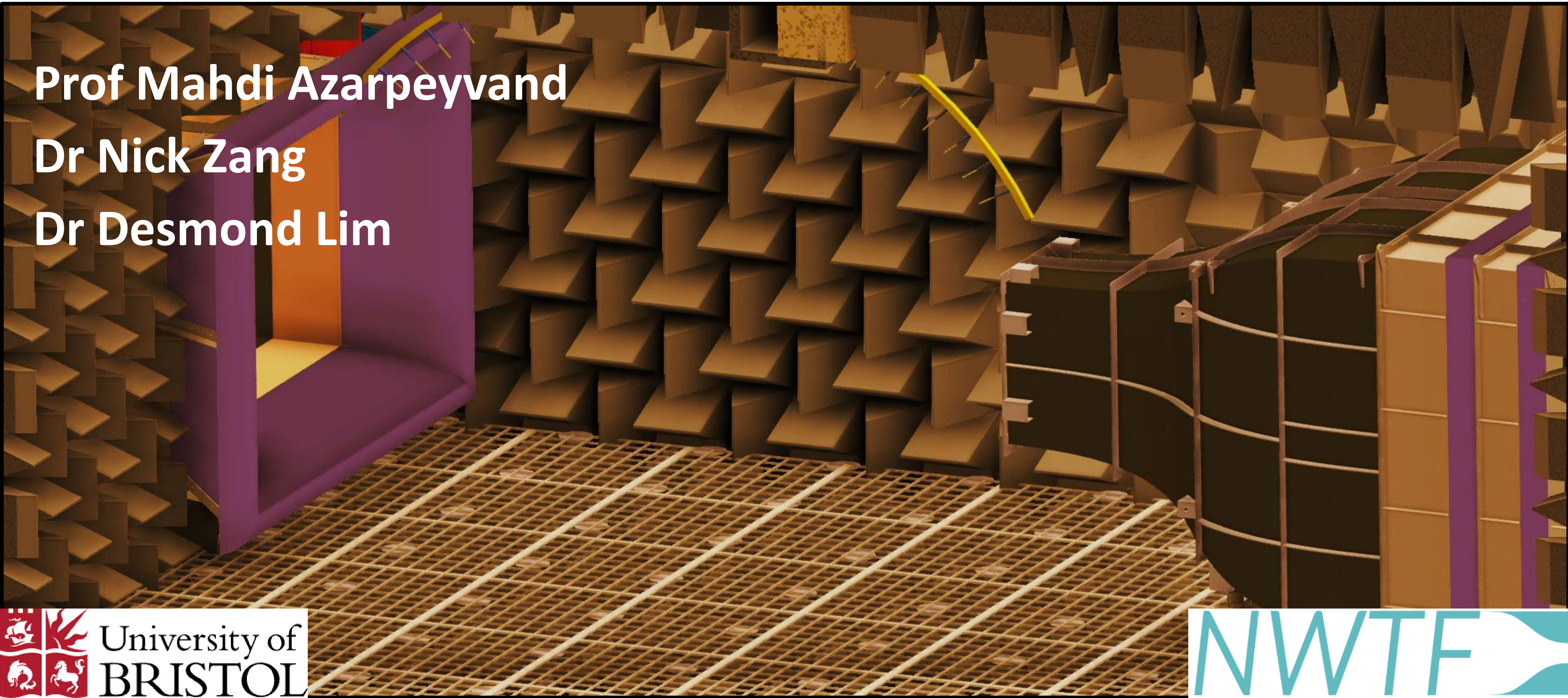
National Aeroacoustic Facility



Prof Mahdi Azarpeyvand

Dr Nick Zang

Dr Desmond Lim

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Overview

Design and build between 2015-2017

National Facility in 2018

Attracted over £9M of research funding

(8 EU, 5 EPSRC, 15 industrial, etc)

Produced over 80 journal and conference papers

Collaboration with over 40 academic and industrial partners

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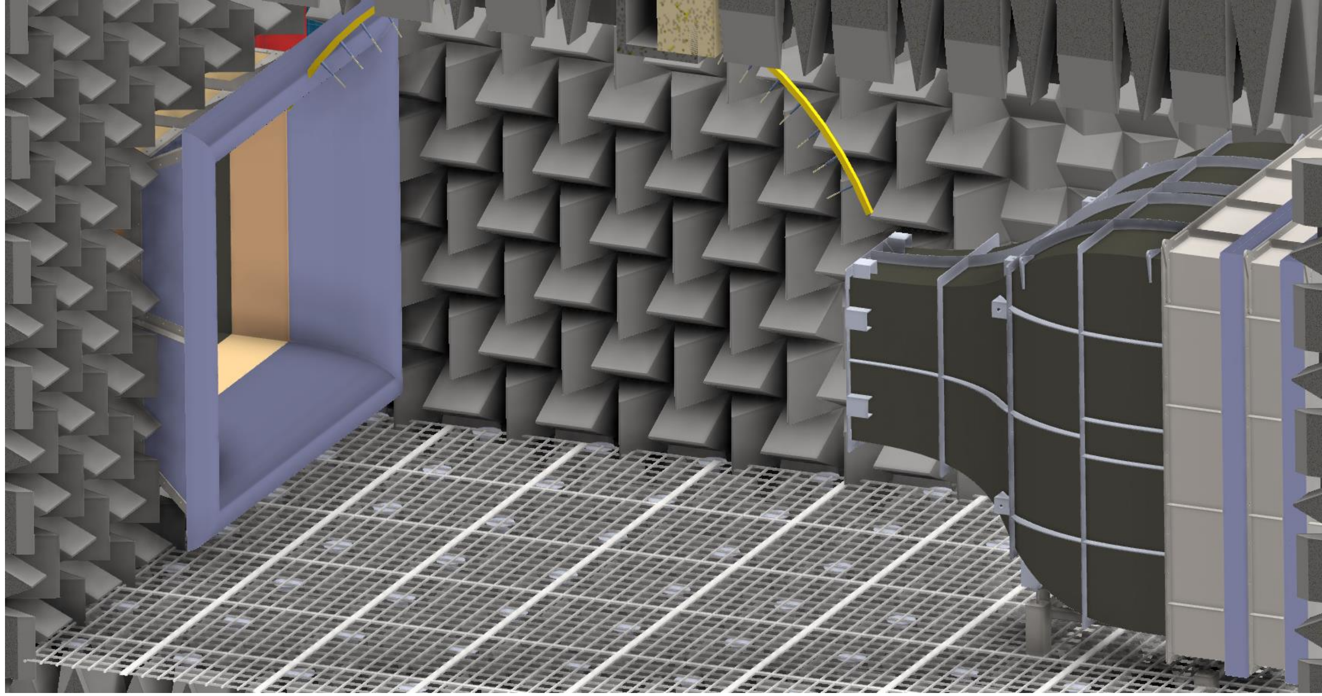
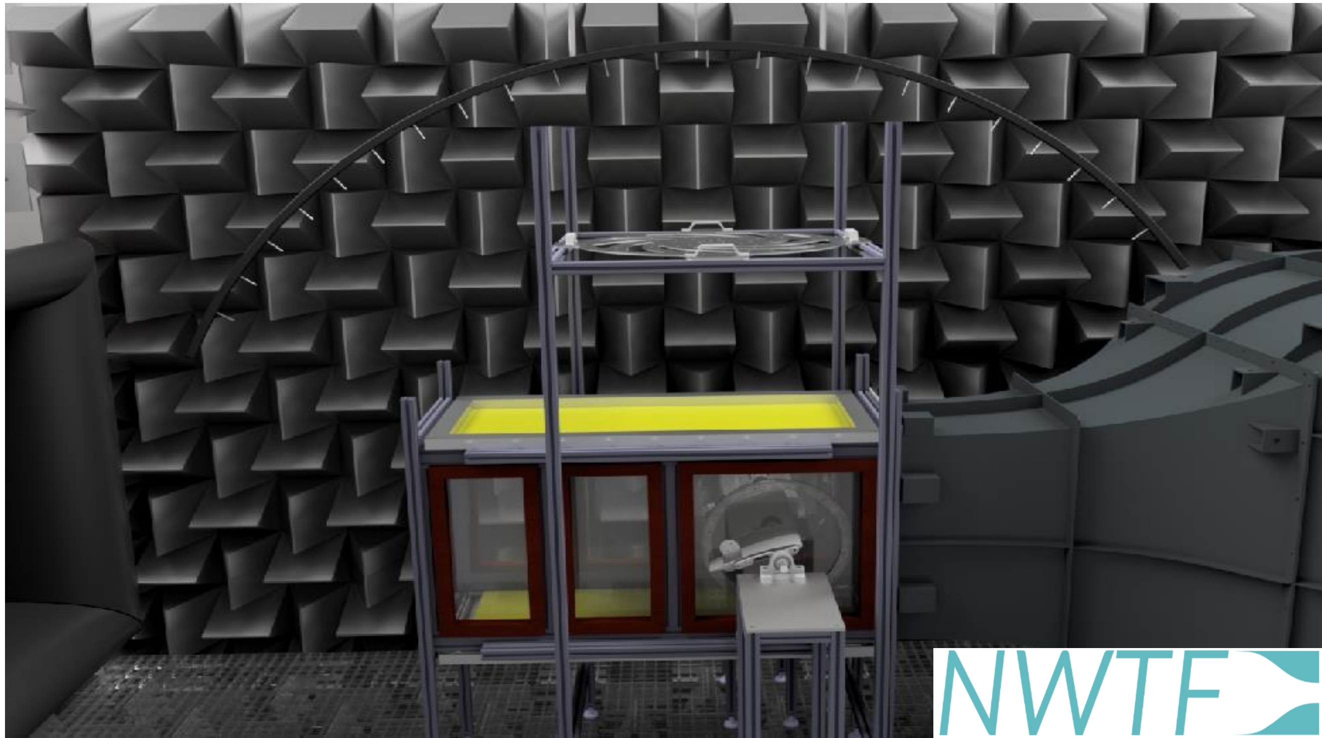
Facility specification:

<u>Large acoustic wind tunnel</u>

- Anechoic down to 160 Hz
- Speed up to 40m/s (large nozzle) and 120m/s (letterbox nozzle)
- 140 free-field microphones and Kulites
- Two large beamforming arrays
- Over 160 NI channels
- Hotwire CTA system
- Hotfilm system (48 channels)
- PIV system (2D2C and Stereo)
- Pressure scanner (160 channels)
- Near-field linear arrays





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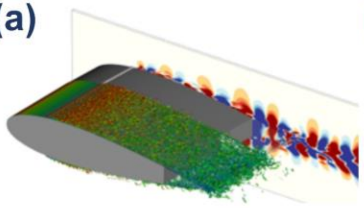
Aeroacoustic & Aerodynamic Research Activities

Noise generation mechanisms

(a)

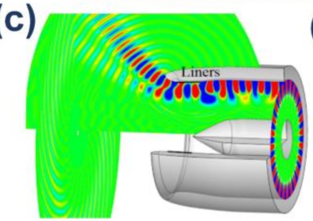


(b)

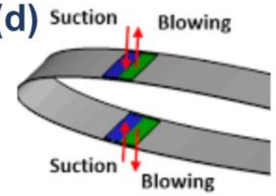
- Trailing-edge noise
- [a]Separation and stall noise
- High lift devices
- Turbulence interaction noise
  - Leading-edge
  - Wake-aerofoil
- [b]Propeller noise
- Jet noise
- Bluff body
  - Rod-aerofoil

