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# Drone Noise Characterization and Mitigation for Unmanned Traffic Management

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## BACKGROUND & PURPOSE

DriveOhio, the project sponsor, wishes to safely integrate an Unmanned Aircraft Traffic Management (UTM) solution into the Columbus Smart City US Route 33 Smart Mobility Corridor in order to monitor traffic and roadway conditions more effectively. DriveOhio wants to take precautionary measures to ensure that the drones will not adversely affect people and livestock living along US Route 33, as recent studies have exposed negative effects of drone noise. If drones are to be deployed in a public setting, the sound that they produce must be characterized and considered in the design of DriveOhio's UTM initiative. The objective of the DriveOhio project is to characterize and mitigate the noise emitted from small unmanned aerial systems (sUAS) to an appropriate level for a commercial use case.

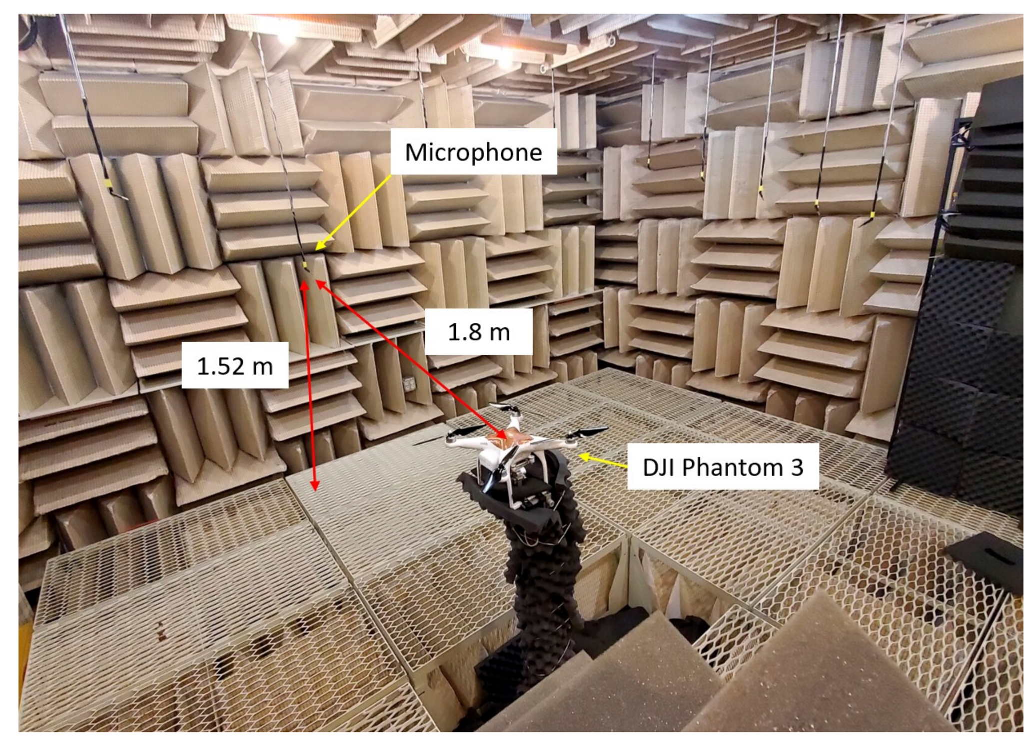
## OBJECTIVES

1. Develop two formal drone noise test plans: indoor anechoic chamber and outdoor field
2. Collect and analyze frequency spectrum and sound pressure amplitude data for 2 drone operation modes and for 4 different rotor props
3. Form 2-3 recommendations for sUAS operation in the UTM project based on conclusions from the noise data and background research about the hearing ranges of humans and livestock.

