

U.S. DEPARTMENT OF
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**IOWA STATE
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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:

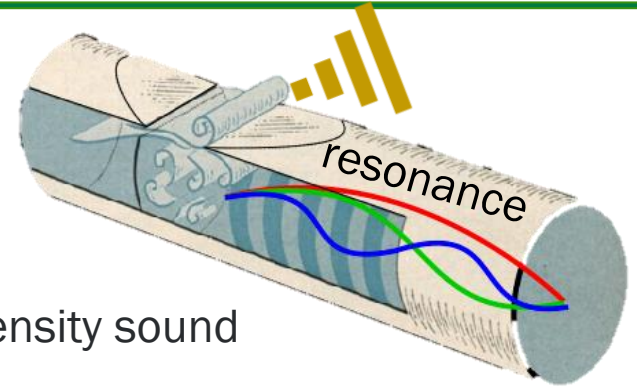
- Mitigate bat mortality at wind farms with little-to-no reduction in energy capture
- Cost savings by replacing *operational mitigation* with the proposed deterrent

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

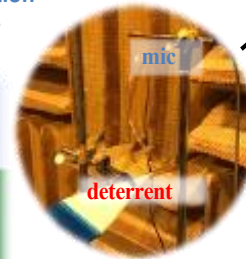
- Adaptation of dog (Galton's) whistle
- Working principle:
 - flow instability coupled with a resonator → high-intensity sound
- Multiple resonators for broad spectral coverage (20 - 50 kHz)
- Blade-relative air flow for passive operation
 - no moving parts → less possibility of mechanical failure
- 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

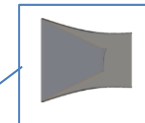
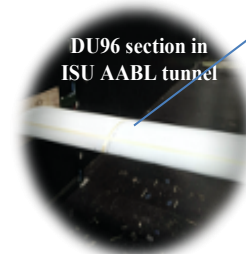
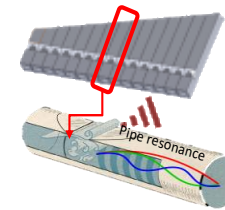
- Design the deterrent device and characterize its acoustics in lab tests
- Design optimization to produce the desired ultrasound spectra with minimum pressure and flow rate
 - Acoustic characterization in the anechoic chamber
- “Intake” design to mount the deterrent on rotor blades
 - Identify mounting 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**

1) Acoustic characterization in anechoic chamber



- Verify ultrasound generation in ISU anechoic room
- Single mic (B&K 4135) measurements
- Pressurized air to drive deterrent

2) Passive ultrasound generation and aero performance test in a wind tunnel



zoom view of deterrent w/ intake nozzle

- Wind tunnel test w/ deterrent mounted
- Measure ultrasound (passive generation ability) and wake profiles (aero impact)

