Future Needs for Experiments in Aerodynamics 2018 – 2038

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City, University of London

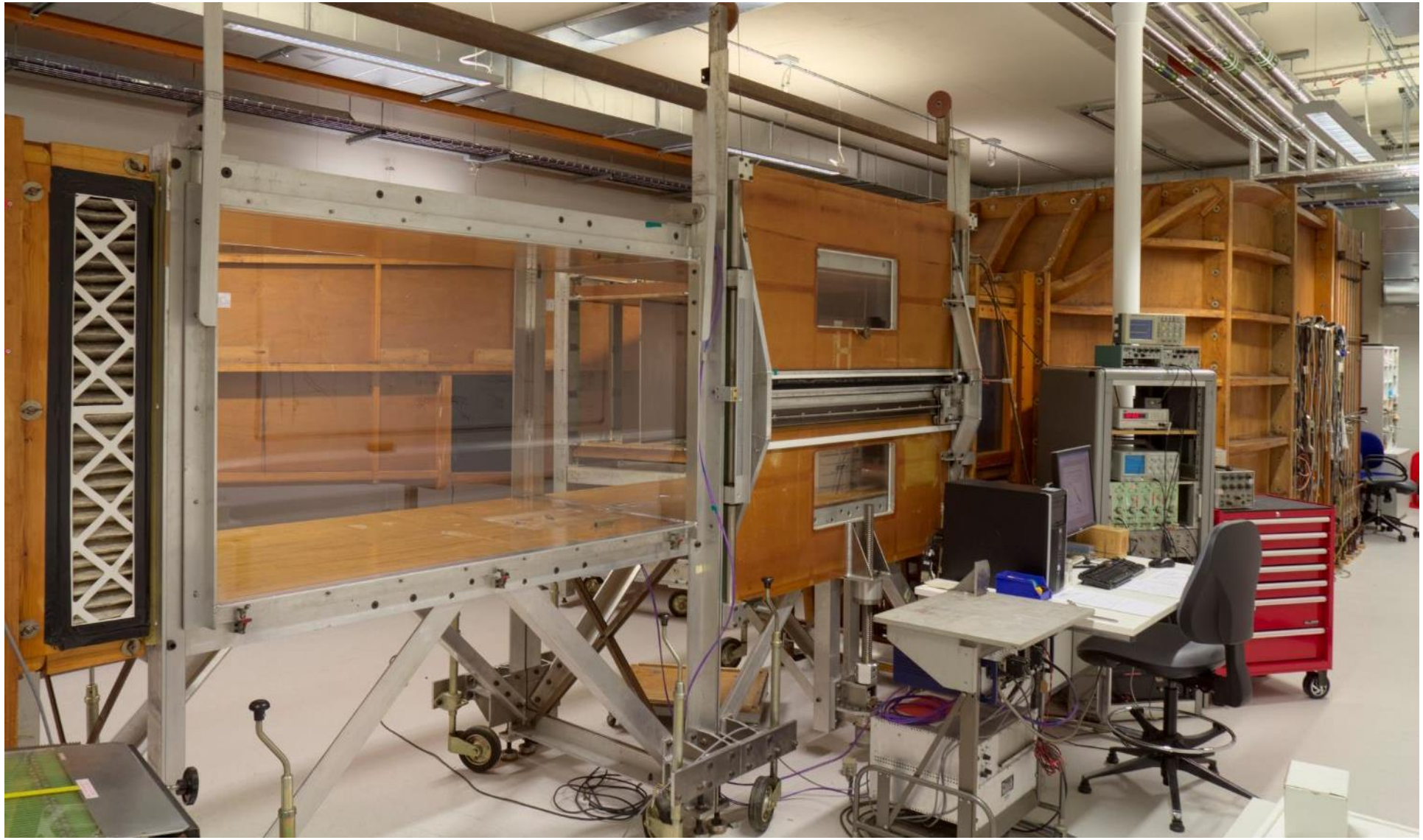
Acknowledgements

In chronological order:

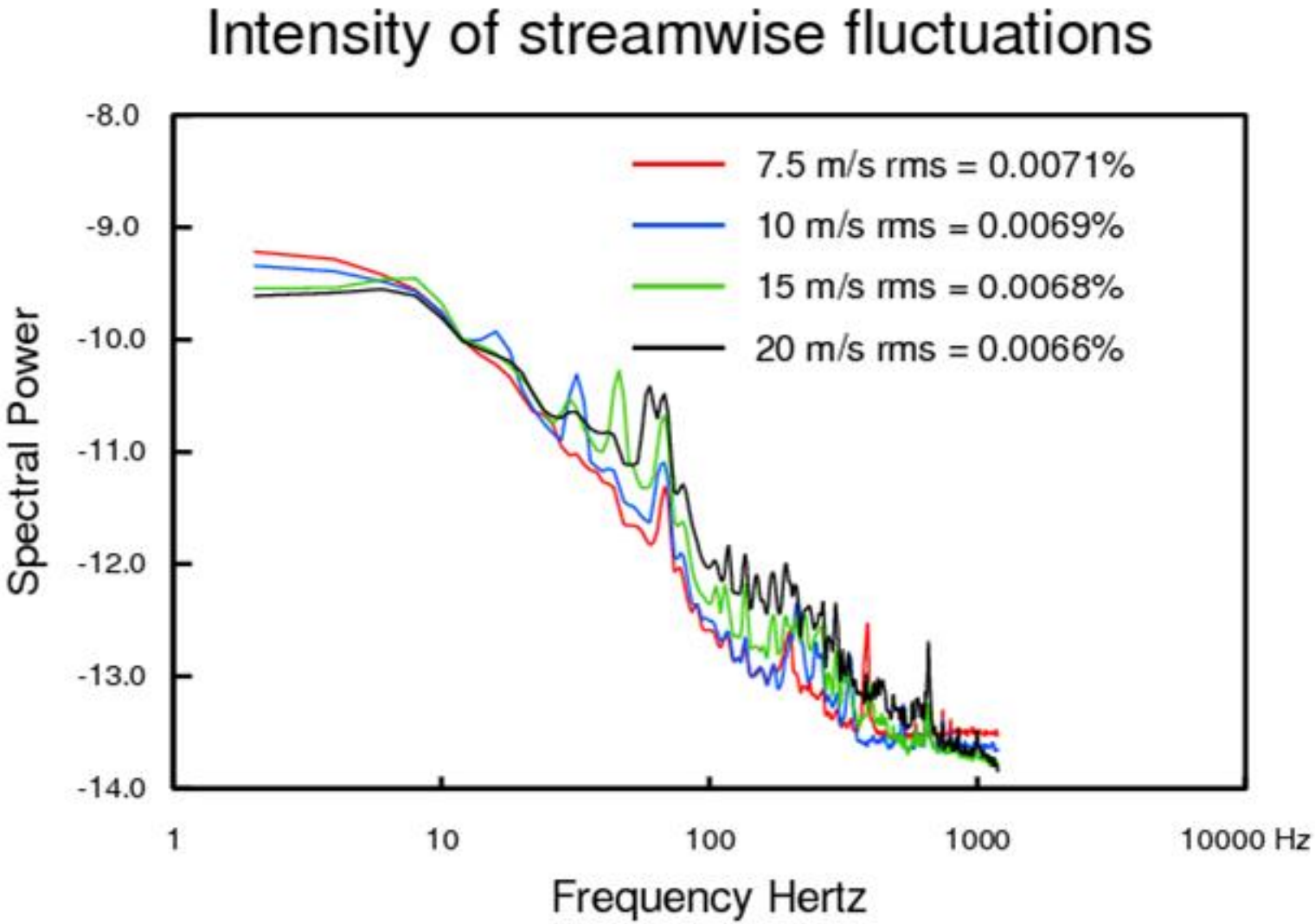
- Airbus Group Innovations
- City, University of London
- BMT Ltd
- Department of Business, Enterprise, Innovation & Skills
  - Gaster Tunnel Grant (UK Aerodynamics)
- Engineering and Physical Sciences Council
  - National Wind Tunnel Facility
  - Deterministic Turbulence Project
- InnovateUK, Airbus & Bombardier

