

## ***VLRCOE Facilities***

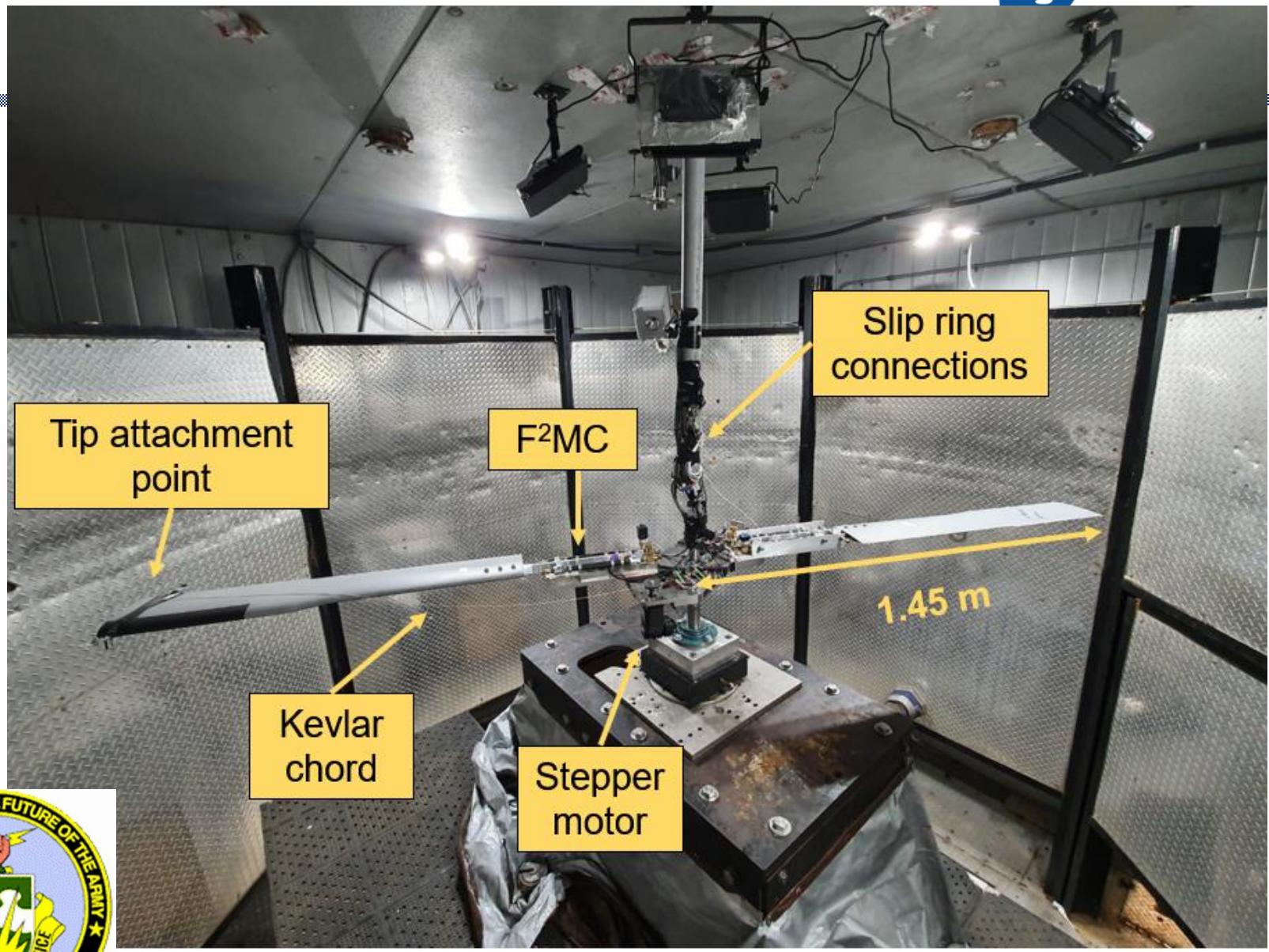
***INSPIRE***

***CHALLENGE***

***EDUCATE***

***students and sponsors***

# Rotating lag damping test – AERTS chamber



Tip attachment point

F<sup>2</sup>MC

Slip ring connections

Kevlar chord

Stepper motor

1.45 m





**VP of Black Hawk,  
Sikorsky Aircraft**

**President,  
Piasecki  
Aircraft**

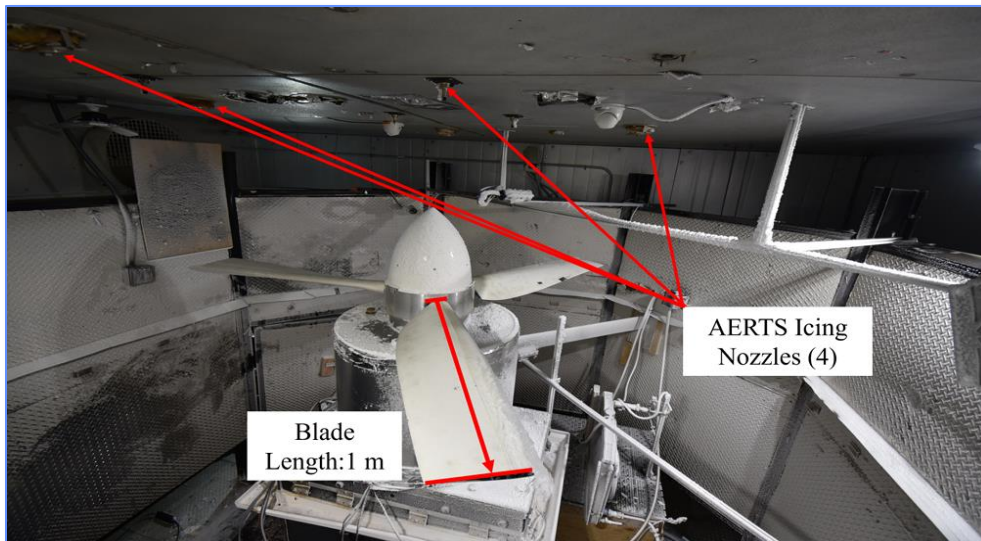
**Graduate student,  
PSU VLRCOE  
(now at US Army)**

