ASME
IDETC-CIE 2025

INTERNATIONAL DESIGN ENGINEERING TECHNICAL CONFERENCES & COMPUTERS AND INFORMATION IN ENGINEERING CONFERENCE

HILTON ANAHEIM
ANAHEIM, CALIFORNIA, USA

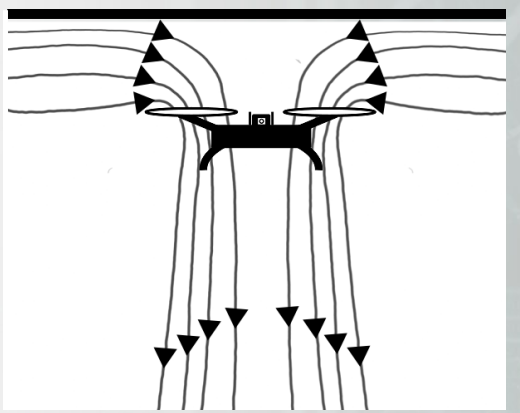
ASME IDETC-CIE 2025
INTERNATIONAL DESIGN ENGINEERING TECHNICAL CONFERENCES & COMPUTERS AND INFORMATION IN ENGINEERING CONFERENCE

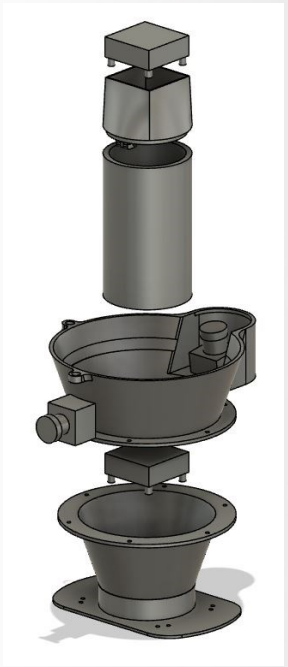
A STUDY ON THE EFFECTS OF THE CEILING EFFECT ON A PROPELLER THRUST FORCE

Joud N. Satme; University of South Carolina Department of Mechanical Engineering
Ryan Yount; University of South Carolina Department of Mechanical Engineering
Spencer Schwartz; University of South Carolina Department of Mechanical Engineering
Austin R.J. Downey; University of South Carolina Department of Mechanical Engineering
Stanley Ling; University of South Carolina Department of Mechanical Engineering

Outline

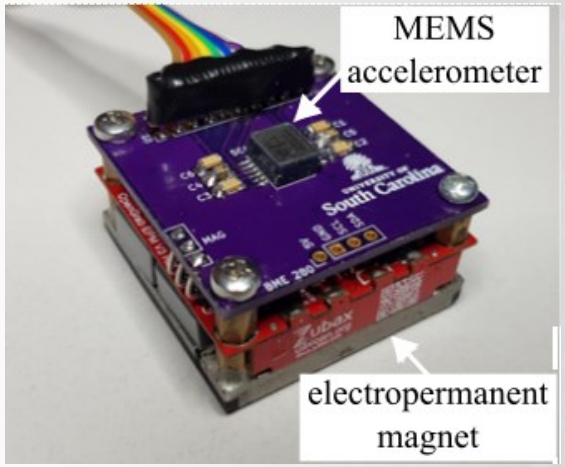
- Methodology
  - UAV-aided sensor deployment
  - Ceiling effect
- Experimentation
  - Variable ceiling experiment
- Simulation Setup
- Results and Discussion
  - Thrust vs. ceiling distance
- Future Work
  - Flight controller implementation