The Low-Turbulence Wind Tunnel

The Low-Turbulence Wind Tunnel



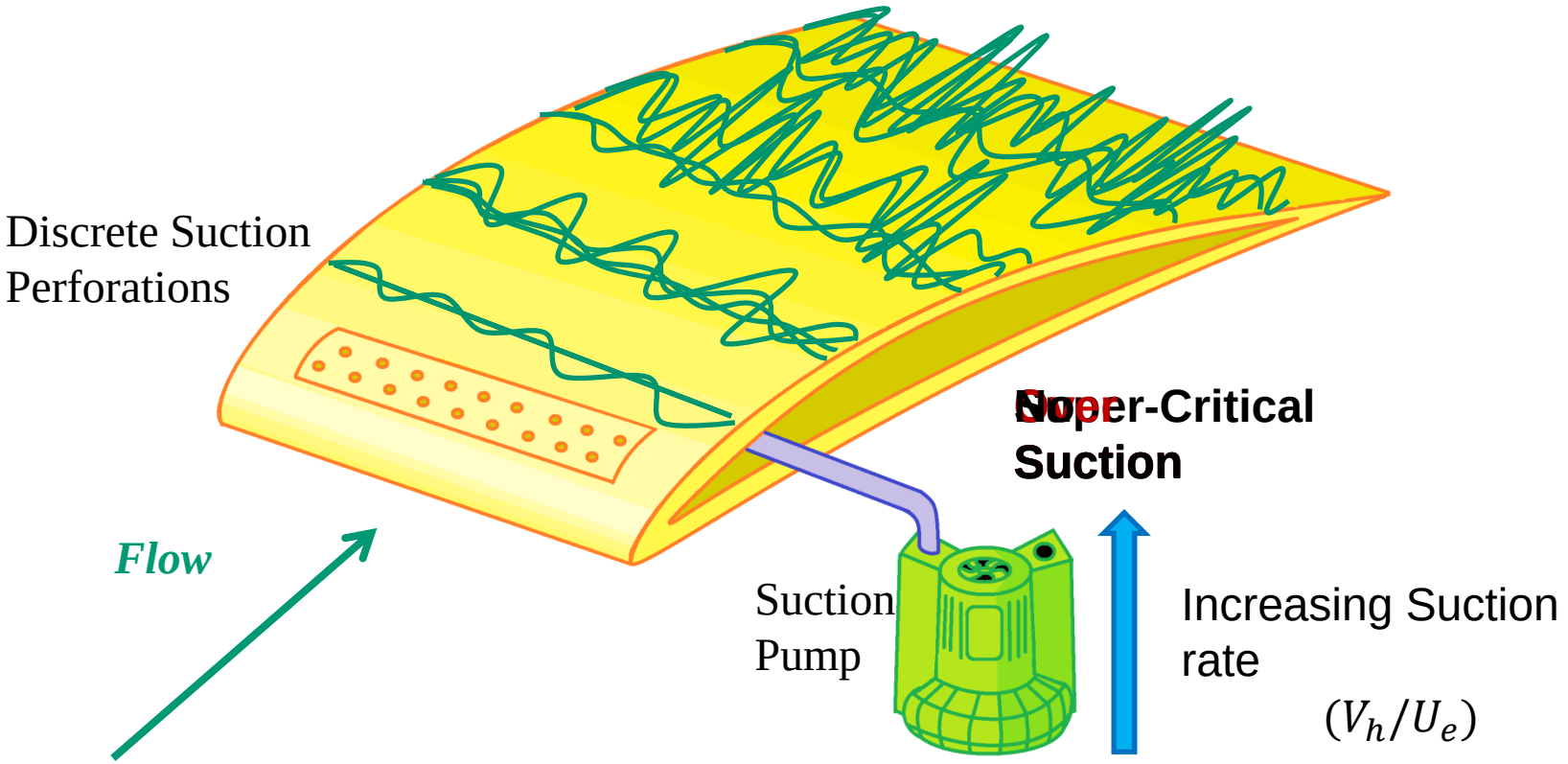
Free-stream Turbulence – Power Spectra



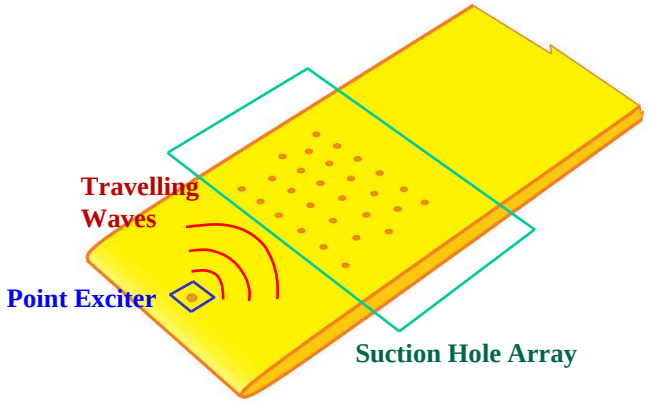
Effectiveness of LFC by Suction

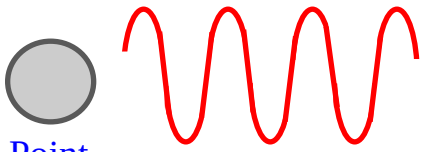
Mr Barry Crowley

Discrete Effects of Suction



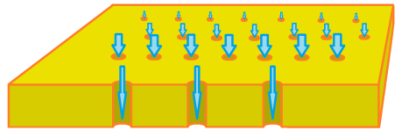
Flat Plate Experiment





Point
Exciter

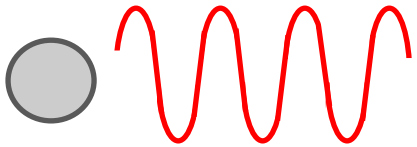
Travelling Waves



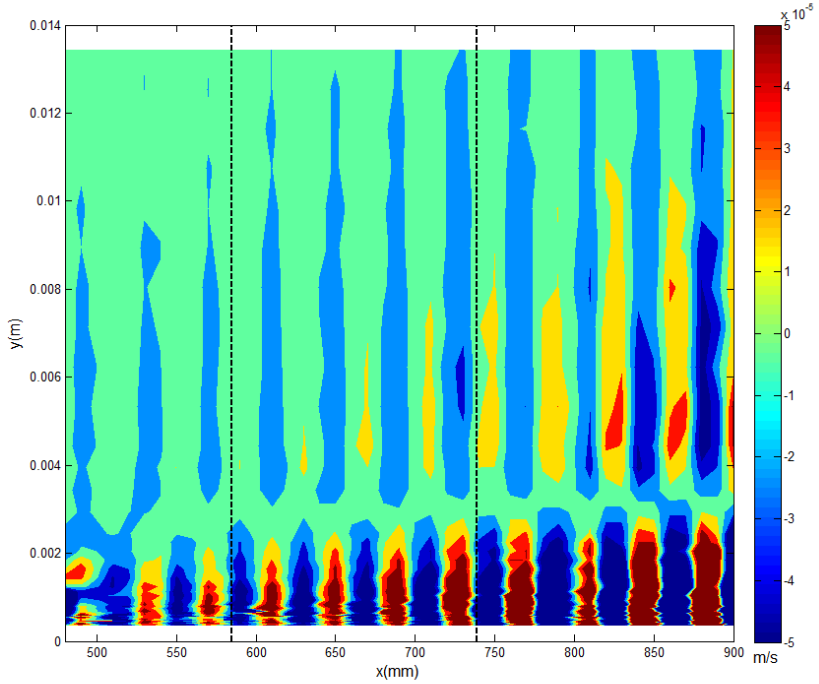
Suction Hole Array

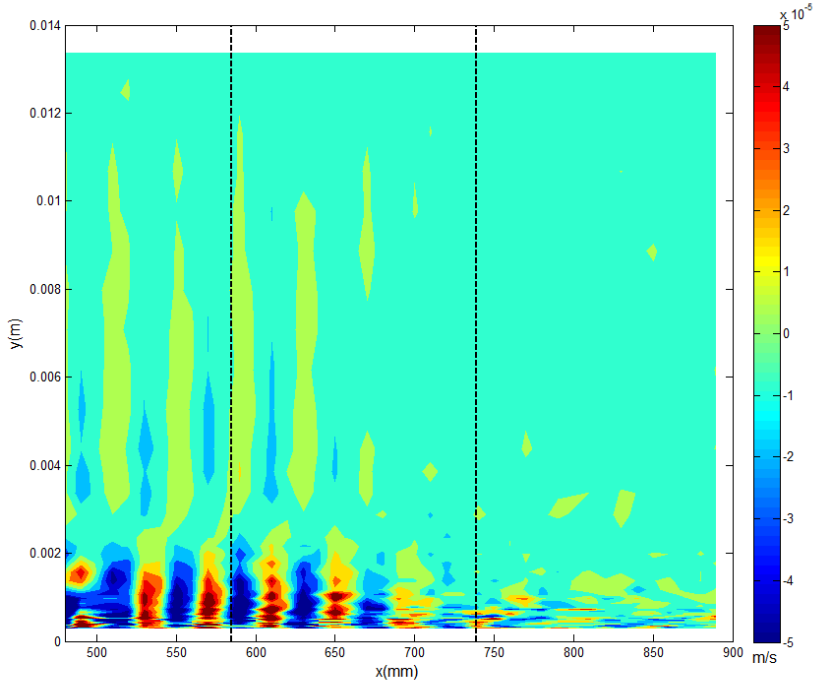
