Aeroacoustic Wind Tunnel experiments on propeller noise at the University of Bristol

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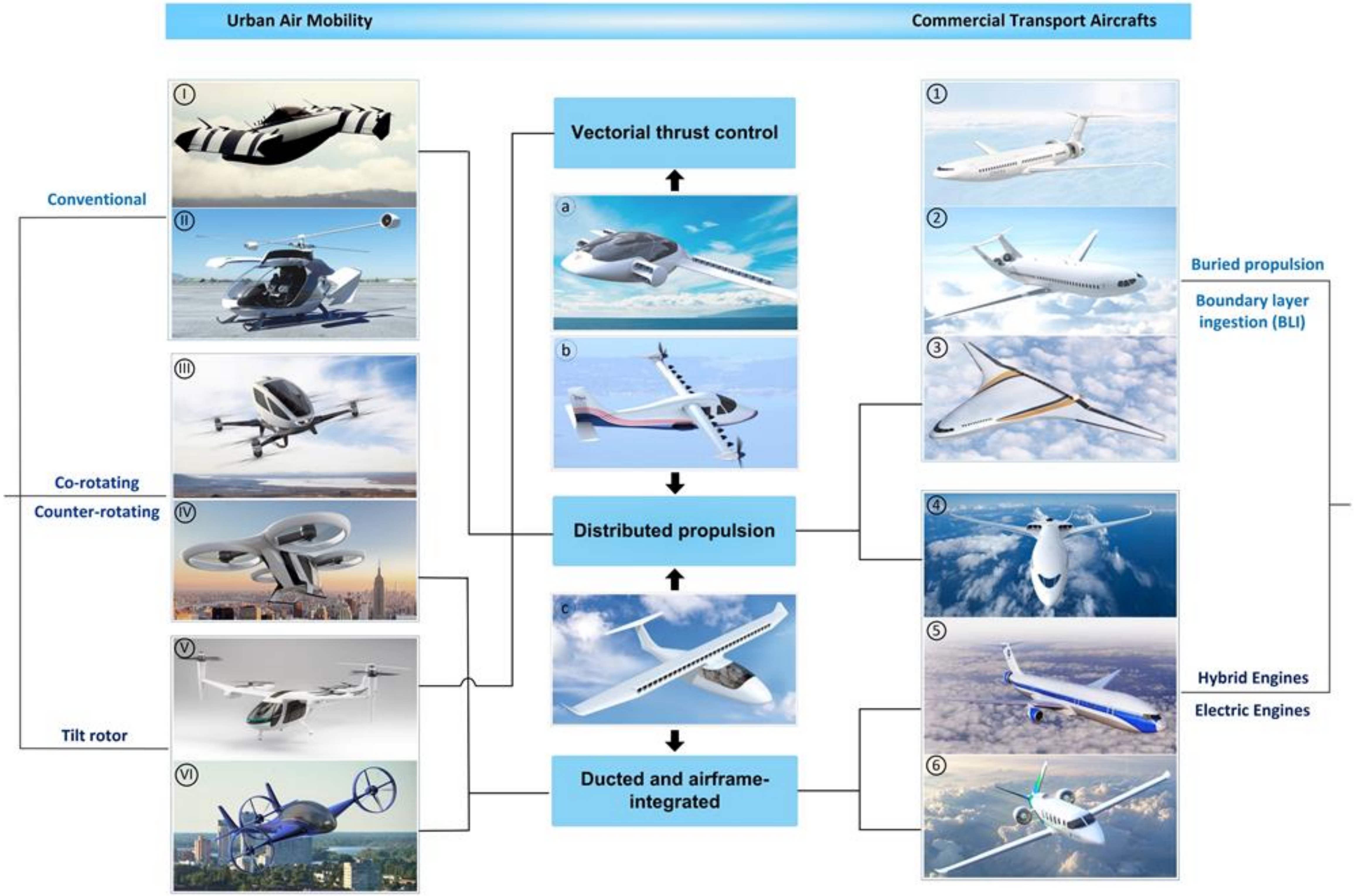
National Wind Tunnel Facility Conference (NWTF)

The Exchange, Birmingham.

Overview – Future Flight



Overview

- The National Wind Tunnel Facilities at the University of Bristol have been used to support numerous propellers aeroacoustics research projects in collaboration with many academic and industrial partners.
- Some configurations investigated are shown below:

NASA D8

1. Boundary Layer Ingestion [1]

NASA X-57 Maxwell

2. Distributed Electric Propulsion [2]

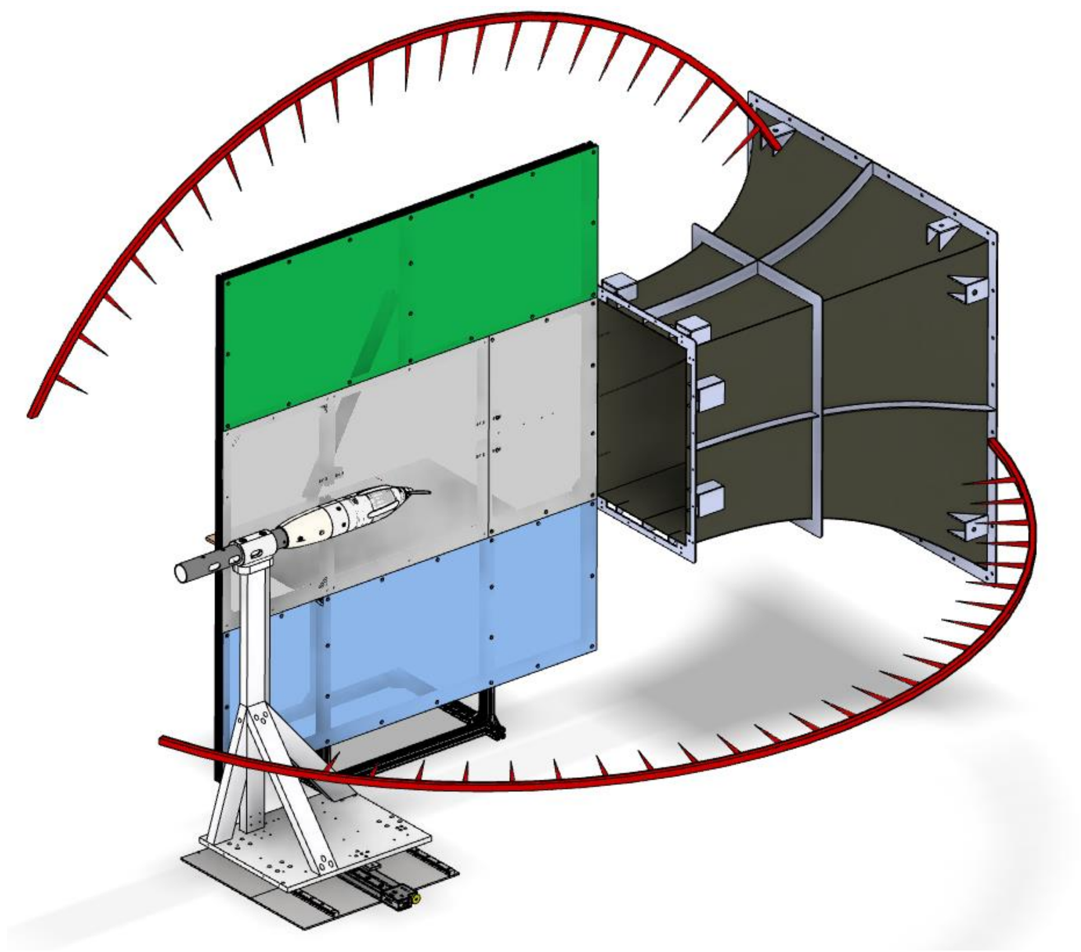
Vertical Aerospace VX4

3. Tilt-rotor eVTOLs [3]

[1] Ian Clark, Russell H. Thomas and Yueping Guo. "Far Term Noise Reduction Roadmap for the NASA D8 and Single-Aisle Tube-and-Wing Aircraft Concepts," AIAA 2019-2427. 25th AIAA/CEAS Aeroacoustics Conference. May 2019.
[2] https://sacd.larc.nasa.gov/asab/asab-projects-2/x57maxwell/
[3] https://www.businesswire.com/news/home/20240722056469/en/Vertical-Aerospace-Begins-Testing-on-New-VX4-Prototype