Noise mitigation strategies

(c)



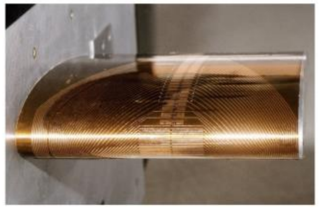
(d)



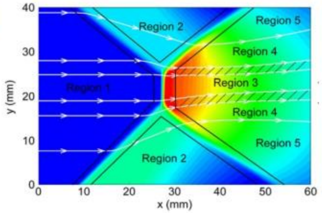
- Serrations
- Bio-inspired treatments
- Porous materials
- [c]Acoustic liners
- Meta-materials
- [d]Active flow control

Advanced measurement techniques

(e)



(f)



- Pressure – velocity coupling
- Phase-locking technique
- Particle image velocimetry
- [e]Hot-film anemometry
- Large beamforming arrays
- [f]Pressure reconstruction
- High order analyses

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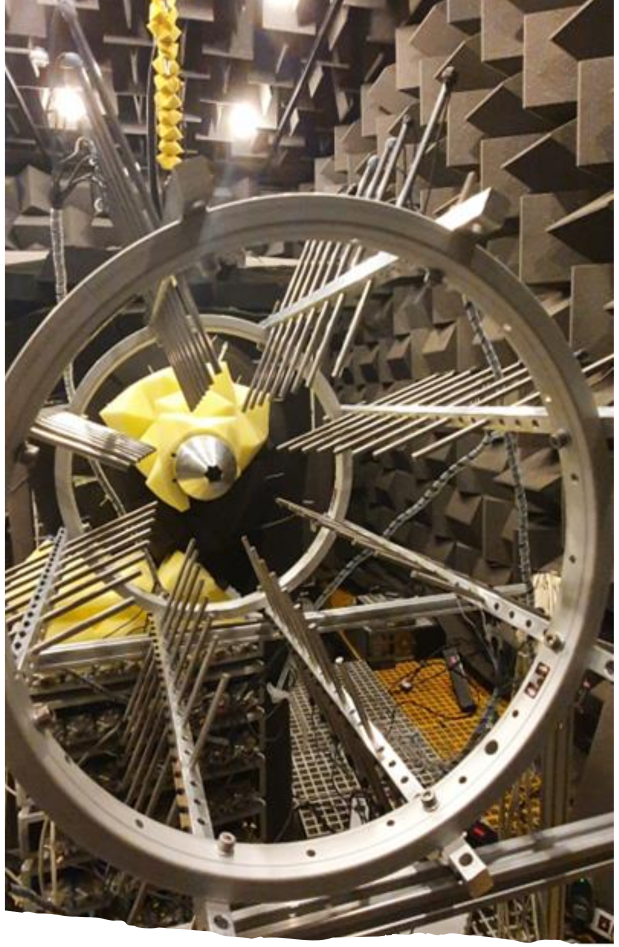

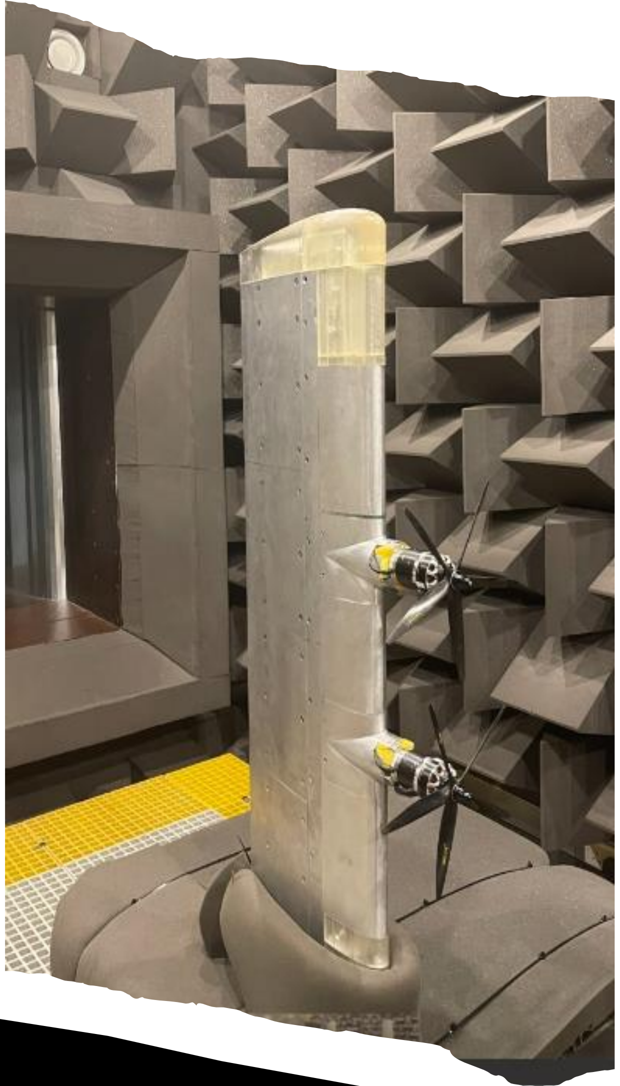

Noise generation mechanisms

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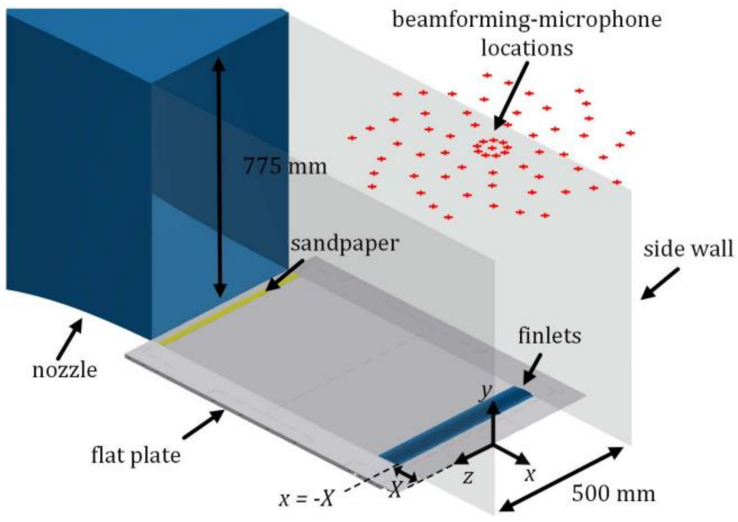
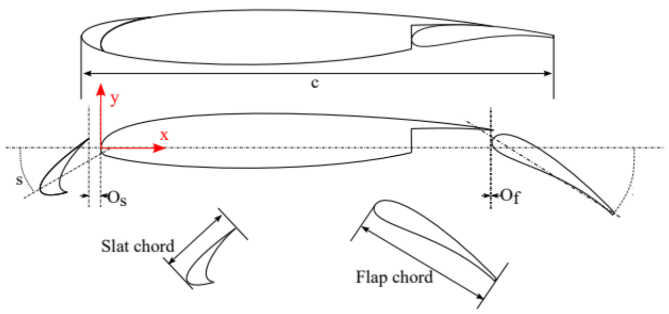
Lifting surfaces

- **Flat plates** (ZPG, APG, FPG)
- **Aerofoils** (NACA0012, NACA0024, NACA16-510, NACA16-413, …)
- **High-lift devices** (30P30N, LEISA2, …)