Excited Fourier Mode

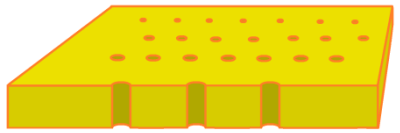
Free-Stream Velocity=14m/s



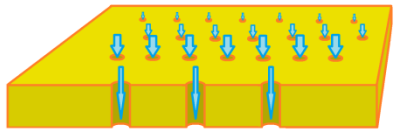
121Hz







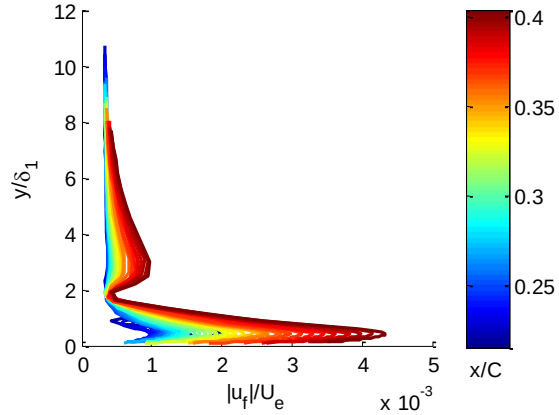
No Suction
(Holes Covered)

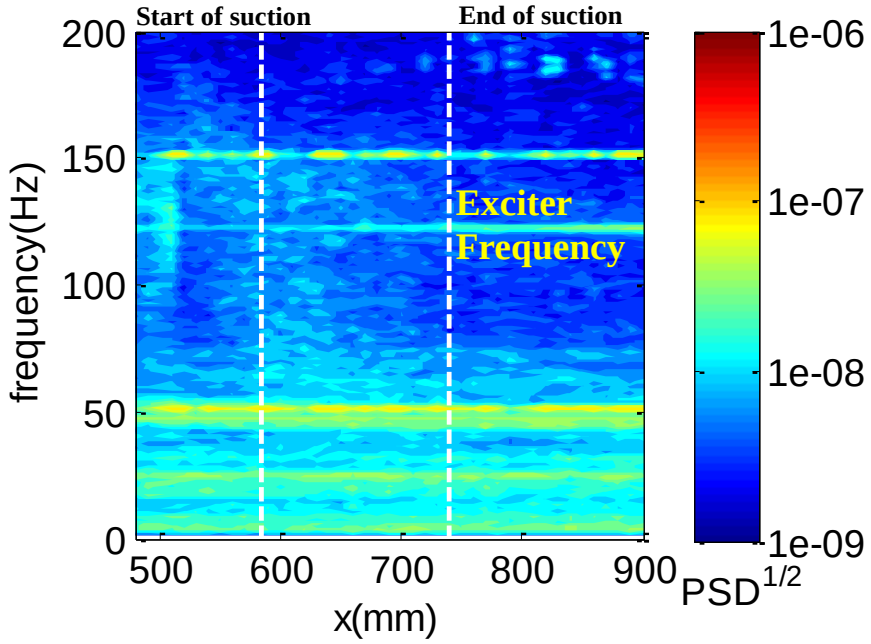


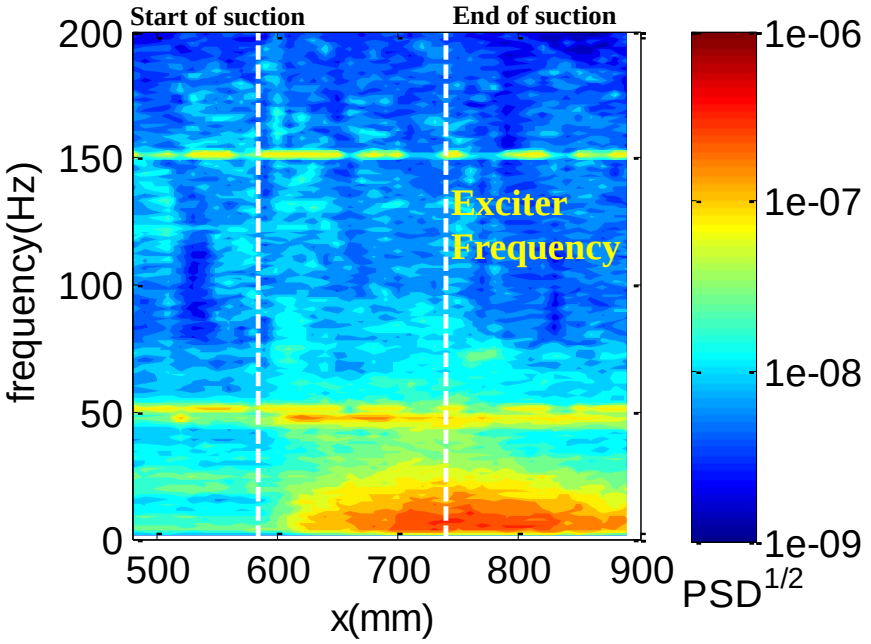
Suction
(32 L/min)

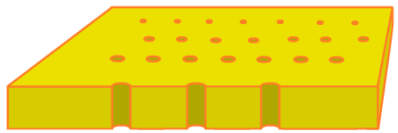
Excited Fourier Mode

Free-Stream Velocity=14m/s

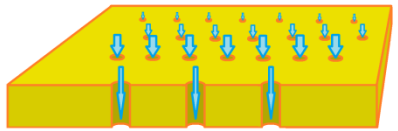






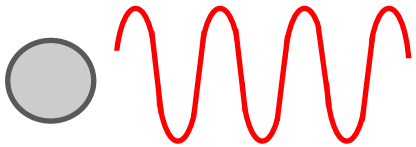


No Suction
(Holes Covered)



