U.S. DEPARTMENT OF ENERGY
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

IOWA STATE UNIVERSITY

Passive Ultrasonic Deterrents to Reduce Bat Mortality in Wind Farms

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Project Overview

Idea/Technology:

- Blade-mounted ultrasonic deterrent driven by blade-relative flow

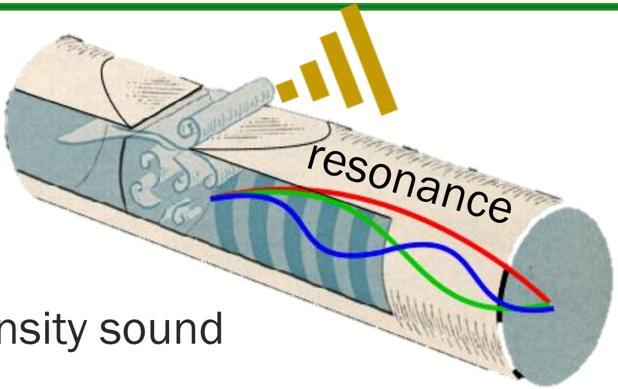
Technology Impact:

- Mitigate bat mortality at wind farms with little-to-no reduction in energy capture
- Cost savings by replacing *operational mitigation* with the proposed deterrent

Project Goals:

- Develop a passive, blade-mounted ultrasonic bat deterrent
- Characterize ultrasound generation in anechoic chamber & aero performance in wind tunnel

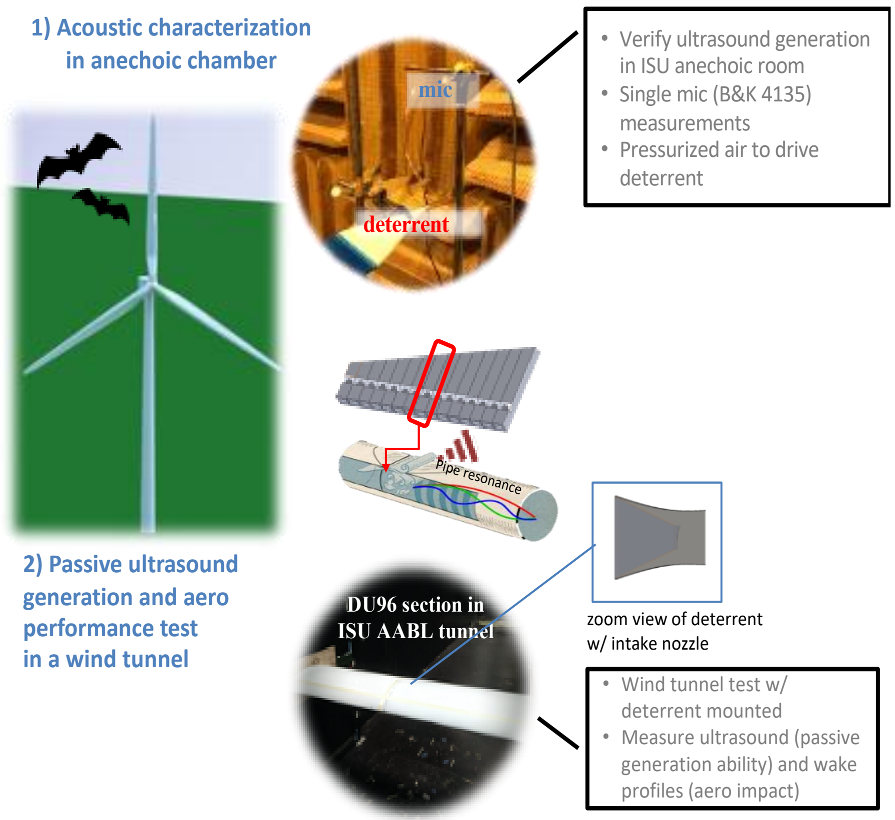
Concept and Technical Merit



- Adaptation of dog (Galton's) whistle
- Working principle:
  flow instability coupled with a resonator → high-intensity sound
- Multiple resonators for broad spectral coverage (20 - 50 kHz)
- Blade-relative air flow for passive operation
  - no moving parts → less possibility of mechanical failure
- Blade-mounted ultrasonic deterrents need to radiate smaller distance (~5-10 m);
  - Nacelle/tower-mounting requires coverage of the entire rotor disk (50-100 m)

