

# ACOUSTIC TECHNOLOGY FOR WAKE VORTEX DETECTION

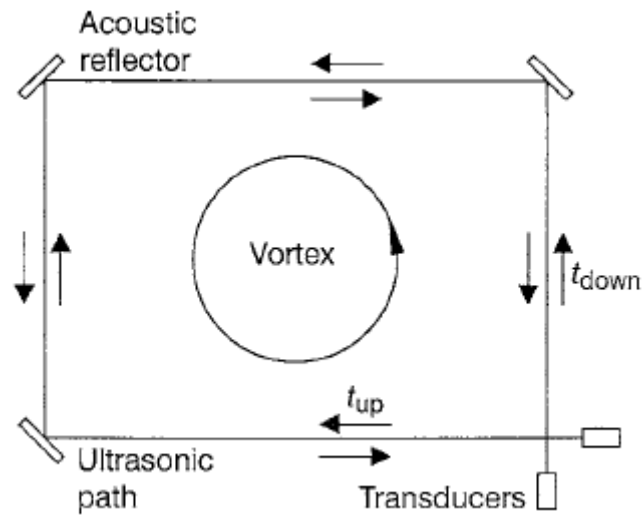
WakeNet 3 – Europe  
29<sup>th</sup> and 30<sup>th</sup> March 2010  
Palaiseau, France

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# Vortex Enclosed by Acoustic Path



# Circulation Determined by Integral Around Path

$$\begin{aligned}\Gamma &= \oint \mathbf{u} \cdot d\mathbf{l} \\ &= \int_A \boldsymbol{\omega} \cdot d\mathbf{A} \\ &= \oint u_l dl\end{aligned}$$