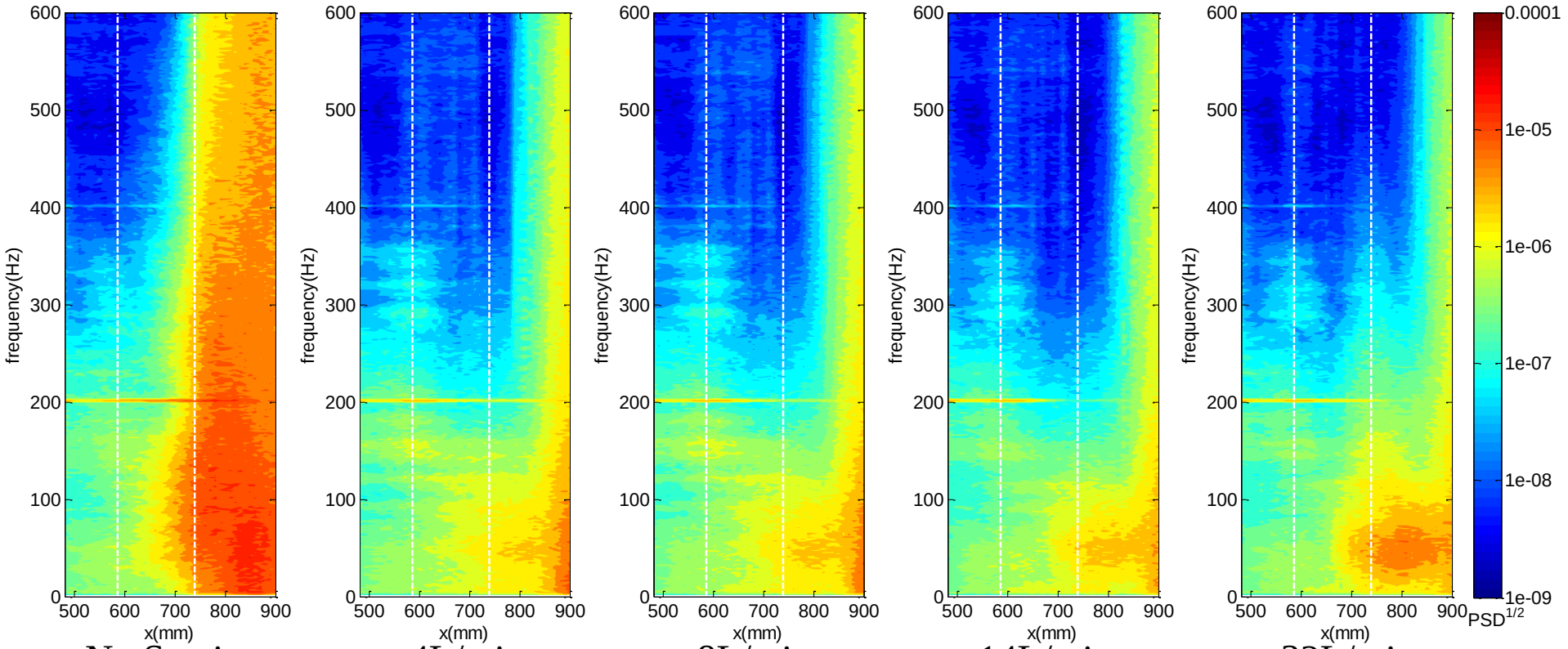
Suction
(32 L/min)

Results (Stronger Forcing)



Free-Stream Velocity=14m/s

Increasing Suction → Increasing Suction → Increasing Suction → Increasing Suction



No Suction, No Holes | 4L/min | 8L/min | 14L/min | 32L/min

Forcing of Crossflow Vortices

Dr Marco Placidi, Ms Evelien van Bokhorst

Experimental design of a swept test bed

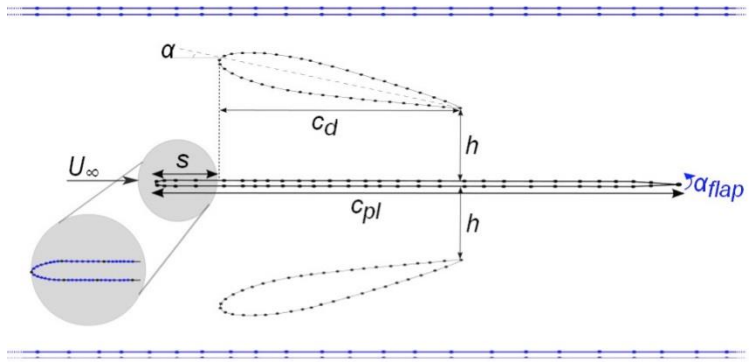
Requirements

- Flat plate + displacement body
- Encourage CF instability (Λ + Δp)
- Force CF using roughness elements

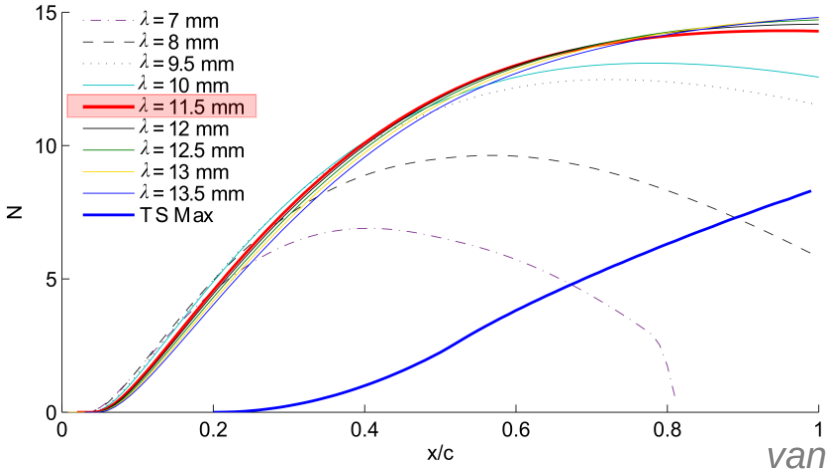
Linear stability analysis

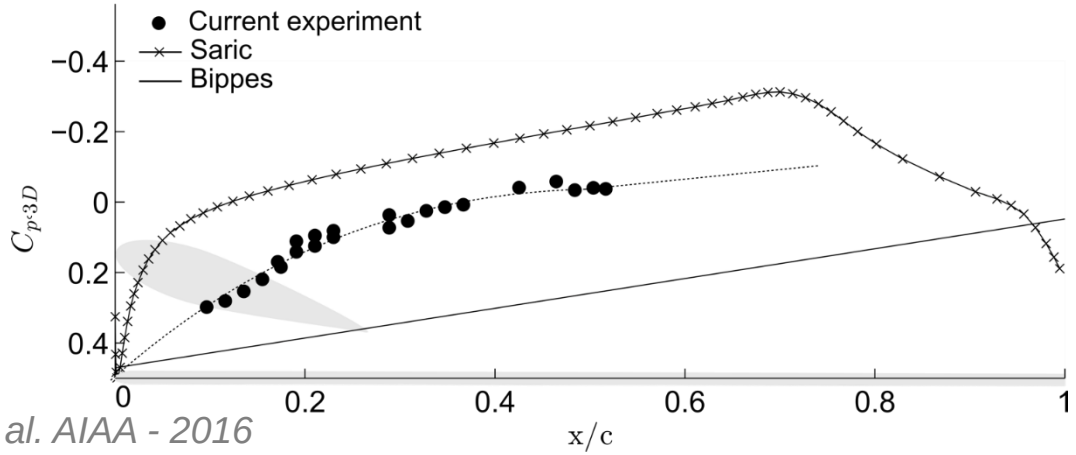
- CF dominated flow (T-S waves damped)
- Neutral stability point (NSP)
- Wavelength of most unstable wave (λ)

Panel Code Design



van Bokhorst et al. IACP - 2015

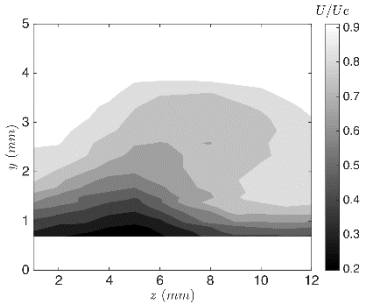




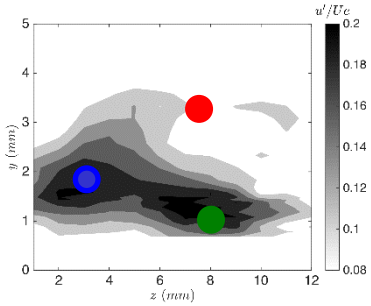
van Bokhorst et al. AIAA - 2016

Basic structure of Stationary CFVs

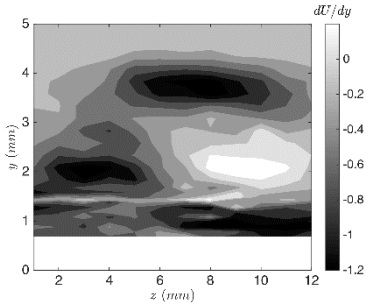
- Fully developed CFVs (x/c = 40 %) present three areas of high intensity fluctuations
- Our tests capture these features previously reported in the literature