Flat plate



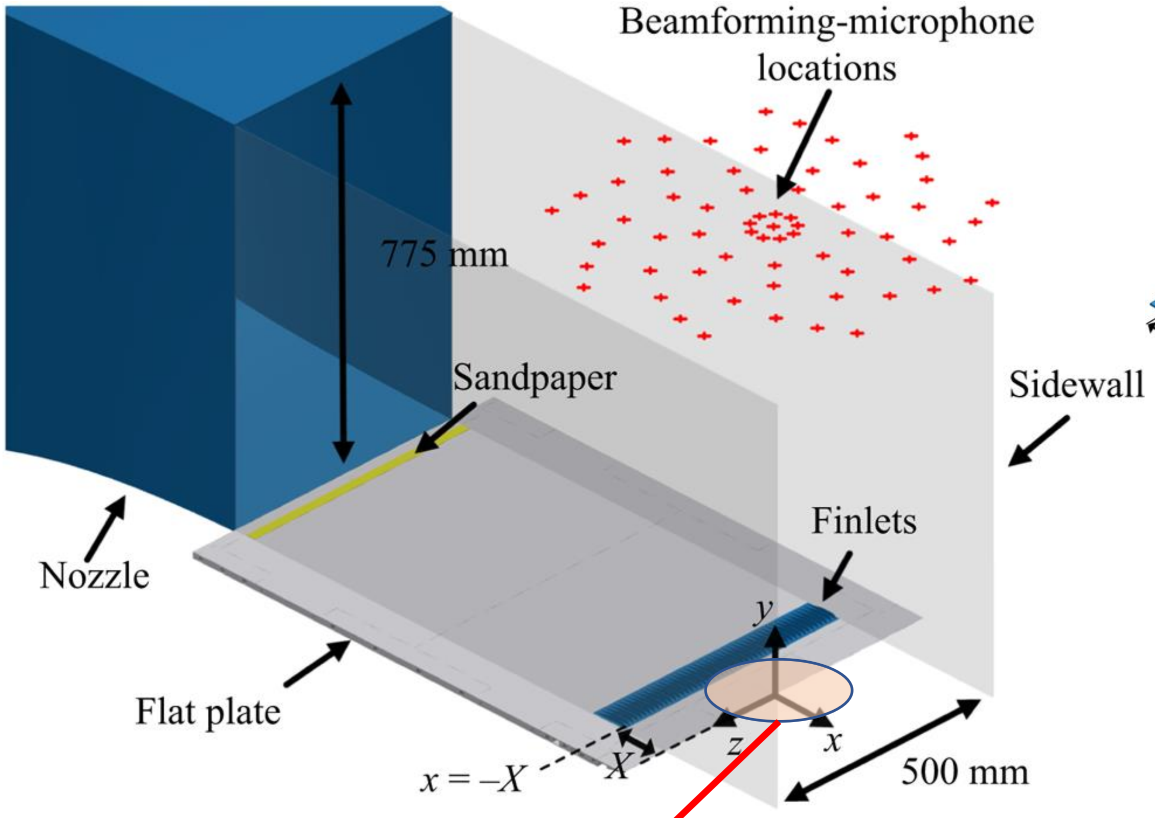
30P30N

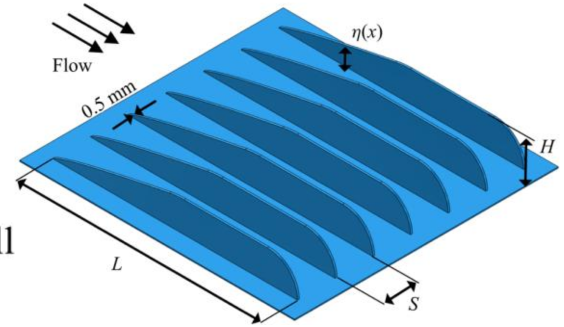


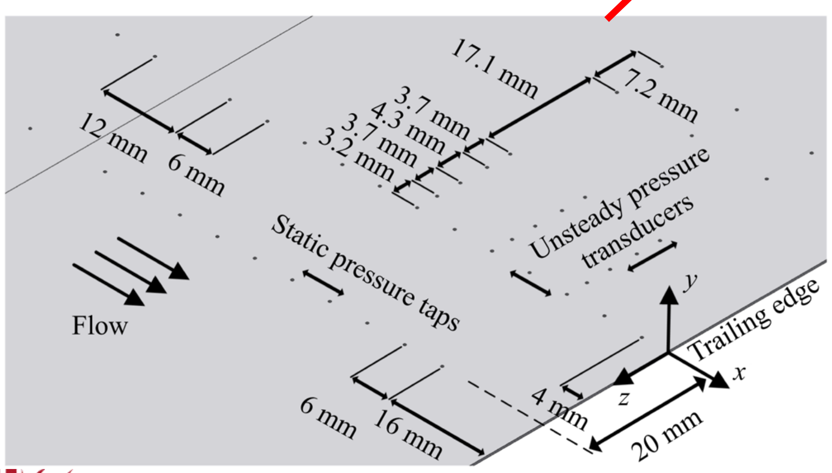
Kevlar wall extension

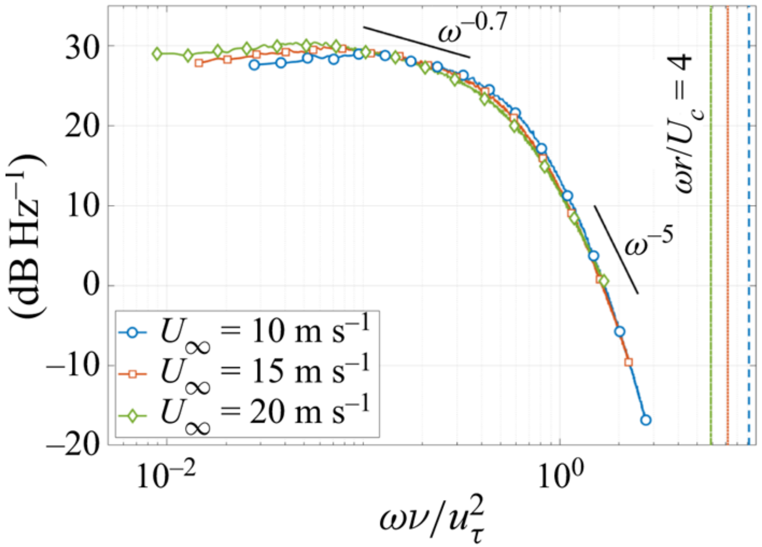
Pitching rig

Beamforming array









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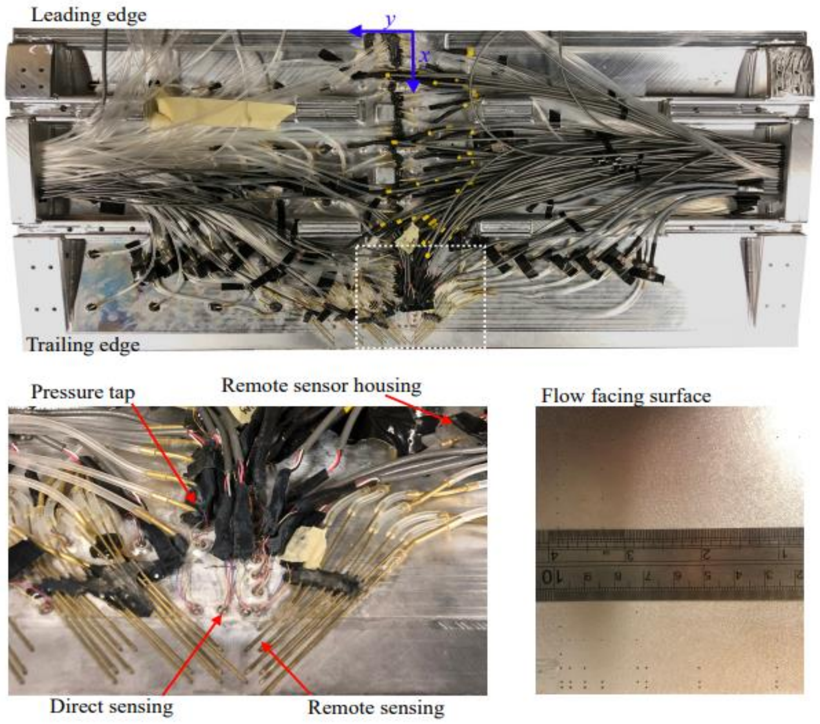
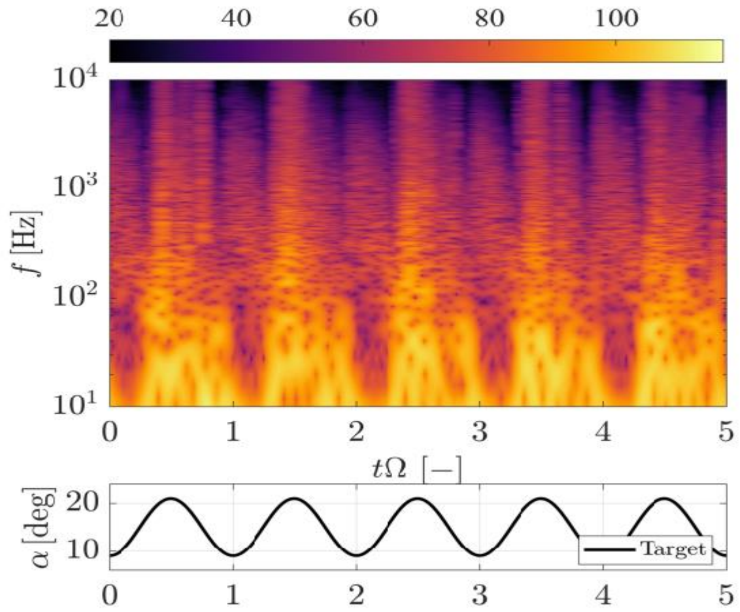
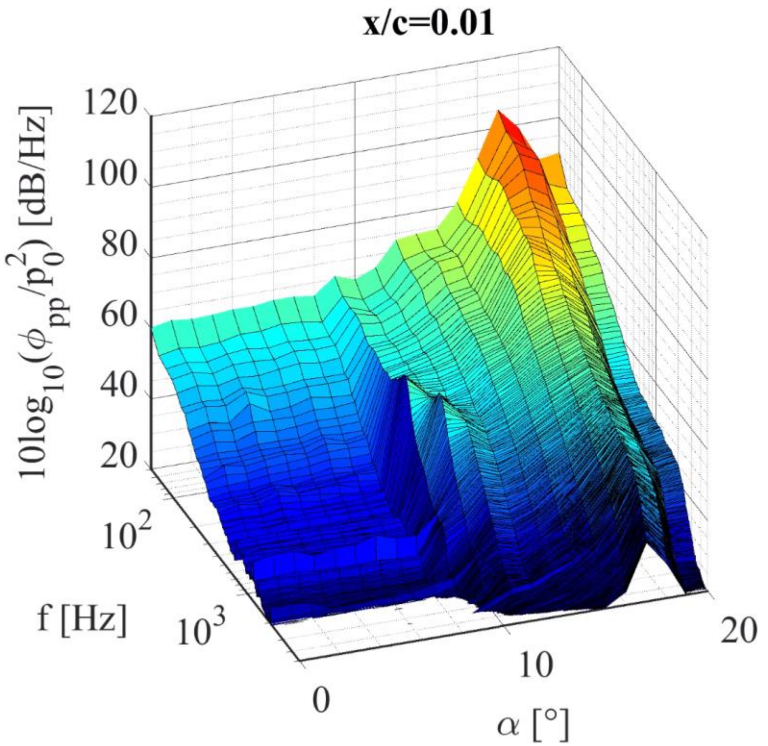
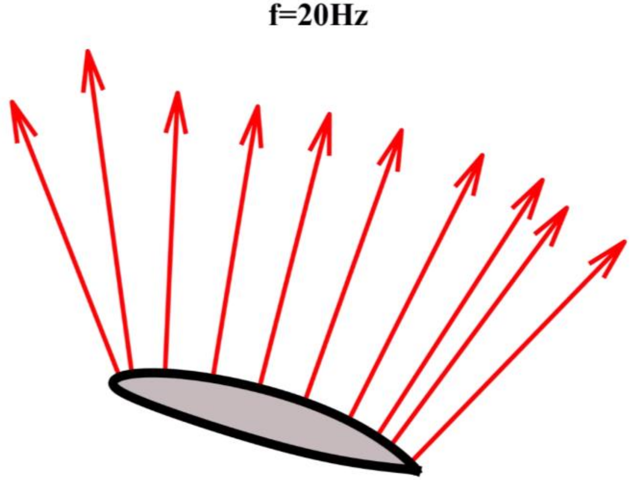
Kevlar duct









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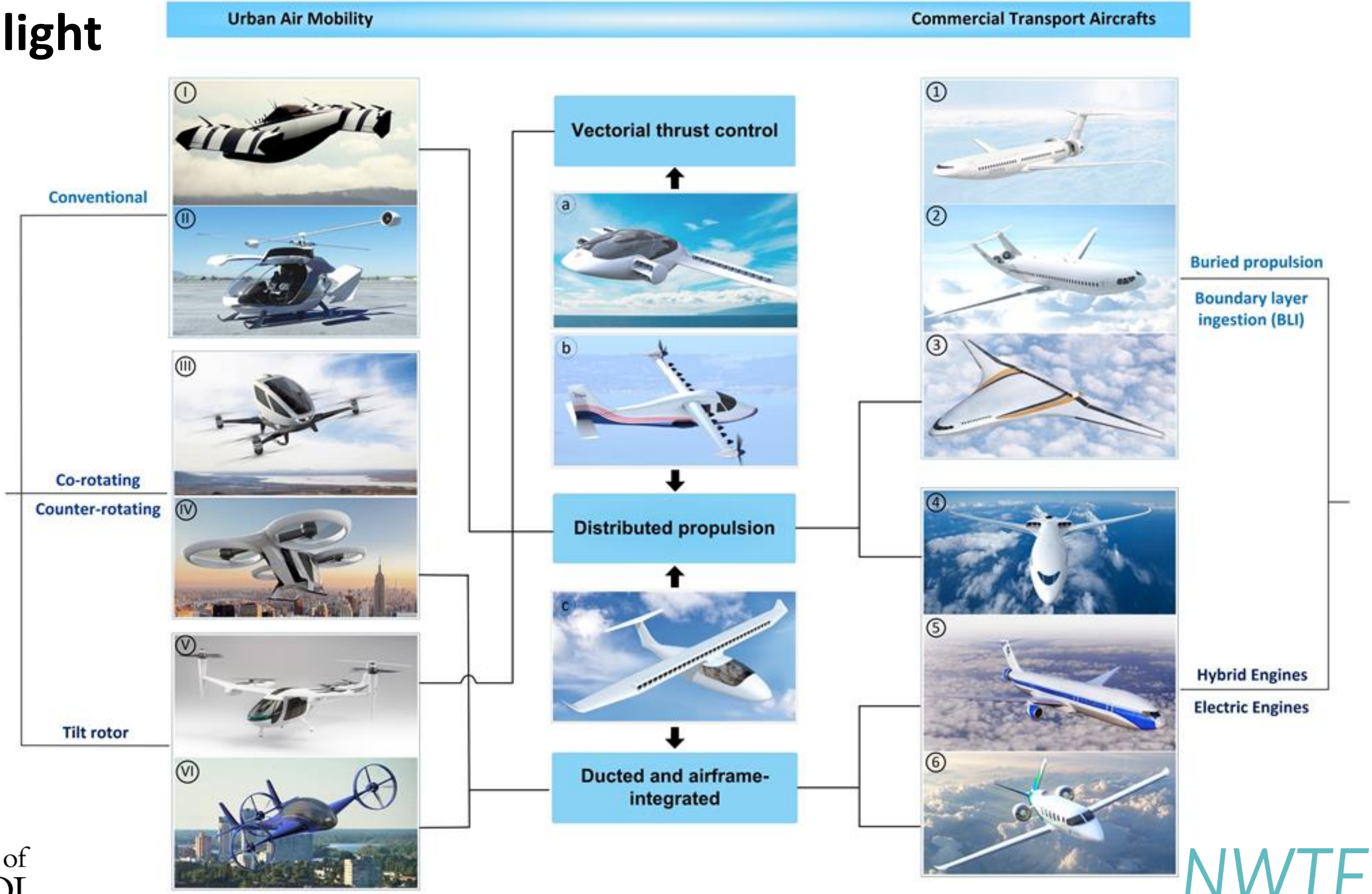
Future Flight