# Enclosed Circulation in terms of $\Delta t$

$$\oint u_l dl \approx \frac{c^2}{2} \Delta t$$

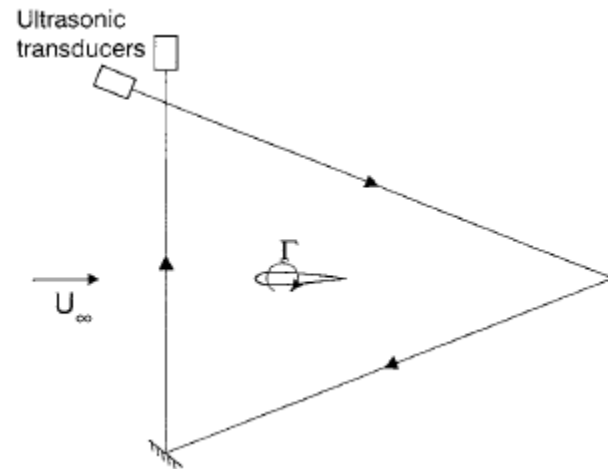
$$\Delta t = t^+ - t^-$$

$$u_l \ll c$$

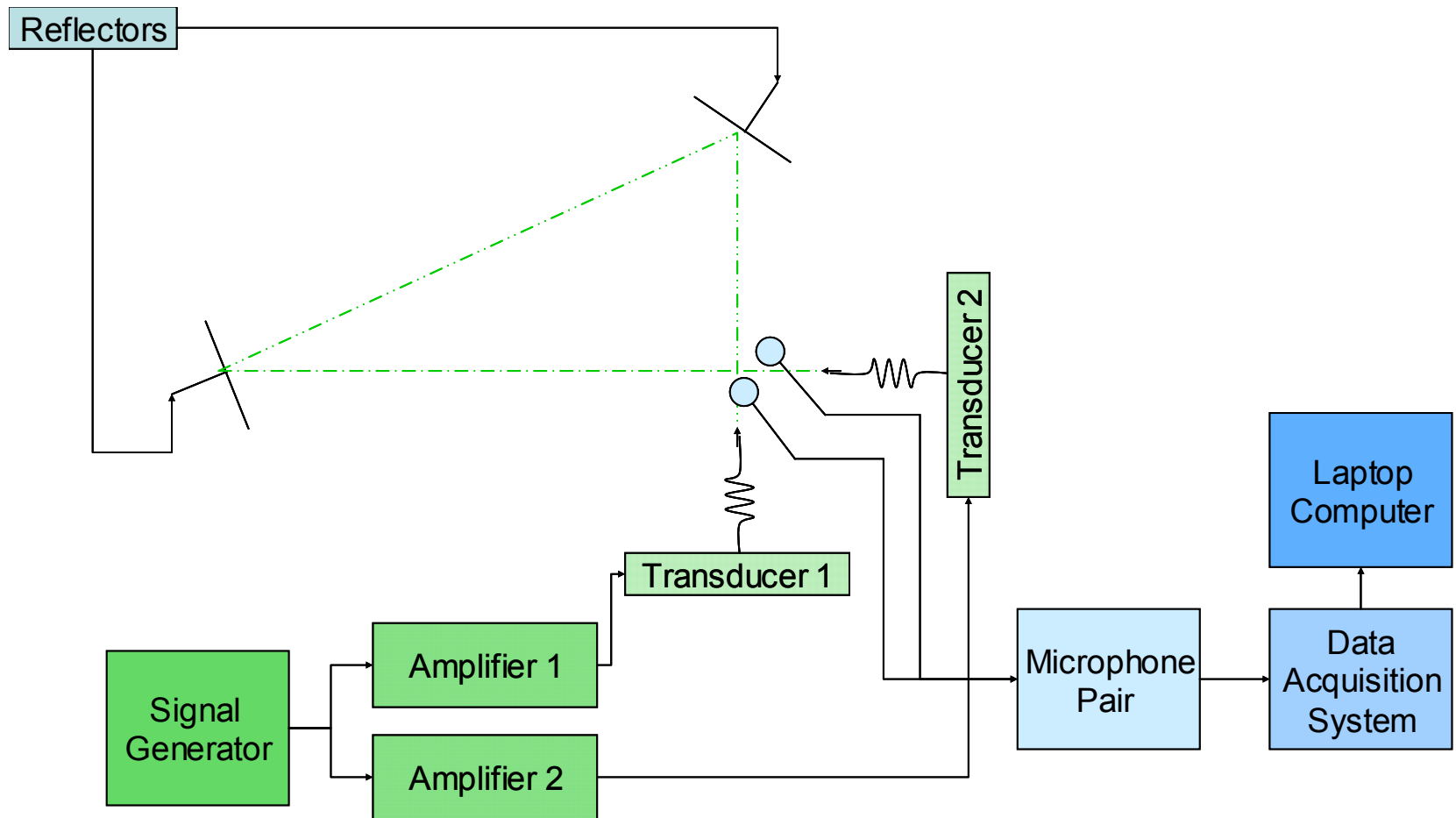
$$c = \frac{L}{(t^+ + t^-)/2}$$