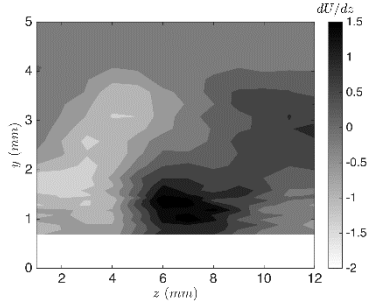
Mean velocity



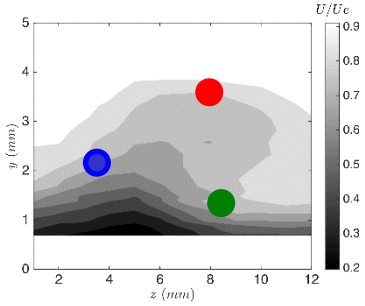
Fluctuations



dU/dy



dU/dz



Type I instability

$(dU/dz)_{min}$

Z-mode

Type II instability

$(dU/dy)_{high}$

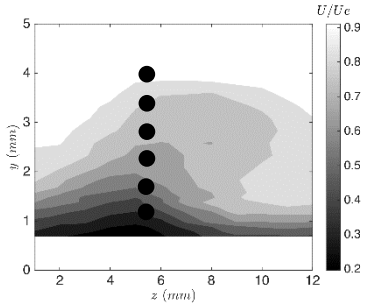
Y-mode

Type III instability

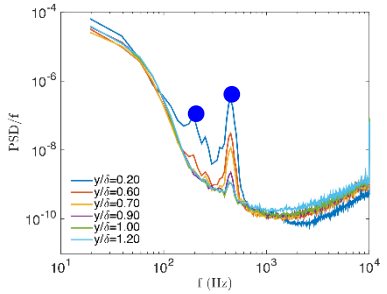
$(dU/dz)_{max}$
High and low patches
(spanwise gradient)

CFVs spectral considerations

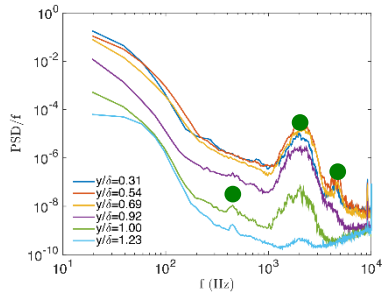
- Tests capture all features previously reported in the literature