**Director of  
R&D,  
Boeing**

**Principal Director  
to the Deputy  
Assistant  
Secretary of  
Defense for South  
and South East  
Asia  
BG, USMC**

**Director,  
PSU VLRCOE**

# *AERTS Rotor Test Facility*



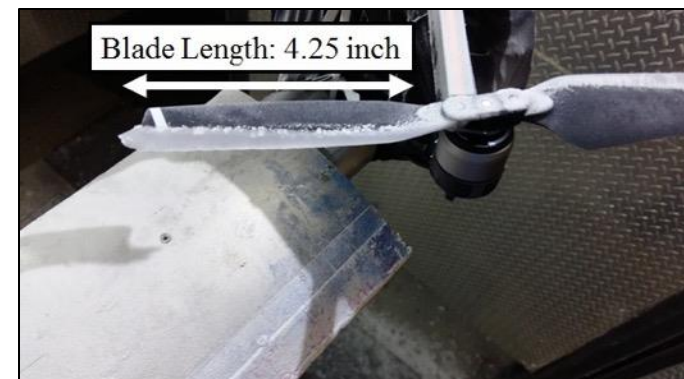
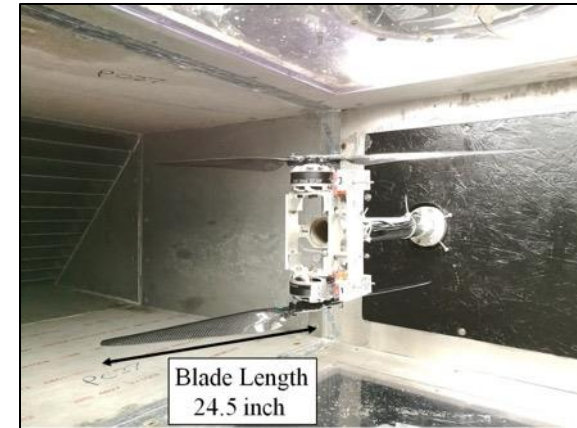
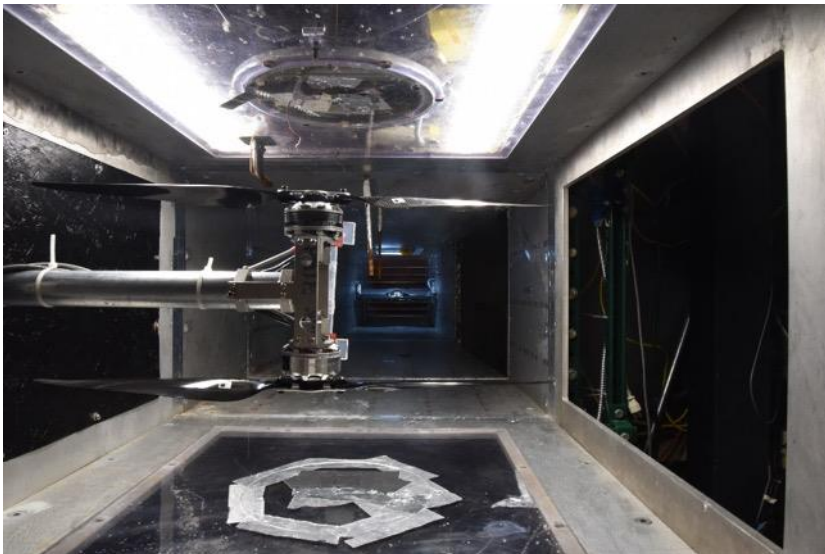
*eVTOL rotor icing*



*Ice protective coating  
evaluations*

# UAV Icing Testing

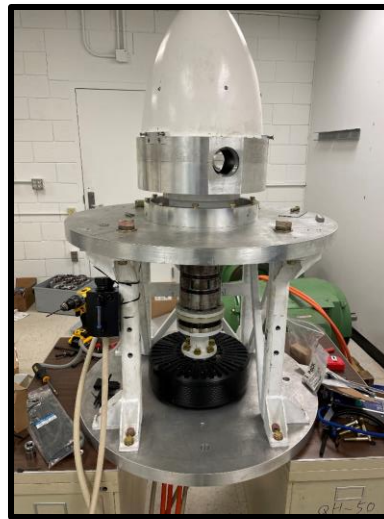
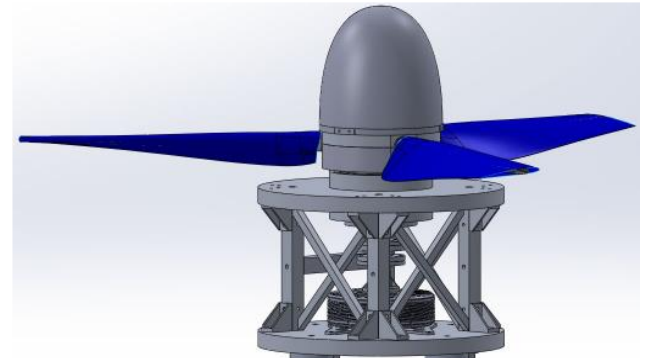
## Icing and wind tunnel testing



# VLRCOE 2021-2026

## Key Facilities

**Outdoor Out-of-Ground Effect Hover Stand:** A new facility is currently under construction and it will be available by August 2021. The outdoor hover stand spins a three bladed 7 ft. diameter rotor such that the downwash is pointed upwards, reducing ground effects. The rotor is powered by a 120 HP brushless motor. Thrust and torque sensors will quantify rotor performance. All components of the facility have been purchased and a custom hub is to be fabricated by May 2021. The rotor blades to be spun were donated to the Center by Joby Aerospace.