NWTF

Far-field



Two far-field microphone arcs populated with 46 GRAS -40PL microphones

Near-field

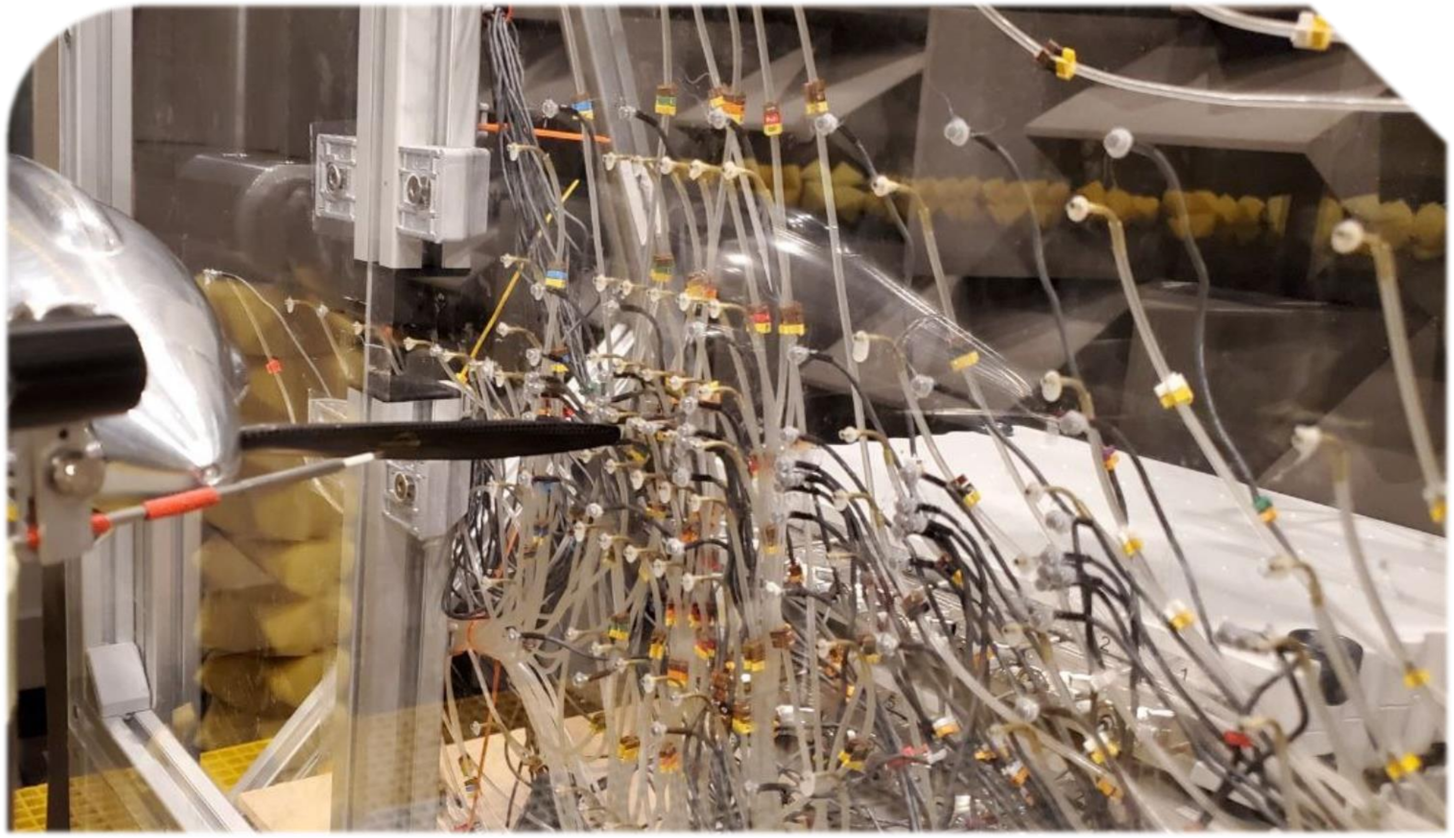


Plate heavily instrumented with 112 static pressure taps and 69 surface pressure transducers