## METHODS

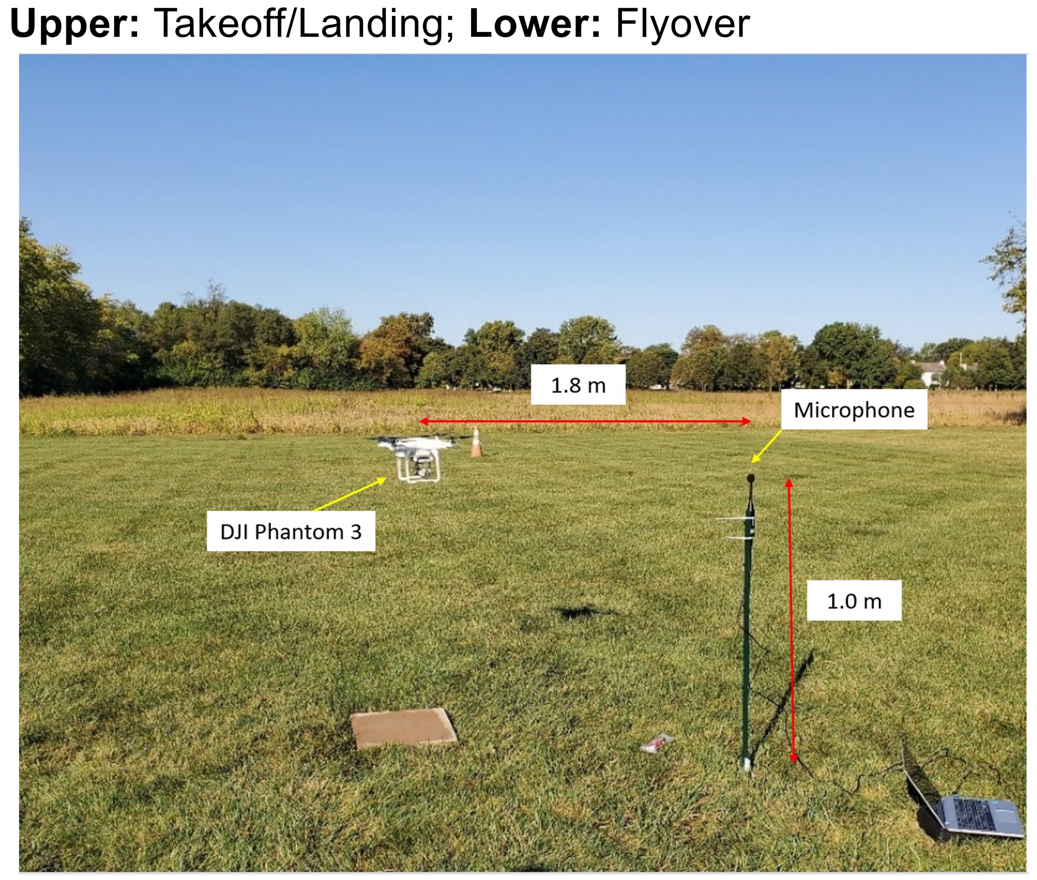
### Various Propeller Props Tested

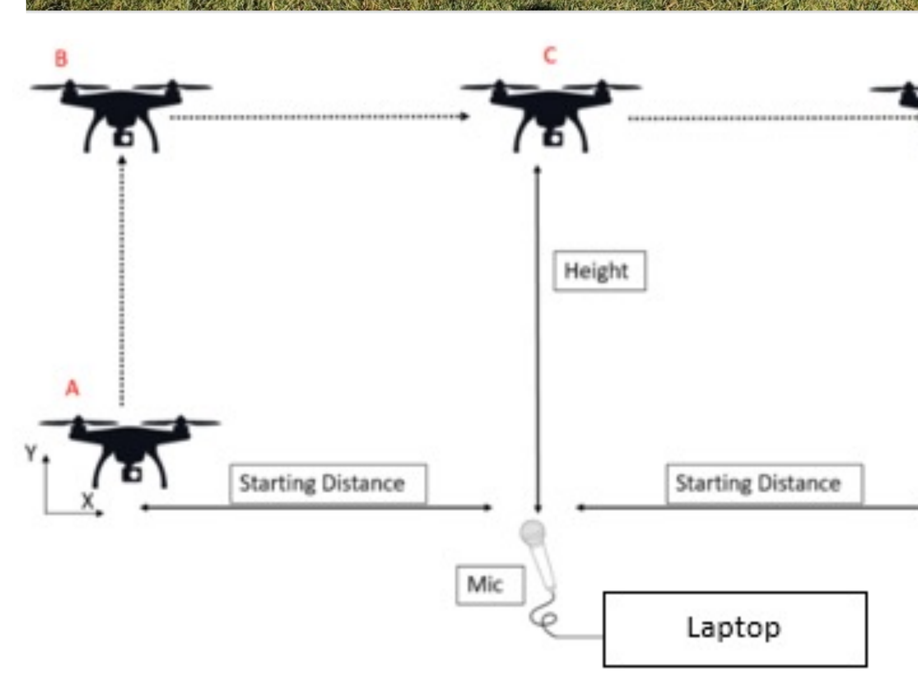

*Upper Left: Glass Fiber Dual Blade Prop; Bottom Left: Standard Plastic Dual Blade Prop*
*Upper Right: Carbon Fiber Dual Blade Prop; Bottom Right: Plastic Triple Blade Prop.*