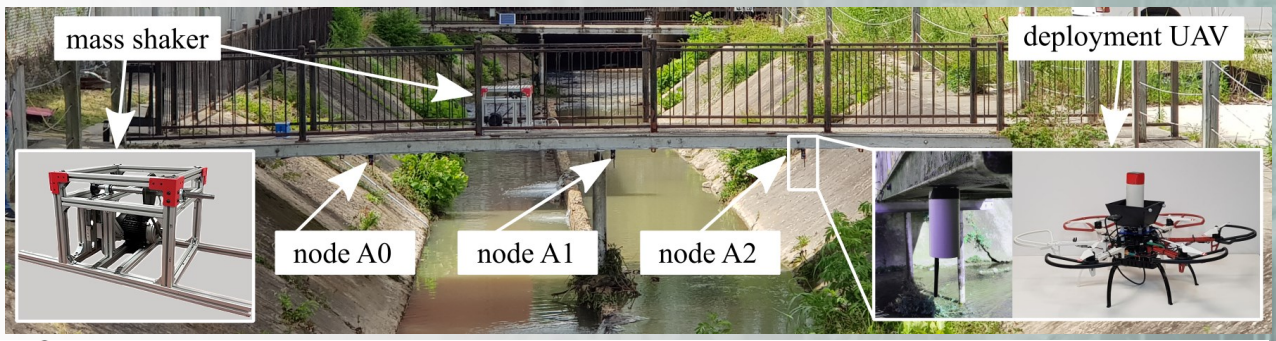


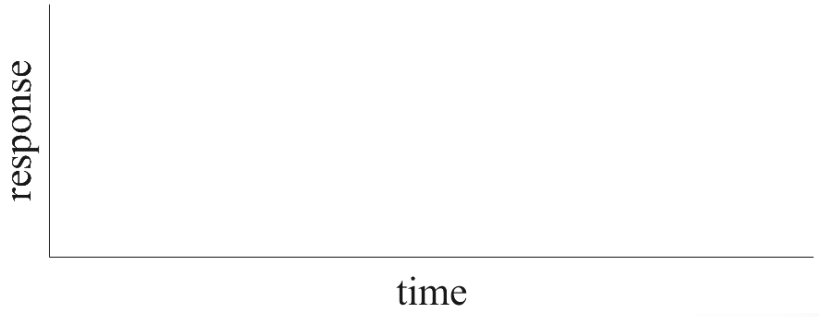


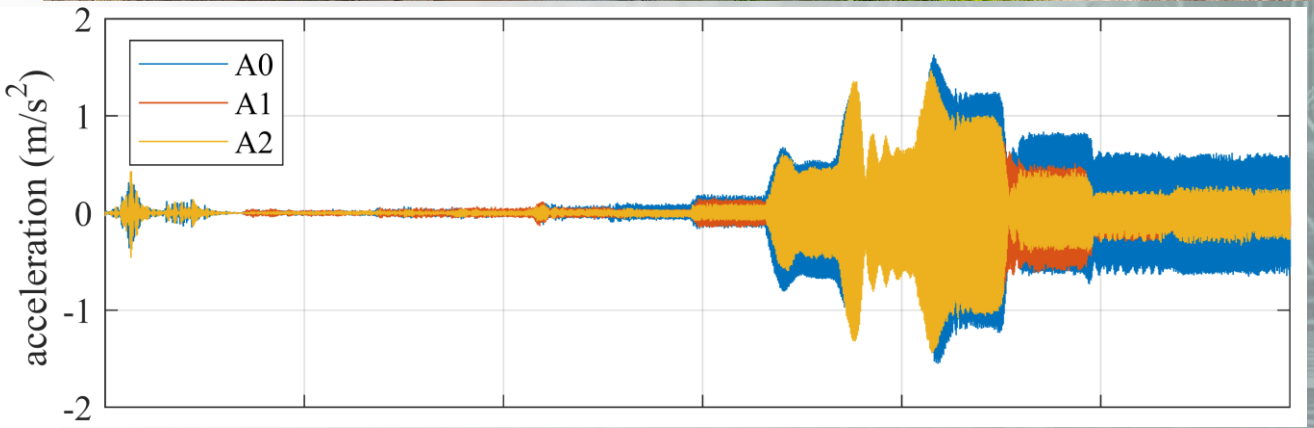
Methodology

- UAV-aided sensor deployment
  - UAV delivery of SHM sensors
  - Electropermanent magnet docking system
  - Capture frequency response of civil structures