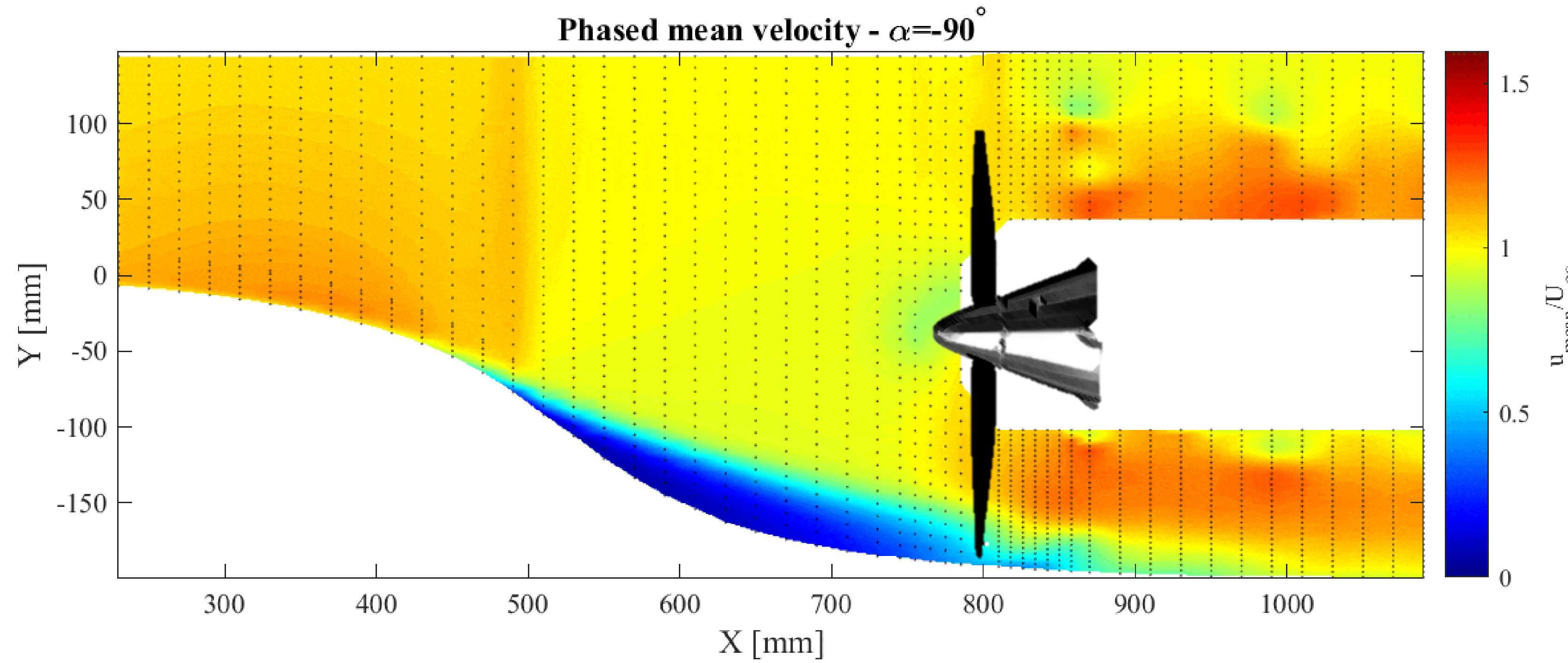
Boundary Layer Ingestion

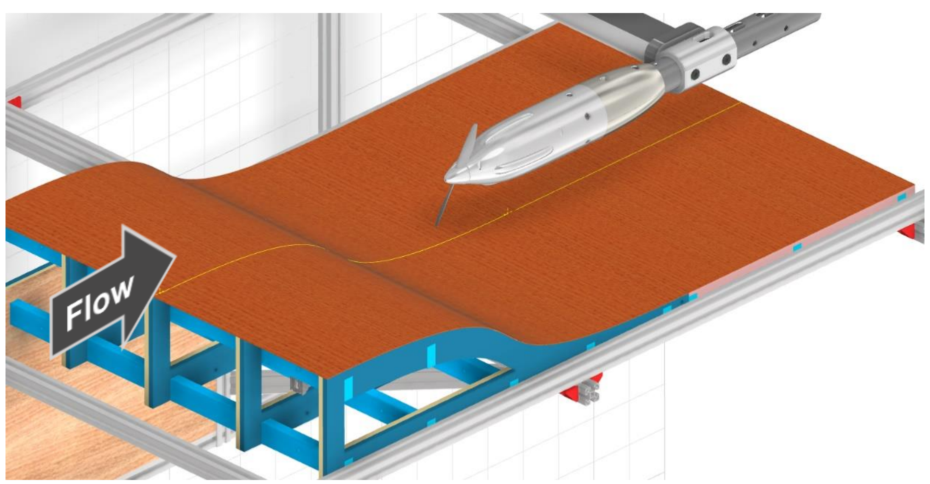
Boundary Layer Ingestion

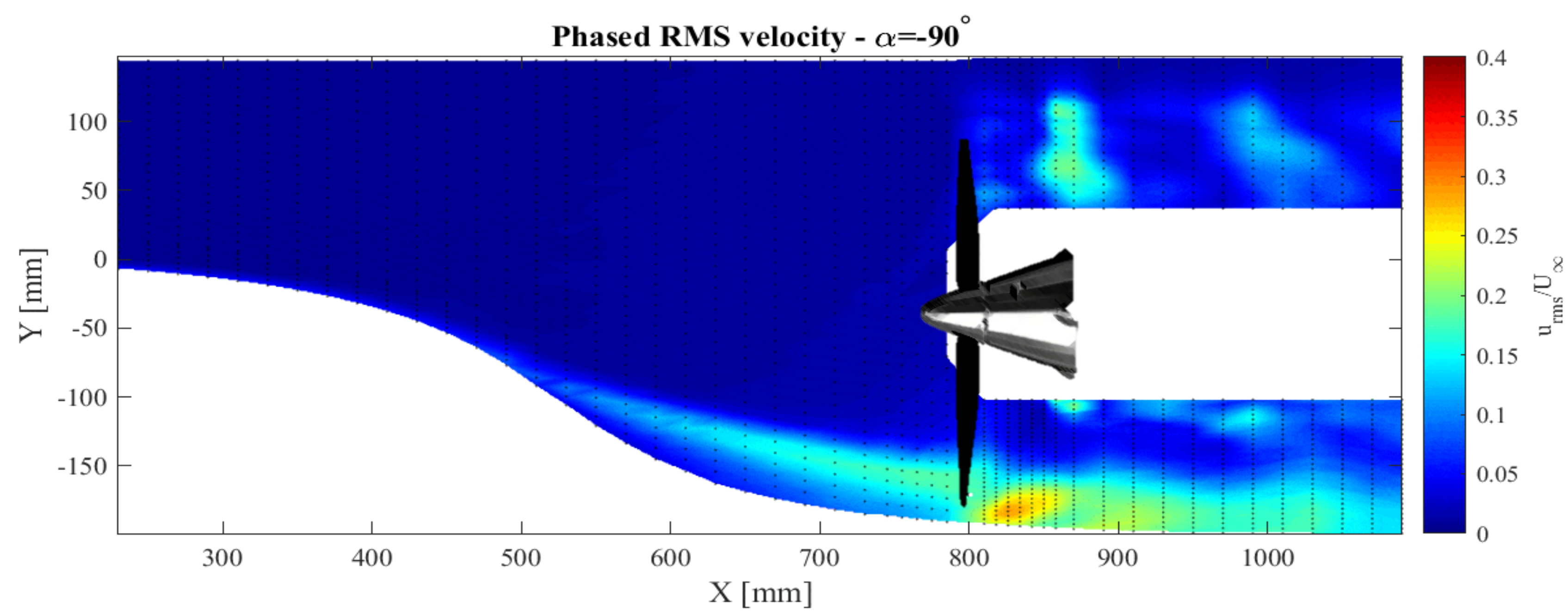
<u>Flow field Survey Phase-Averaged Results</u>

Velocity fluctuations (RMS 7500RPM)

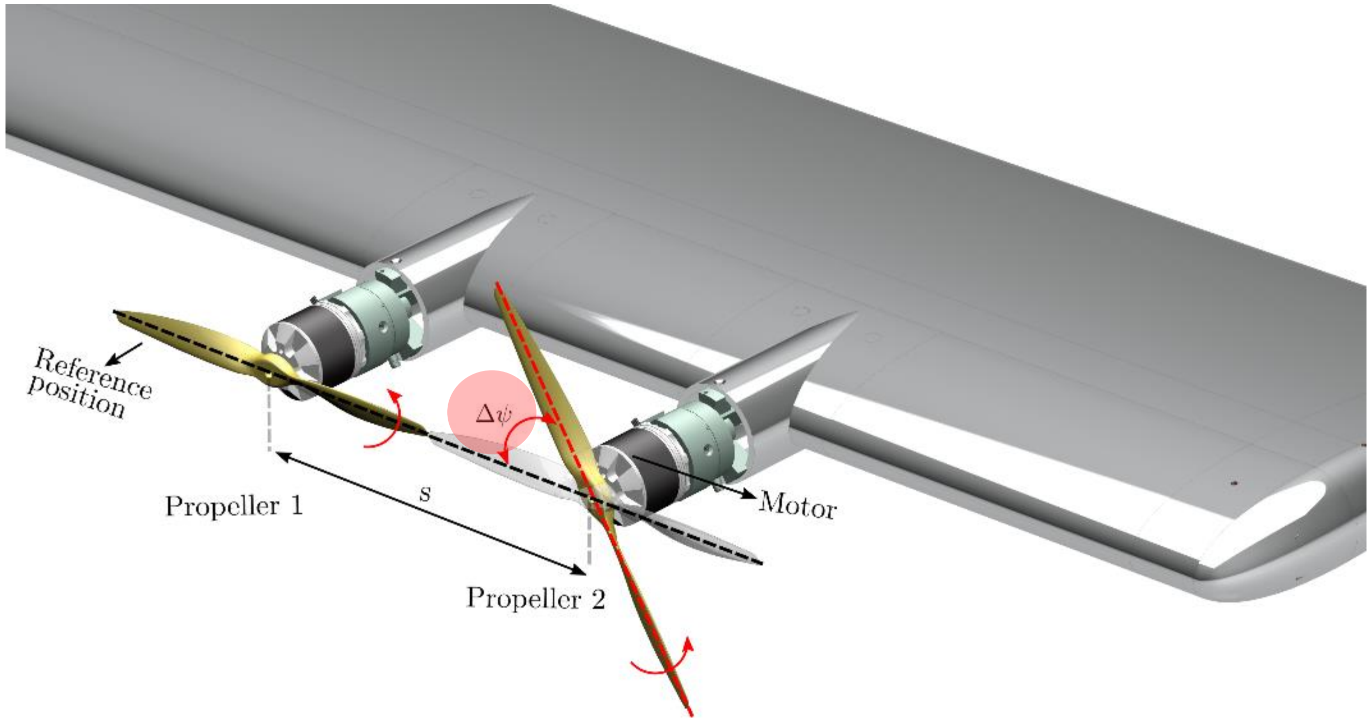
- Able to compare vortex generation and convection between nearside and far side.
- Consequence on vortex-stator interaction
- Observe limited influence on upstream