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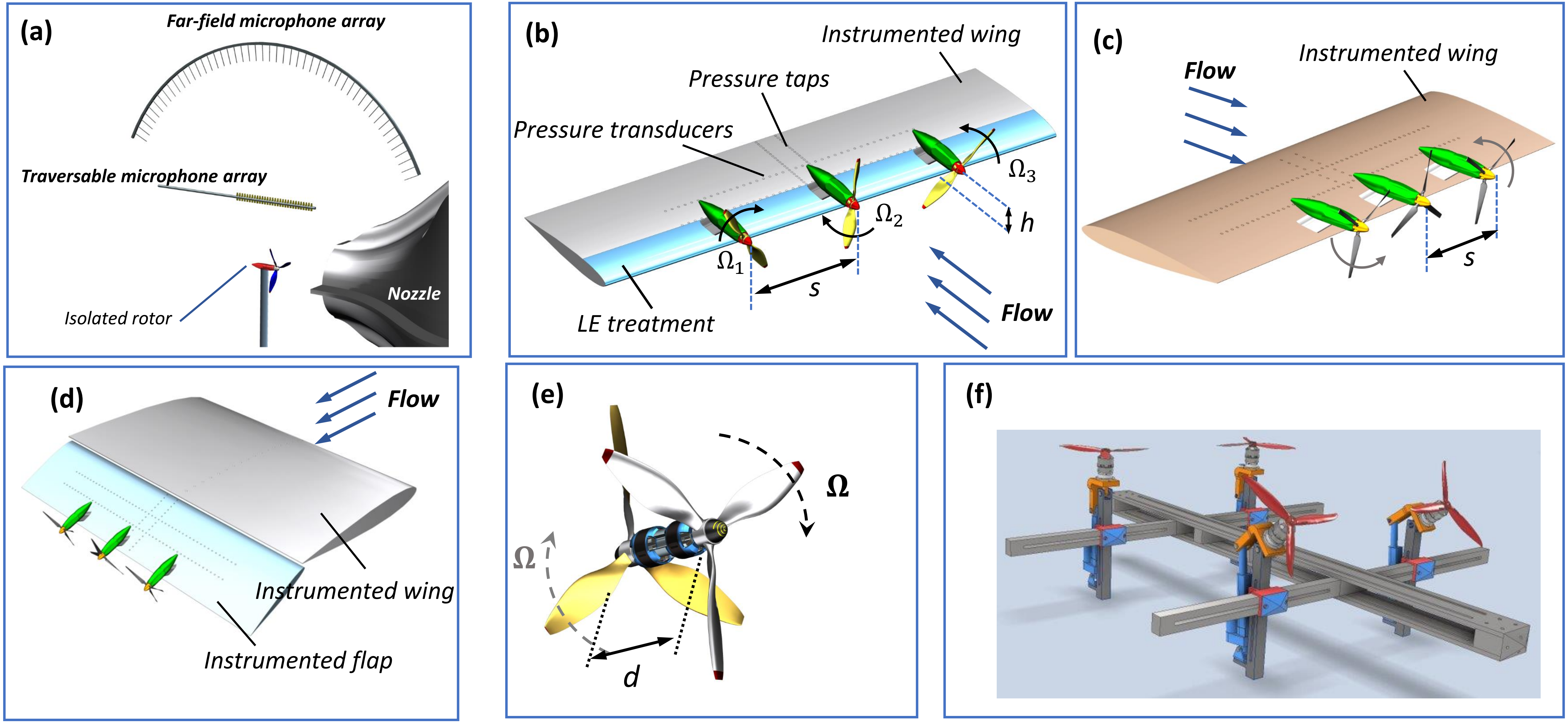

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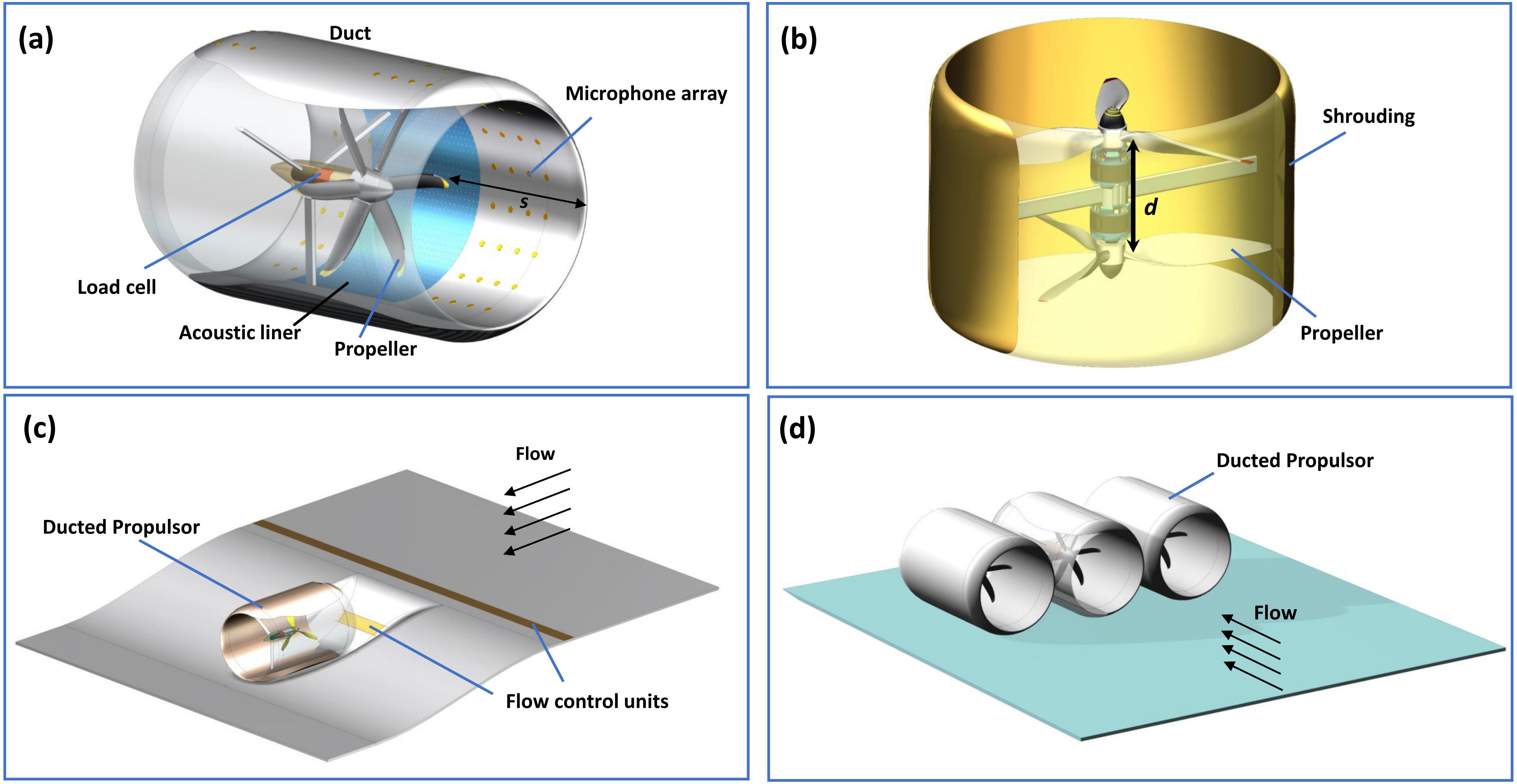