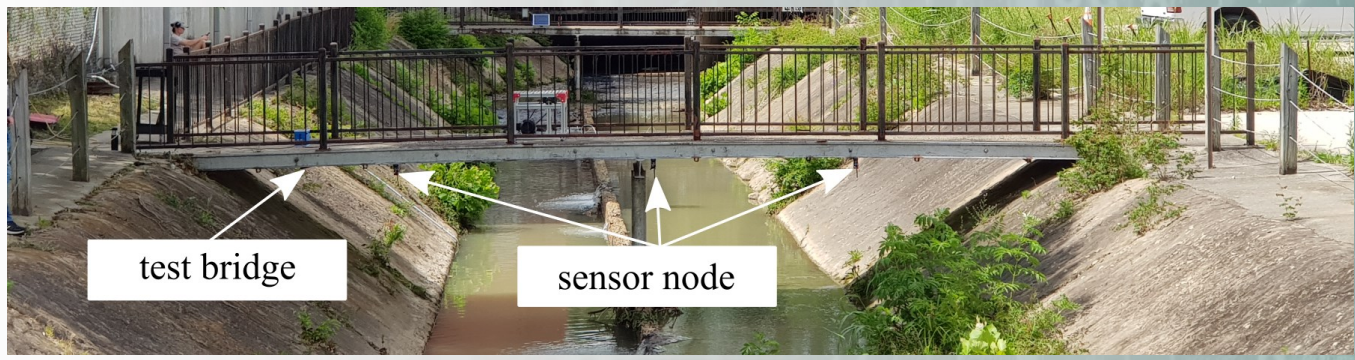






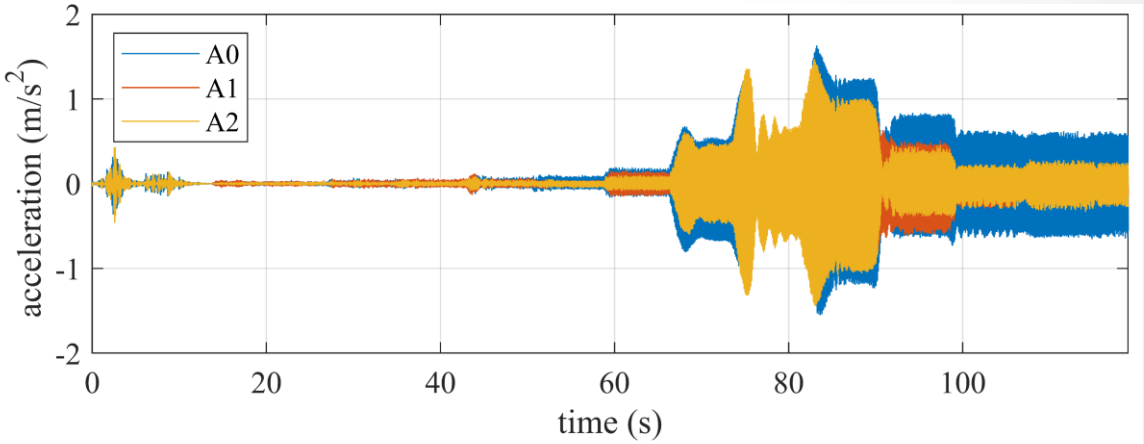
Methodology

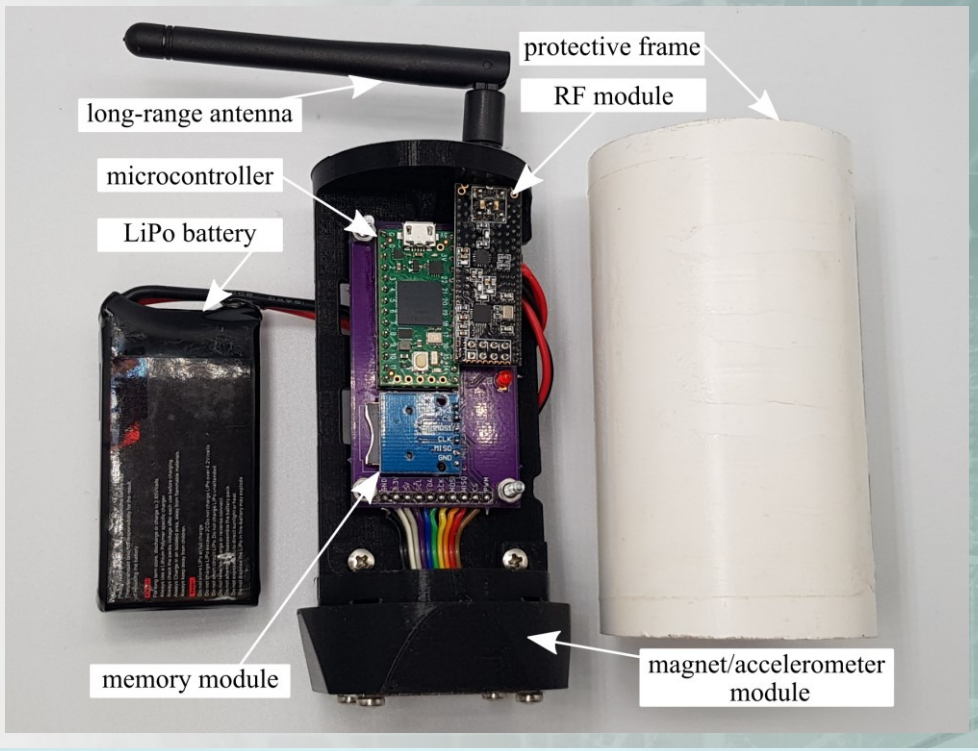
- Rapid structural health monitoring
- Remote SHM sensing systems
- Transmission bandwidth and power limitations

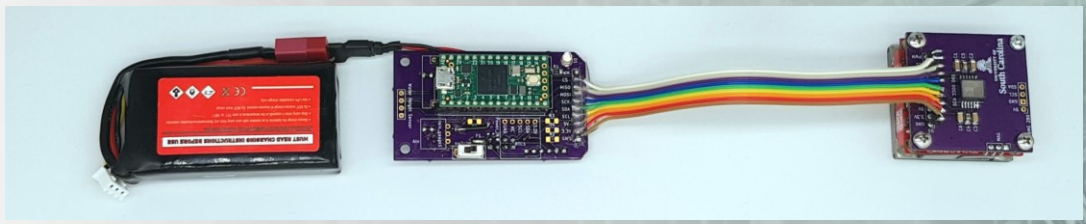


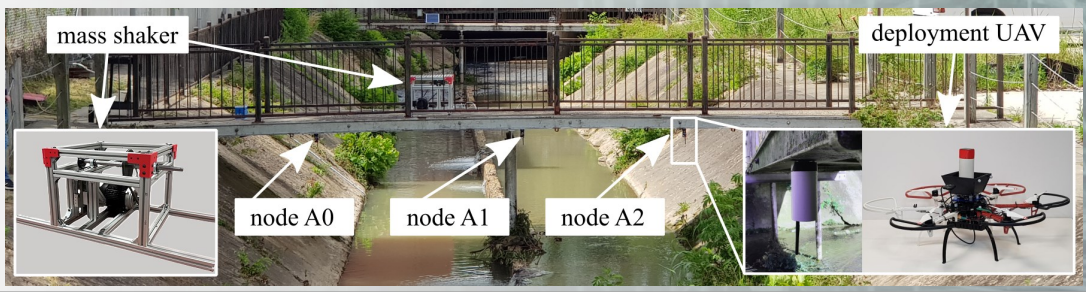
Methodology

- Rapid structural health monitoring
- Remote SHM sensing systems
- Transmission bandwidth and power limitations