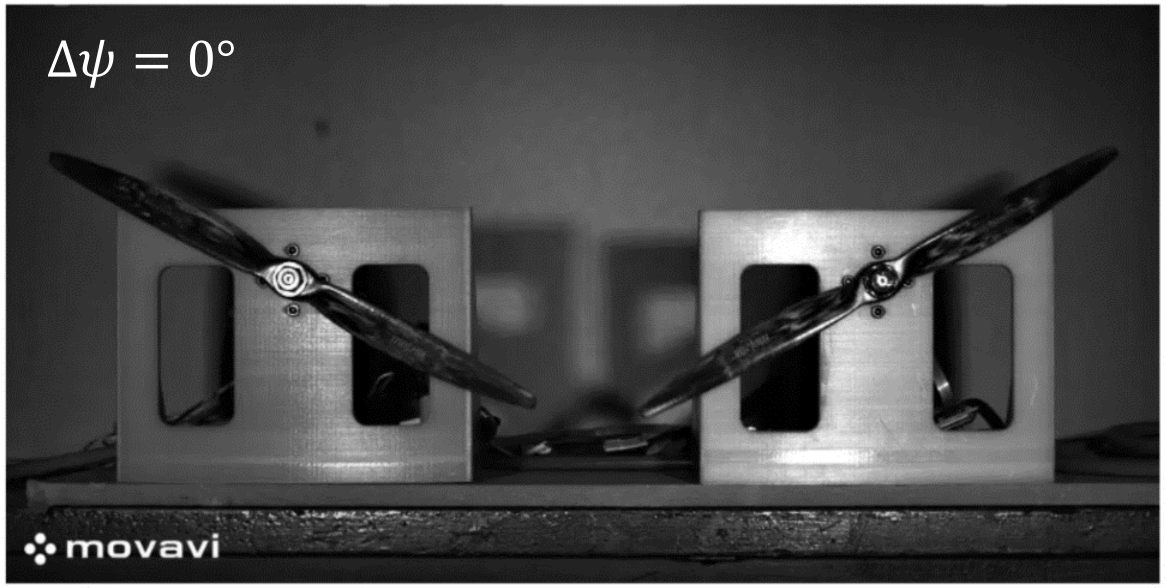


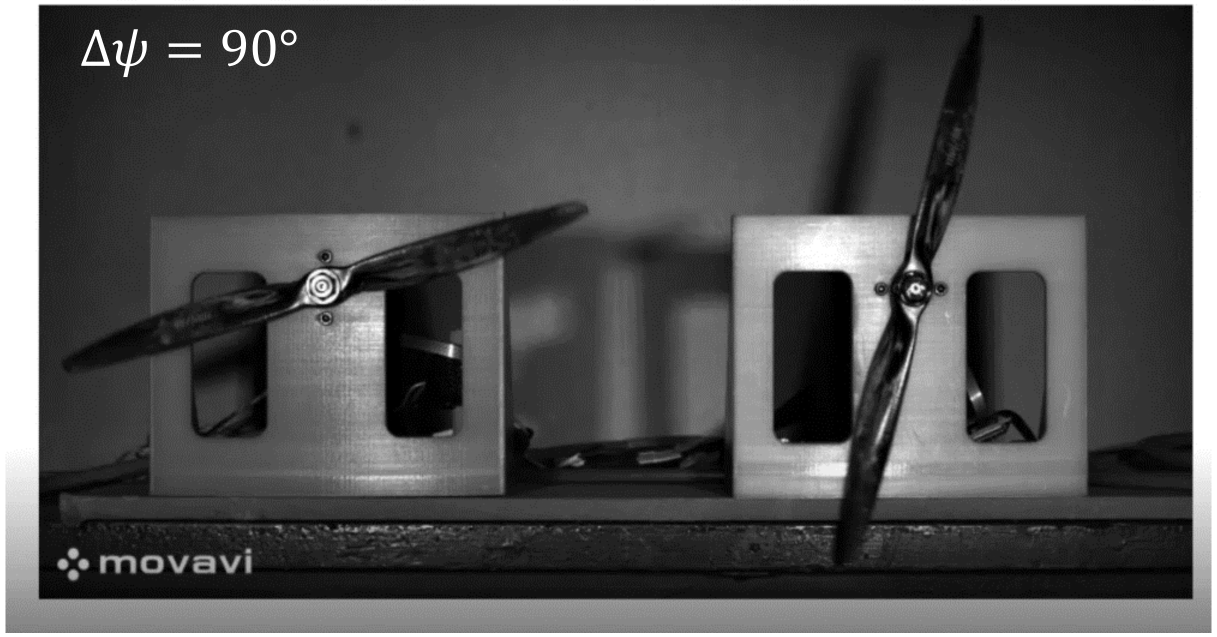




Phase control, or phase synchronization, implies that the propulsors are synchronized (i.e., rotating at equivalent rates).