Project Timeline

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

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

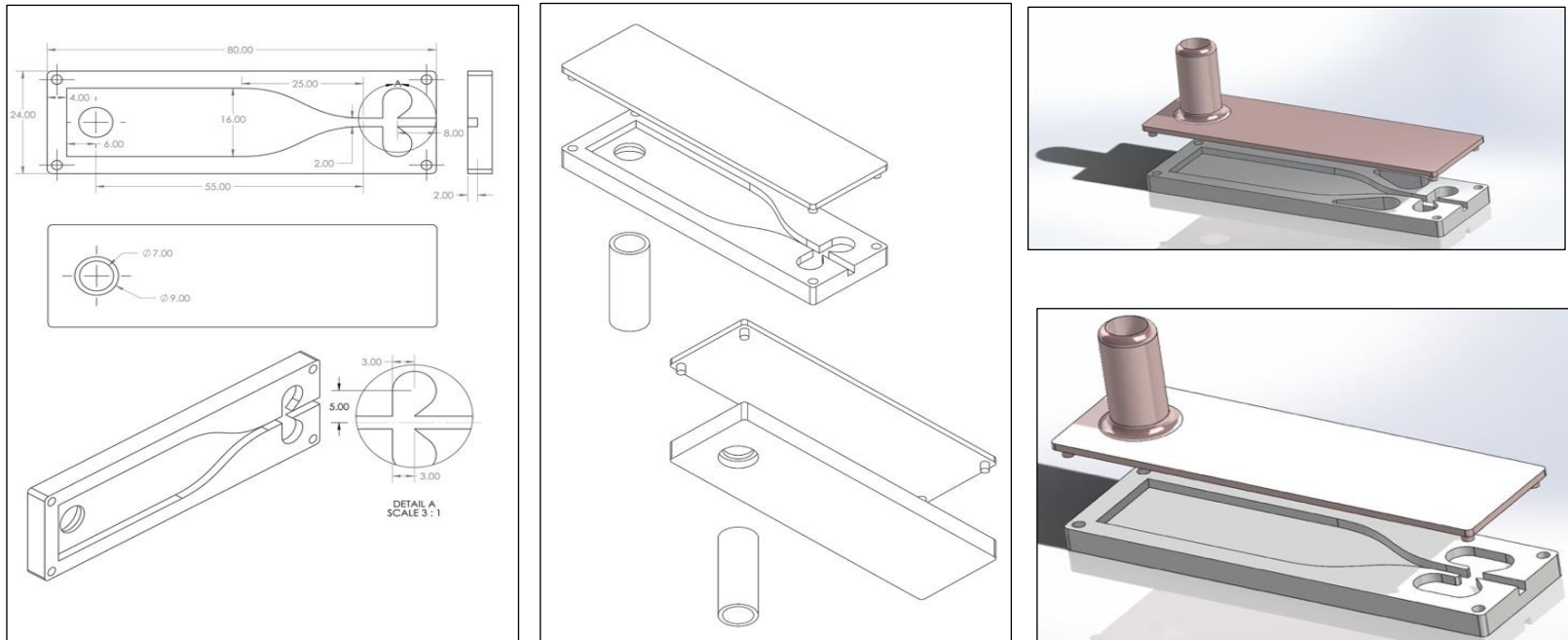


Figure: A CAD design of the fluid ultrasonic generator.

* 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

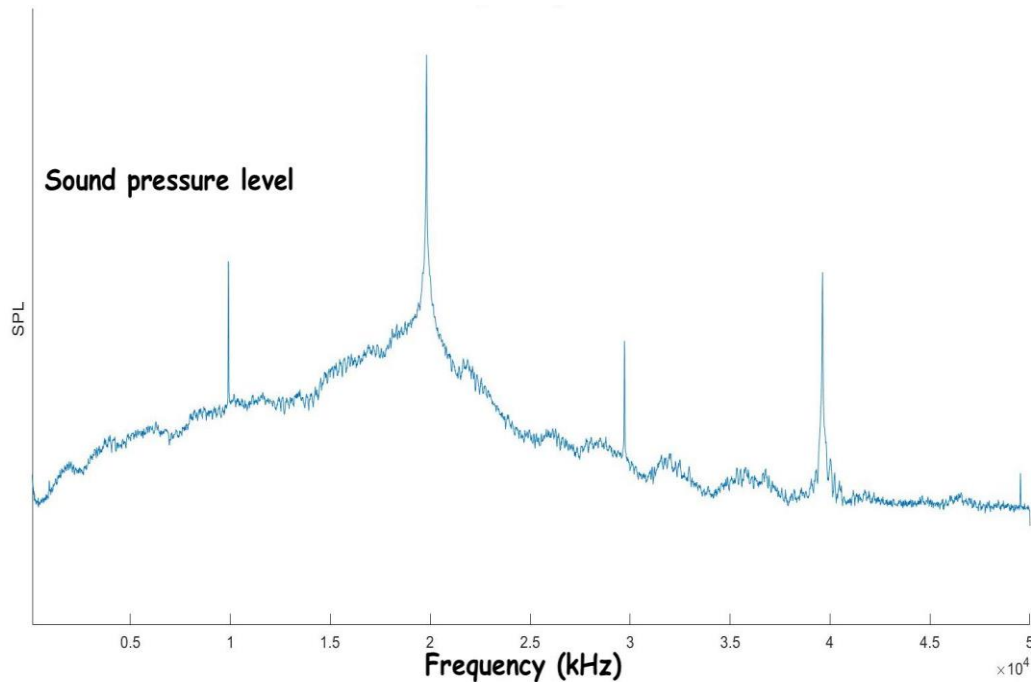


Figure: Preliminary acoustic measurements for the first prototype of the ultrasonic whistle - single resonator



Figure: design variations to cover a large ultrasound frequency range

Acknowledgement

Acknowledgement

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