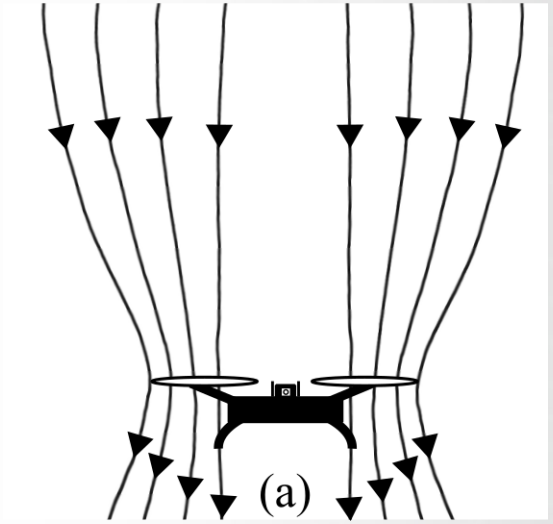




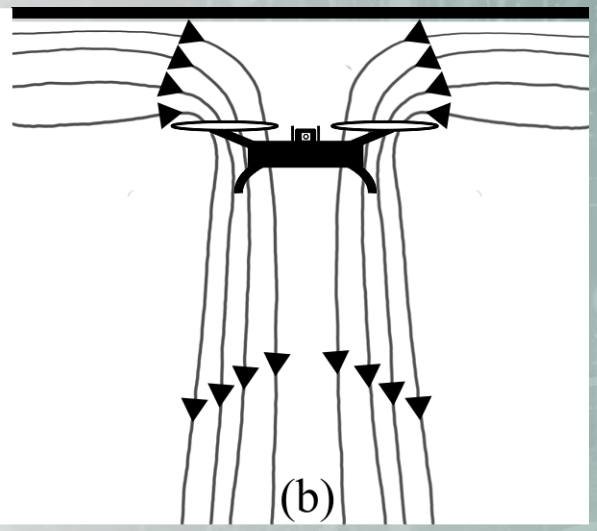
Methodology

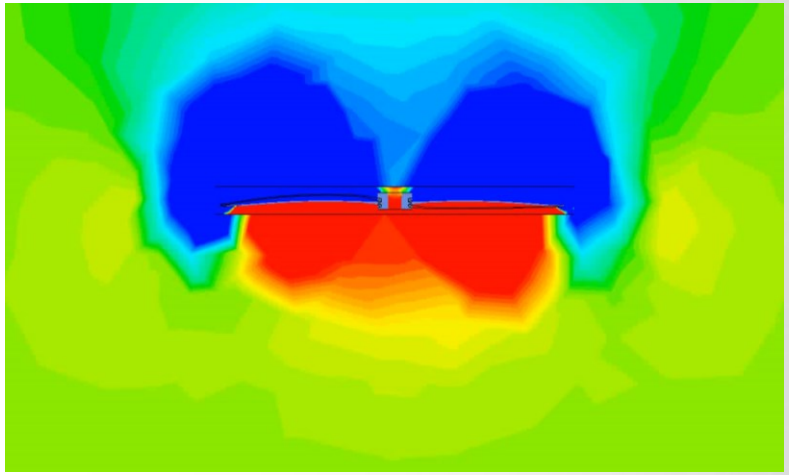
- Ceiling effect
  - Occurs when a rotating propeller is near a barrier such as a ceiling
  - Felt as turbulence or lack of control
  - Creates sudden increase in causing instability