# Outdoor Tiltrotor Download Test Stand

*Designed and University Park Airport site plan in 2019 (\$600K)*

*Model 247 UAV Concept (USMC)*



**1/4 scale**

**2 x 300 HP electric motors**

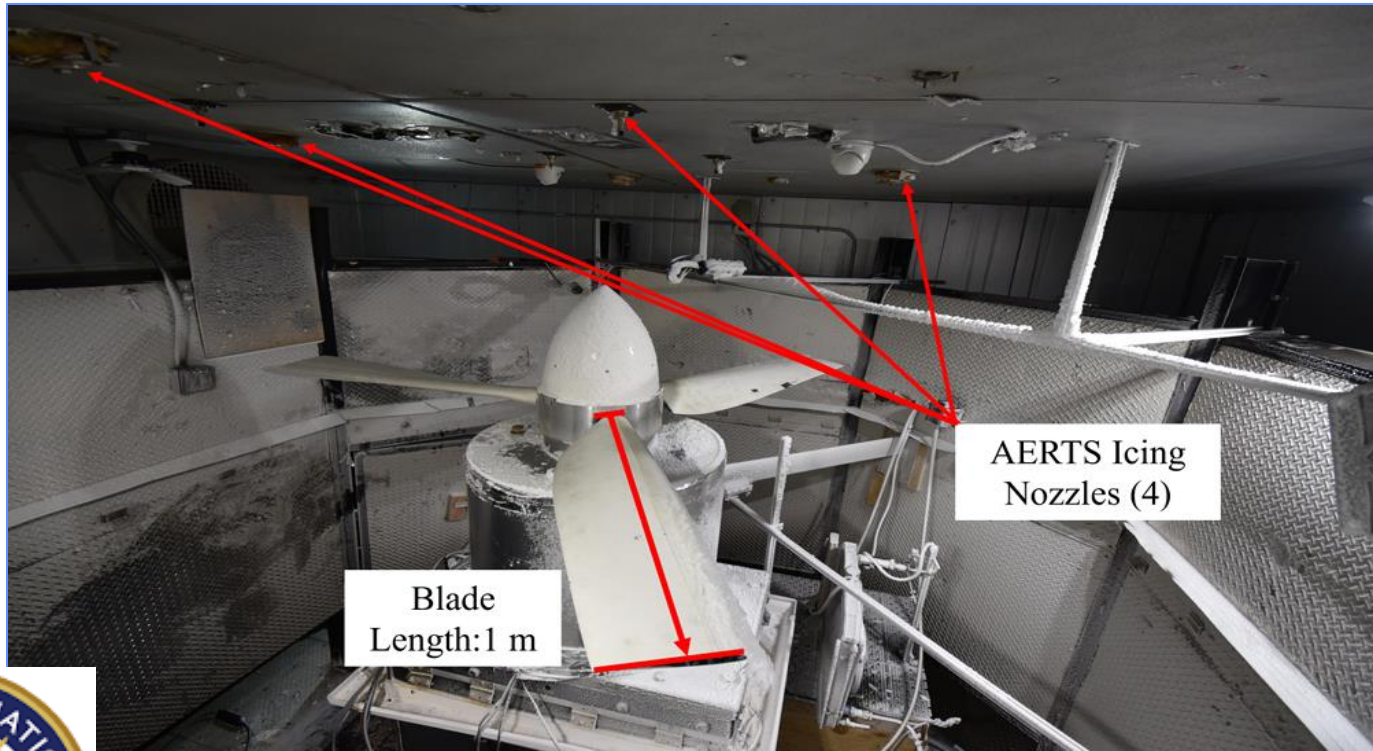
**Instrumented rotor and wing**



***Anticipated Bell/Army/PSU Development  
and testing in 2024-2026***

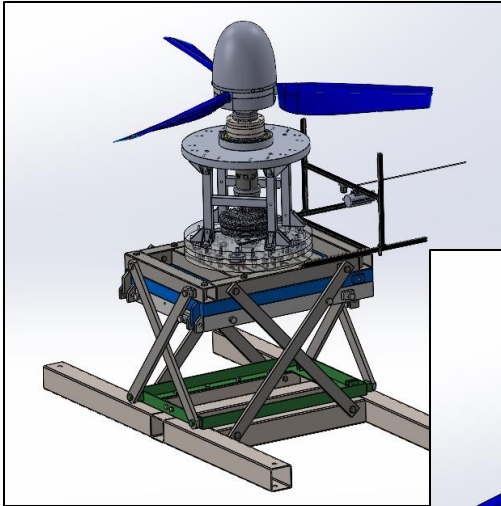
# Full Scale Hover Stand in AERTS

## Preliminary Icing Testing

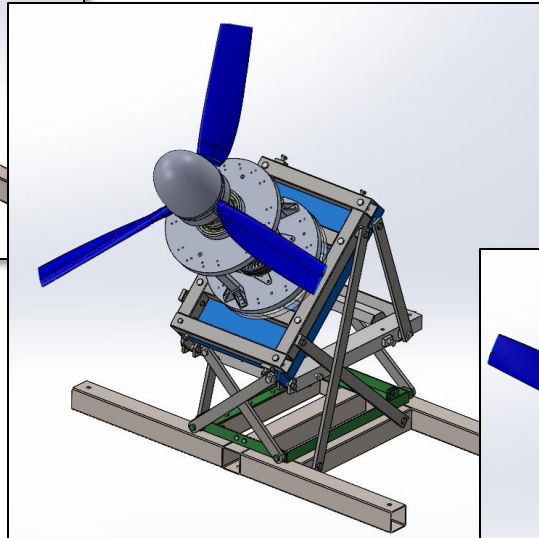




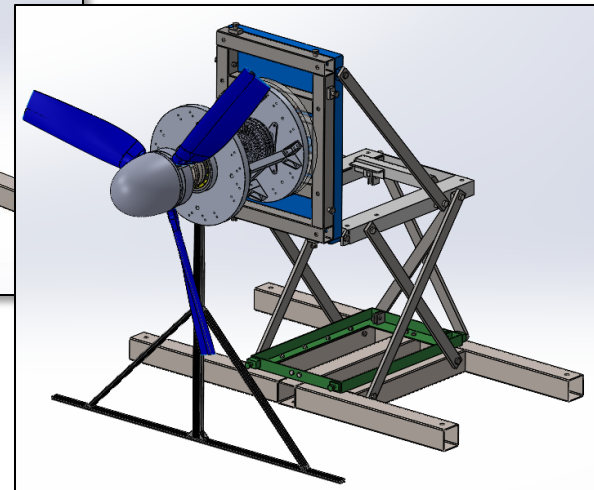
# Hover



# Transition



# Cruise



# Proprotor Icing test in Austria (May 2023)



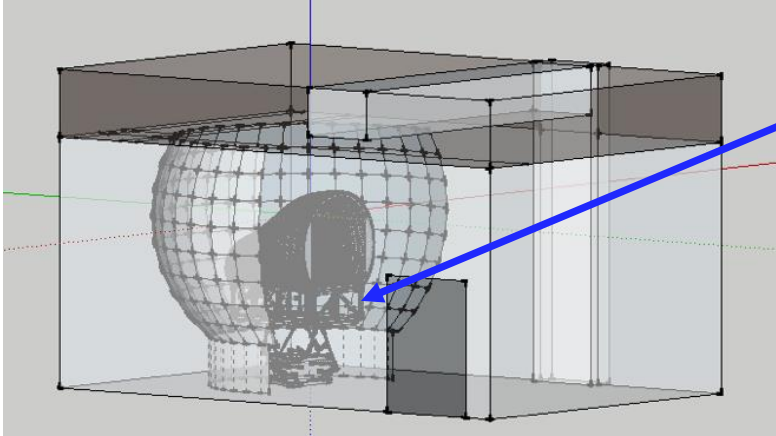


**6 DOF MOTION SYSTEM**

**DURIP**



# Flight Simulator



*+/- 30° deg roll / pitch / yaw motion  
12" translations*

*(MOTION SYSTEM FULLY  
FUNCTIONAL)*

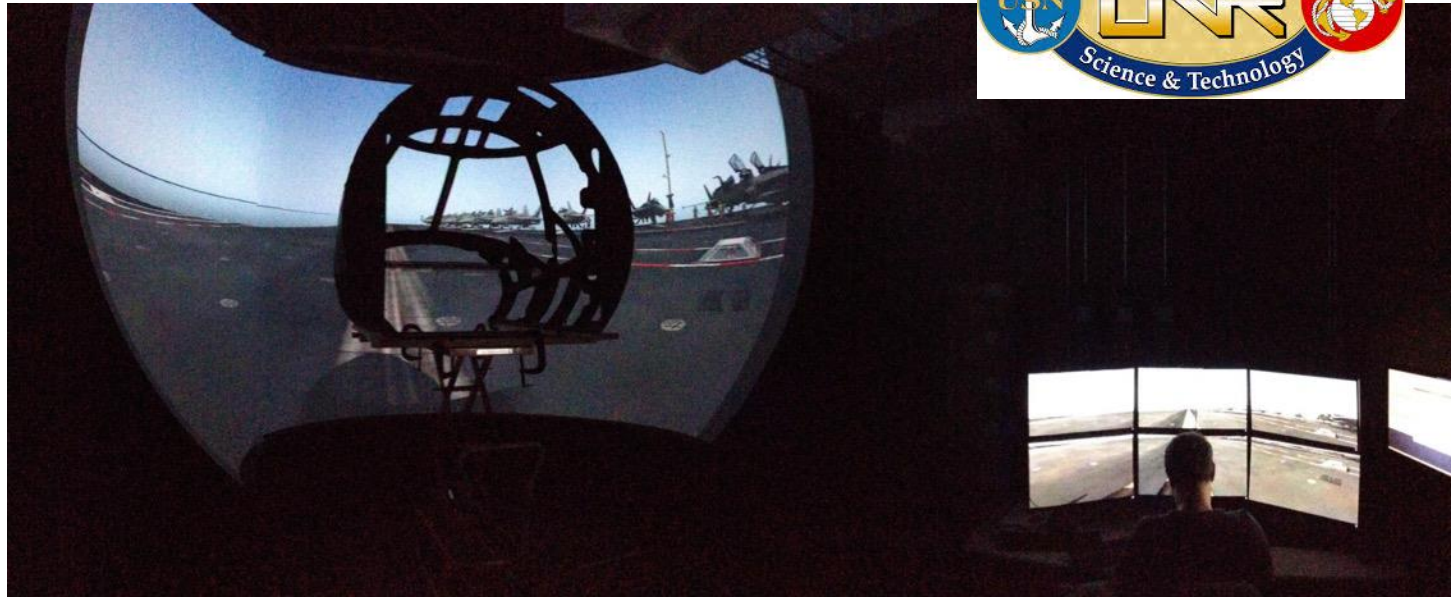
*DURIP*



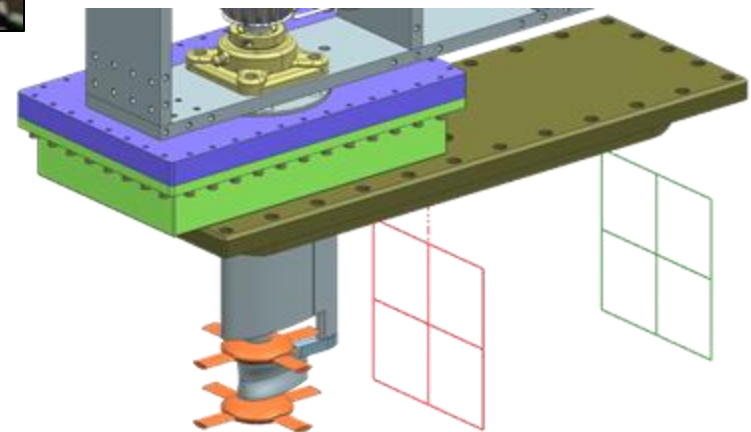
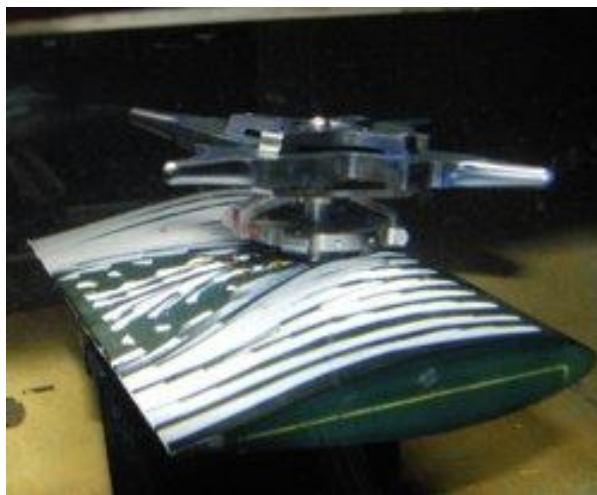
*210° horizontal  
field of view*