### Phase 2: Outdoor Tests

**Upper:** Takeoff/Landing; **Lower:** Flyover

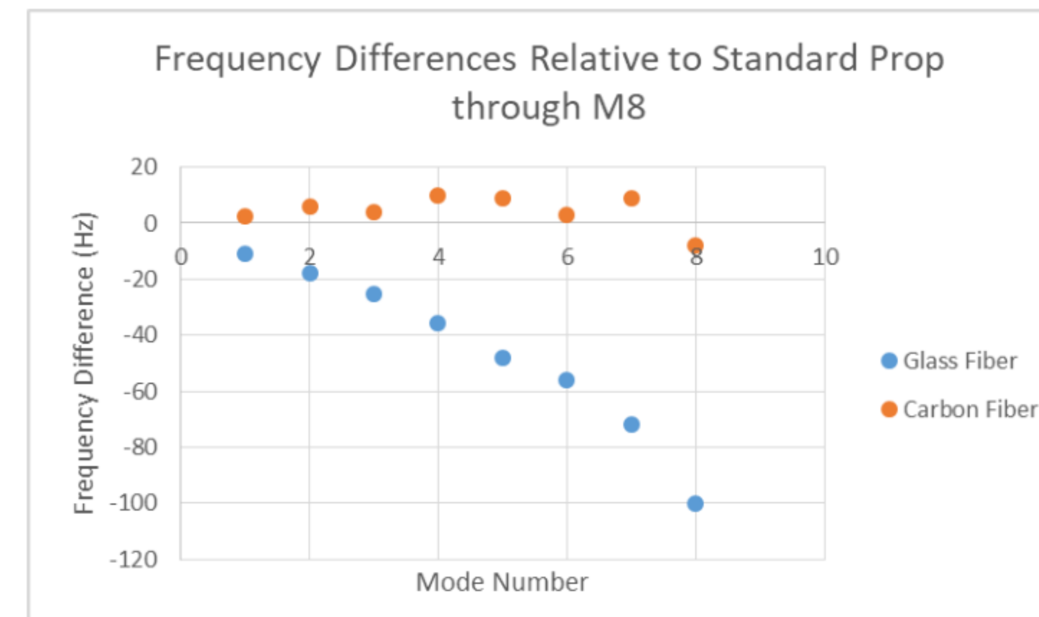


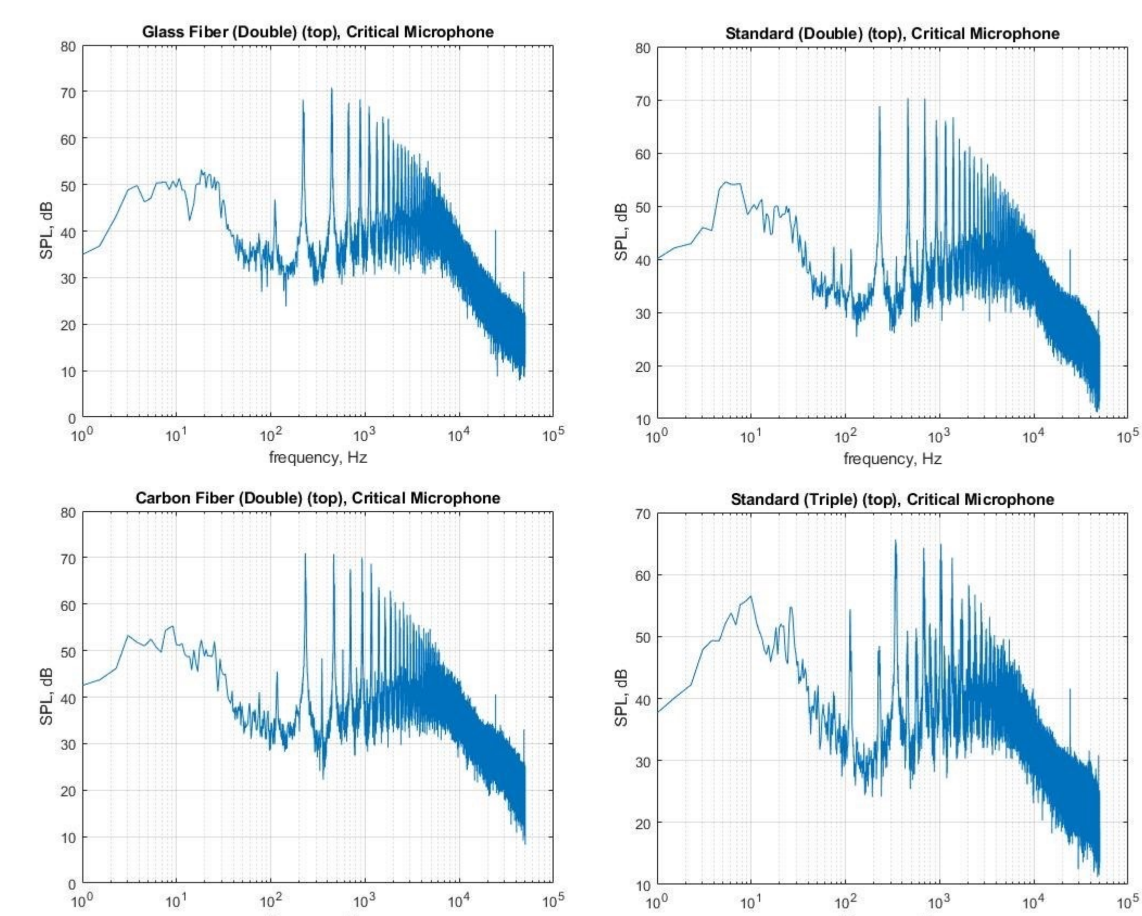




*Starting Distance: 50 ft.; Point B Heights: 25 ft., 50 ft., 75 ft., 100 ft.*

## RESULTS

### 2-Blade Propeller Type Frequency Comparison




### Outdoor Takeoff/Landing SPL Results

| Trial | Max Height ( | Takeoff Noise (dB) | Landing Noise (dB) | Noise at Max Height (dB) |
|---|---|---|---|---|
| 1 | 55 | 74.15 | 65.57 | 57.62 |
| 2 | 61.5 | 67.8 | 72.29 | 57.21 |
| 3 | 63 | 67.85 | 66.35 | 56.66 |
| Average | 59.833 | 69.933 | 68.070 | 57.163 |

### Outdoor Flyover SPL Results

**ElectroScience Lab**

| Flyover Height (ft) | Peak Noise (dB) |
|---|---|
| 25 | 78.61 |
| 50 | 73.98 |
| 75 | 71.46 |
| 100 | 69.74 |

**ODOT**

| Flyover Height (Ft) | Peak Noise (dB) |
|---|---|
| 25 | 95.75 |
| 50 | 84.43 |
| 75 | 73.22 |
| 100 | 70.65 |

## CONCLUSIONS

- Indoor Takeoff/Landing:
  - All blade frequencies fall in human detrimental range of hearing (2,000 – 4,000 Hz) and cattle detrimental range (~8,000 Hz)
  - Glass fiber and triple-blade prop SPLs are consistently below traffic sound level of 70 dB
- Outdoor Takeoff/Landing
  - All takeoff/landing noise approaches or exceeds noise of traffic until max height
- Outdoor Flyover
  - All flyover noise approaches noise of traffic, with extra concern at 25 ft. and 50 ft.
- Recommendations
  - Take precautionary flight noise measures for takeoff/landing and flyovers below 50 ft.
  - Utilize glass fiber rotor props to reduce overall dB levels
  - Utilize triple-blade rotor props to reduce fundamental frequencies to more "acceptable" range

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## ACKNOWLEDGEMENTS

*DriveOhio and ODOT: Rich Granger, Dave Gallagher*
*Ohio State ARC: Jim Gregory, Braxton Harter, Ryan Thorpe, Brandon Emshoff*
*Ohio State Mechanical Engineering: Russell Marzette, Tim Lastrapes*

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MECHENG 4901.02 General Capstone, Autumn 2019