$$\Gamma = \frac{2L^2}{(t^+ + t^-)^2} \Delta t$$

# Example – Wind Tunnel Application



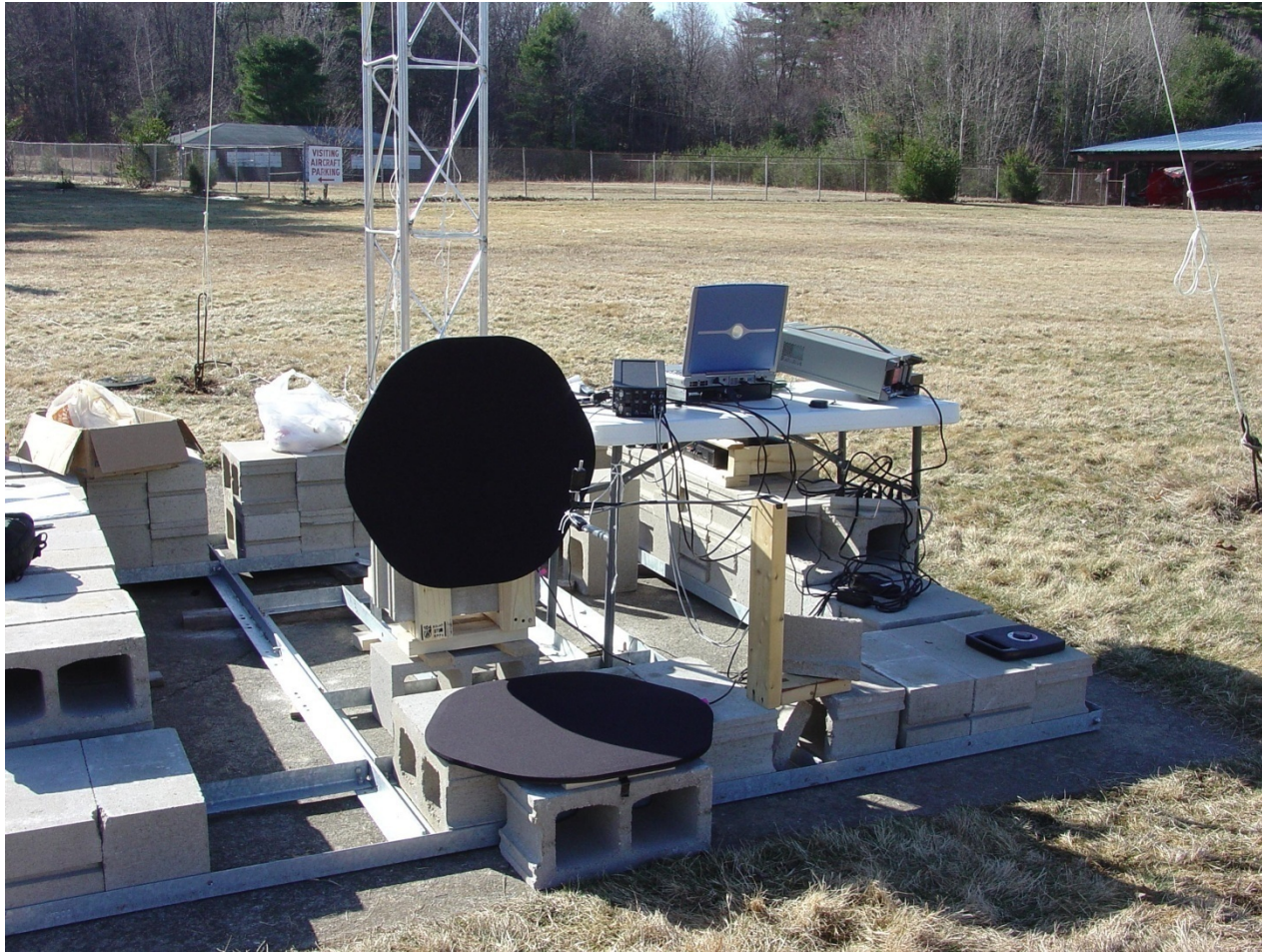
# Experimental Set-up Schematic



# Experimental Apparatus - Airport

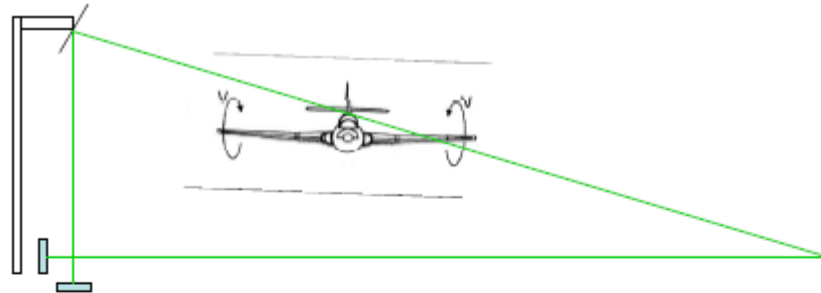