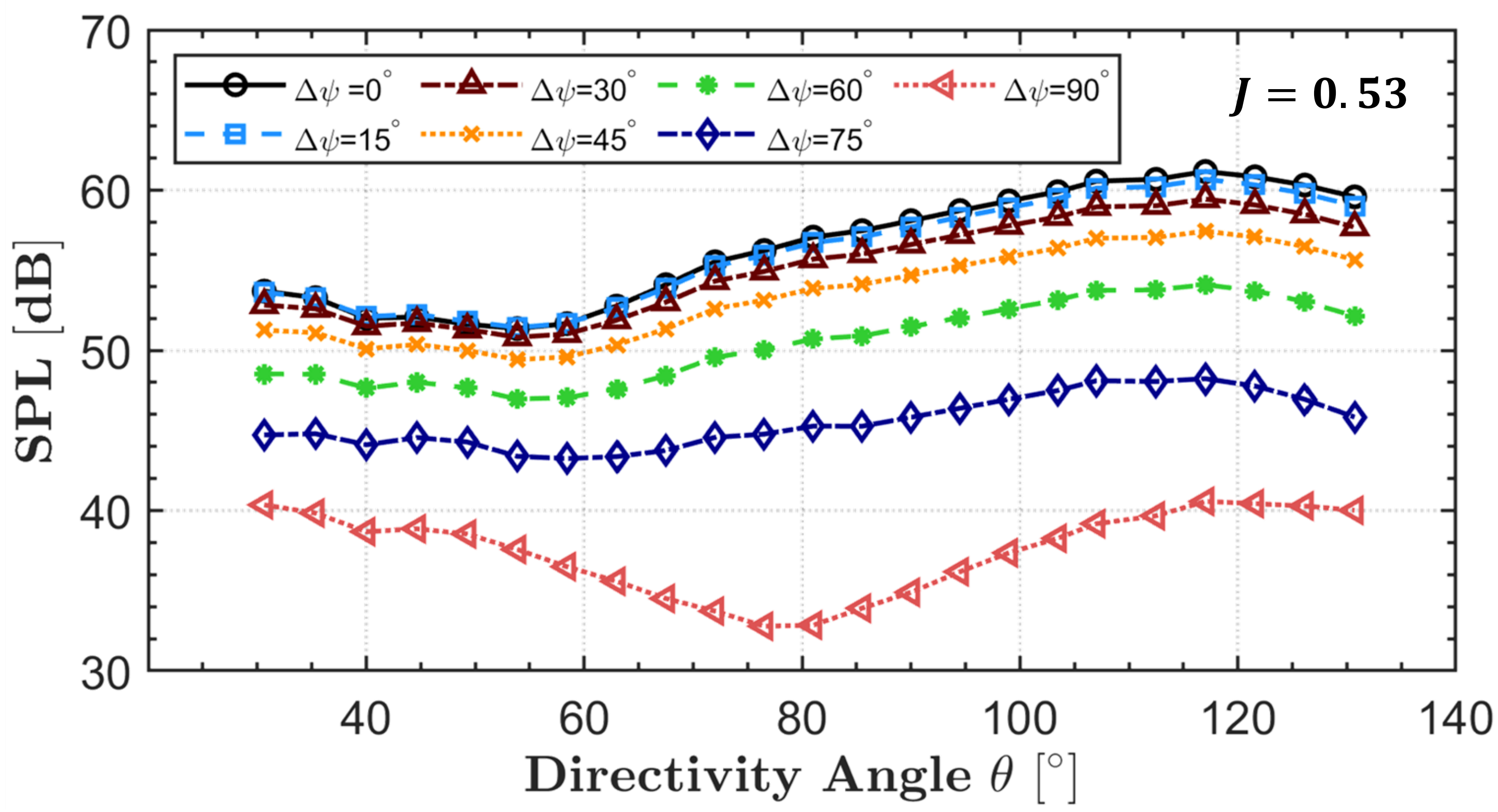


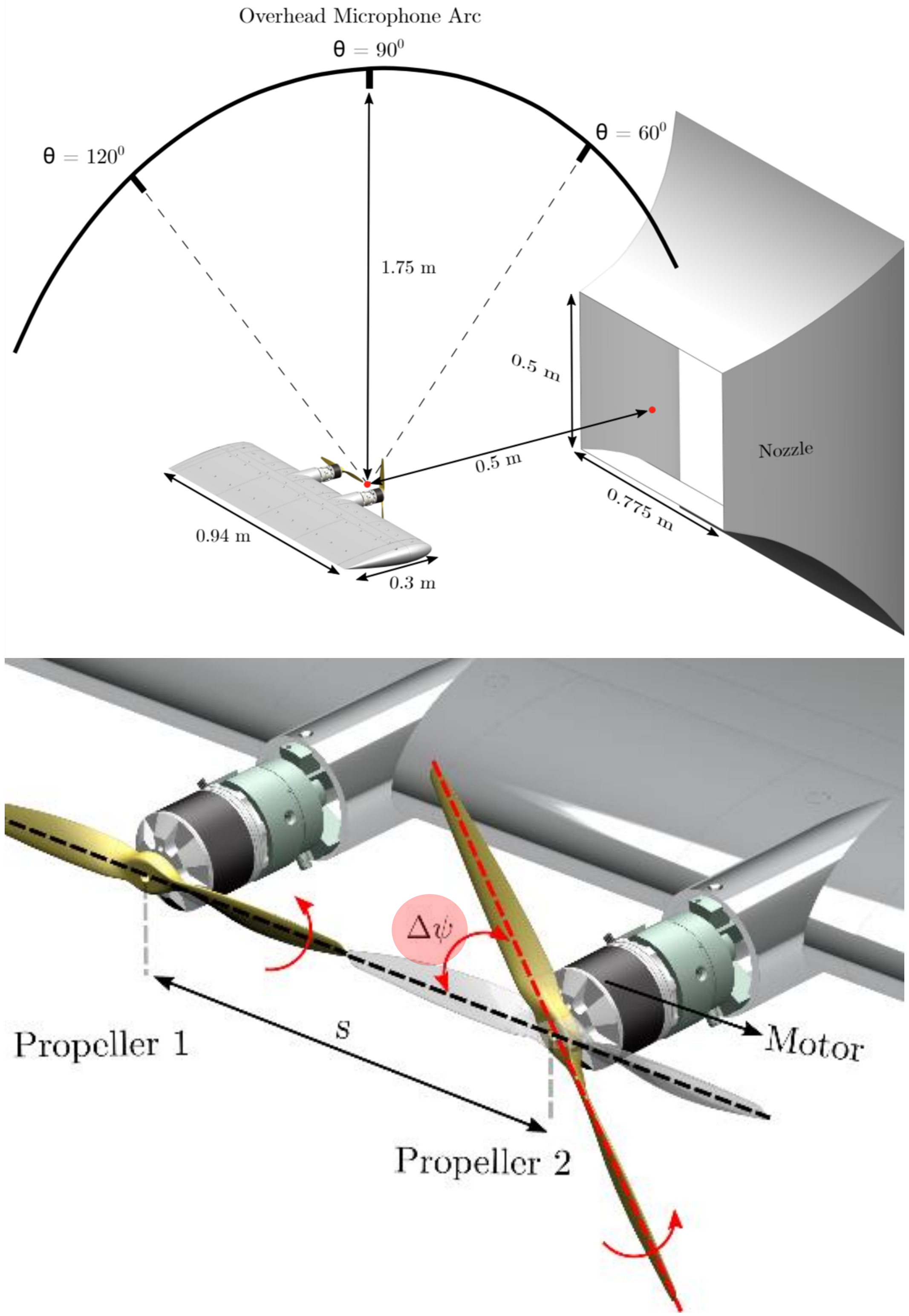




Phase control can significantly reduce the blade passing frequency tonal noise produced by the propellers.

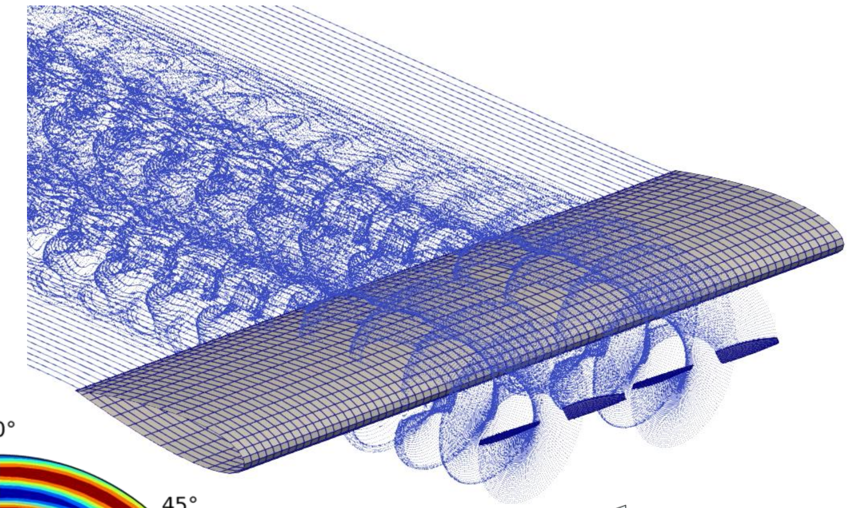
Directivity pattern of sound pressure level of the BPF