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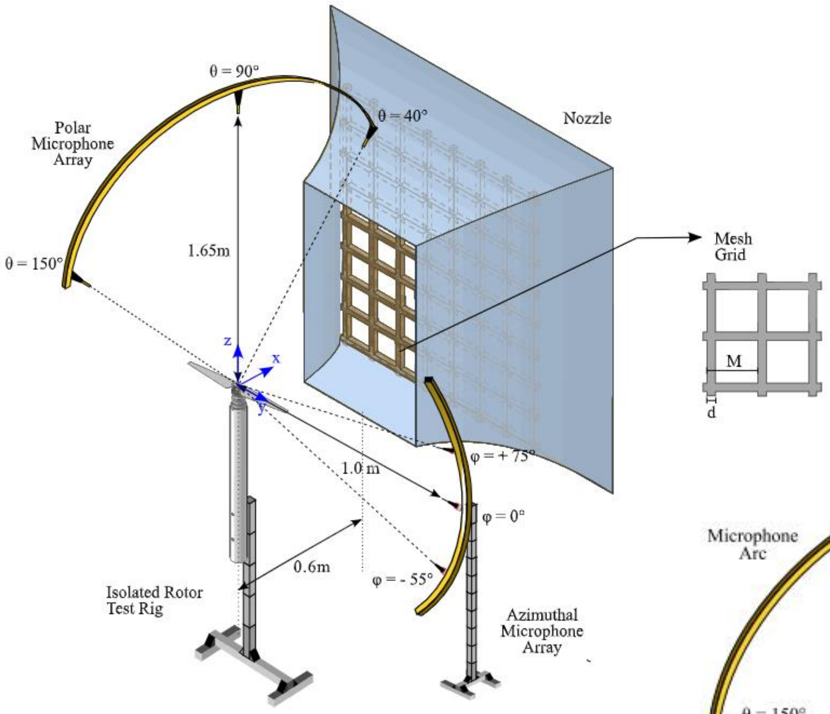
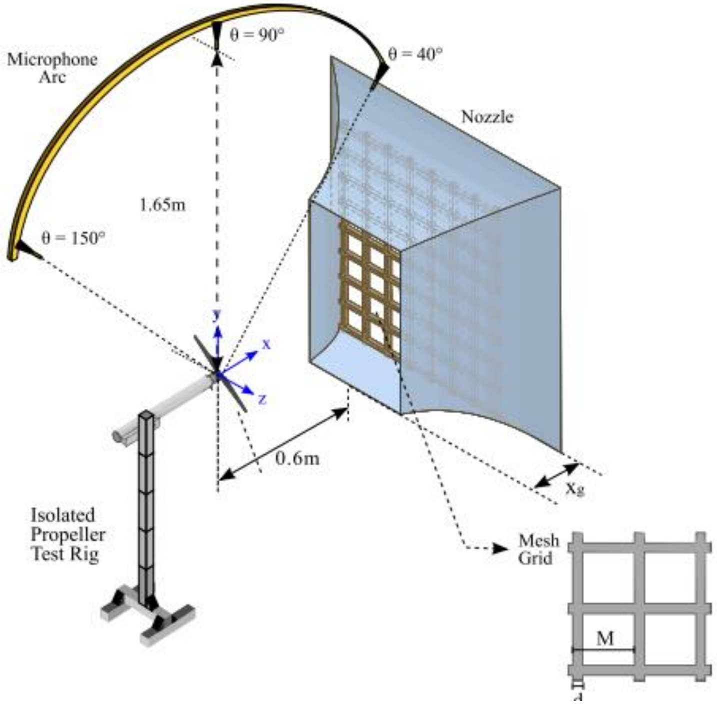
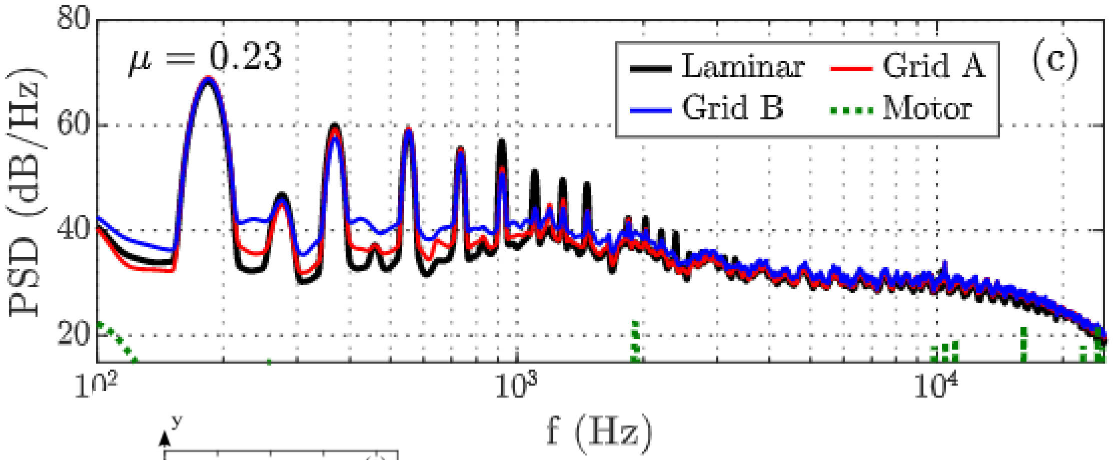
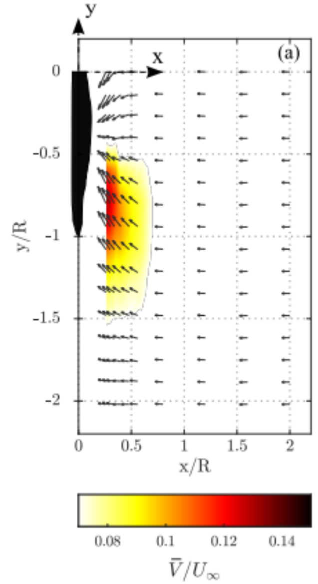
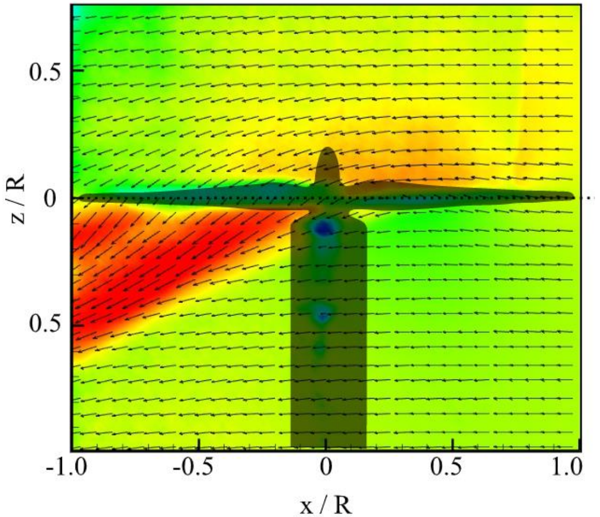
Aeroacoustic of propellers and rotors











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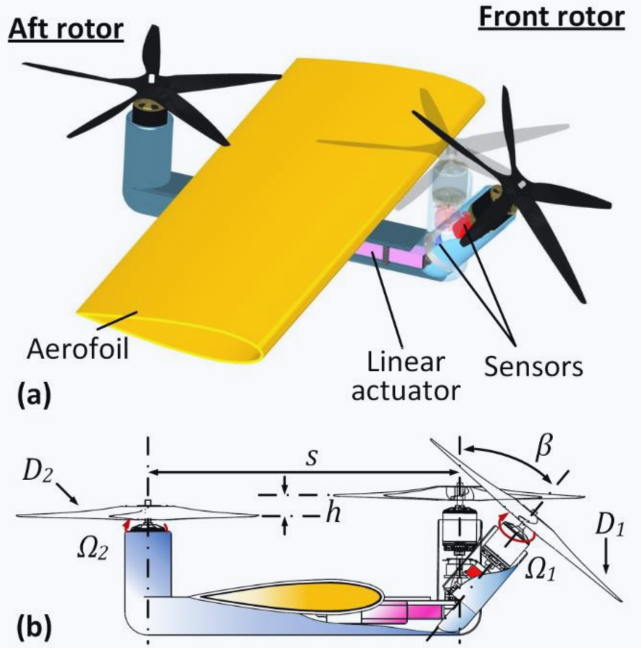
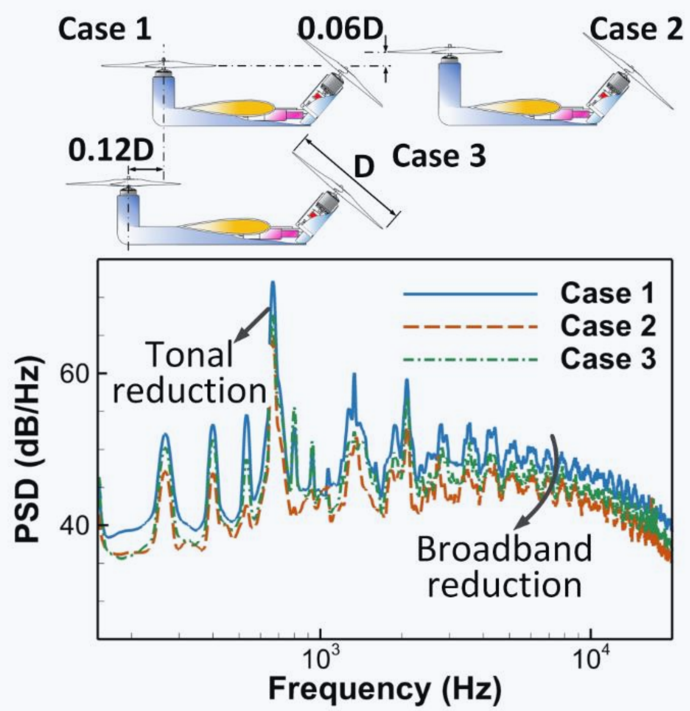
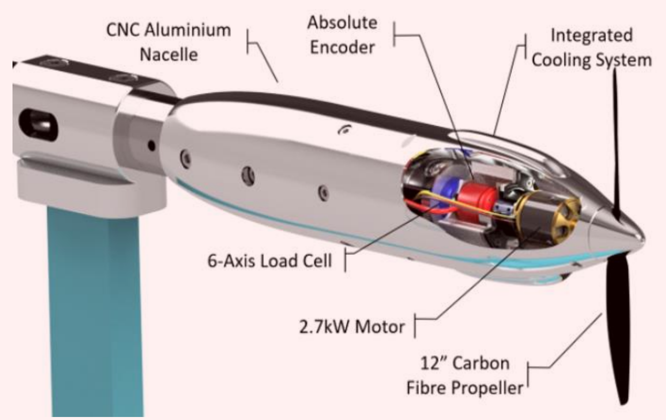
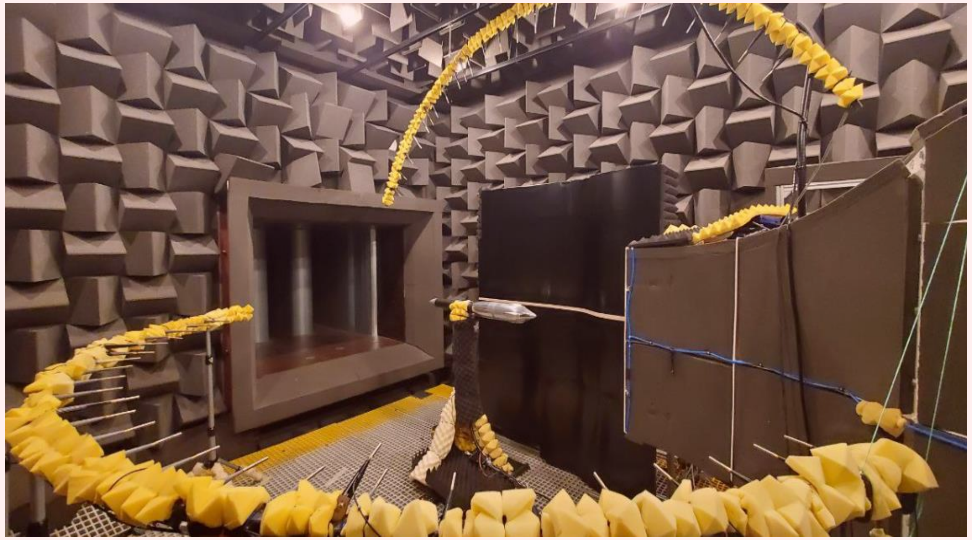
Tandem rotors