# Acoustic Transducers and Electronics

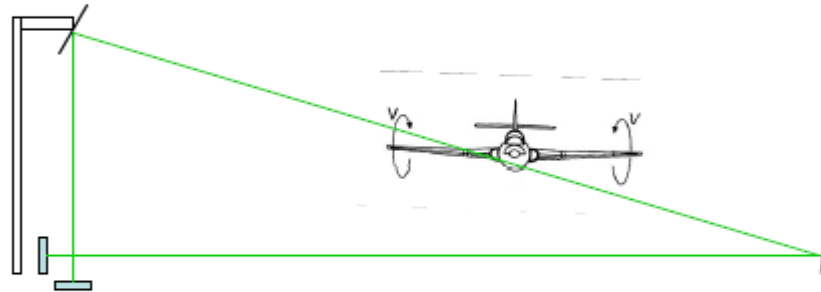




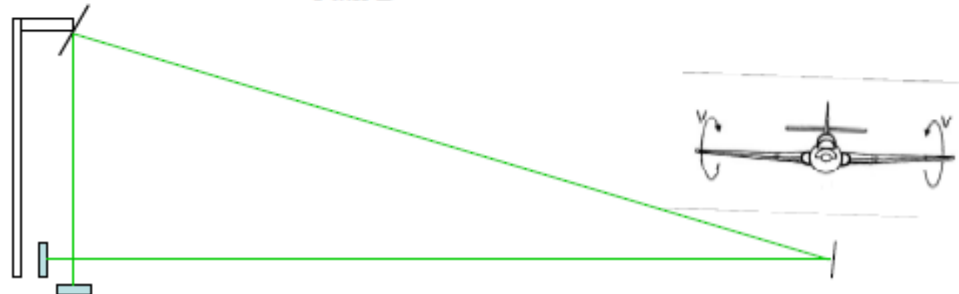
# Test Flight Schematic



Path A

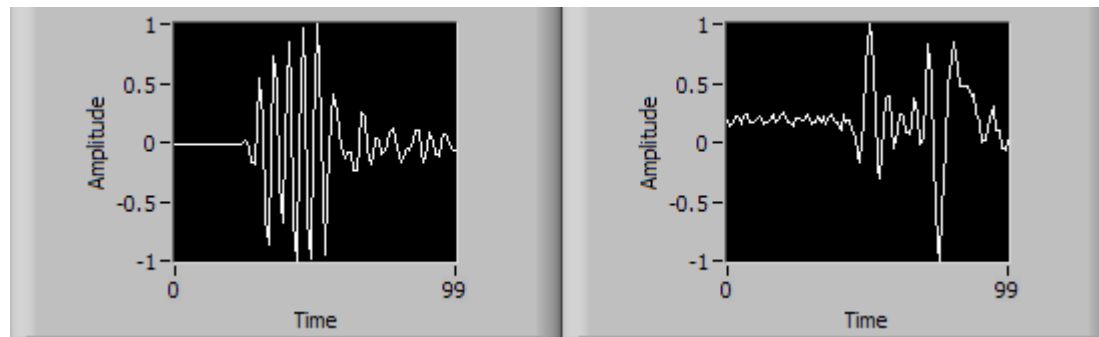


Path B

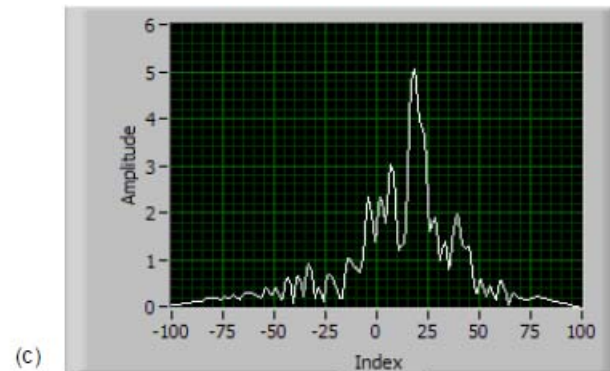
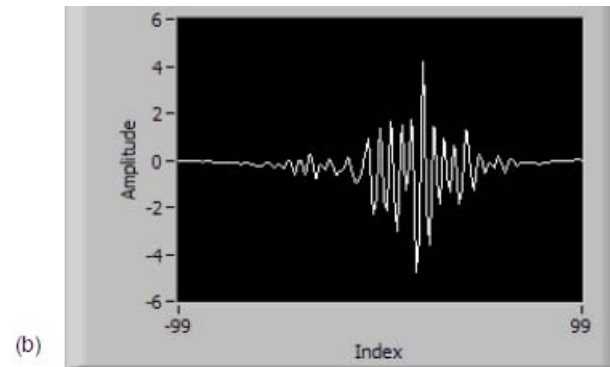