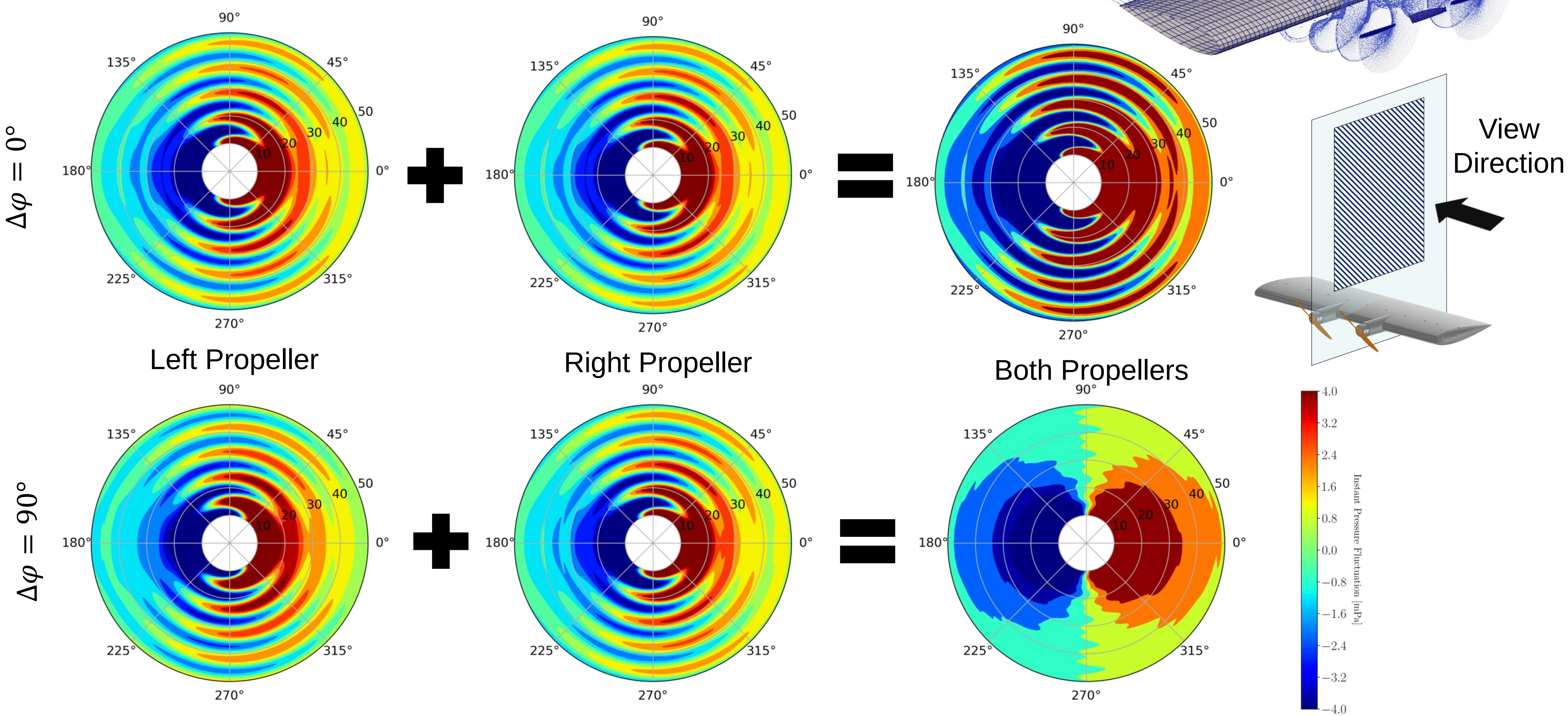




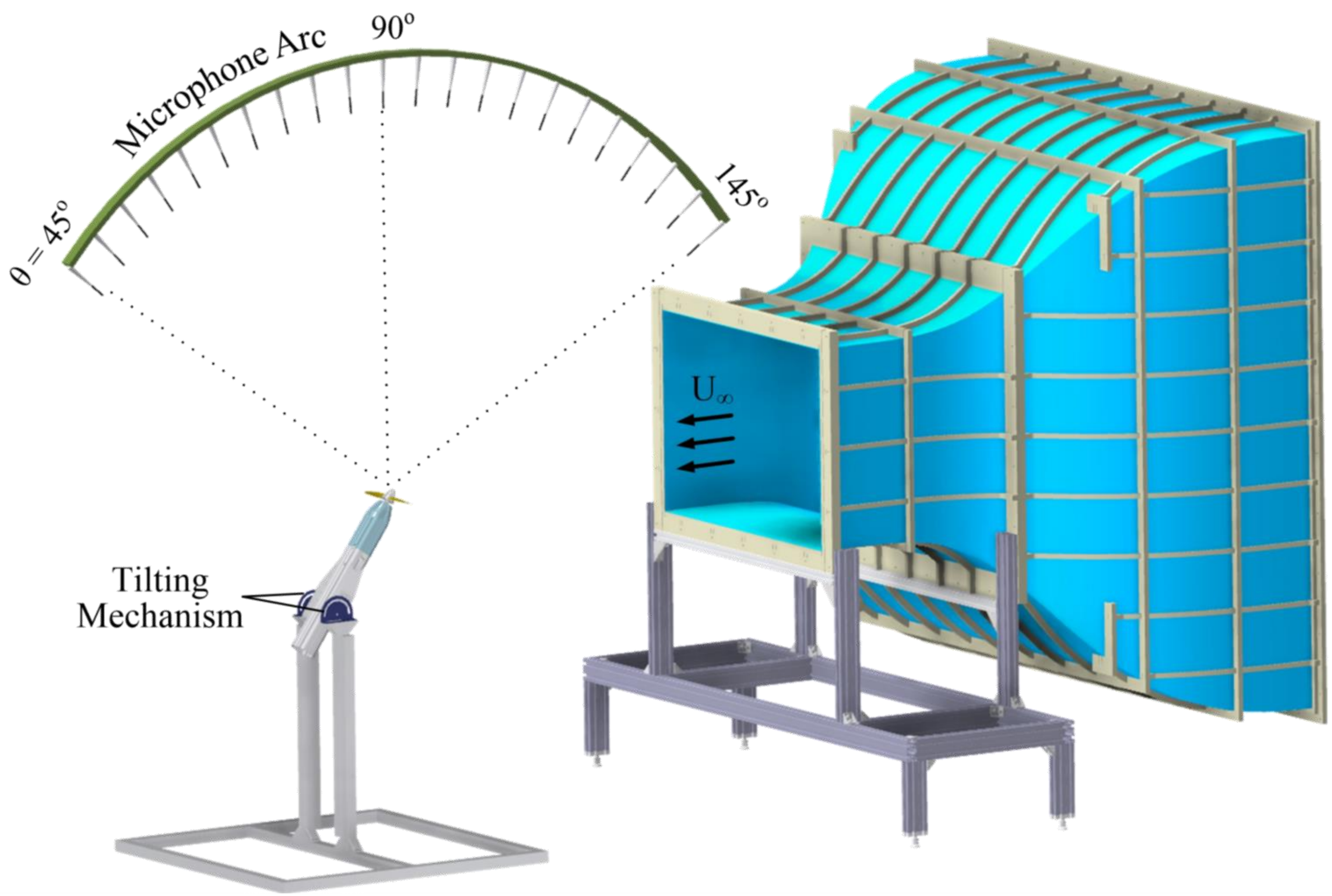
Distributed Electric Propulsion

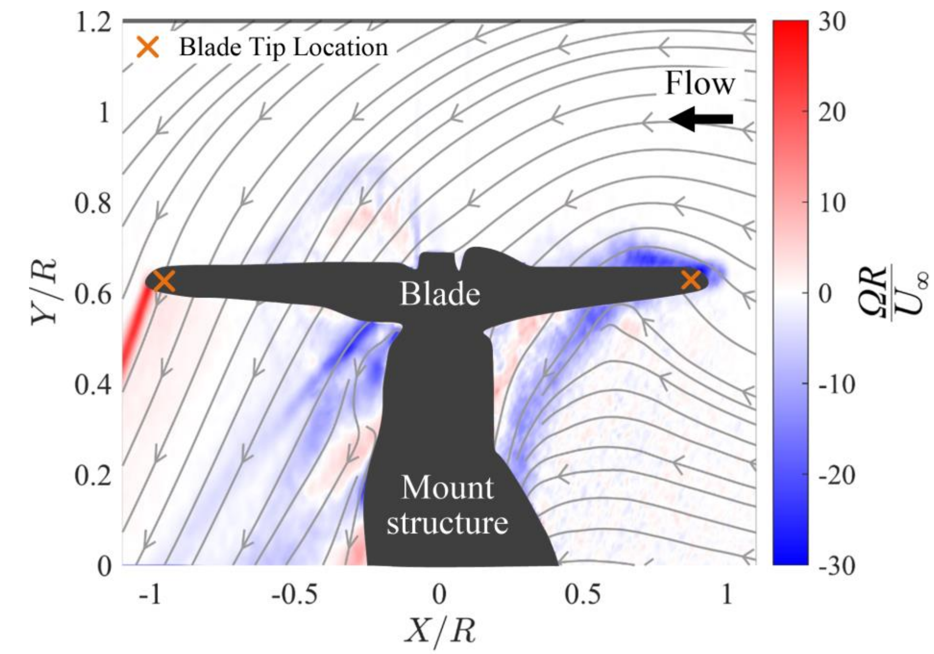
- Mid-fidelity aerodynamics numerical software VLM/VPM coupled with in-house python-based code to compute acoustic propagation using Farassat's 1A Acoustic Analogy.

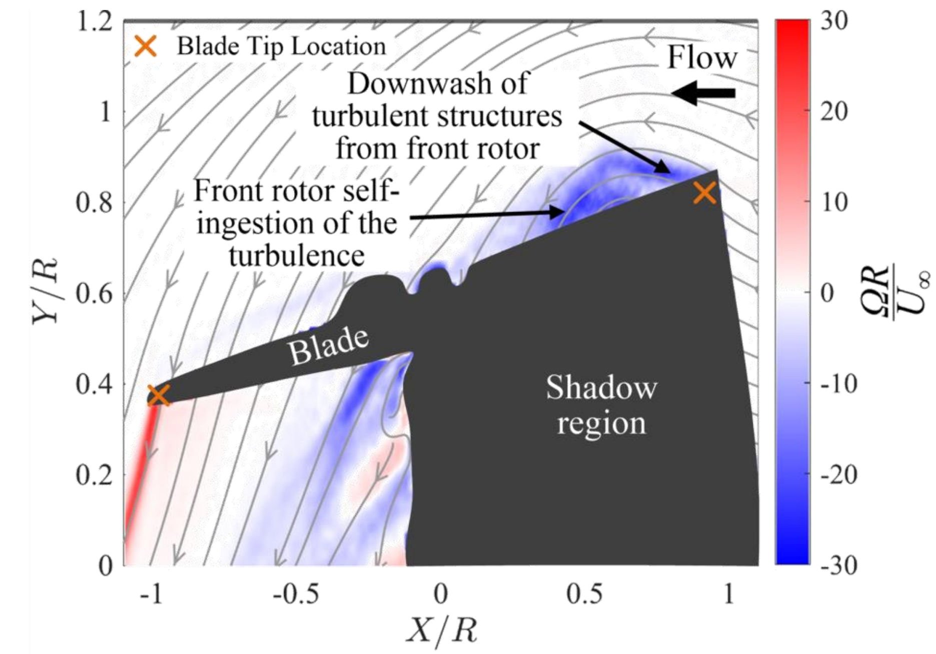




- Numerous experiments have been performed of a propeller operating at various tilt-angles which simulate the take-off, cruising flight, and landing stages of an eVTOL aircraft.