*and*

*50° vertical  
field of view*



# 12" – Penn State Water Tunnel



 Coaxial Hub and Root Airfoil Testing

# ***New rotor acoustics facilities*** ***(Profs Greenwood & Palacios)***

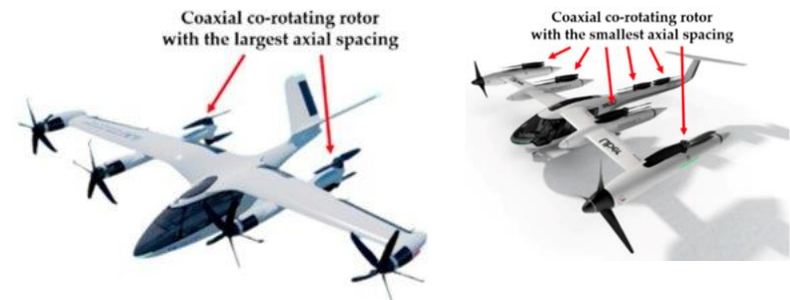


**Flow through anechoic chamber**

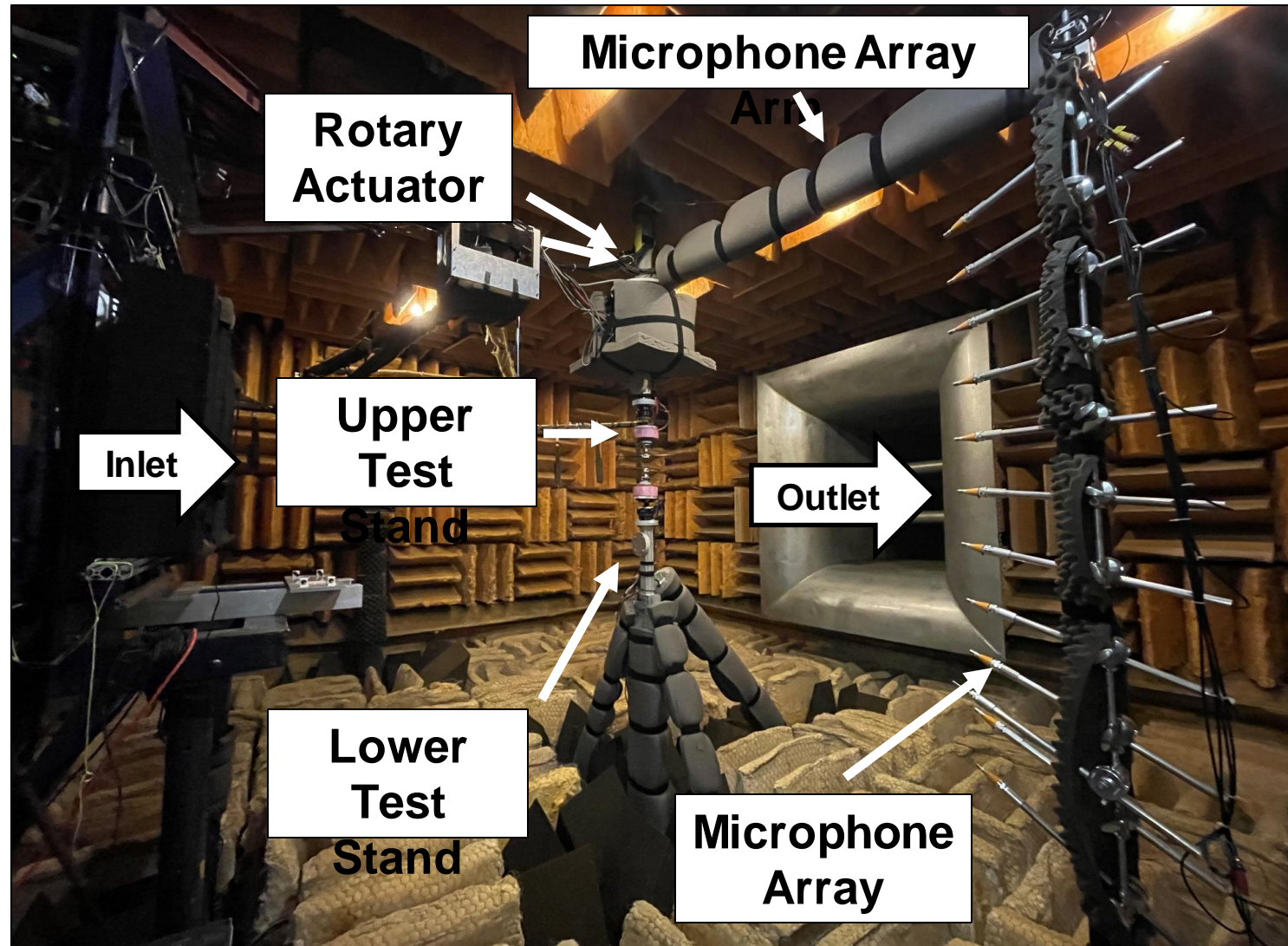
**comprehensive  
microphone array**

**Co-axial rotors**

**Leveraging “Jet-noise facility”  
developed by Prof Dennis  
McLaughlin and his students**



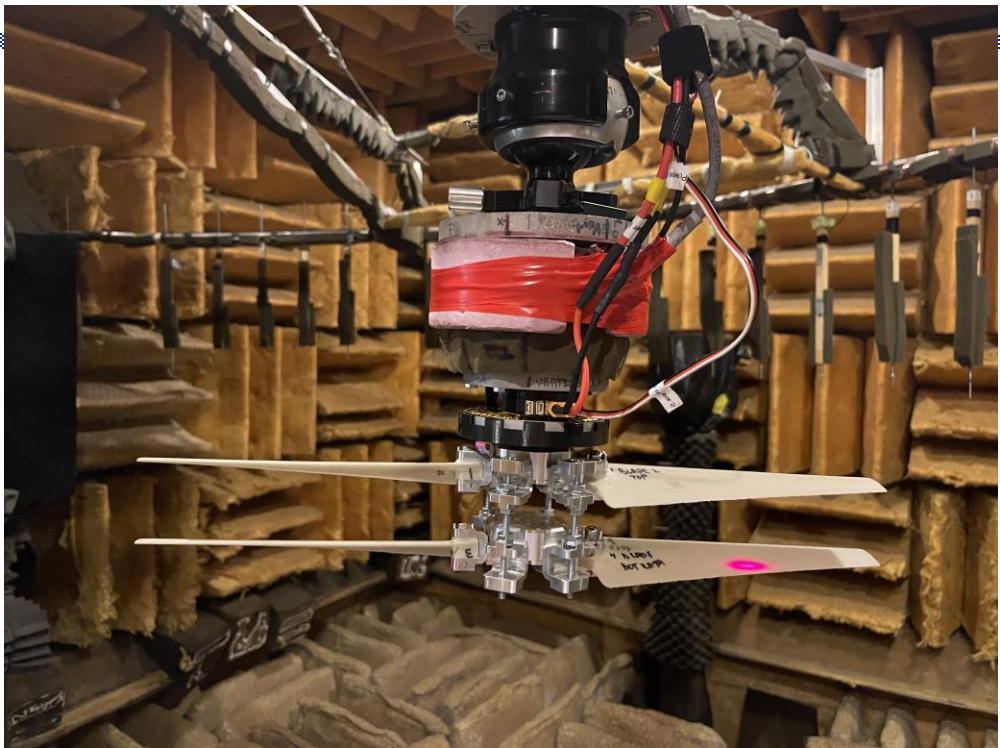