Research Plan

- **Design the deterrent device and characterize its acoustics in lab tests**
- **Design optimization to produce the desired ultrasound spectra with minimum pressure and flow rate**
  - Acoustic characterization in the anechoic chamber
- **“Intake” design to mount the deterrent on rotor blades**
  - Identify mounting locations on rotor blades
  - Design intakes to supply airflow to the deterrent
- **Characterize the aerodynamic performance and aeroacoustics of the deterrent mounted on a rotor blade section**
  - Aero/acoustics performance characterization of a blade section with the deterrent
  - Iterate on deterrent design based on performance results
- **Biological efficacy will need to be assessed in the future … not part of this project**



Project Timeline

Research Task	**Q4 '19**	**Q1 '20**	**Q2 '20**	**Q3 '20**	**Q4 '20**	**Q1 '21**	**Q2 '21**	**Q3 '21**	**Q4 '21**
Development of the deterrent device	▓	▓	▓	▓					
Initial prototype and its acoustic characterization	░	░							
Design optimization & verification of the optimized design			░	░					
Design of intake to mount the deterrent					▓	▓			
Identify blade mounting locations					░				
Develop inlet designs for airflow						░			
Lab testing of the deterrent mounted on a blade section							▓	▓	
Aero performance characterization							░		
Design iterations								░	
Acoustic characterization of the optimized design								░	
Project reporting and publication									▓

Key Dates:

- Development of the deterrent device (initial design) — Q3 ‘20
- Intake design + blade mounting ideas — Q1 ‘21
- Lab testing of the deterrent mounted on a blade section — Q3 ‘21
- Project reporting — Q4 ‘21

Preliminary Results

- Whistle fabrication & testing
  - Initial whistle design ideas ready and lab setup prepared for testing

    Derivative of the design by Beeken (1969)*
  - 3D printing (for fabrication) has been evaluated → works well

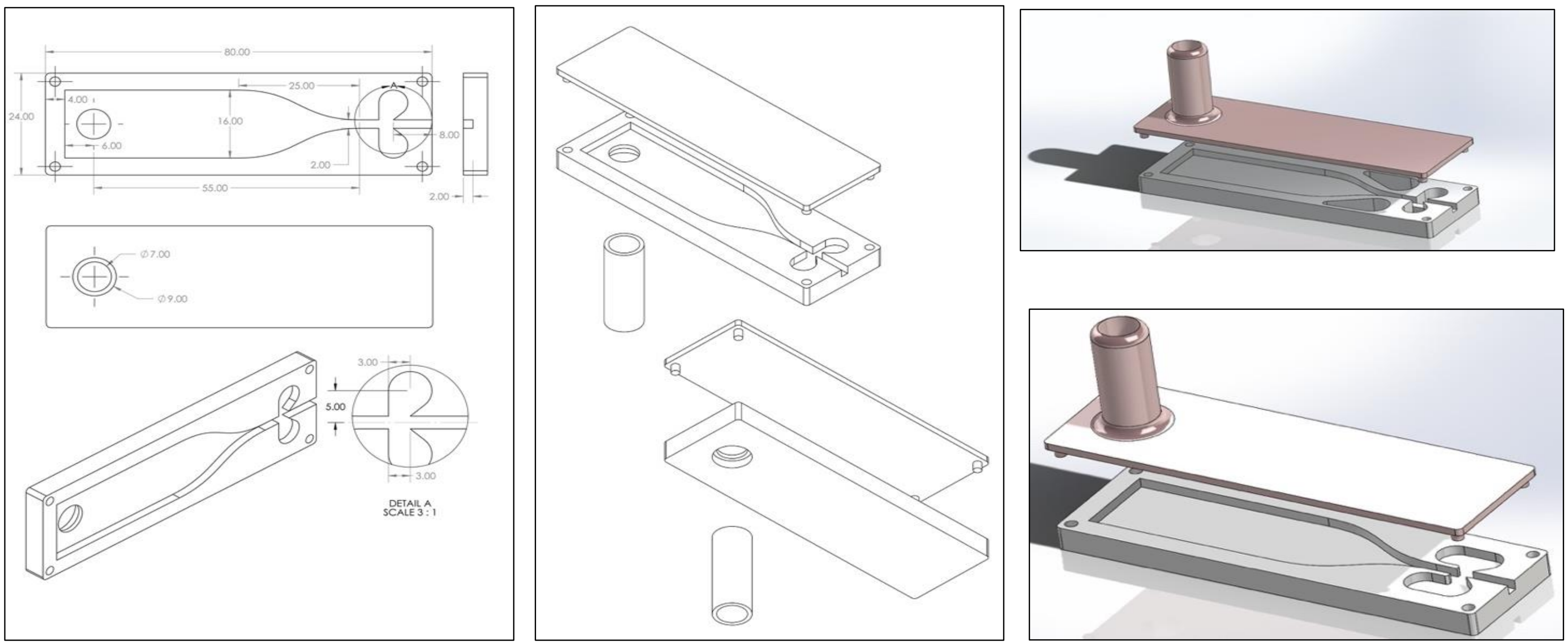


Figure: A CAD design of the fluid ultrasonic generator.