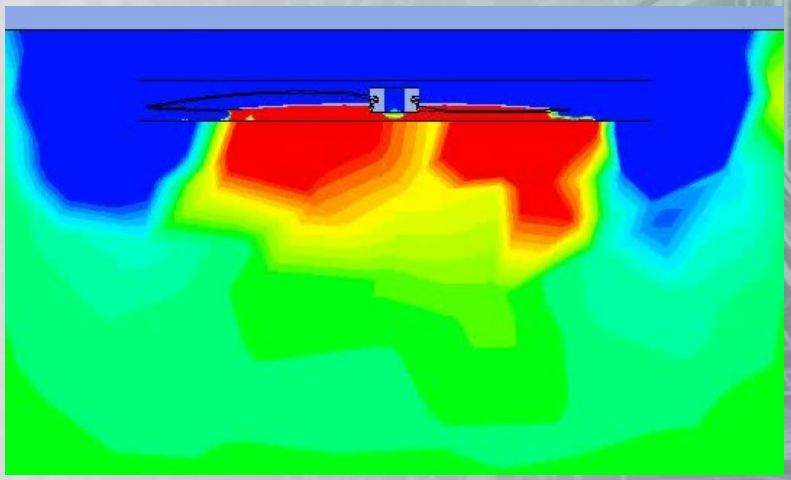
propeller in open air



propeller under ceiling effect





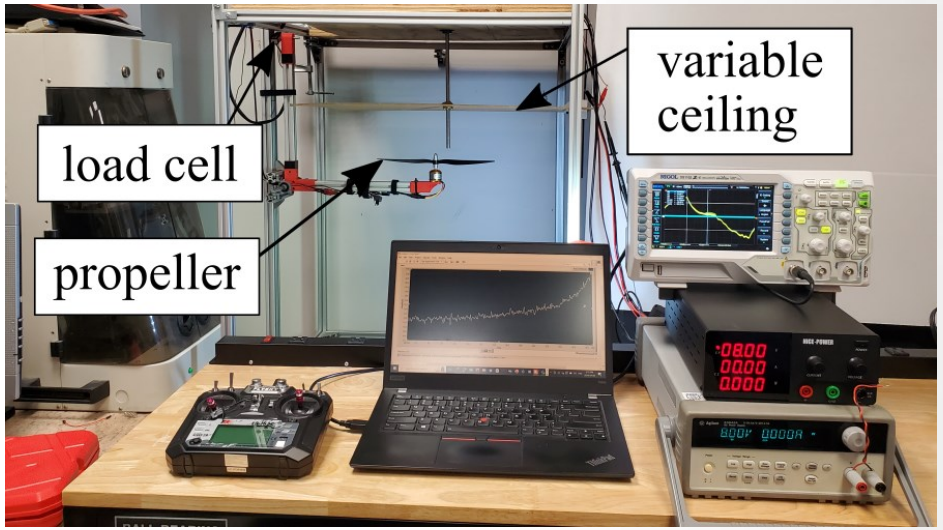


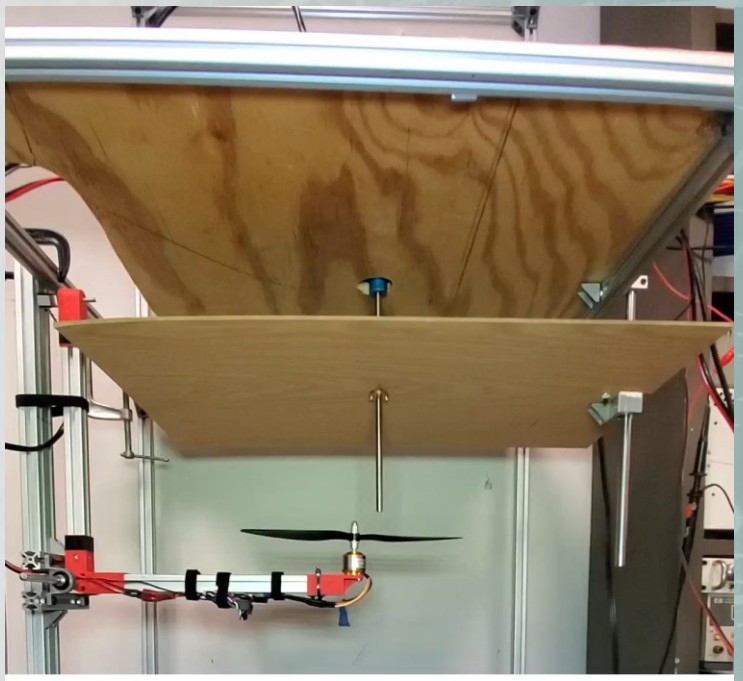
Methodology

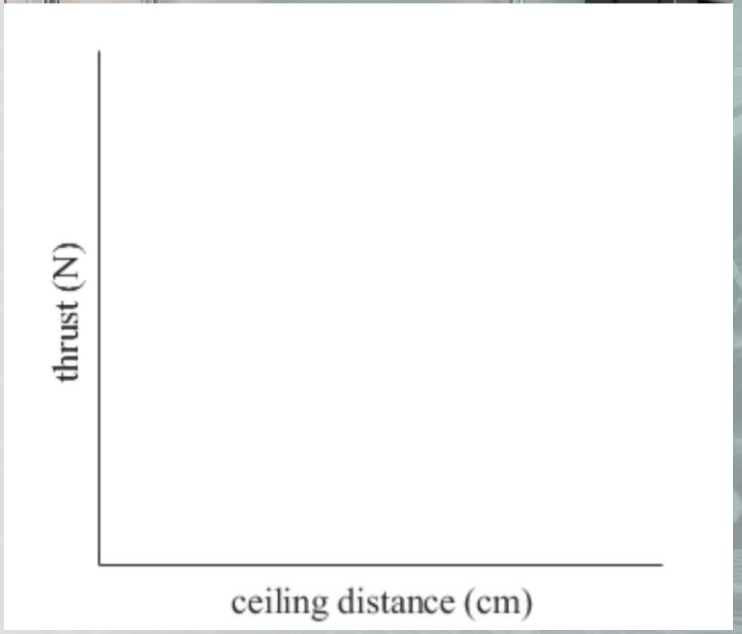
- Ceiling effect
  - Occurs when a rotating propeller is near a barrier such as a ceiling
  - Felt as turbulence or lack of control
  - Creates sudden increase in causing instability

Experimentation

- Thrust force vs. ceiling distance experiment
  - Variable ceiling (2.5-25 cm)
  - Load cell to measure thrust force
  - Oscilloscope to measure RPM
  - Power meter to monitor power consumption





