U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

A Biomimetic Ultrasonic Whistle For Use As A Bat Deterrent On Wind Turbines M16, DE-EE0007032

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Presented by Jocelyn Brown-Saracino on behalf of

University of Massachusetts Amherst

FY17-FY18 Wind Office Project Organization

"Enabling Wind Energy Options Nationwide"

Technology Development	Market Acceleration & Deployment
Atmosphere to Electrons	Stakeholder Engagement, Workforce Development, and Human Use Considerations
Offshore Wind	Environmental Research
Distributed Wind	Grid Integration
Testing Infrastructure	Regulatory and Siting
Standards Support and International Engagement	
Advanced Components, Reliability, and Manufacturing	

Analysis and Modeling (cross-cutting)

Project Overview

M16: A Biomimetic Ultrasonic Whistle For Use As A Bat Deterrent On Wind Turbines

Technology Summary: Design a novel mechanical ultrasonic deterrent for use on wind turbines in order to reduce bat fatalities around wind turbines.

Period of Performance: September 1, 2015 – December 31, 2019

Technology Impact: These whistles are intended to be operated passively, blown by the wind, and to be positioned at intervals along a turbine blade. Because the source of sound generation will be mechanical in nature, these devices will require no external power source, should require little maintenance, and will be small and cost-effective.

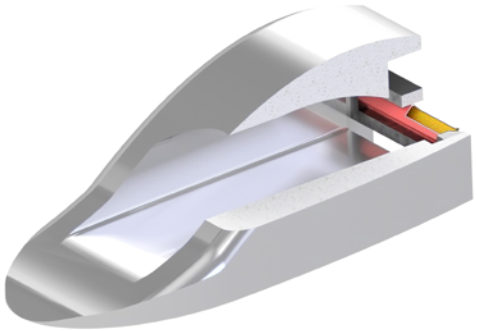
Project Goals: Design a series of ultrasonic pulse generators, or whistles, to be affixed to a wind turbine blade, which produce ultrasound through mechanical means, and thus deter bats from approaching.

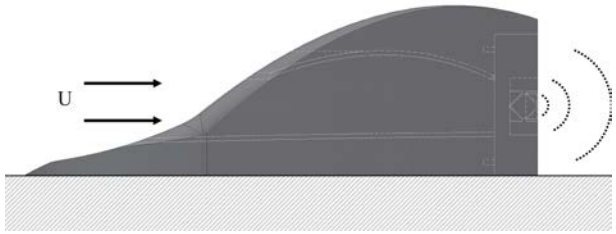
Partners:

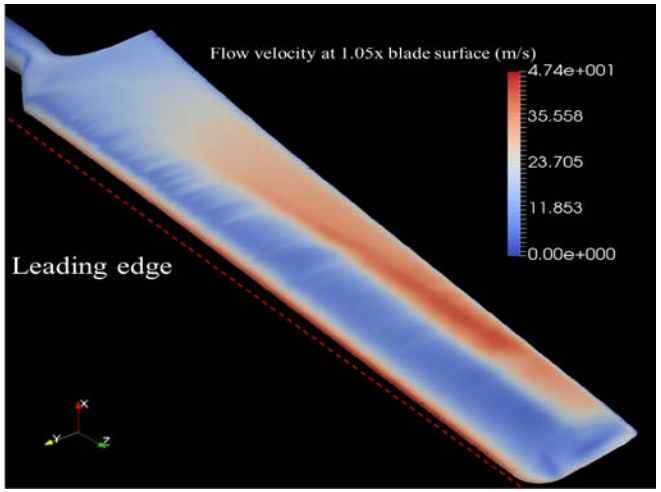
- American Wind Wildlife Institute (National Wind Coordinating Collaborative) https://www.nationalwind.org/
- UMass Department of Mechanical and Industrial Engineering (whistle design)
- Texas A&M University (testing whistles as bat deterrent)
- Massachusetts Clean Energy Center

Technical Merit and Relevance

- Due to rapid attenuation of ultrasound in the atmosphere, current state of the art hub-mounted ultrasonic deterrents cannot cover the entire rotor swept zone of a turbine.
- These whistles are intended to be operated passively, blown by the wind, and to be positioned at intervals along a turbine blade.
- Because the source of sound generation will be mechanical in nature, these devices will require no external power source, should require little maintenance, and will be small and cost-effective.