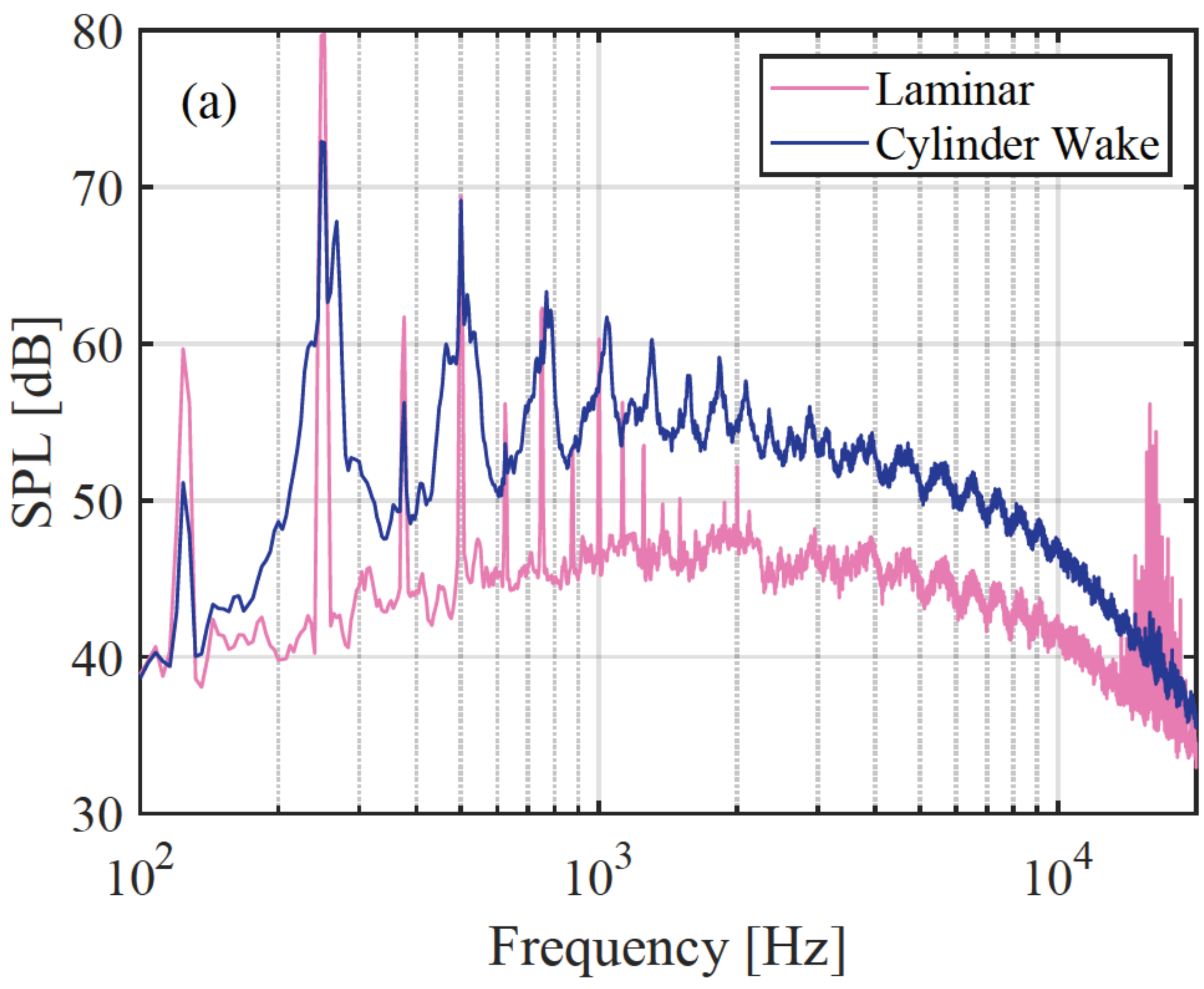


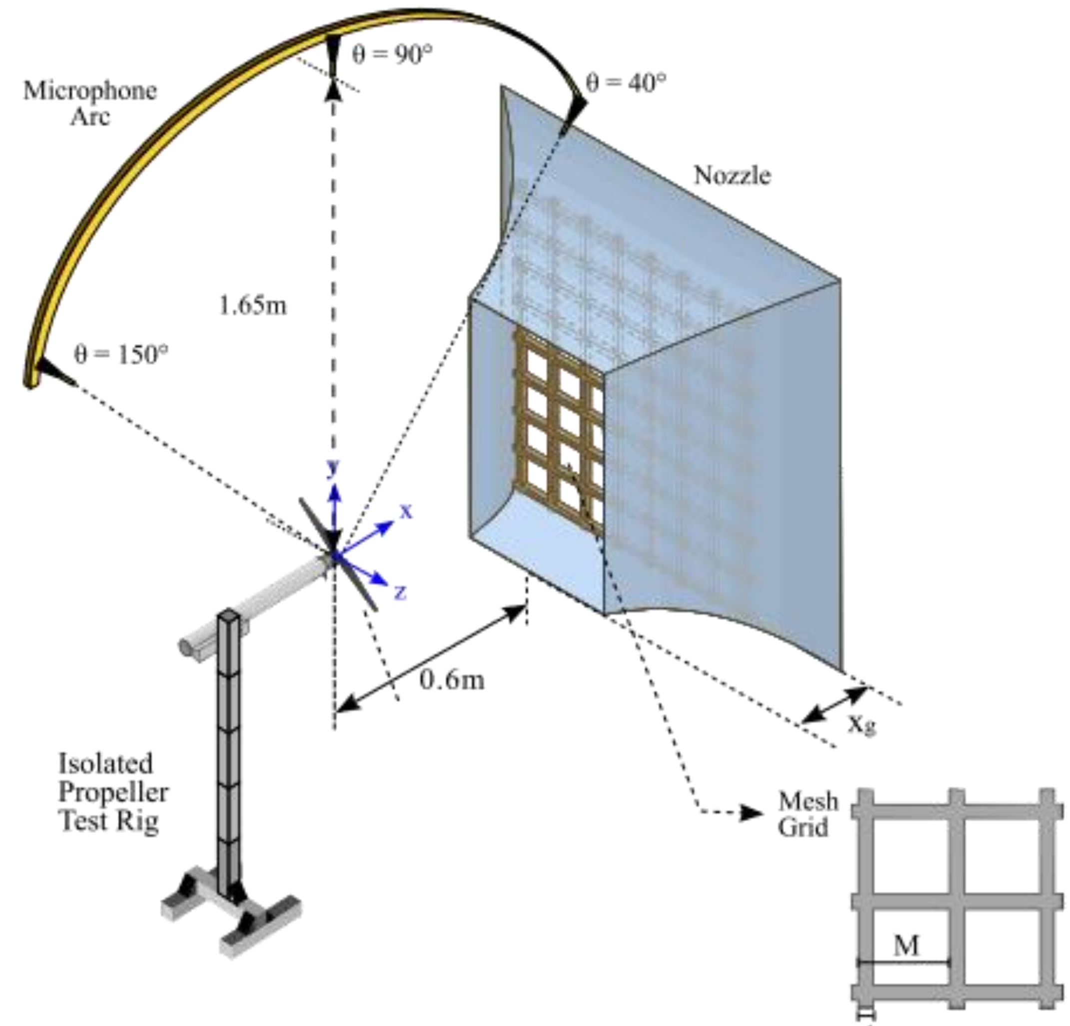


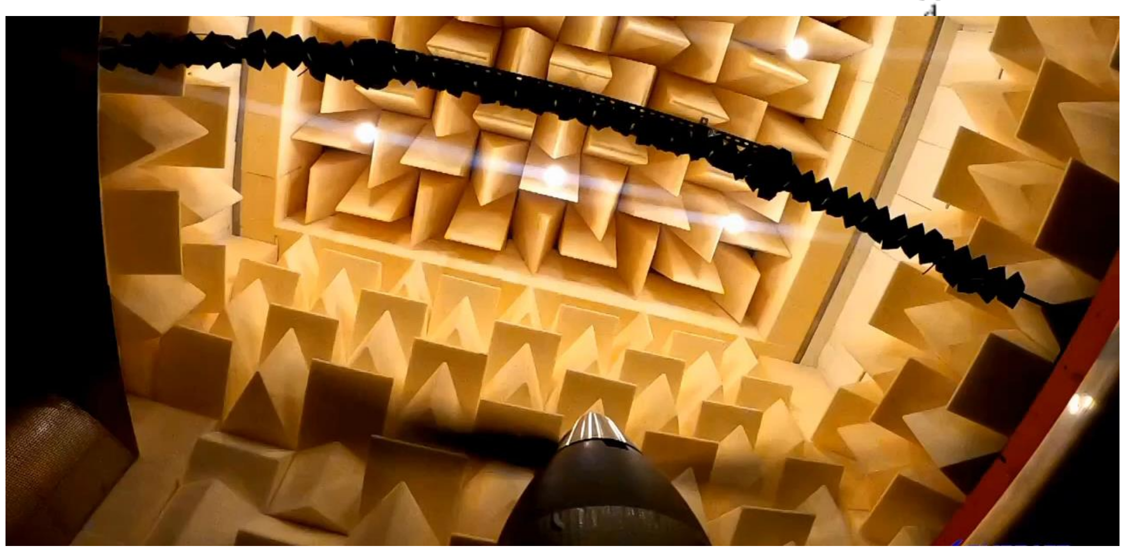


Propeller - Turbulence interaction noise

- Propellers operating outdoors are likely to be subjected to turbulent inflow conditions from the surrounding urban environment such as wakes generated by buildings and trees or the surrounding airframe fuselage such as wings or booms.







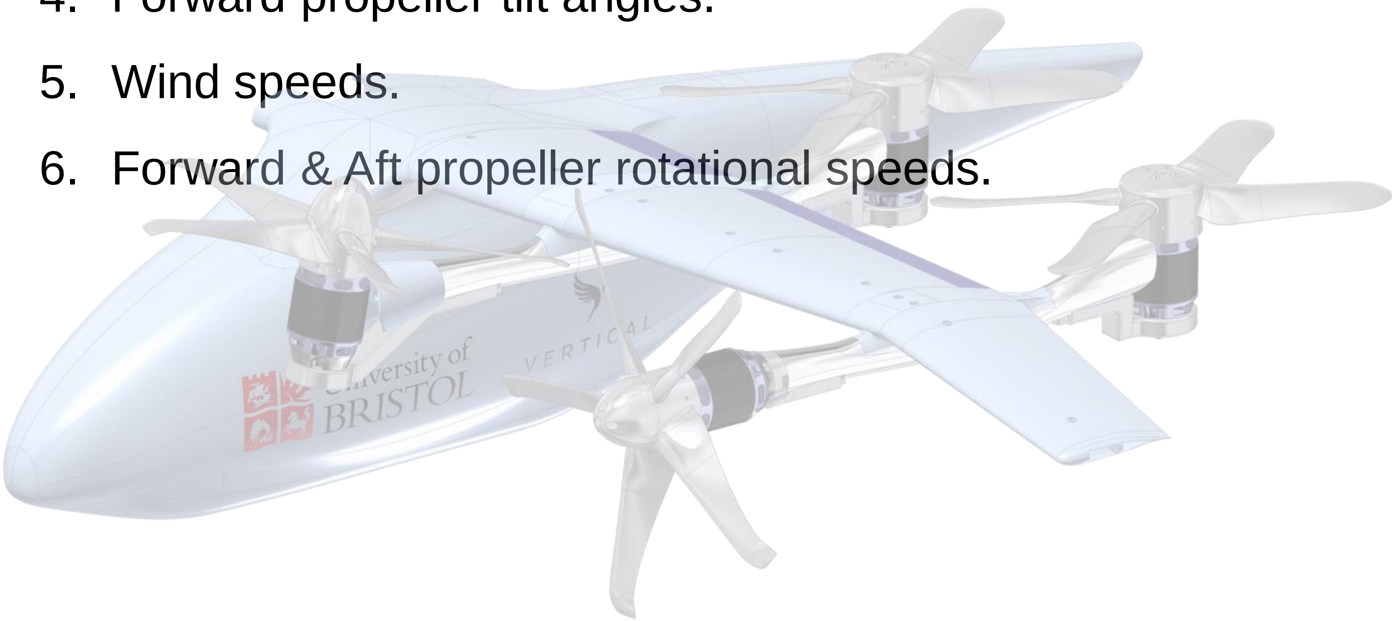