# Acoustic Rotor Test Stand



# New Setup: Coaxial Co-Rotating on Vertiq



Separated 2+2 with electronic phase control



Physically Stacked 2+2

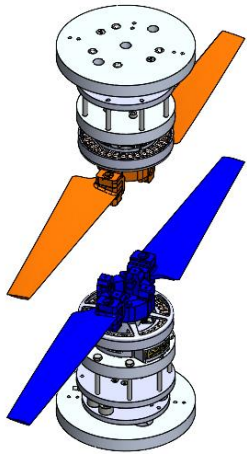
Switch to Vertiq IQ Motors



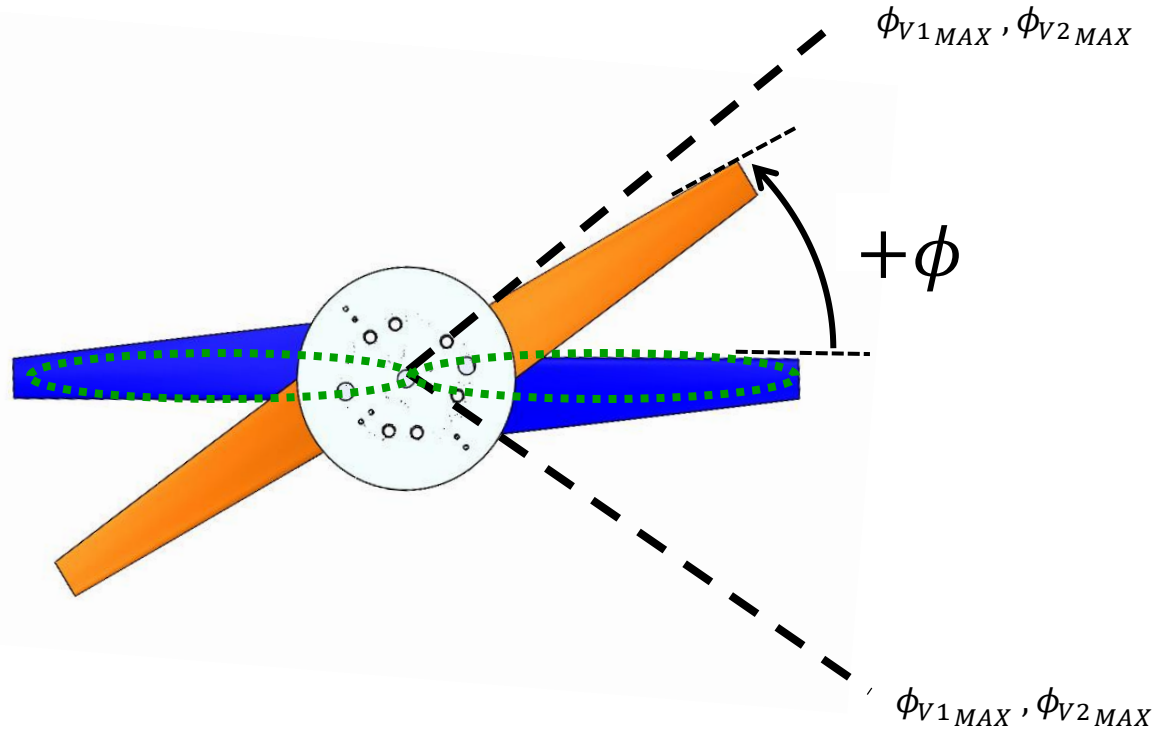
# New Setup: PSU Phase Controller

Purpose: Vary & hold azimuthal phase offset angle at any separation distance while not mechanically connected

ISO VIEW



TOP VIEW



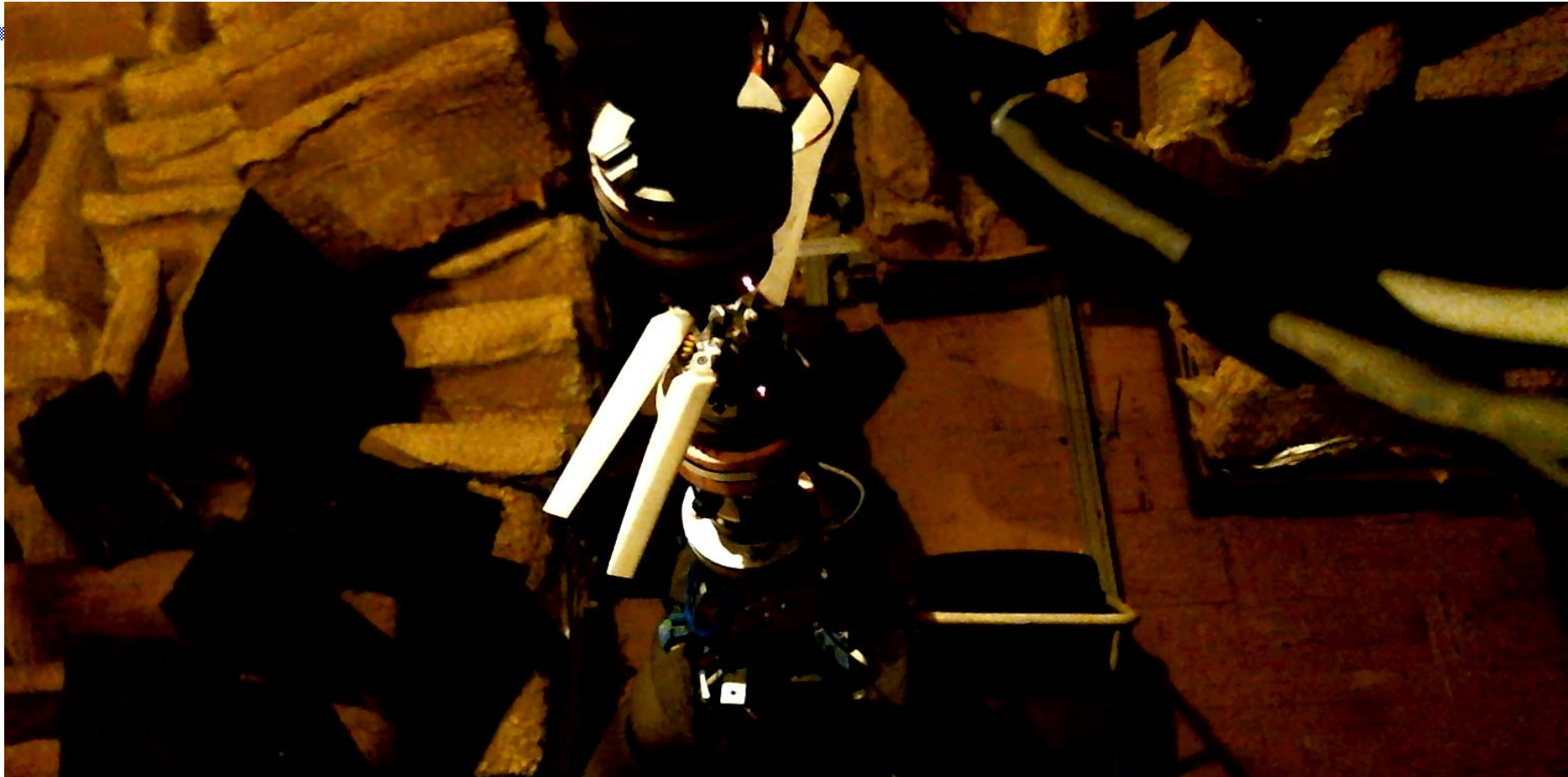
- Upper Rotor
- Lower Rotor
- Virtual Motor