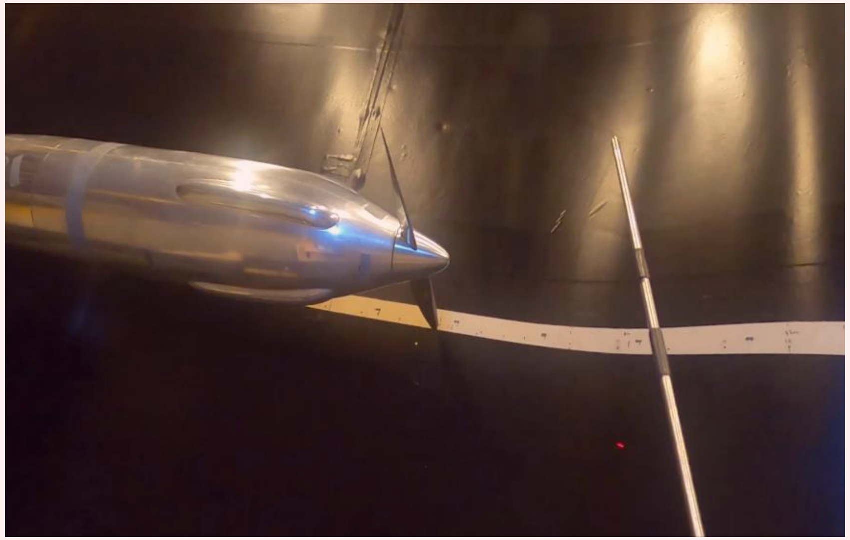




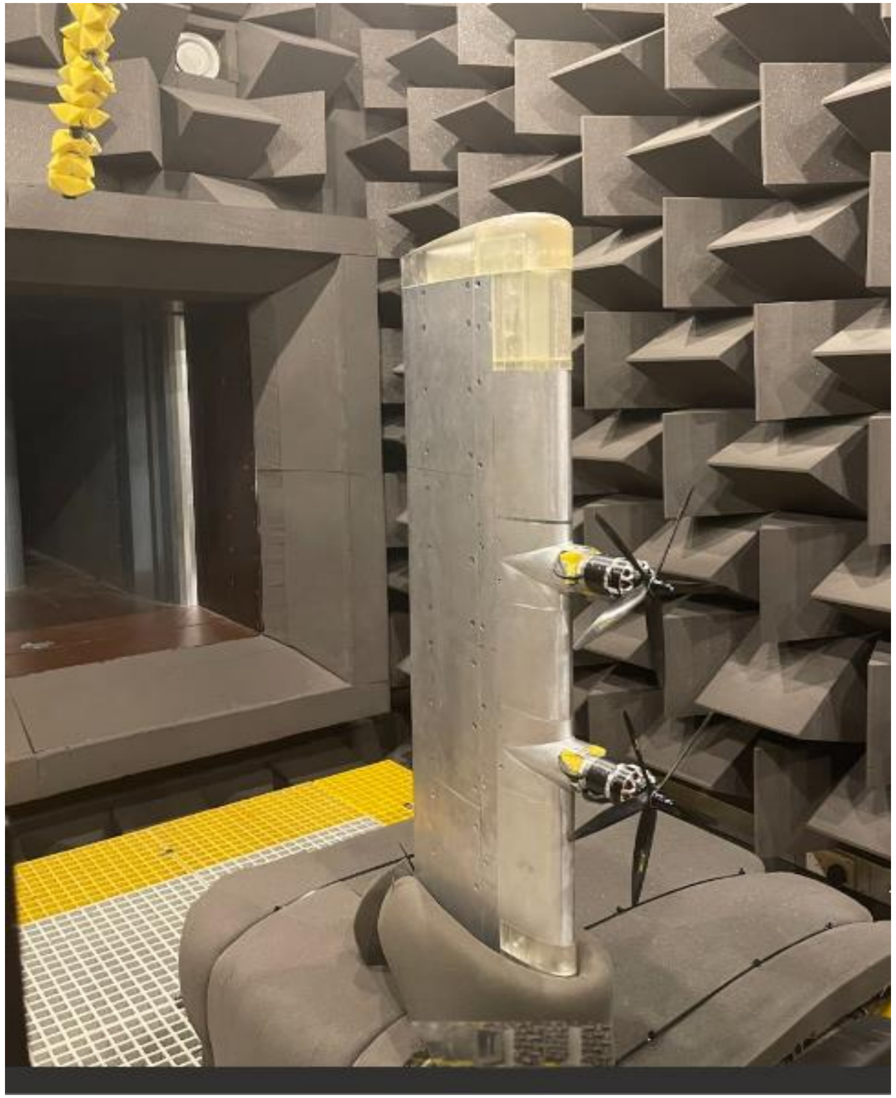
Boundary Layer Ingestion

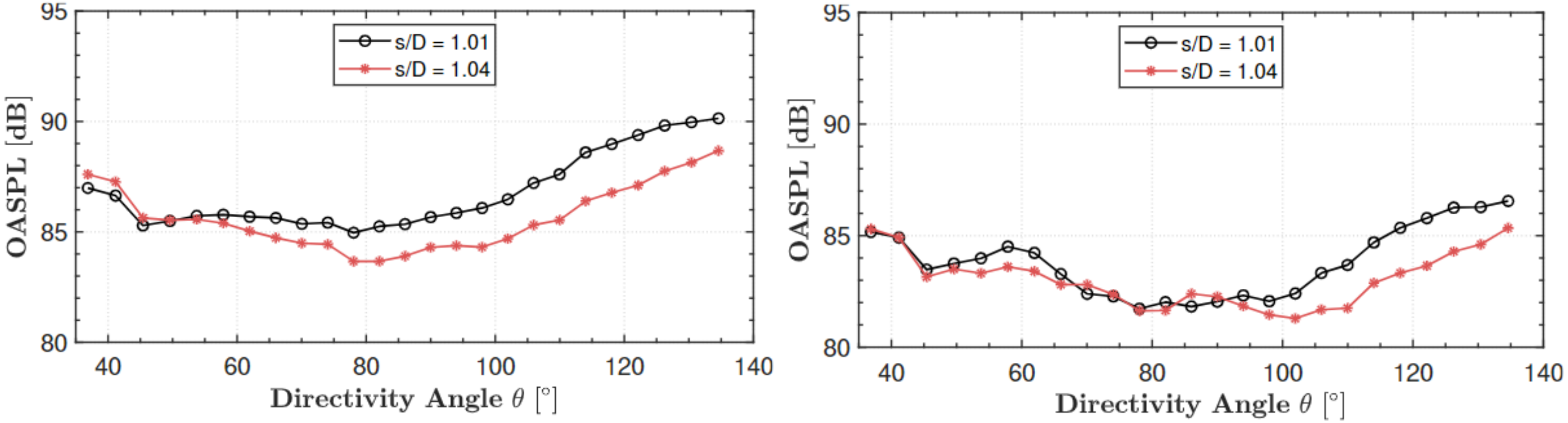






Distributed Electric Propulsion (DEP)





(a) $J = 0.46$

(b) $J = 0.72$

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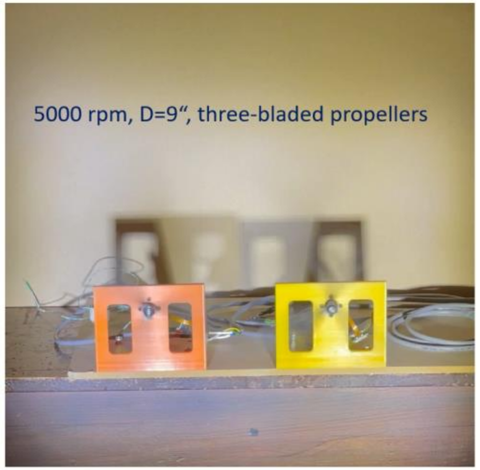
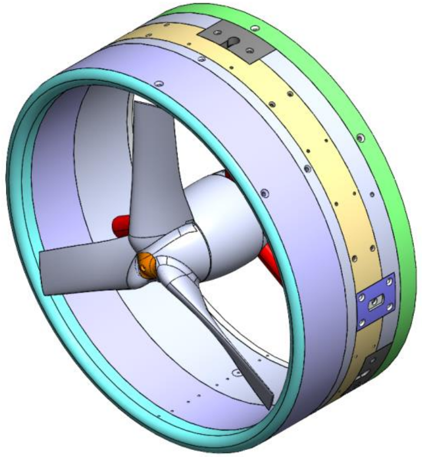
Clean Sky 2
University of Nottingham UK | CHINA | MALAYSIA

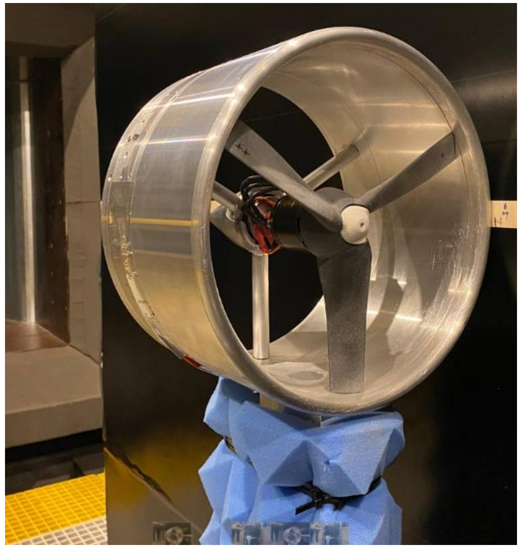
The high-speed camera view of the phased-locked propellers at φ=0°

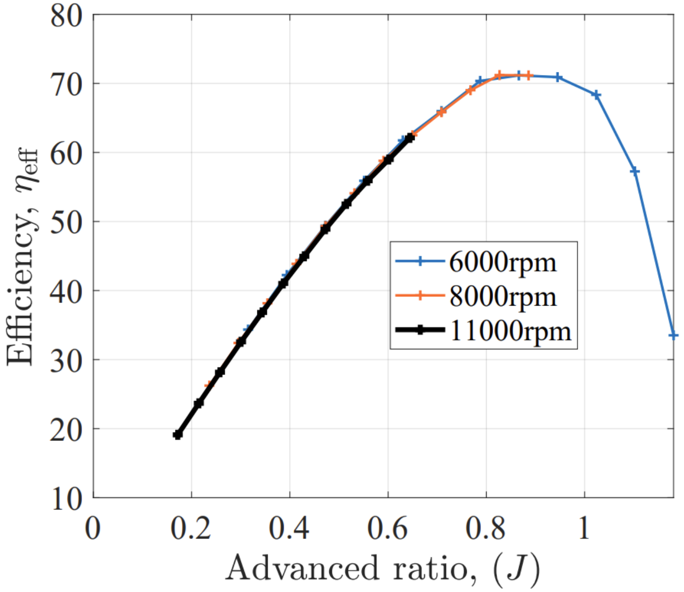


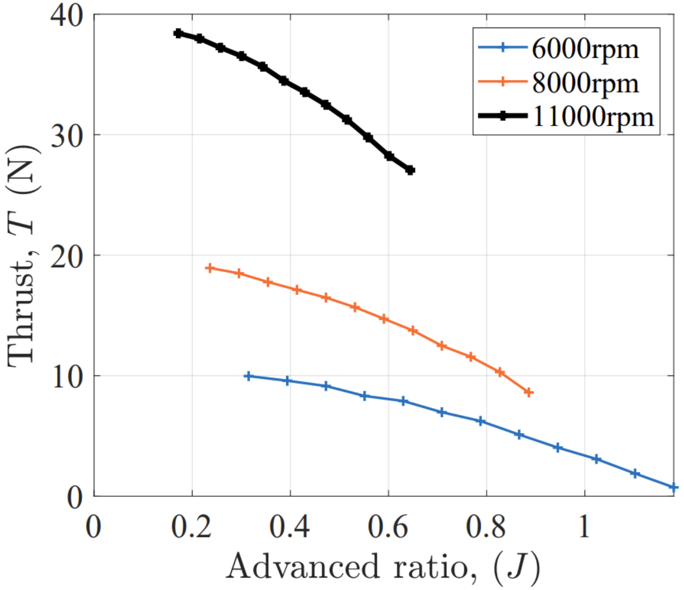
High-Speed camera setup for side-by-side configuration