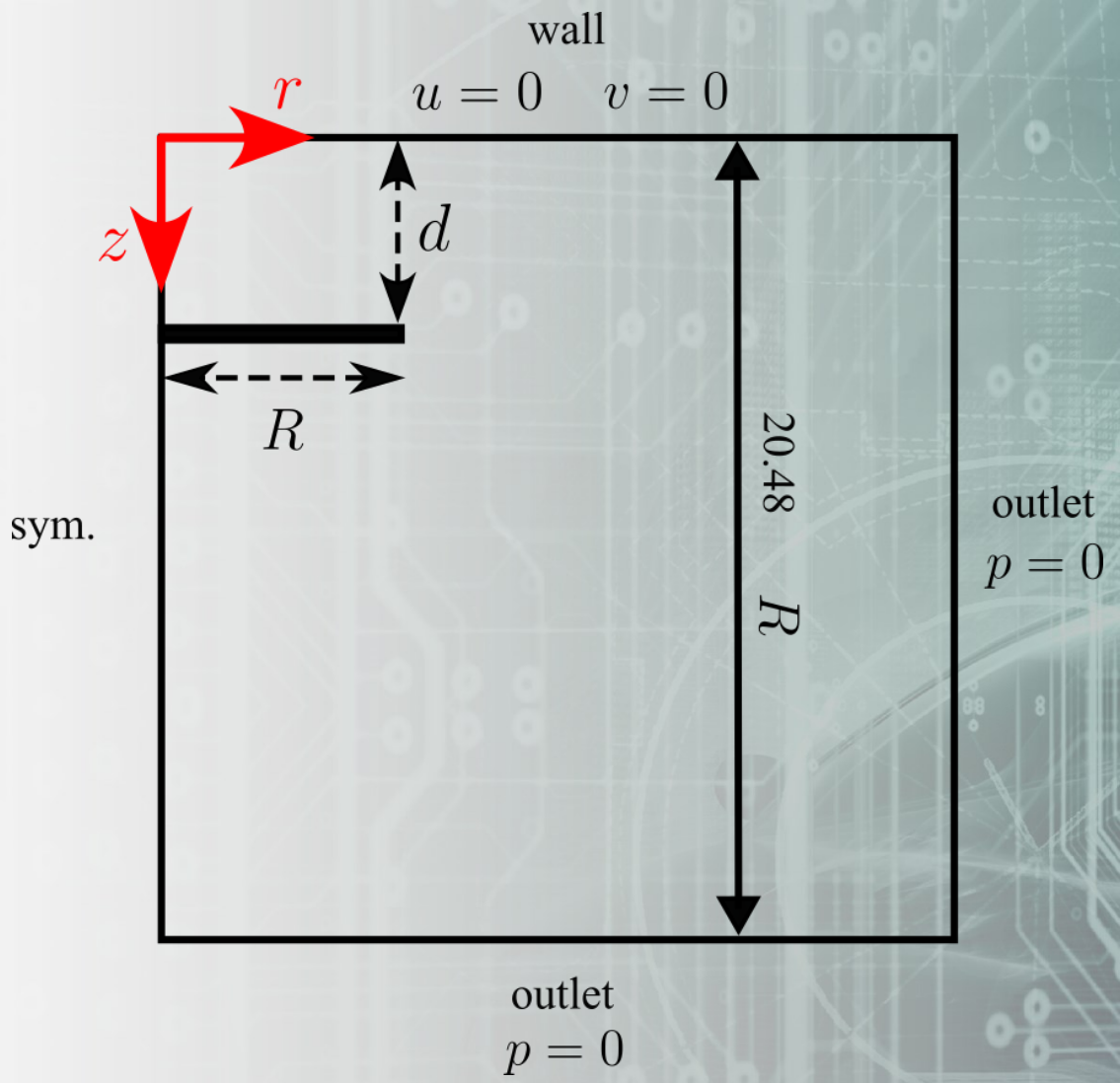


Simulation Setup

- *Basilisk* open-source CFD software
- Axisymmetric grid with adaptive mesh refinement (AMR)
- The propeller is modeled using disk actuator theory, i.e. a constant pressure jump across an infinitely thin propeller:

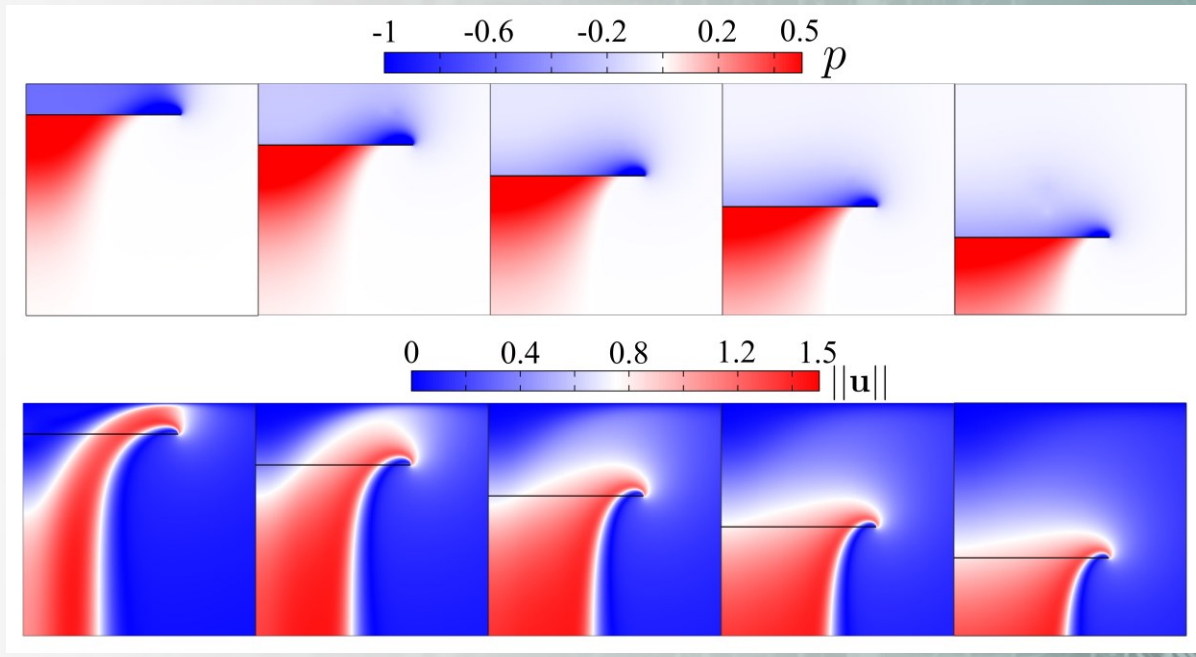
$$\Delta p = \frac{T}{A}$$

- T: thrust
- A: disk area



Results and Discussion

- Decreasing the distance from the propeller to the ceiling creates a low-pressure region between them, explained by the Bernoulli effect
- This low-pressure region is responsible for the increase in thrust
- However, it is significantly diminished beyond d/D = 0.3