Switch to Vertiq

IQ Motors

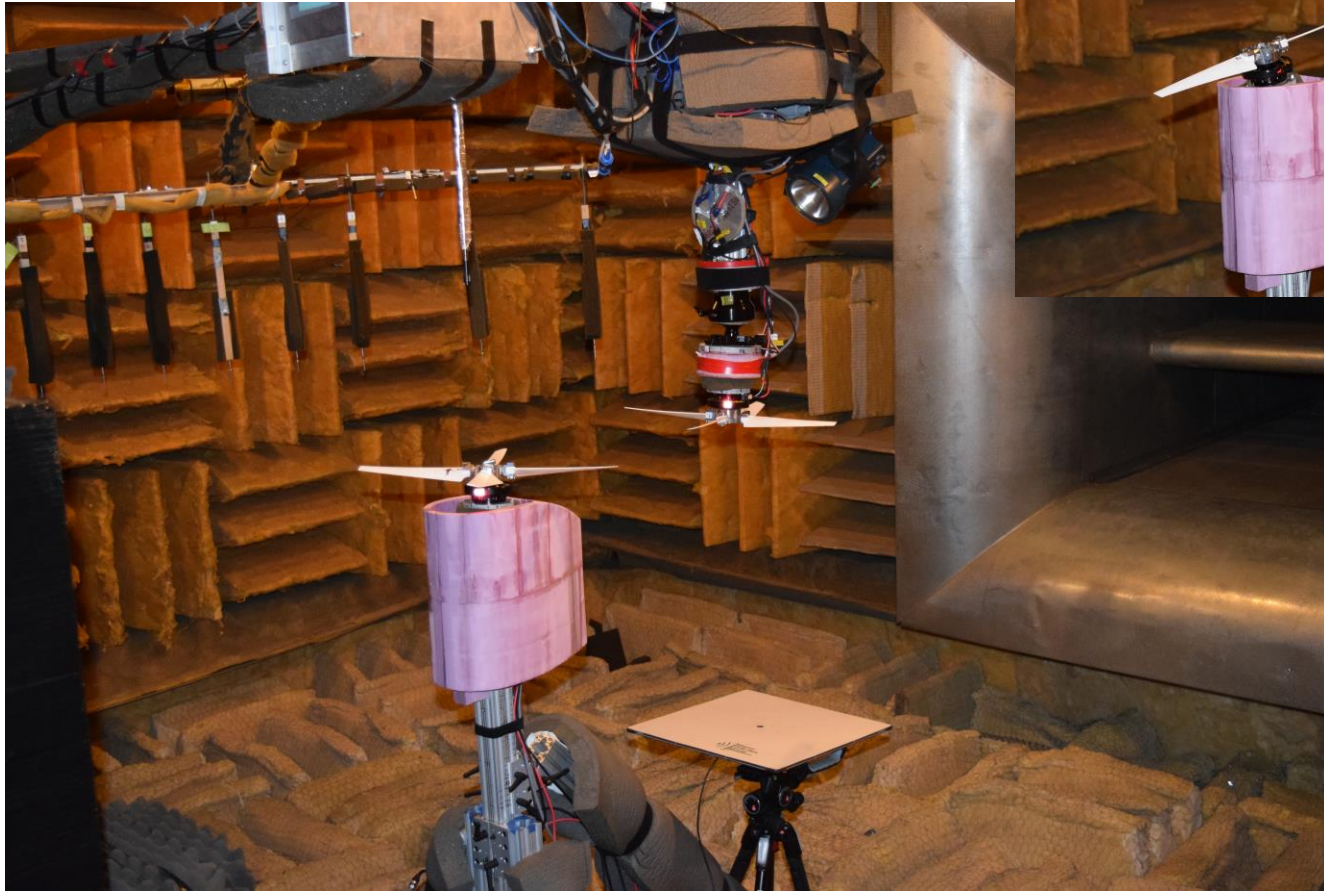
Paper 2023

# *PSU Phase Controller at 5000RPM*

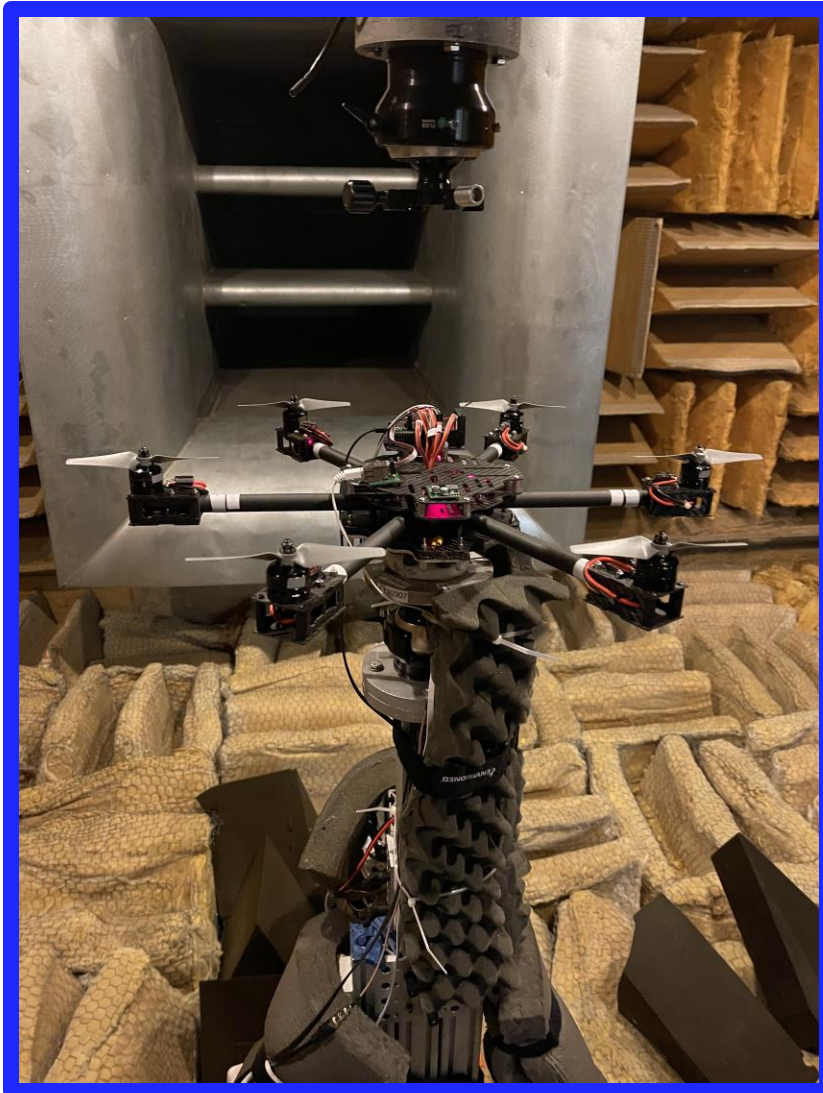


**PSU Phase Controller**

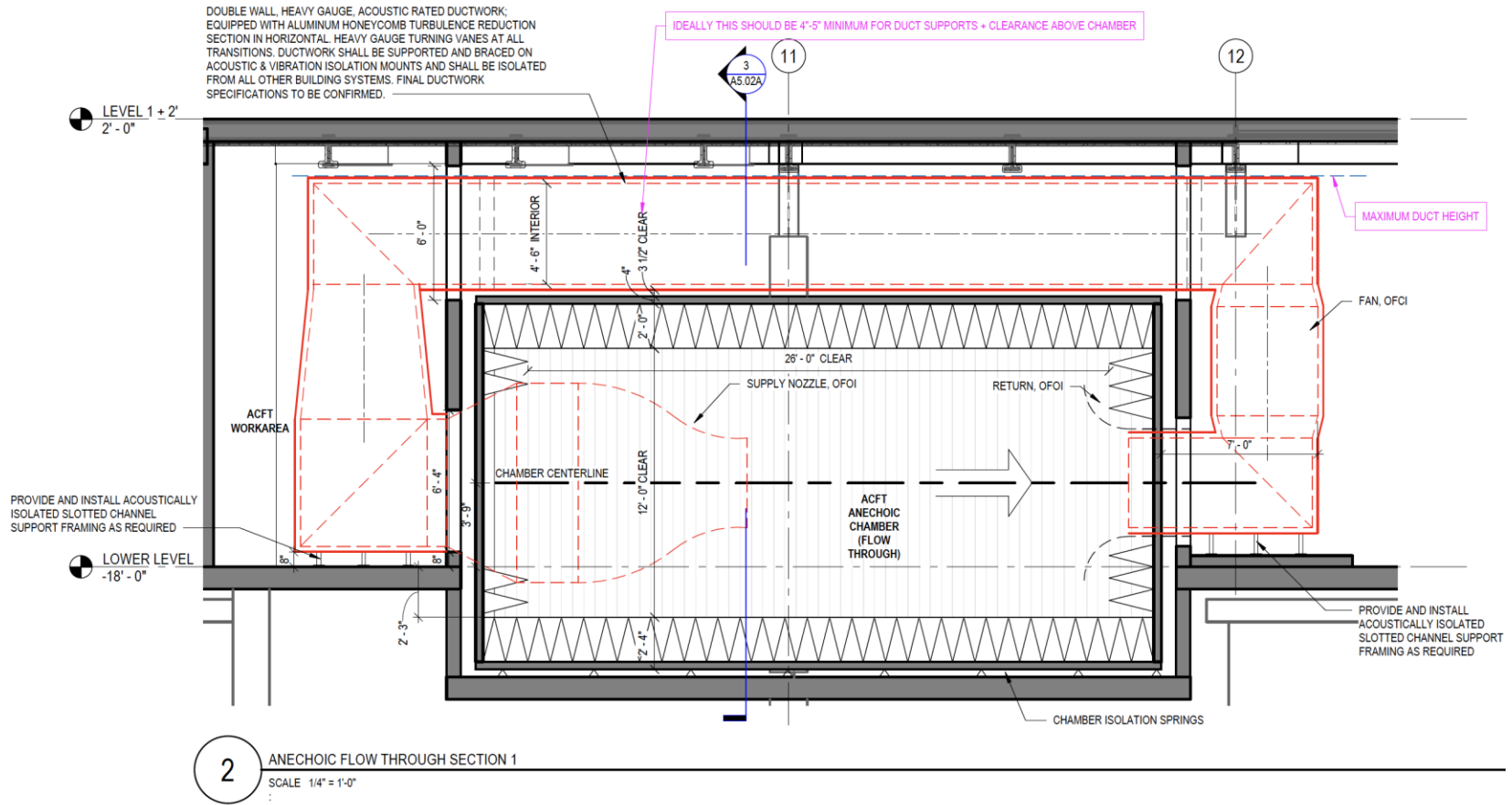
# *Tandem rotor descent*



# *Multi-rotor flow-through tests*



# New rotor acoustics facilities (Prof Eric Greenwood)



**Anechoic wind tunnel section  
nom. 4' x 4' open jet with 80 kts flow**

# Outdoor Noise Measurements (electric multicopter UAS)



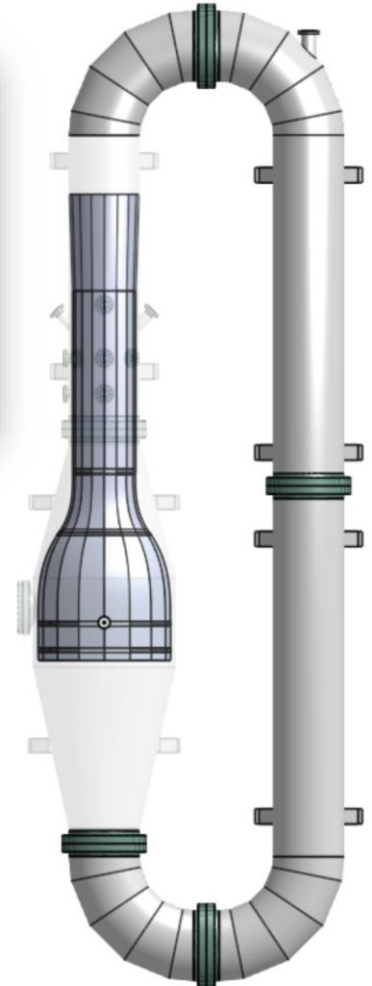