Path C

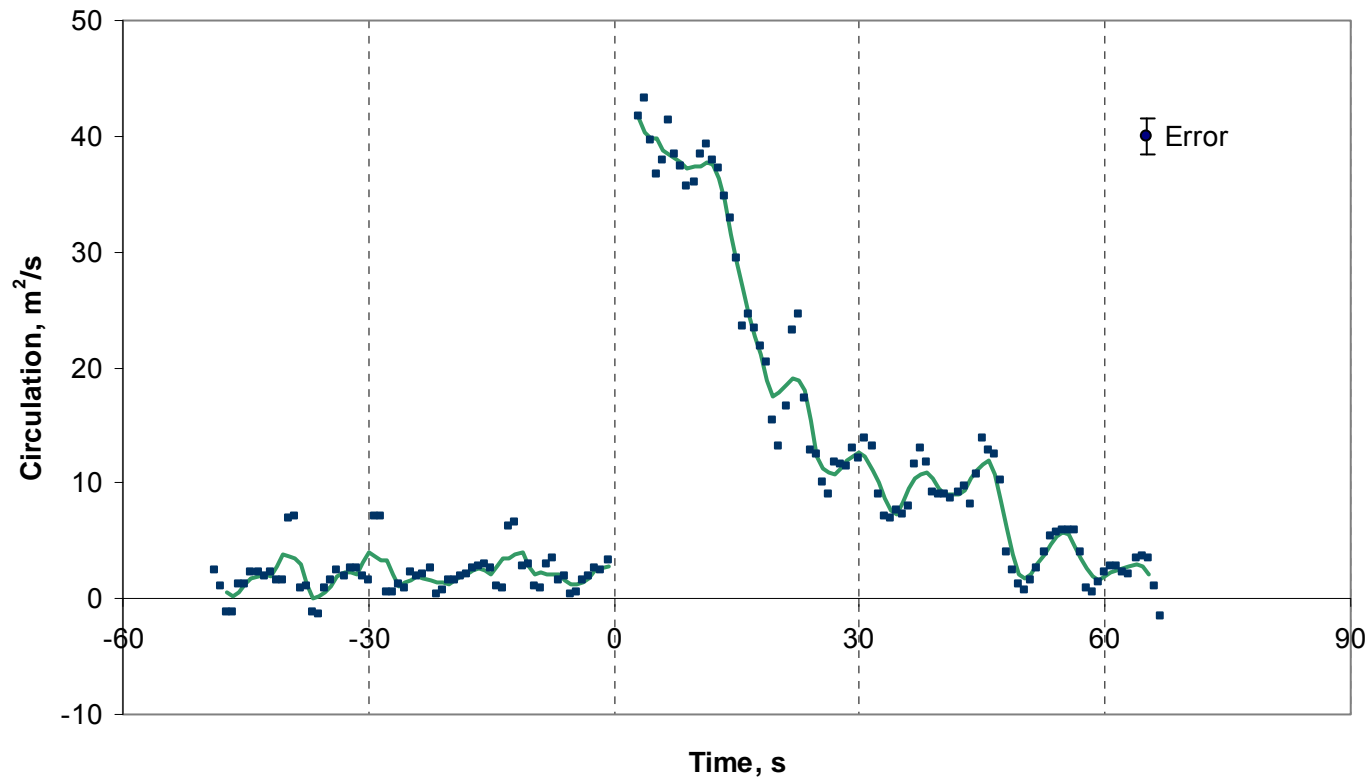
# Transmitted and Received Signals



# Correlation and Hilbert Transform

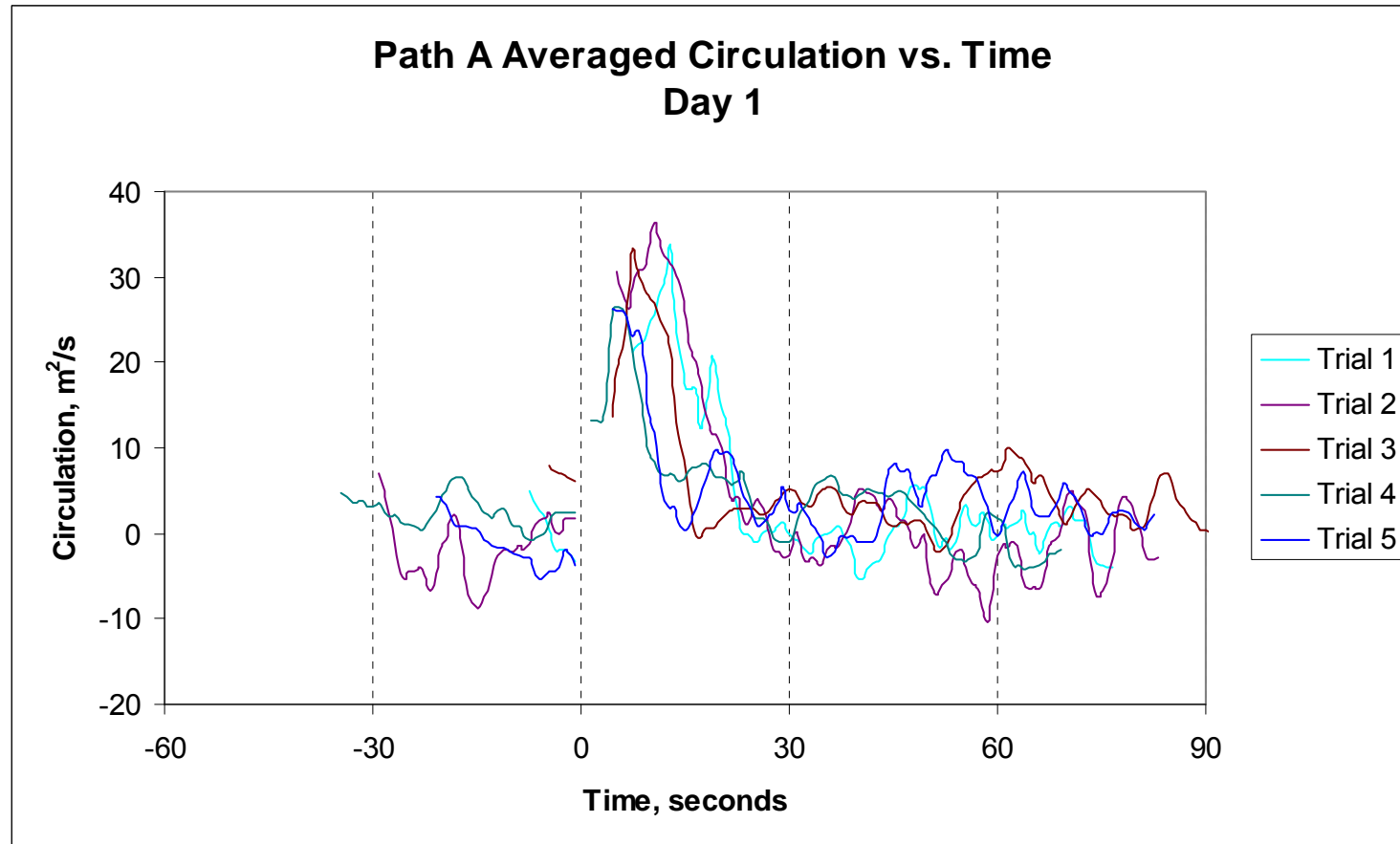