10% scale model eVTOL aircraft

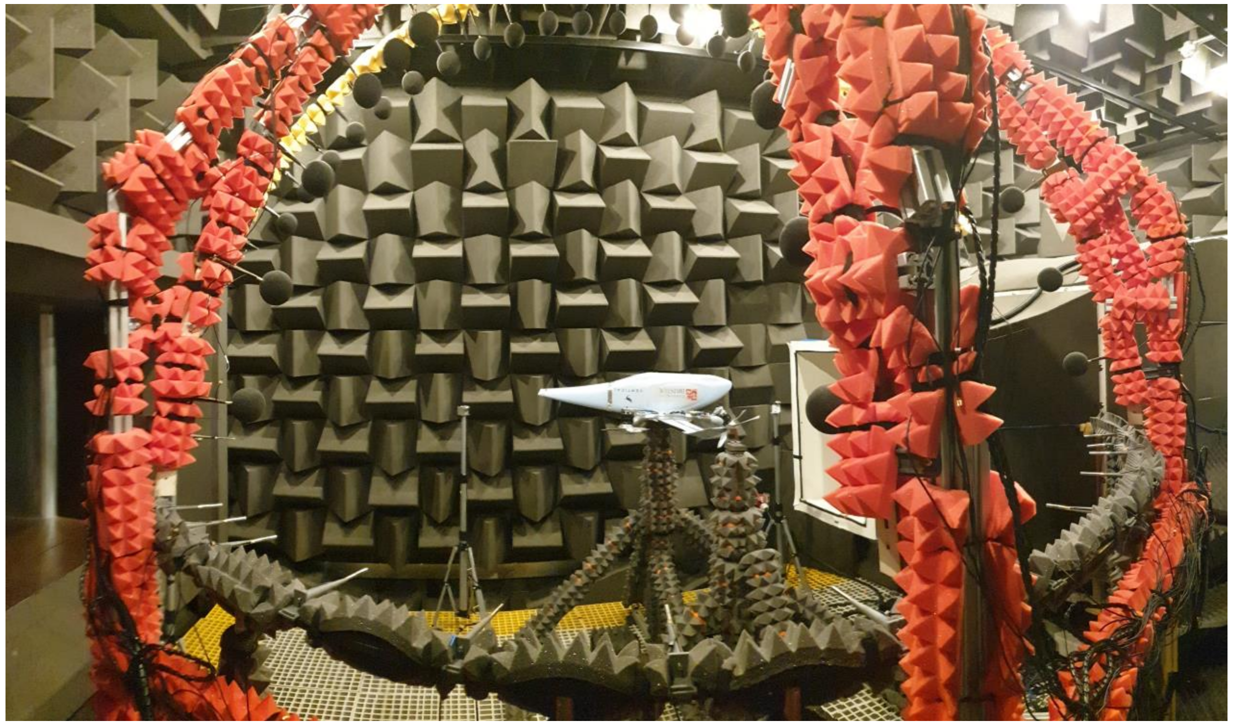
Objective:

Perform experimental work to support development of acoustic models and aerodynamic interaction understanding.

Test-matrix parameters:

1. Different propeller designs.
2. Flap angles.
3. Aircraft pitch angles.
4. Forward propeller tilt angles.
5. Wind speeds.
6. Forward & Aft propeller rotational speeds.





Q&A

Thank you for your kind attention