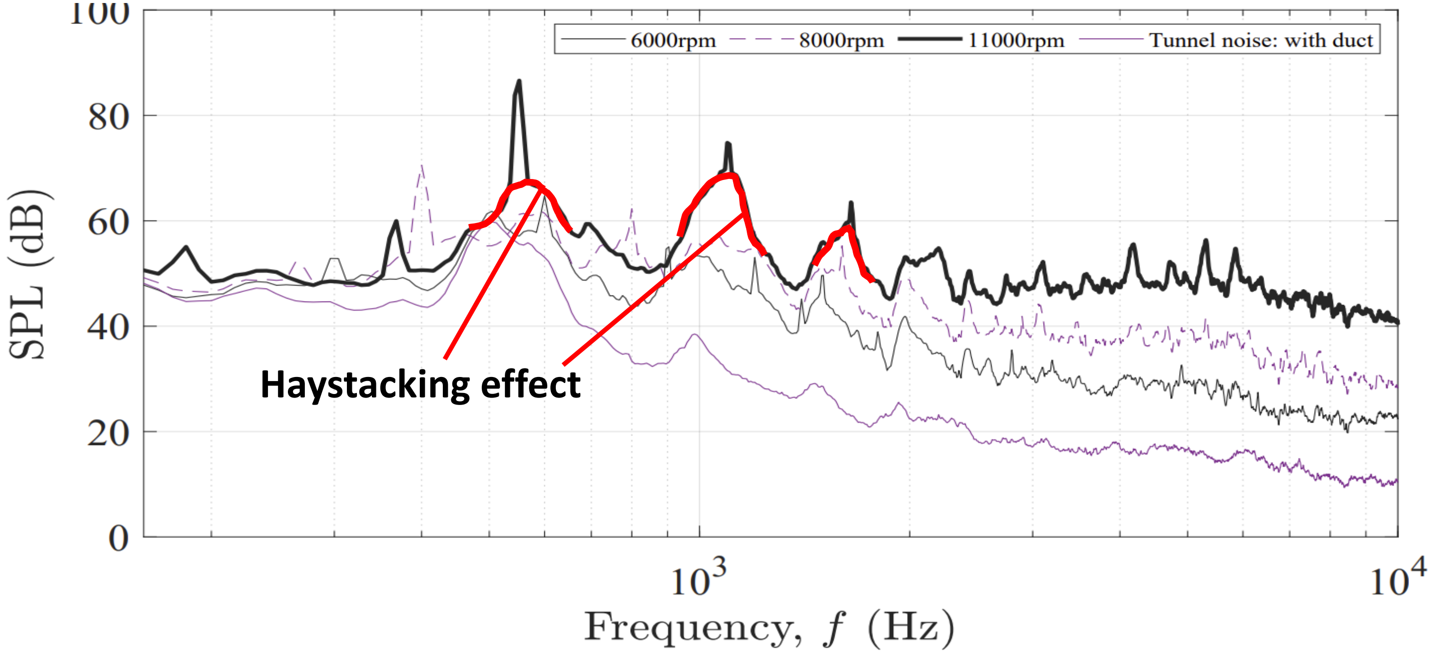
Ducted propellers











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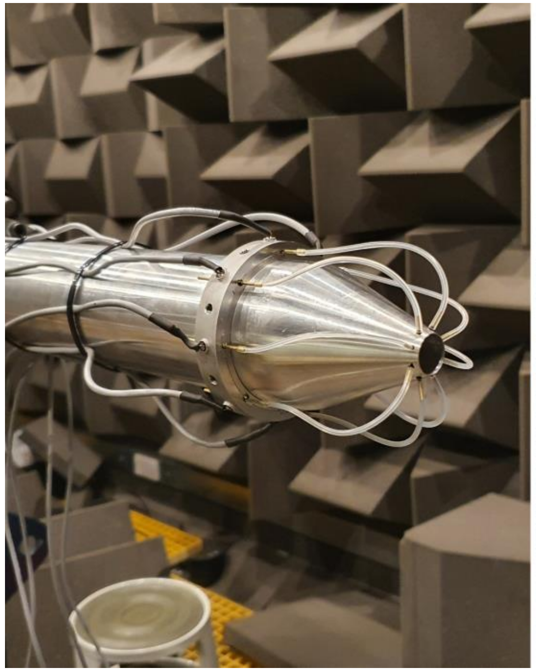
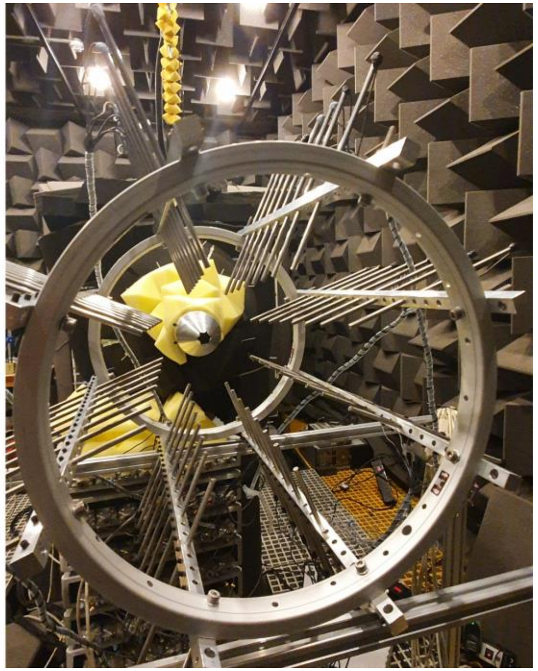
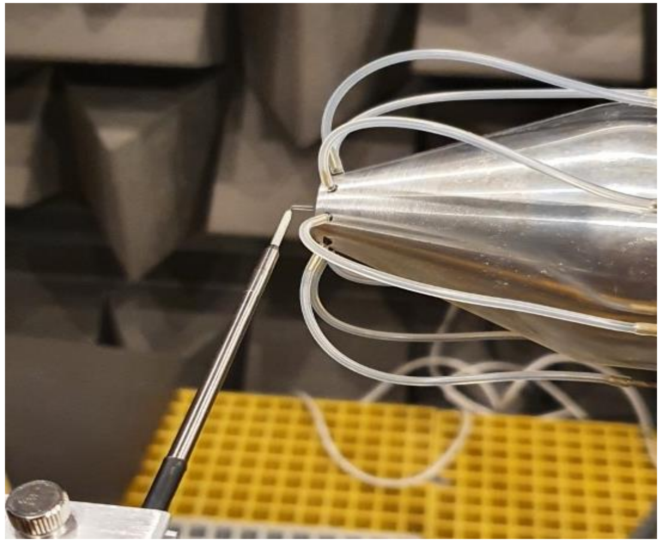
High-speed jet

- Far field array with over 70 mics - GRAS 40PL/46BE
- Near-field linear array GRAS 46BE
- Wall-mounted Kulite sensors
- Near/far field array using FG mics 64 mics.
- Beamforming arrays (80 mics)
- National Instrument, 10+ PXle-4499 cards, 160 channels
- TR-PIV
- Dantec Hotwire – single/cross wires, 90 degree probes
- Schlieren imaging (FASTCAM SA-Z)







High speed flow regimes

Subsonic studies

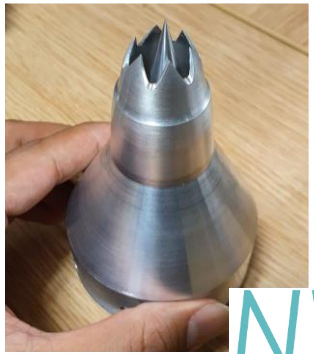
It can reach Mach number of 0.9 based on Bridges and Brown
Scarfed nozzles between 10 and 40 degrees
Several elliptic and rectangular nozzles

SMC 000 SMC 001 SMC 002 SMC 003

Supersonic studies

It can reach up to jet Mach number of 2-3

Nozzles fitted with a **stubbed and sharp plug**



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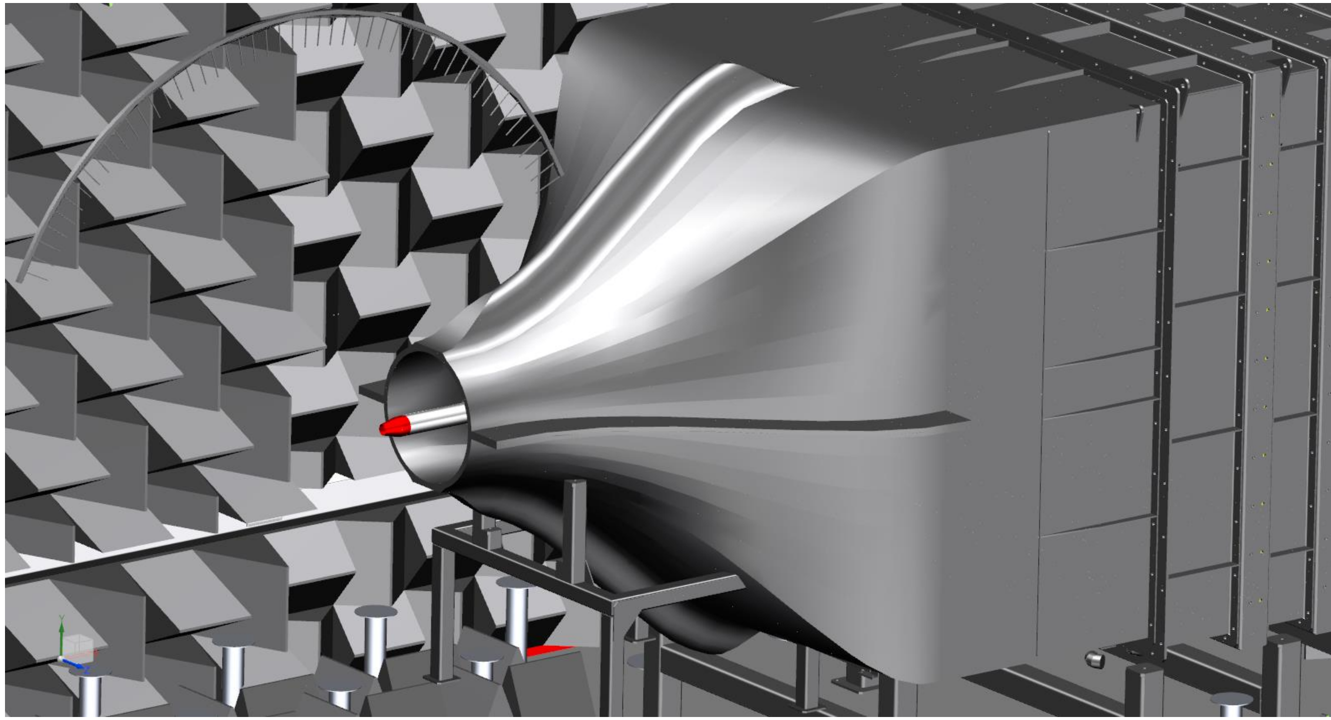
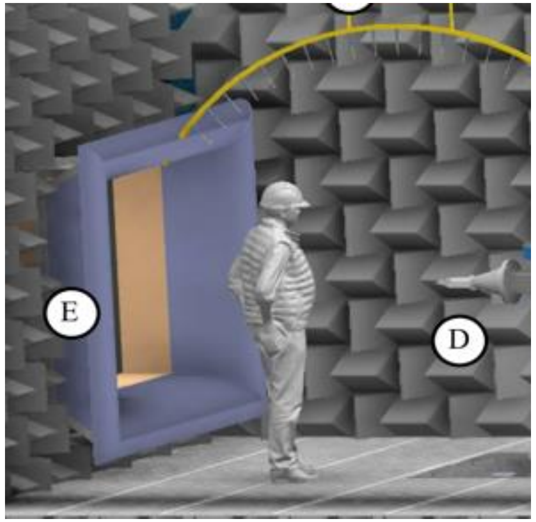
Flight stream configuration

- Flight stream velocity of up to 100m/s
- Temperature control
- Active flow removal from the chamber
- Jet Mach number range of 0.2 < M < 0.9.