# Typical Result – Calm Wind

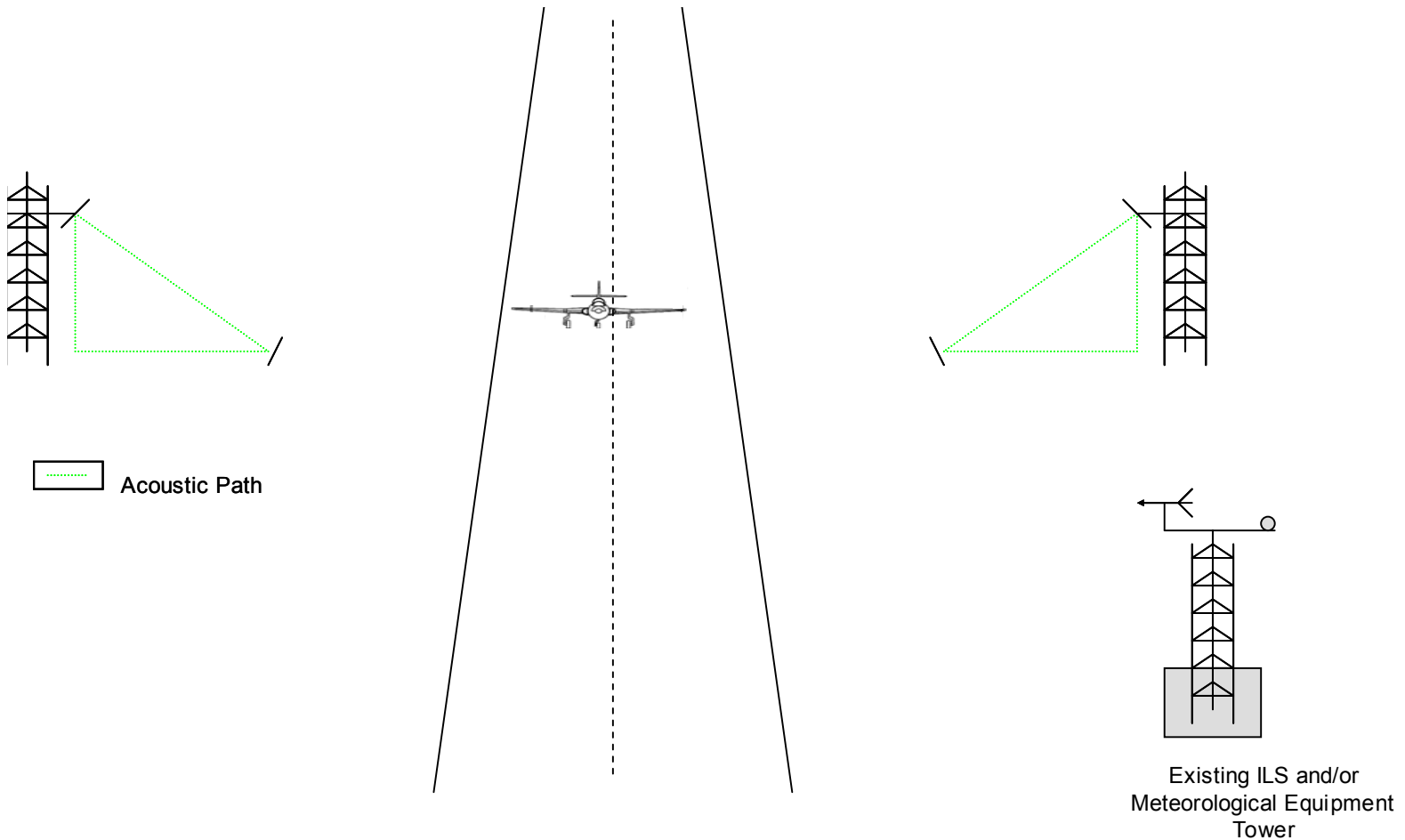


# Field Trials

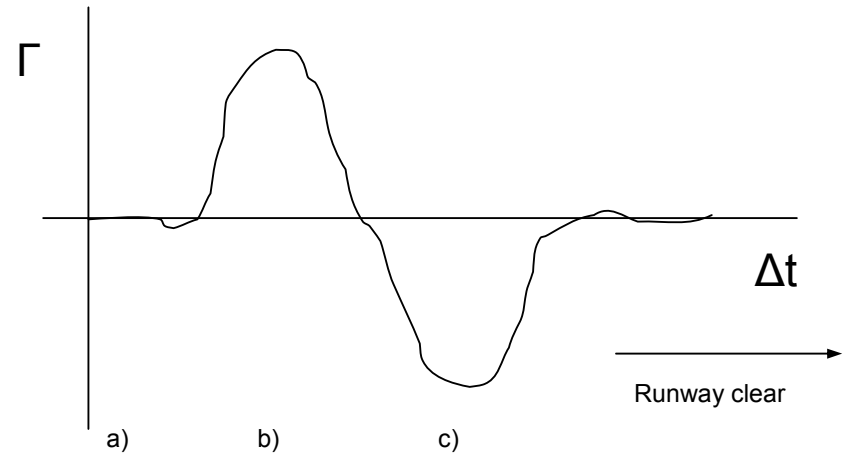