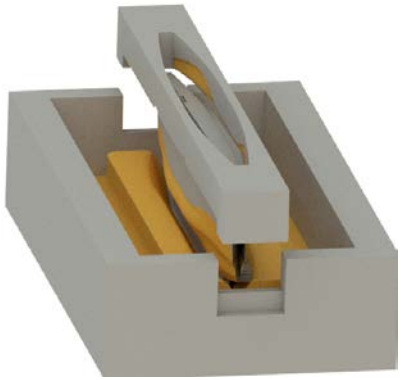


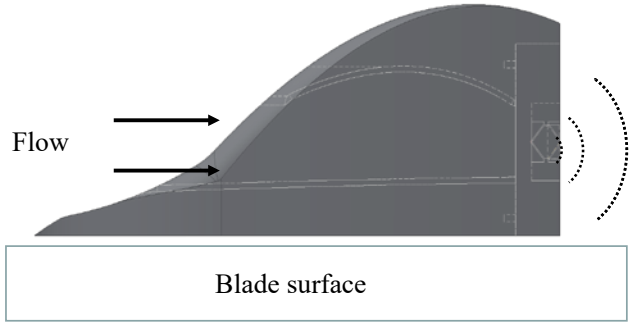




Technical Merit and Relevance

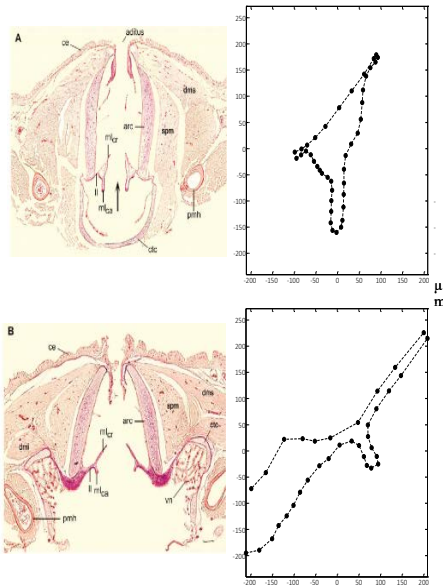
- The small size of our devices will allow us to position them along the turbine blade, ensuring full ultrasonic coverage of the rotor swept zone.
- These devices should have insignificant impact on blade efficiency, and we anticipate that these devices could ultimately be housed within vortex generators, which are known to delay flow separation and increase efficiency of turbine blades.



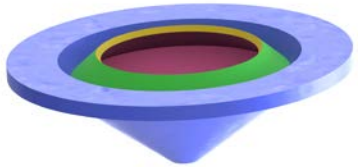


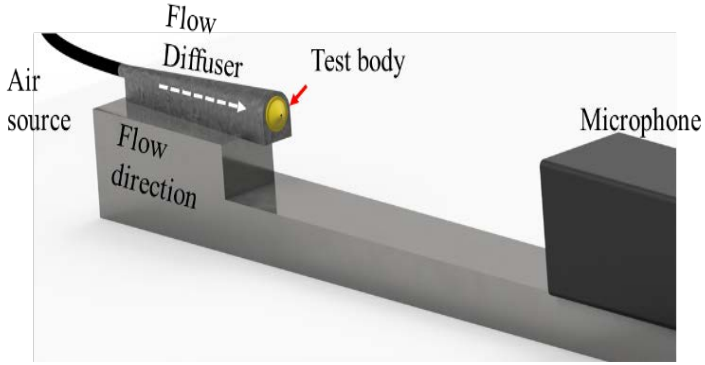
Approach and Methodology

- UMass used a biomimetic modelling approach to develop ultrasonic pulse generators (whistles) that are based on the structure of the greater horseshoe bat larnyx and the concave-eared torrent frog larynx.
- Whistles were designed in the Fluid Structure Interactions Laboratory and tested in the wind tunnel facilities at the University of Massachusetts Amherst.