Flight stream and jet nozzles



Collector

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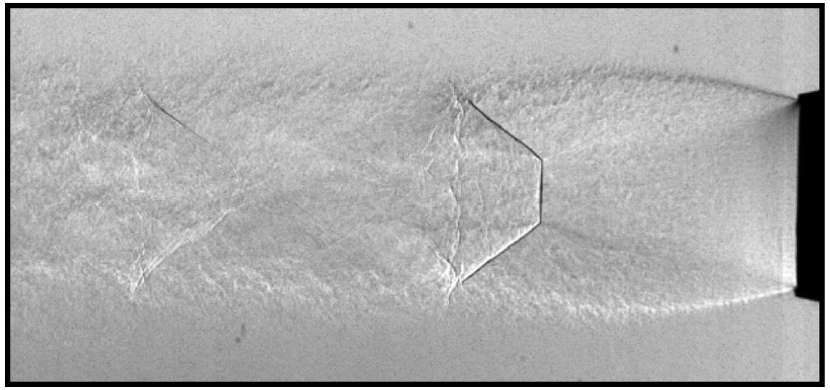
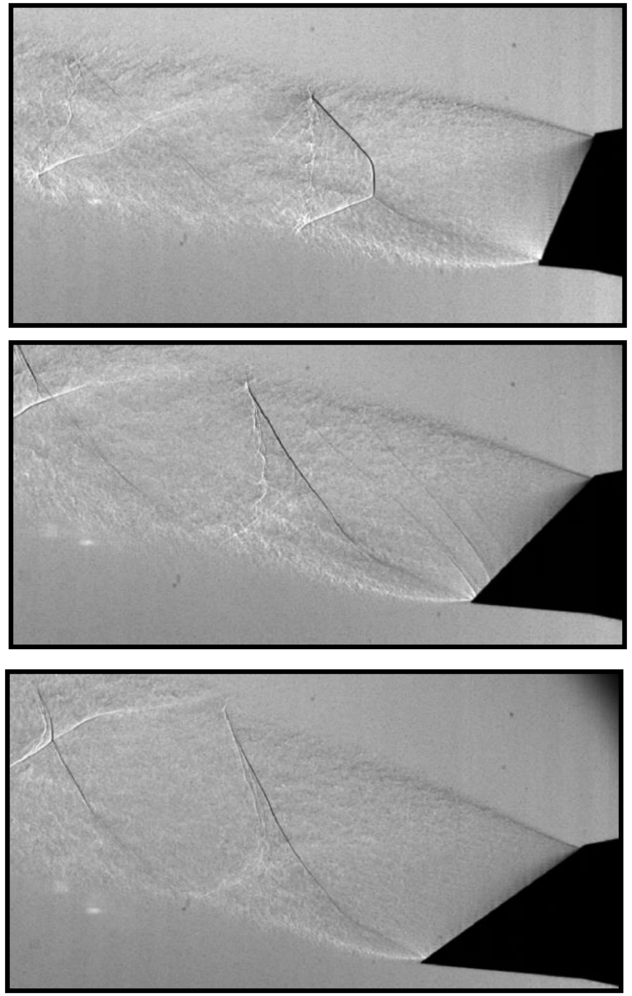
Supersonic jets

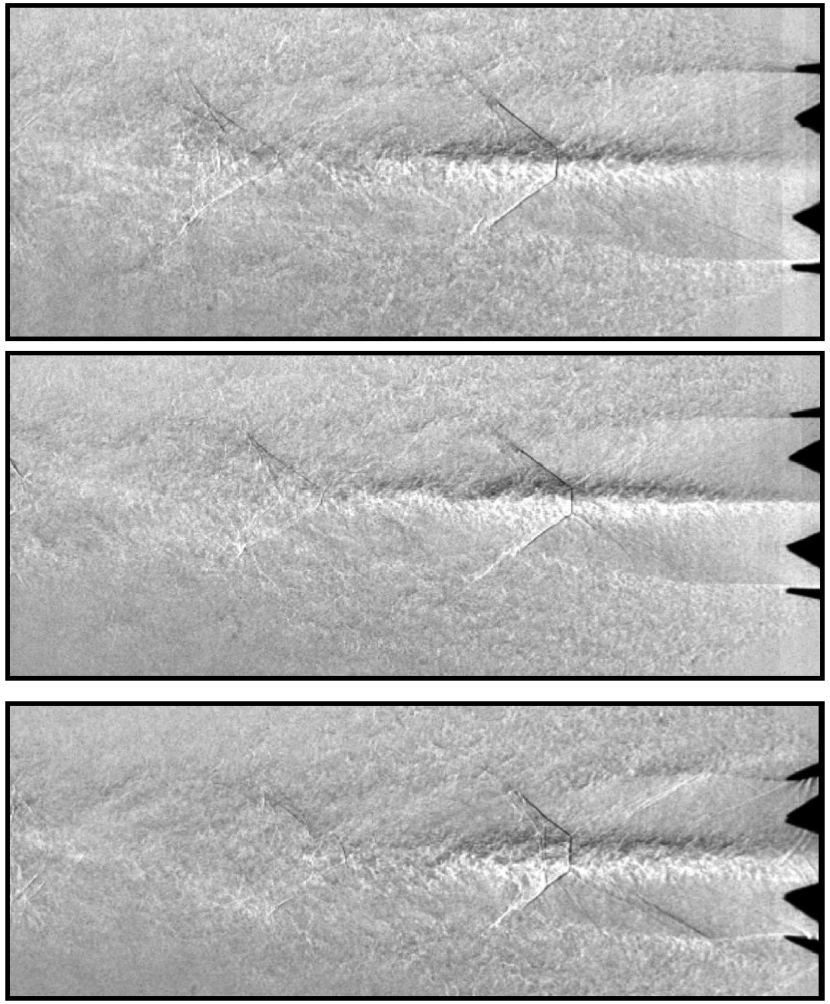
Round nozzle



Scarfed nozzle

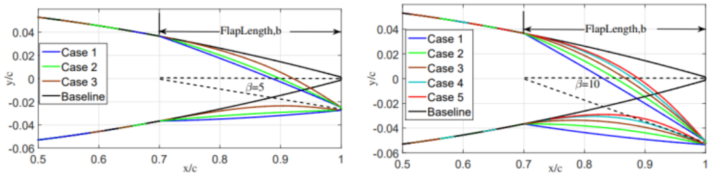


Chevron nozzle

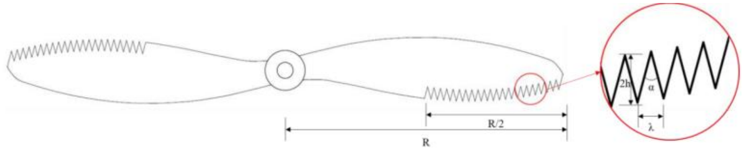


Noise control technologies

- **Serrated aerofoils**
- **Porous treatments**
- **Morphing structures**
- **Surface treatments**
- **Flow suction**
- **Flow injection**
- **Micro and sweeping jets**

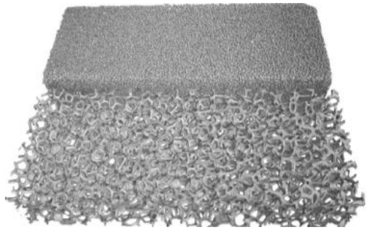


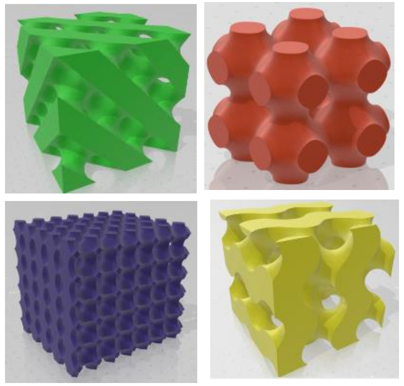
Passive morphing



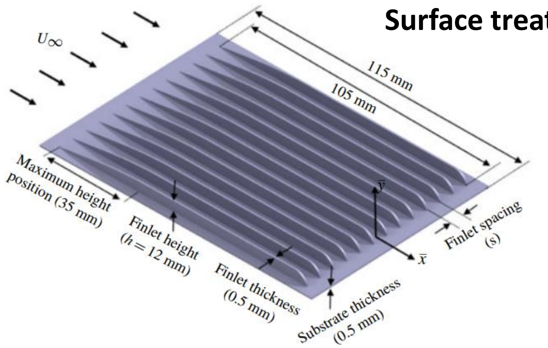
Serrated trailing-edge

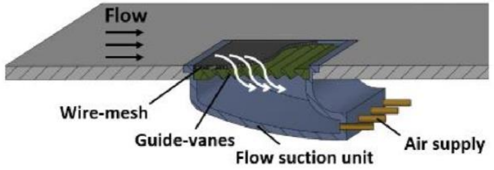
Porous treatment

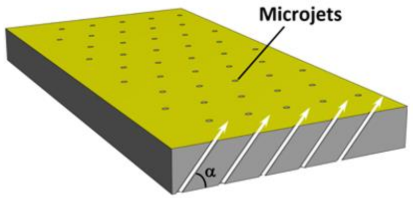


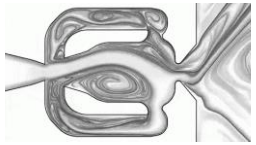


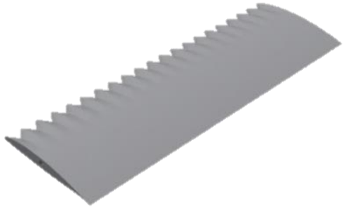
Surface treatments

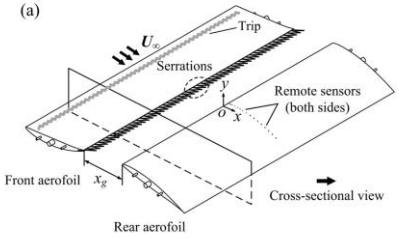


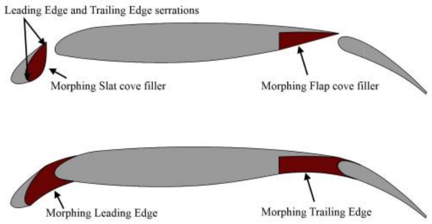












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Summary

- The National Aeroacoustic wind tunnel at the University of Bristol is a multi-purpose facility
- A strong academic and technician team is formed around the facility
- The facility is well equipped
- The facility enables high-fidelity fundamental turbulence, aerodynamic and aeroacoustic studies, as well as industrial and consultancy activities
- The facility has been used by over 15 external teams