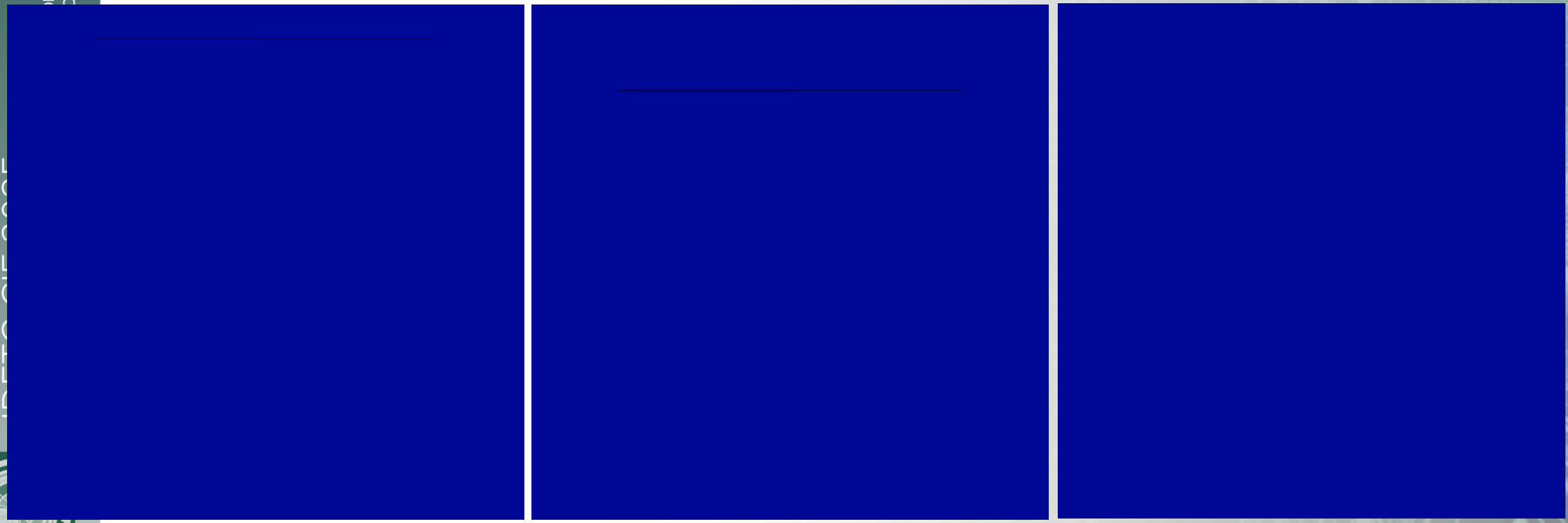


Results and Discussion

d/D = 0.1

d/D = 0.25

d/D = 0.5

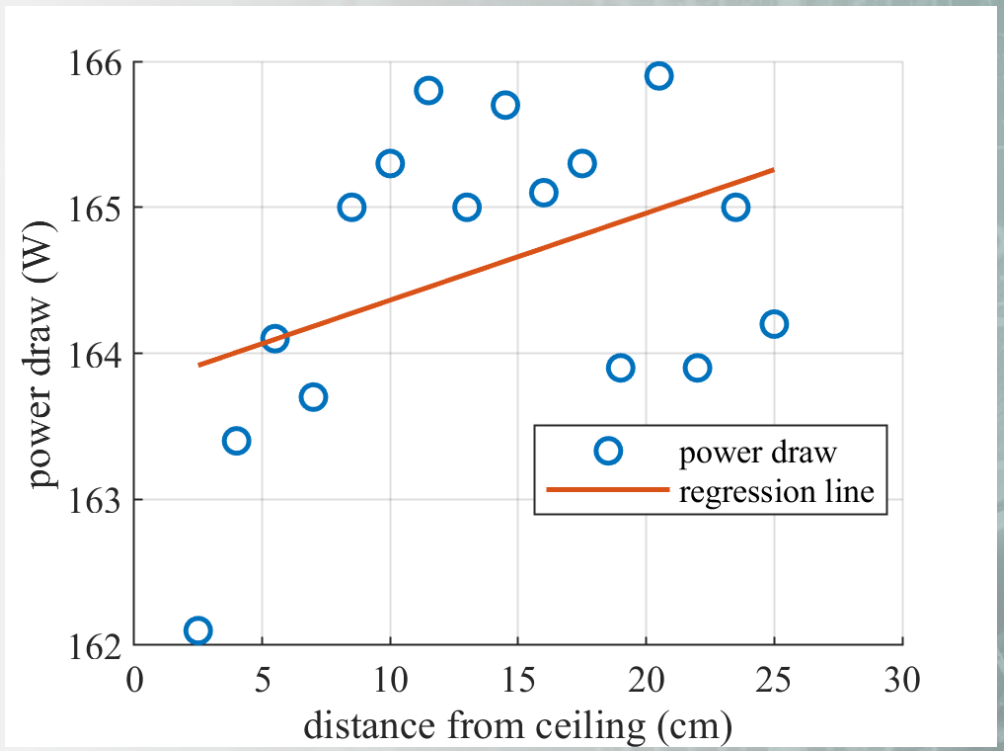


p

||**u**||

Results and Discussion

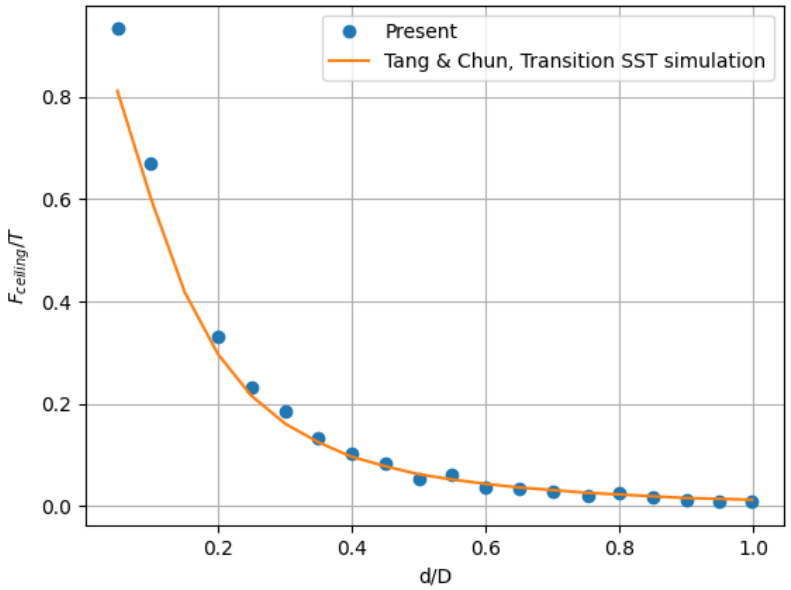
- Power and RPM:
  - RPM is shown to be constant at 50% throttle control input
  - Power consumption trend and analysis