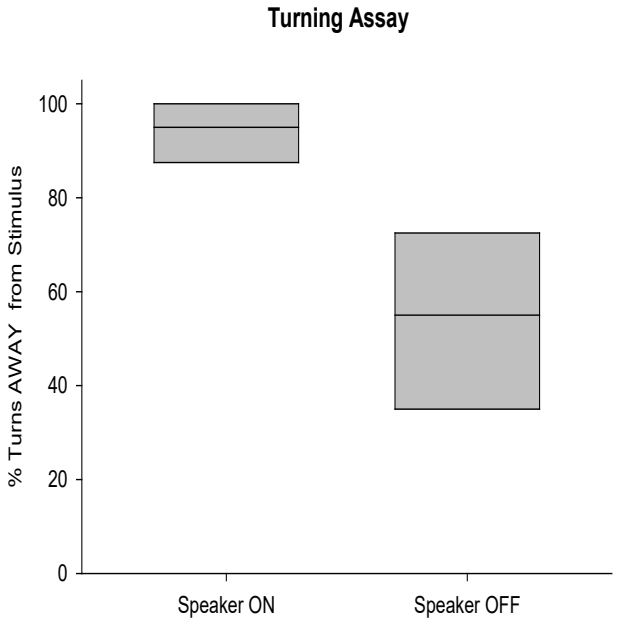
Suthers *et al.* 2006

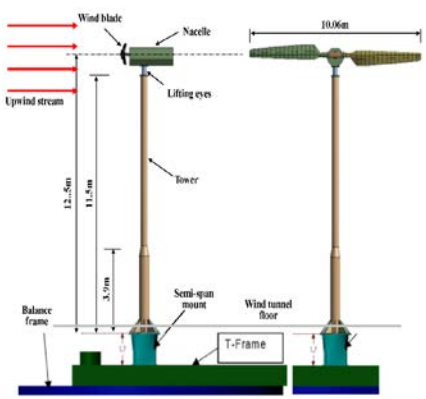




Approach and Methodology

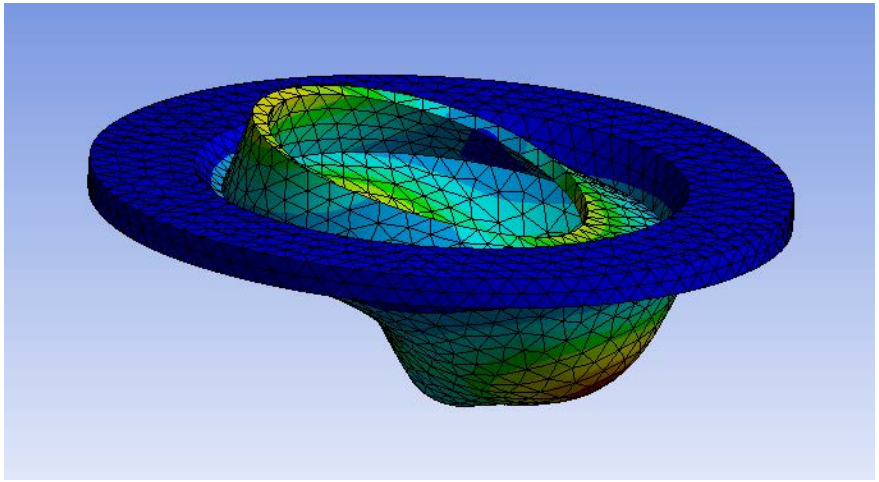
- The effectiveness of the ultrasound deterrent is being tested on bat species by Dr. Michael Smotherman at Texas A&M University, both in the lab and field (thermal imaging).
- Whistle placement on turbine blades will be guided by Dr. Matthew Lackner of the UMass Wind Energy Center.