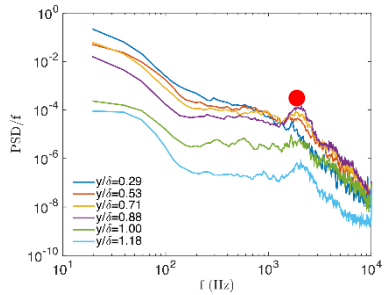
Mean velocity



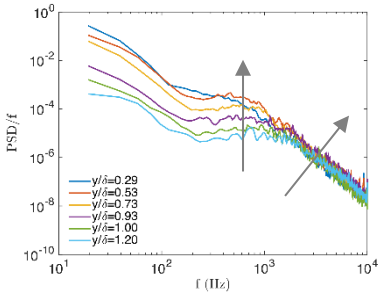
x/c = 27 %



x/c = 35 %



x/c = 42 %



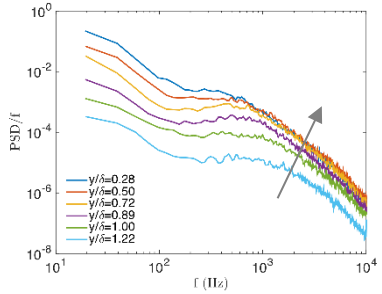
x/c = 47 %

Location x/c = 27 %

- 150 - 200 Hz CF_t
- 350 - 550 Hz T-S?
- No high f activity

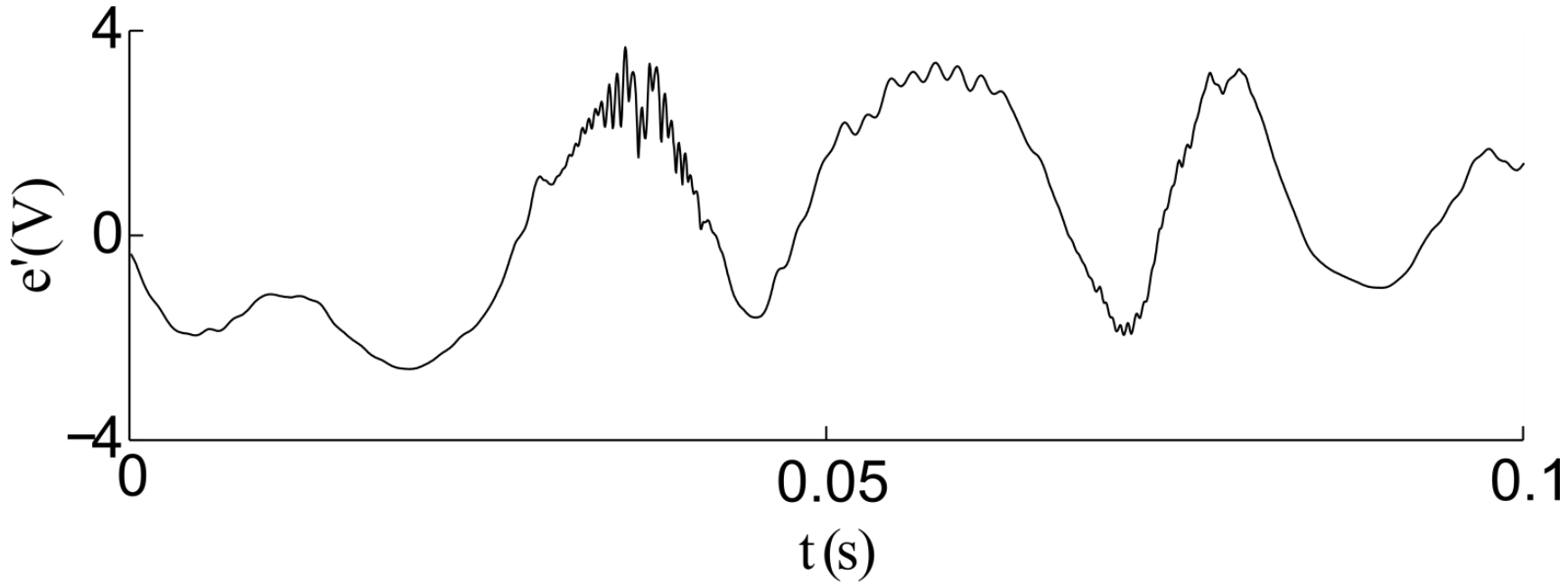
Location x/c = 35 %

- 150 - 550 Hz (↓)
- 1.5 - 3 kHz
- 4 - 5 kHz



x/c = 51 %

Onset of high frequency bursts



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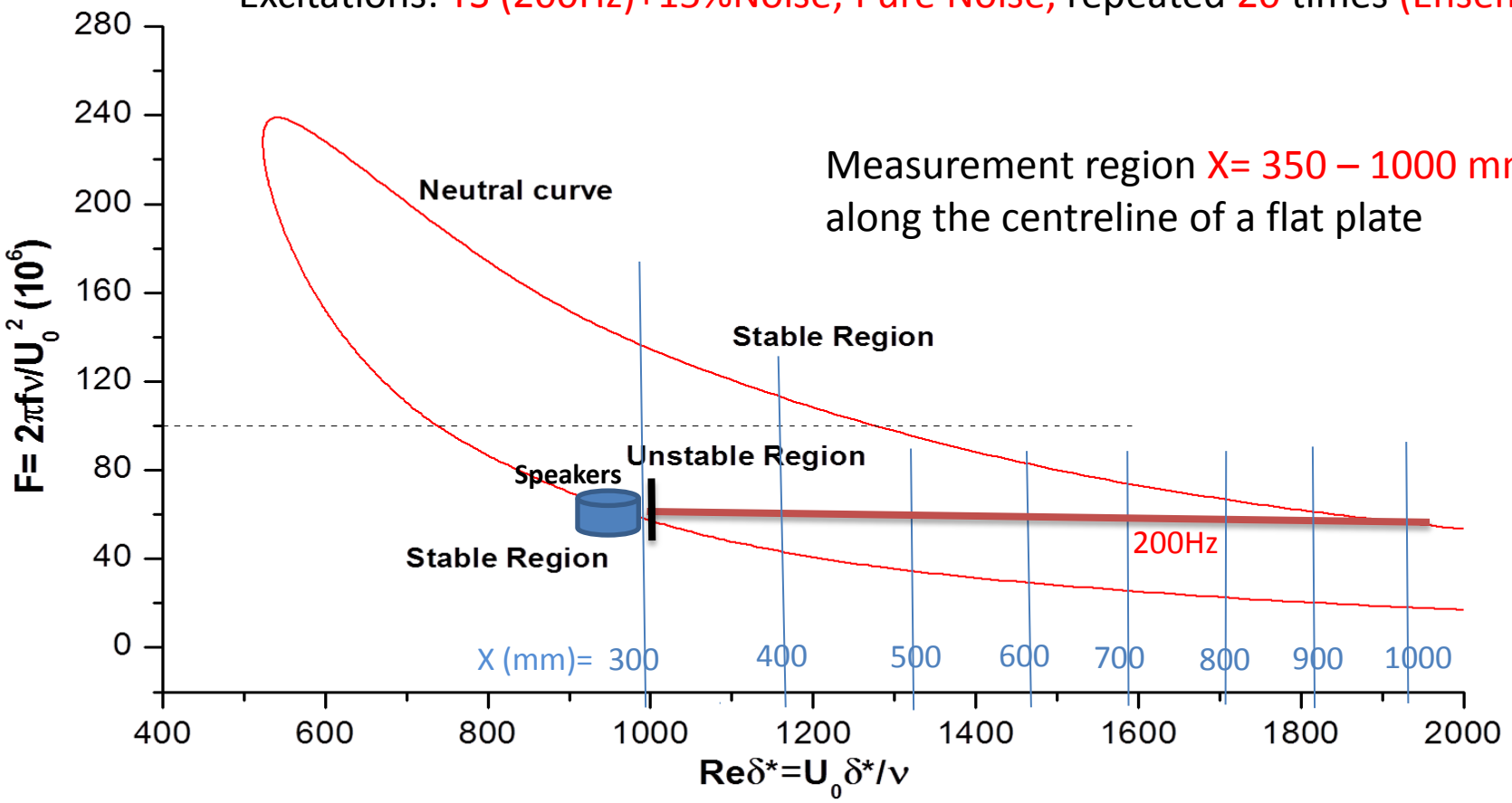
UNITED KINGDOM · CHINA · MALAYSIA

Deterministic Turbulence Project
PI Prof K-S Choi, Nottingham

Researcher: Dr Yaxing Wang

Experimental Regime

Experiments in Gaster WT, City University
Excitation sources: 19 miniature speakers (ϕ12 mm) embedded in a flat plate, at X=325mm, covering a span of 320 mm
Excitations: TS (200Hz)+15%Noise; Pure Noise, repeated 20 times (Ensemble)



Measurement region X= 350 – 1000 mm along the centreline of a flat plate

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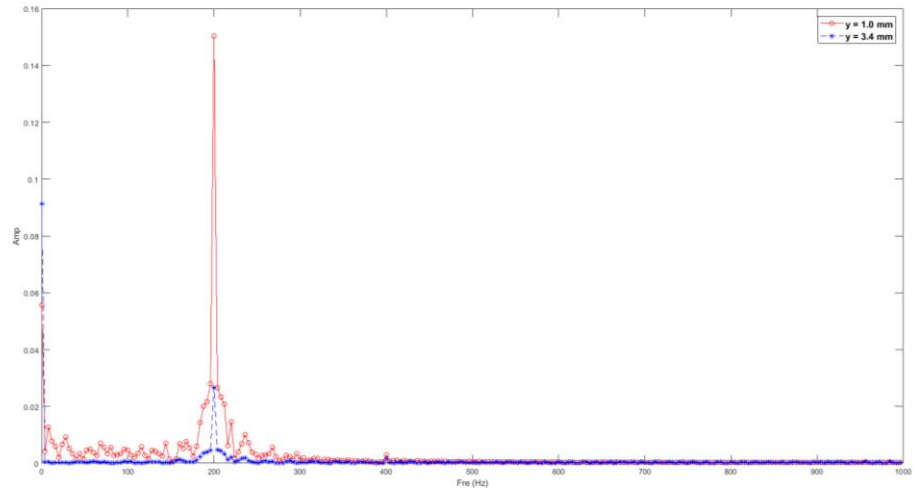
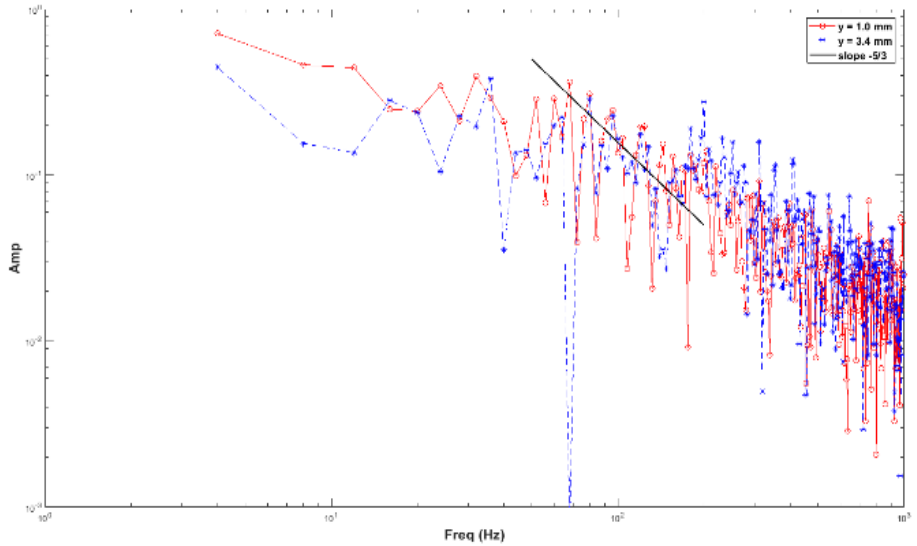
Forcing: TS @200Hz + 15% Noise