# Outdoor Noise Measurements (hydrogen multirotor UUAM)



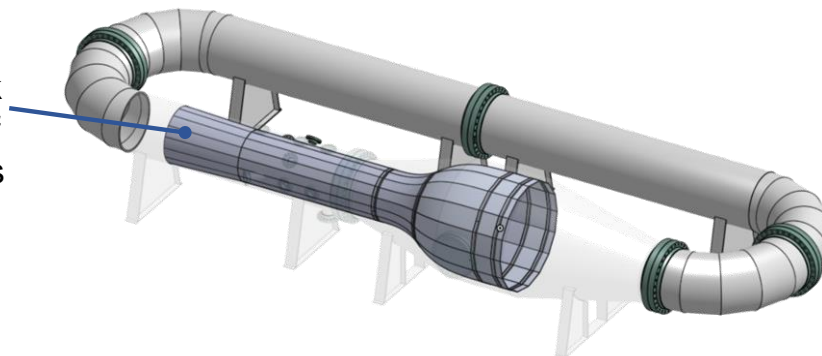
# The Compressed Air Wind Tunnel (CAWT)

Mark A. Miller (Assistant professor, Aerospace Engineering)

Maximum Static Pressure	500 psi (34 atm.)
Max Model <i>Re</i>	9 million per foot
Model diameter at 7% frontal blockage	10"
Max. Wind Speed	31 mph (14 m/s)
Test section shape	Modular, nominally circular
Test section size	42" (1.1 m) diameter, maximum
Facility Weight	100,900 lbs.