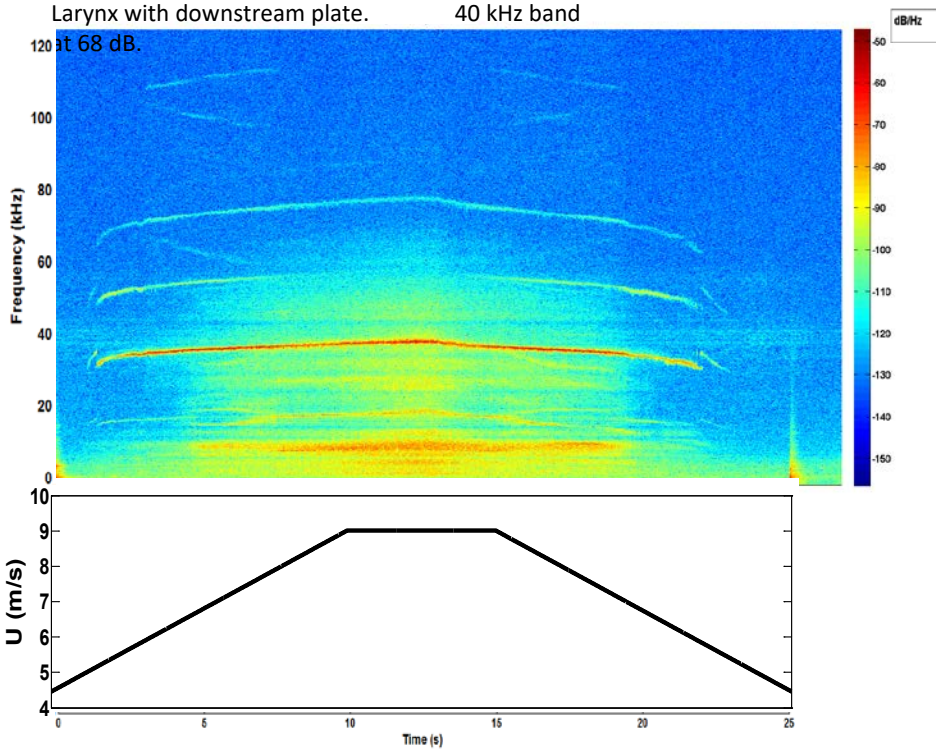




Accomplishments and Progress

Task 1: Completed a report summarizing results from lab trials and detailing the technical operational specifications (frequencies, intensities, and sound patterns) needed for the development of an ultrasonic deterrent device.