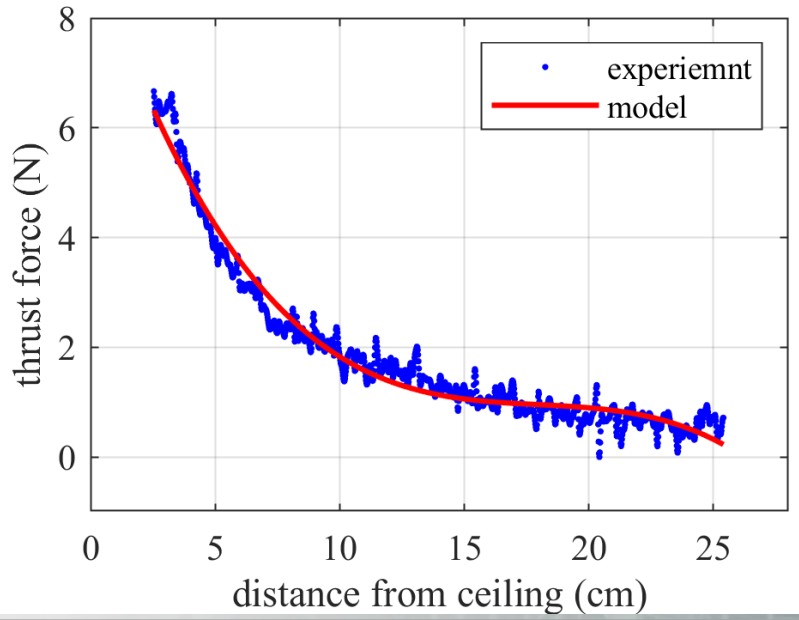


Results and Discussion

- Thrust vs ceiling distance:
  - Distance-to-thrust relationship
  - Curve is manipulated for distance with respect to the propeller

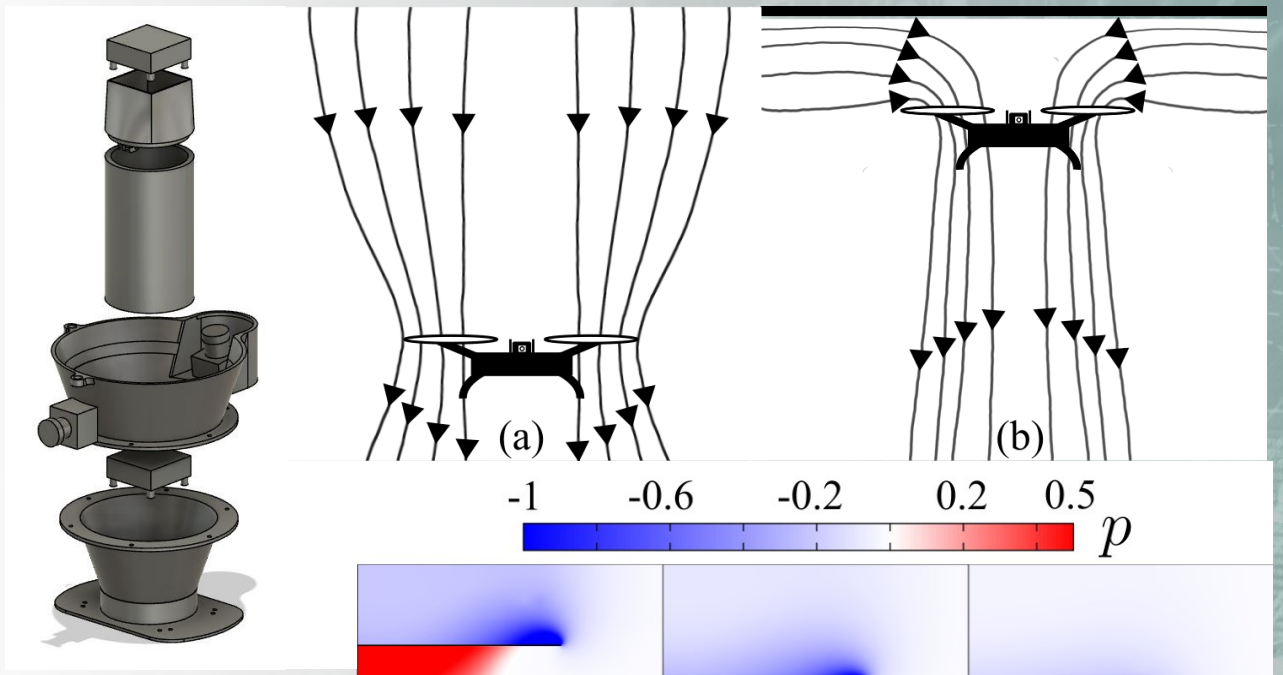
$$F_{\text{ceiling}} = 2\pi \int_0^R prdr$$

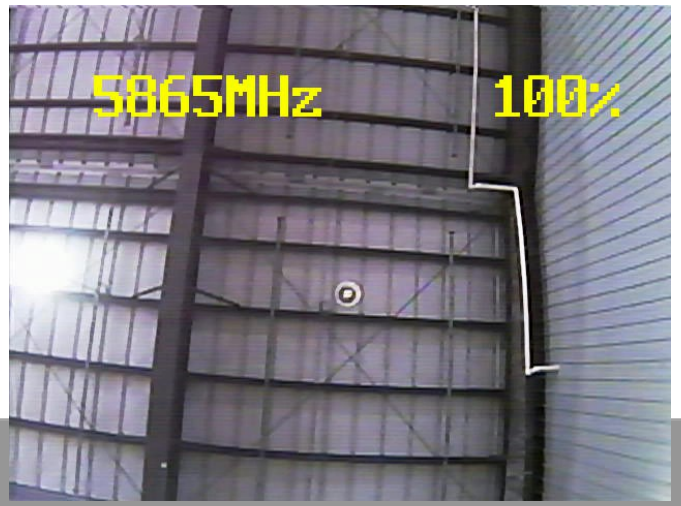




Future Work

- Implementing a range-finding system to map the distance from the ceiling
- Deploy the ceiling effect model onto a flight controller





Acknowledgement

This work is supported by the National Science Foundation, United States Grant numbers 2152896 and 2344357. The support of the National Science Foundation is gratefully acknowledged. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Thanks!

Sensor Package Repo

Sensor Deployment Repo

Ryan Yount
Research Assistant
rjyount@email.sc.edu
LinkedIn