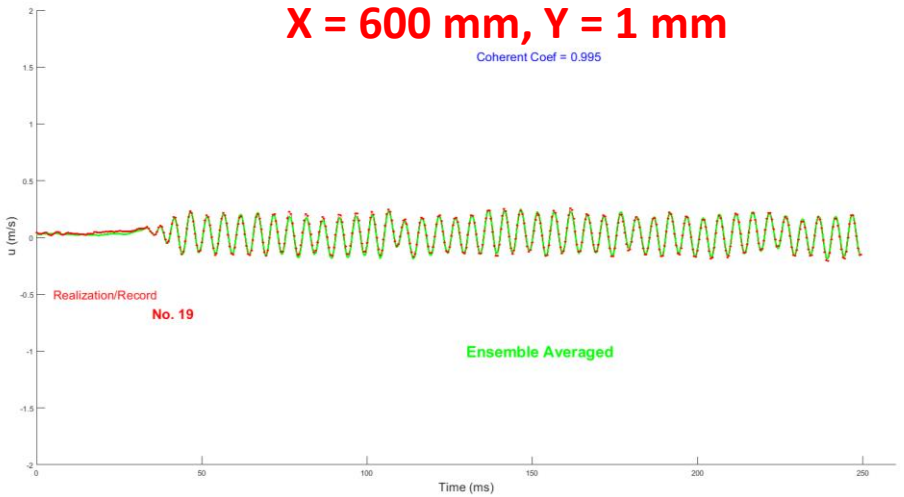
Spectra @ y = 1 mm & y = 3.4mm



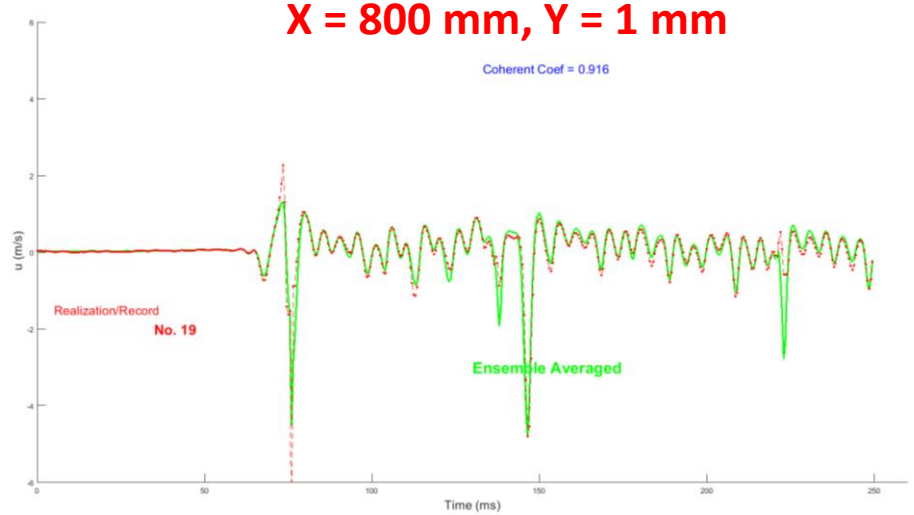


Instantaneous & Ensemble-Averaged Signal

X = 600 mm, Y = 1 mm



X = 800 mm, Y = 1 mm



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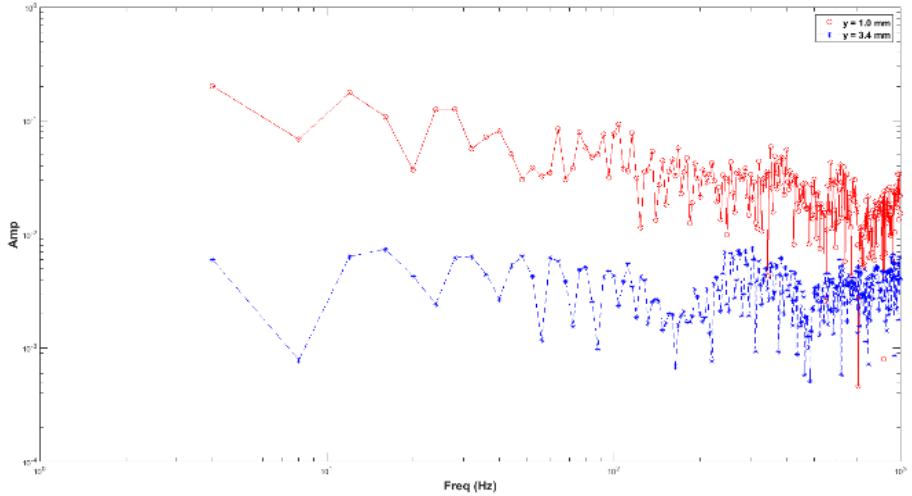
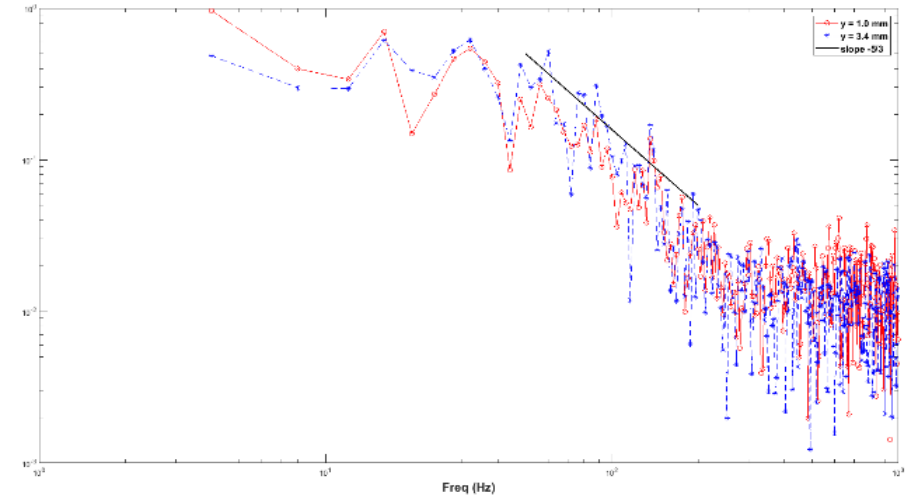
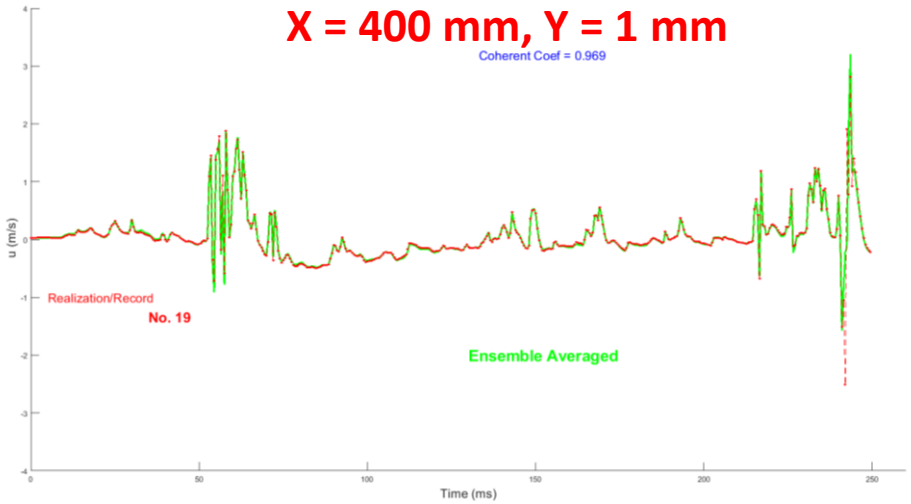
Forcing: Just White Noise