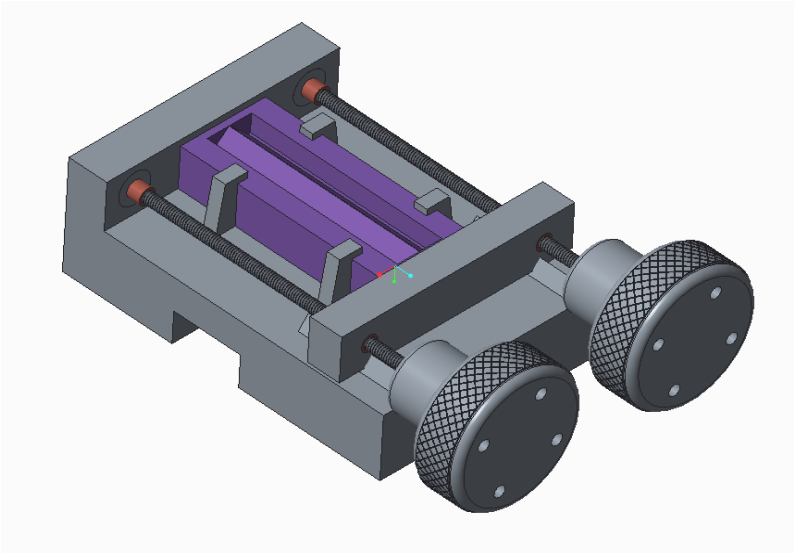


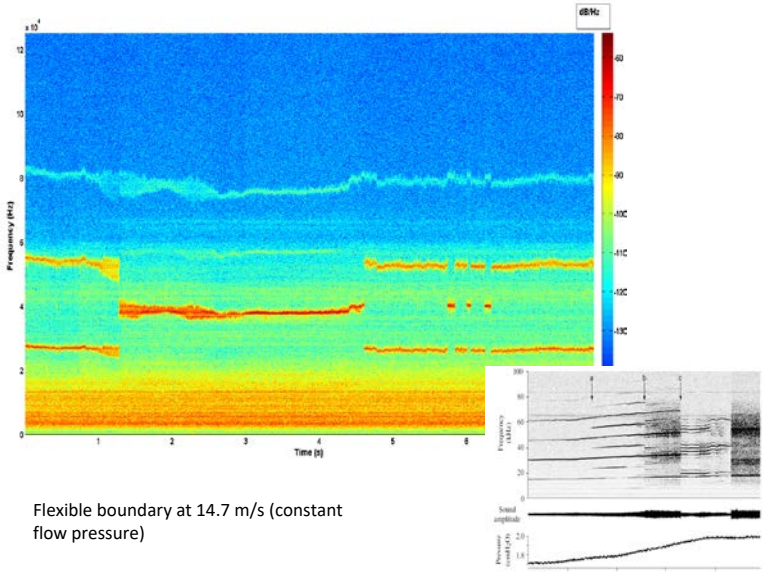


Accomplishments and Progress

Task 2: Completed a report identifying one or more candidate biological models, along with a report providing theoretical estimates of frequency and amplitude output for the candidate model(s).

Task 3: Developed prototype whistles operating in the 25-35 kHz range, 35-45 kHz range, and 45-55 kHz range.



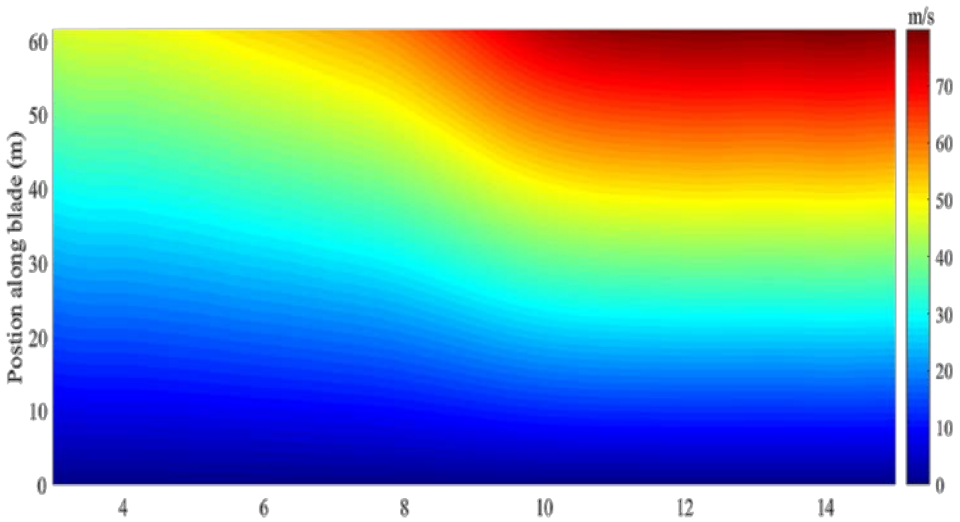


Flexible boundary at 14.7 m/s (constant flow pressure)

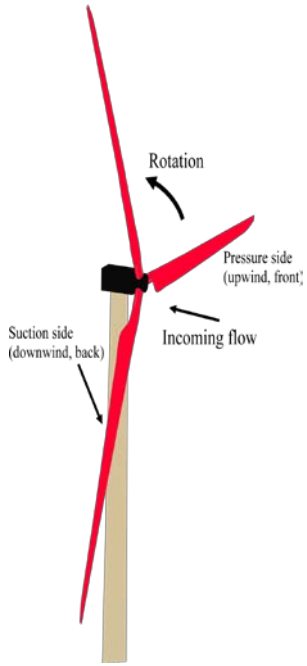
Accomplishments and Progress

Task 4: Collection of field data will continue through spring and summer of 2019, using thermal imaging cameras to measure effect of ultrasound on wild bats.

Task 5: We tested the whistles on a small turbine in a wind tunnel at UMass in a wind tunnel, and we reran our experiments with the deterrent mounted on a rotating turbine case (forced rotation turbine).



