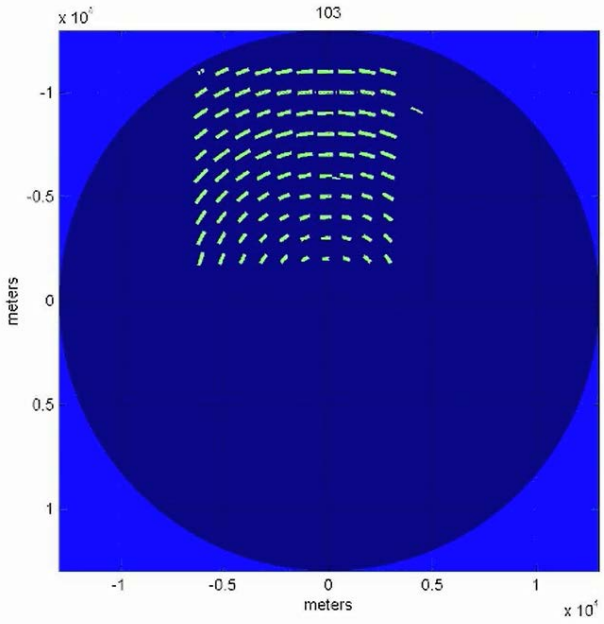
**Wind farm configuration:**
wind turbines with blade length of 63 m and height of 90 m.
100 wind turbines distributed over 100 sq km (1km x 1km apart).




**Radar parameters:**
Frequency = 3GHz
Range resolution = 15 m
AZ Beamwidth = 2 deg
Antenna Gain = 31dB
Sidelobe level = 20dB

- SAIC performed a study to simulate the effect of wind farms on marine radars.

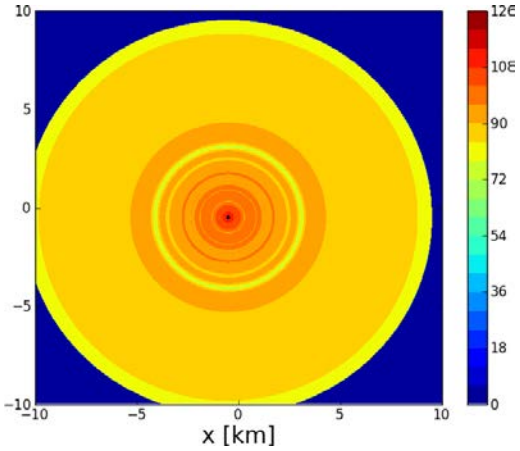
Simulation of PPI Display



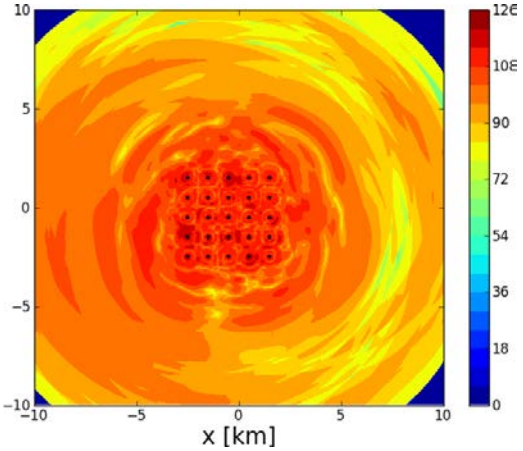

Confusing navigational picture when the boat being tracked is inside the wind farm, but minimal interference to navigation and tracking once the boat exits the wind farm.

# Underwater Sound Fields at 277 Hz

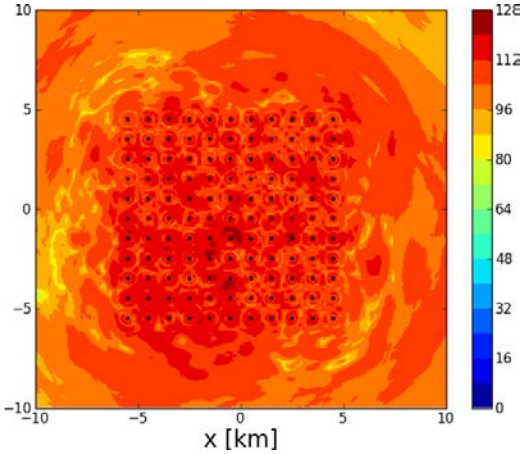
1 x 1 array (1 tower)