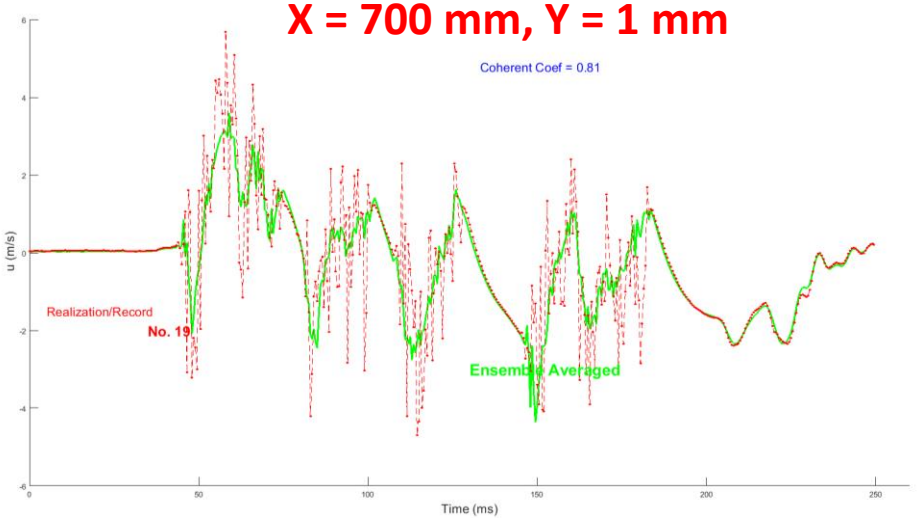
Spectra @ y = 1 mm & y = 3.4mm





Instantaneous & Ensemble-Averaged Signal





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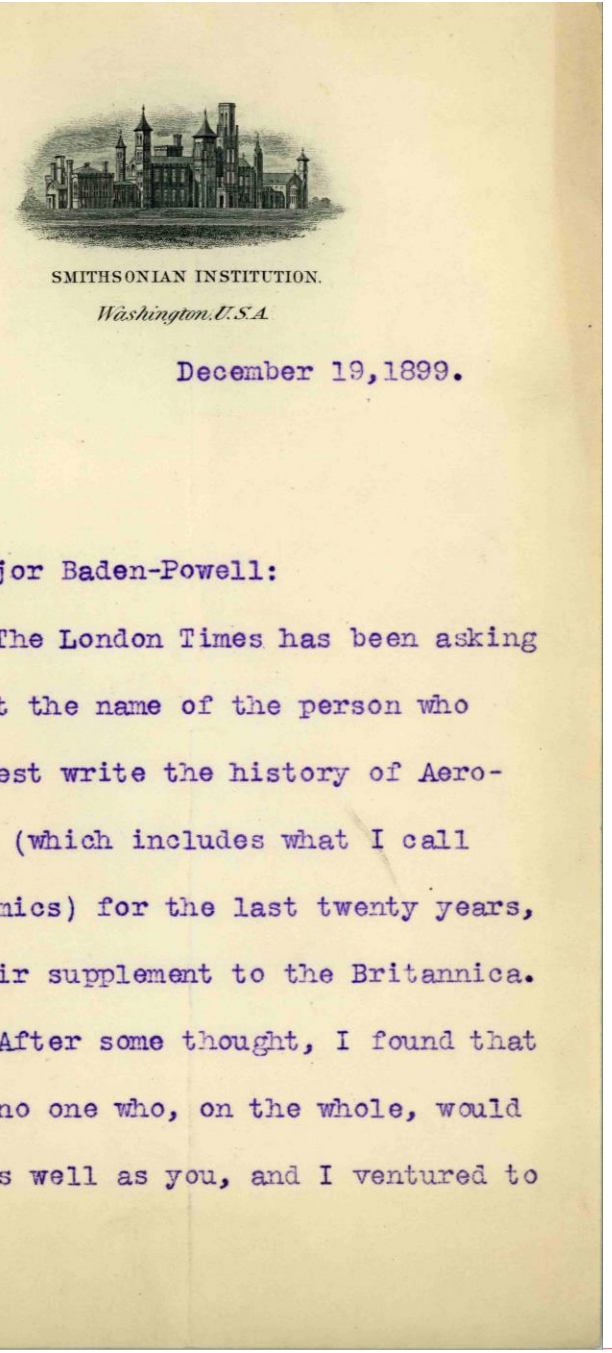


SMITHSONIAN INSTITUTION.

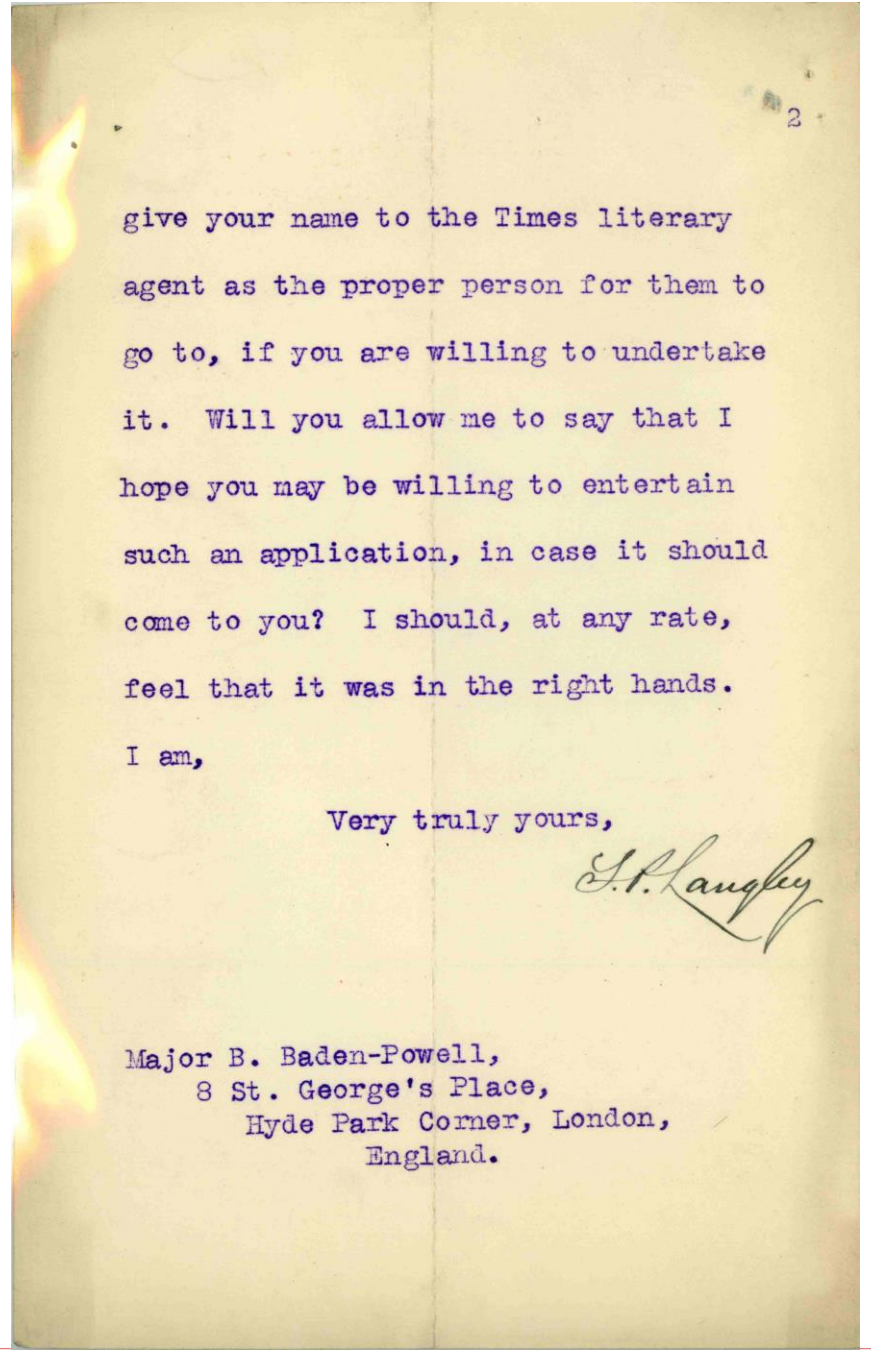
Washington, U.S.A.

December 19, 1899.

Dear Major Baden-Powell:

The London Times has been asking me about the name of the person who could best write the history of Aeronautics (which includes what I call Aerodromics) for the last twenty years, for their supplement to the Britannica.

After some thought, I found that I knew no one who, on the whole, would do it as well as you, and I ventured to



give your name to the Times literary agent as the proper person for them to go to, if you are willing to undertake it. Will you allow me to say that I hope you may be willing to entertain such an application, in case it should come to you? I should, at any rate, feel that it was in the right hands.

I am,

Very truly yours,

S. P. Langley

Major B. Baden-Powell,
8 St. George's Place,
Hyde Park Corner, London,
England.

Closing Remarks

- RAeS was founded 38 years before the Wright Flyer flew
  - Let's not write the history of wind tunnel testing too soon
- Problems with computations
  - The boundary conditions and, where necessary, flow physics models may not be entirely appropriate to the real flow field
- Problems with experiments
  - The boundary conditions are certainly 'realistic', but may not be representative of the 'real' situation, nor controllable
  - The ability to extract data is subject to practical limitations around resolution and intrusion