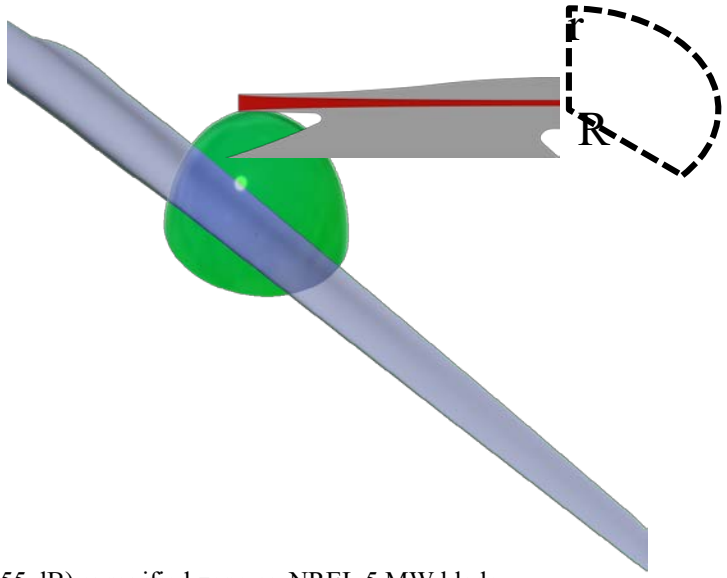
Incoming flow (m/s)



Accomplishments and Progress

Task 6: Produced a report that defined the operating variables under which the whistles will need to perform and how the whistles will need to be modified to functions under these conditions.

Task 7: Developed a revised biological study design that incorporated the insights from other researchers in the field, and this design will include field tests using thermal imaging cameras in 2019.



Scale of 10 m (55 dB) ensonified zone on NREL 5 MW blade

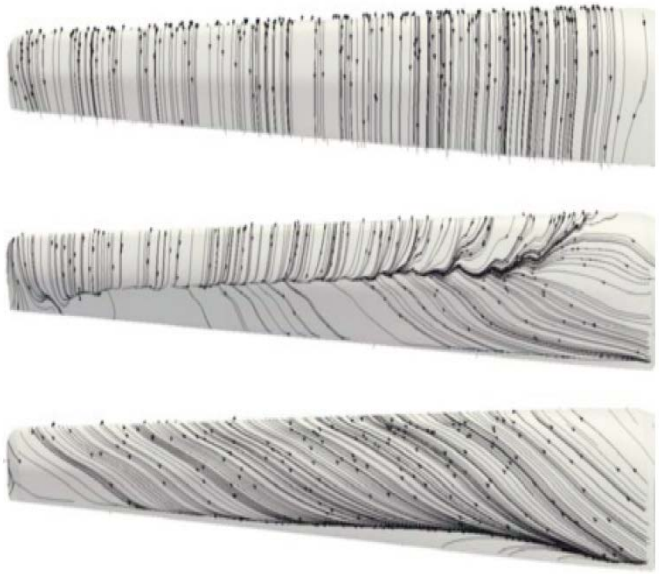


Figure a. Surface streamlines for incoming flow of 5, 10, 21 m/s

Communication, Coordination, and Commercialization

The UMass team has, and will continue to, communicate results to the general public, industry, and the scientific community through Outreach and Presentations:

- 2019: Acoustical Society of America
- 2017: New England Bat Working Group
- 2016: Christian Science Monitor; Local high school classes; Wind Energy Research Group, Lowell, MA; Technical University of Denmark; Massachusetts Clean Energy Center; American Physical Society; Northeast Bat Working Group; UMass IGERT Offshore Wind Energy Group
- 2015: U.S. Forest Service Northeast Research Station; New England Public Radio; Springfield Republican Newspaper

Upcoming Project Activities

- The UMass team revised their Biological Study Design to incorporate the use of thermal imaging photography (suggested by DOE) to evaluate the effect of ultrasonic sound produced by our whistles on the flight behavior of free-flying bats.
- This work will be conducted by Dr. Michael Smotherman at Texas A&M University during the spring and summer of 2019, and will be included in our final report to be submitted in December of 2019.
- This work has been accommodated by a revision of our SOPO and an extension of the project to 31 December 2019.

Thank you!