* Beeken (1969) “Fluid Ultrasonic Generator” US patent #3432804

Preliminary Results

- Preliminary acoustic characterization → verified ability to produce ultrasound tones
- Variations of the design for generating multiple tones to cover a broad ultrasound frequency range being evaluated

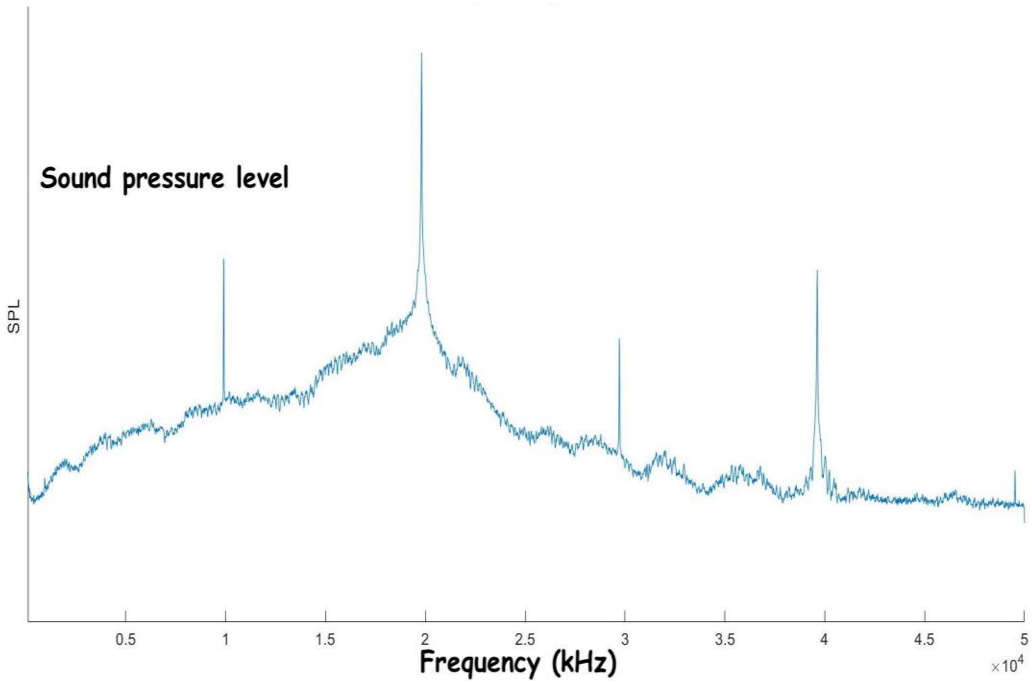


Figure: Preliminary acoustic measurements for the first prototype of the ultrasonic whistle - single resonator

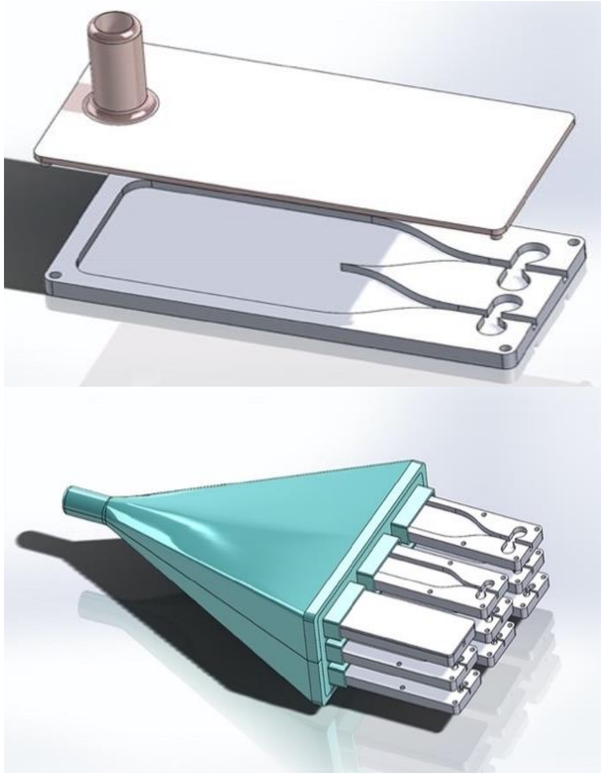


Figure: design variations to cover a large ultrasound frequency range

Acknowledgement

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