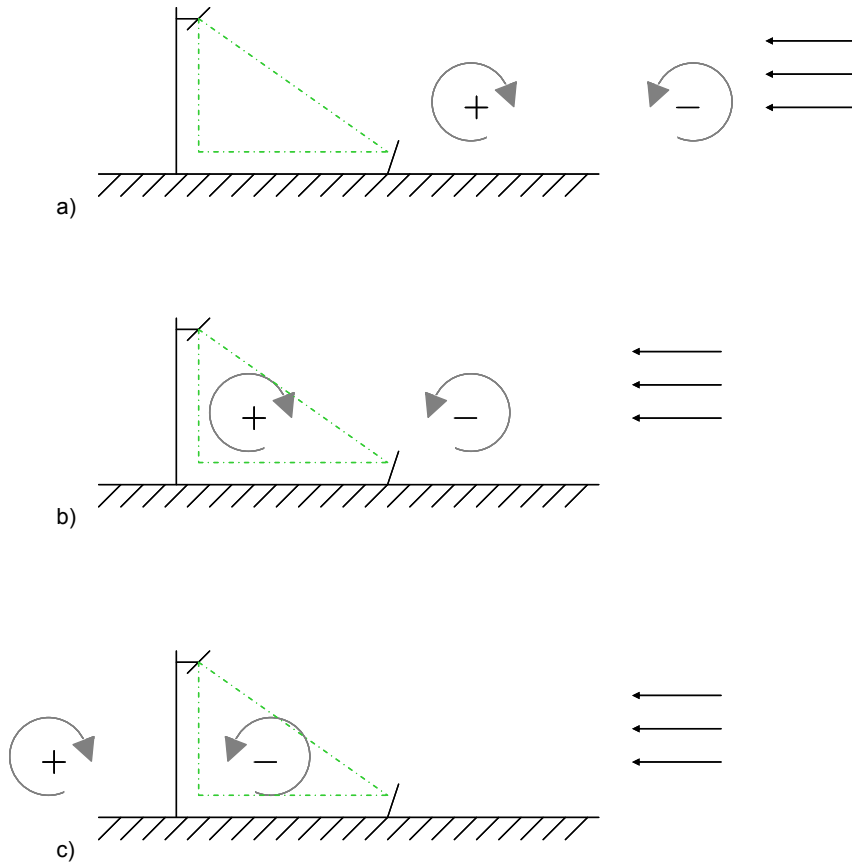
Multiple trials were conducted during field testing, and showed very consistent results, as shown on the following graph.