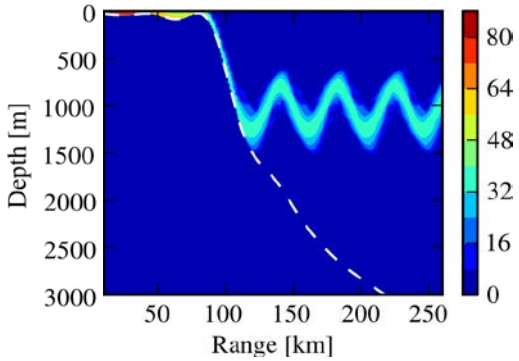

5 x 5 array (25 towers)




11 x 11 array (121 towers)

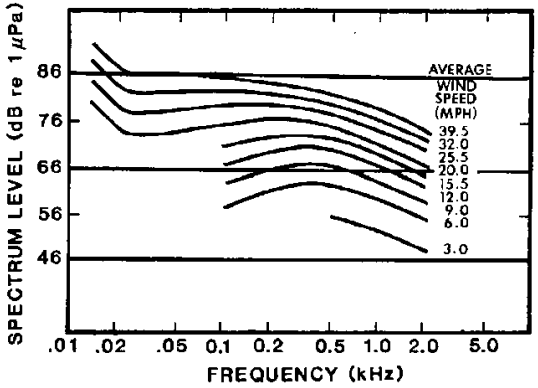



- Conditions: sandy bottom, water depth = 25 m, tower spacing = 1 km
- Color bars are SPL (dB re 1 µPa)




Continuation of simulation above for 1 tower off the continental shelf

After adjustments are made for the incoherent nature of noise radiated from different towers, which lowers the shallow water SPLs above substantially, it is anticipated that, near the east coast, the sound should usually be reduced to background noise levels before it propagates beyond the continental shelf and into open ocean.




Background noise levels along coast of Nova Scotia

## Documentation and Dissemination

- The findings from the study were summarized in a comprehensive final report, which contained both detailed impact assessments and a list of recommendations for future research.
- The intended audience of this report includes the offshore wind power industry, as well as the radar, sonar and other stakeholder communities who may have concerns about their electronic systems being impacted by offshore wind development.
- The report was reviewed by DOE, stakeholders and experts from the Interagency Field Test and Evaluation program.
- A webinar was presented to DOE on 9/4/2013.
- A web site (http://users.ece.utexas.edu/~ling/WindFarms_2.html) was developed to disseminate project-generated information to interested parties, especially those in the stakeholder community.

# Project Plan & Schedule



| Months / Tasks | 2012 | | | 2012 | | | 2012 | | | 2012-13 | | | 2013 | | | 2013 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug |
| 1) Survey potential challenges | | | | | | | | | | | | | | | | | | | |
| 2) Engage stakeholders | | | | | | | | | | | | | | | | | | | |
| 3) Survey non-US R&D activities | | | | | | | | | | | | | | | | | | | |
| 4) Conduct baseline study | | | | | | | | | | | | | | | | | | | |
| 5) Document and dissemination | | | | | | | | | | | | | | | | | | | |
| 6) Meetings and reports | | | | | | | | | | | | | | | | | | | |

- Project completed Aug. 31, 2013

# Project Budget

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

| Budget History | | | | | |
|---|---|---|---|---|---|
| FY2012 | | FY2013 | | FY2014 | |
| DOE | Cost-share | DOE | Cost-share | DOE | Cost-share |
| $0 | $0 | $0 | $0 | $0 | $0 |

- Total project carryover (FY11) = $500K (Cost-share $0)
- Total expended (8/31/2013) = $499K

# Research Integration & Collaboration



**Partners, Subcontractors, and Collaborators:** The project team was led by the Department of Electrical and Computer Engineering at the University of Texas at Austin, and included team members from the University of Texas at Austin Applied Research Laboratories and Science Applications International Corporation.

**Communications and Technology Transfer:** A total of 7 journal papers and 9 conference presentations in the electromagnetics and acoustics communities have resulted from this project.

A web site was developed to disseminate project-generated information: http://users.ece.utexas.edu/~ling/WindFarms_2.html.

## List of Recommendations from Our Report

1. Collect measurement data to corroborate findings.
2. Perform system-specific risk assessment.
3. Conduct R&D on mitigation.
4. Form government working group for information sharing.
5. Develop simulation capability for site-specific assessment.
6. Collect ambient acoustic noise data.
7. Investigate other tower types.