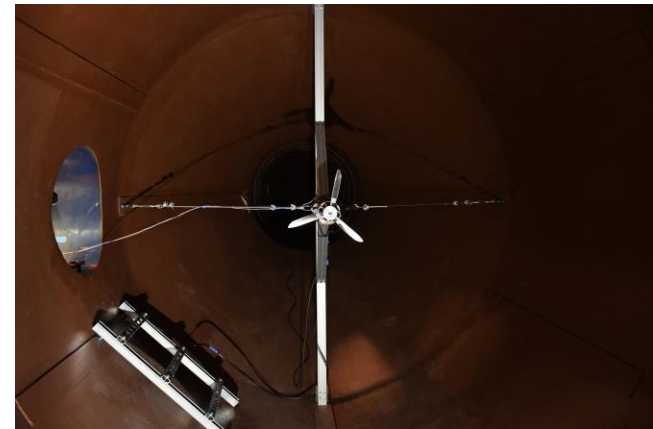
Interchangeable tunnel test section ductwork allows for a range of model sizes and velocities





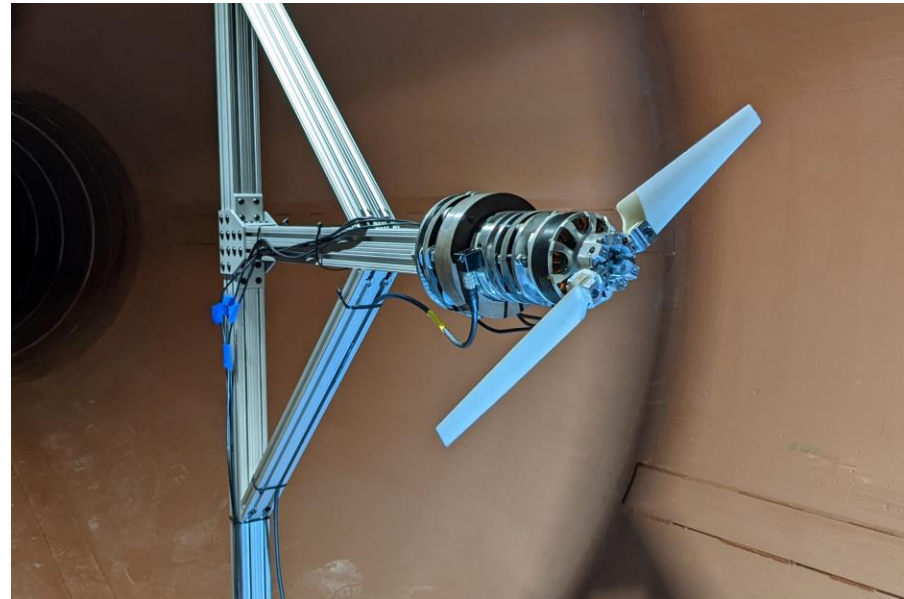
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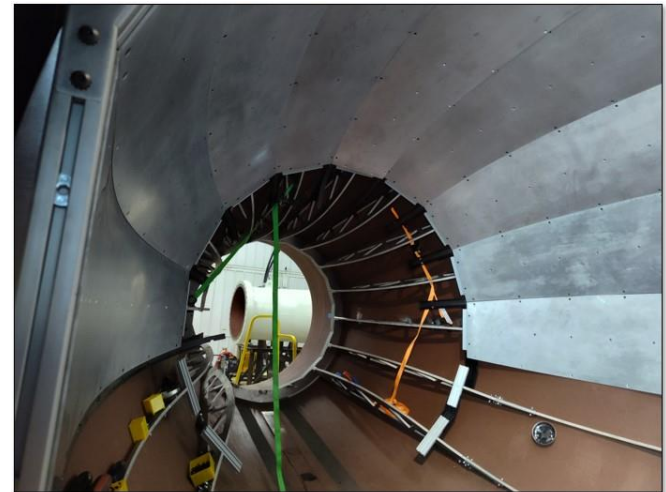
# The Compressed Air Wind Tunnel (CAWT)

Mark A. Miller (Assistant professor, Aerospace Engineering)



# The Compressed Air Wind Tunnel (CAWT)

Mark A. Miller (Assistant professor, Aerospace Engineering)





# ***VLRCOE Home 2006-2023***

## ***2nd Floor, "UNIT C"***



- 40 graduate students
- 5 undergraduate students
- 5 Research Associates
- Flight Simulation Lab
- Benchtop Labs\*
- Vertical Flight Museum

\*Additional Labs in Hammond (rotor tests, icing, vibrations), APB (wind tunnel), Research West (composites)



# VLRCOE Home July 2024 and beyond!!



**VLRCOE Students (50+)**

**Anechoic/reverb chambers and anechoic wind tunnel**

**VLRCOE Flight Sim, Motion Cap & UAS Labs**

**+ Additional large facilities throughout campus: UAV flight test, wind tunnels, composites lab, gear lab (PSU ARL)**

**VLRCOE Labs (AERTS, new larger and more capable rotor test, icing wind tunnel, Benchtop labs,)**

# ECORE Building (c. OCT 2023)

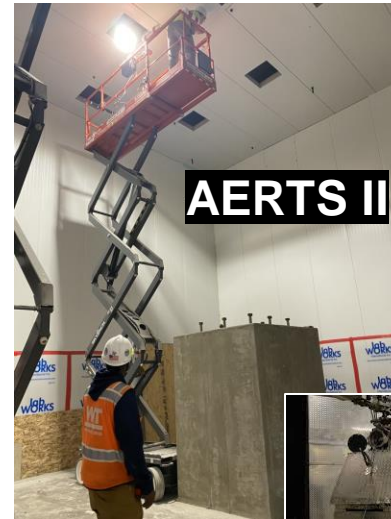


Occupancy June 2024

Shared with AERSP, CE, ACOUSTICS, ARCH ENGR



290,000 sq ft



AERTS II



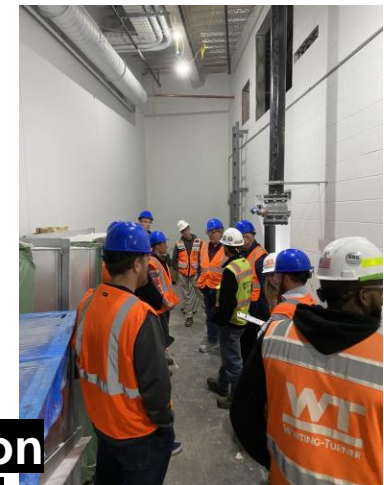
AERTS II  
- ice & rain  
- dynamics  
- aero



Faculty + Students +  
Labs + Classrooms



200+ construction  
Workers per day



PENNSSTATE



# Vertical Lift Research Center of Excellence

**Contact:**

**Prof. Ed Smith**  
**814-863-0966**  
**ecs5@psu.edu**

**Contact (Admin):**

**Prof. Ken Brentner**  
**814-865-6433**  
**ksbrentner@psu.edu**

<https://youtu.be/CeLdivT7MvU>