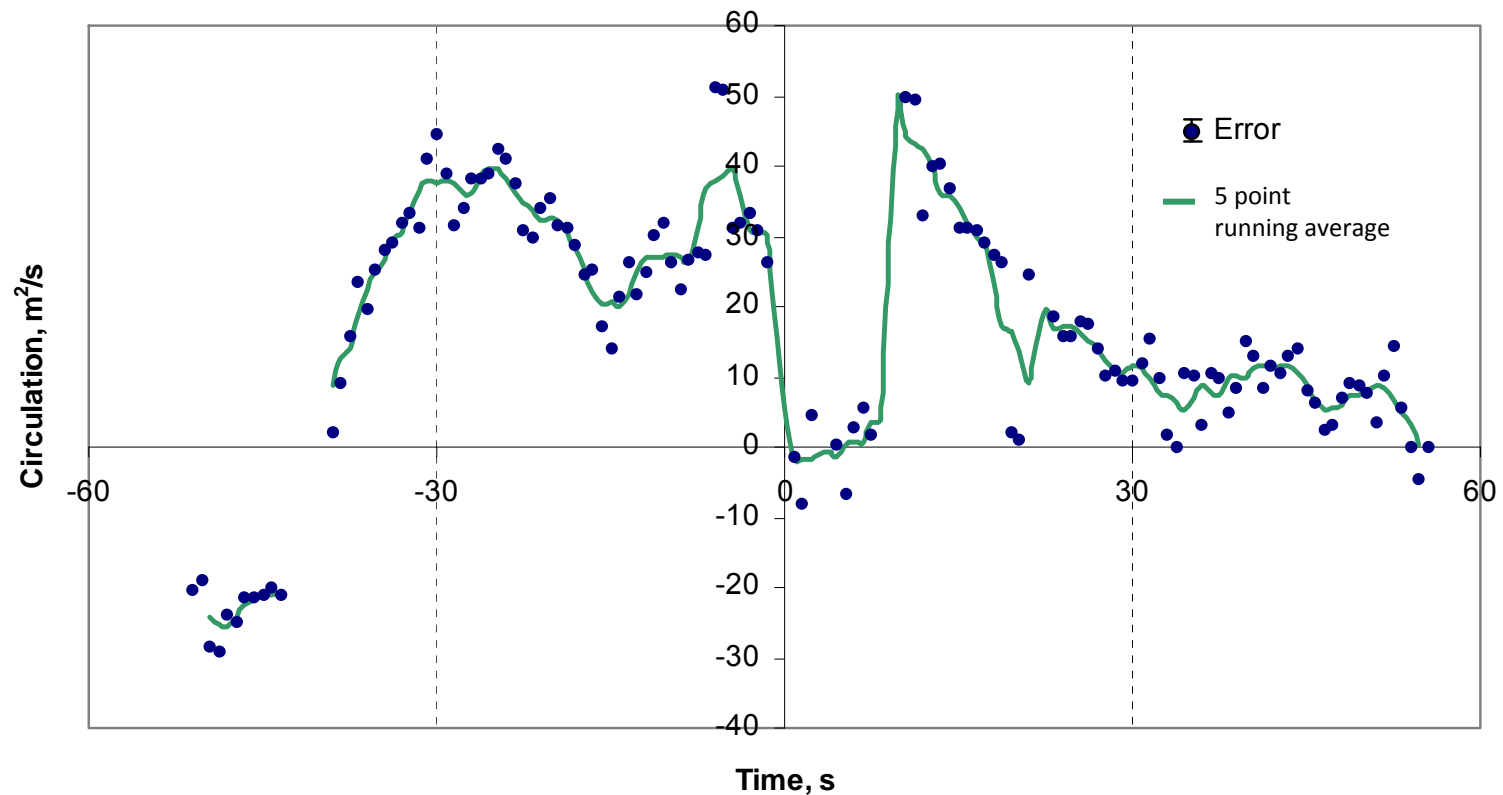
# Possible Runway Monitoring System



# Expected Signature with Cross-wind



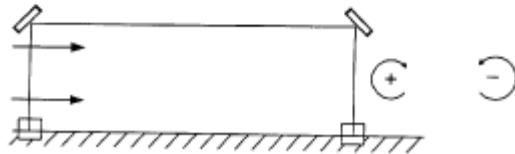
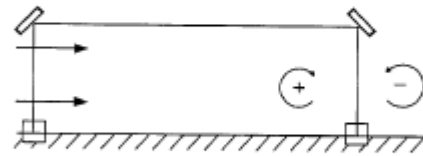
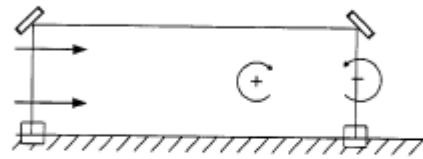
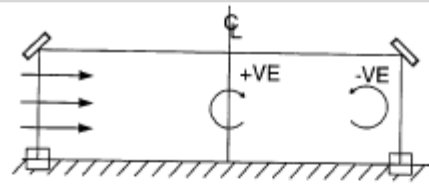
# Sample Circulation in Cross Flow



\*Heavy aircraft generate vortices of 300 – 500 m²/s



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EXPECTED RECORDING OF  $\Delta T$  ( OR  $\Gamma$  )

