# ADVANCES IN INSTRUMENTATION

echologics
A DIVISION OF MUELLER COMPANY

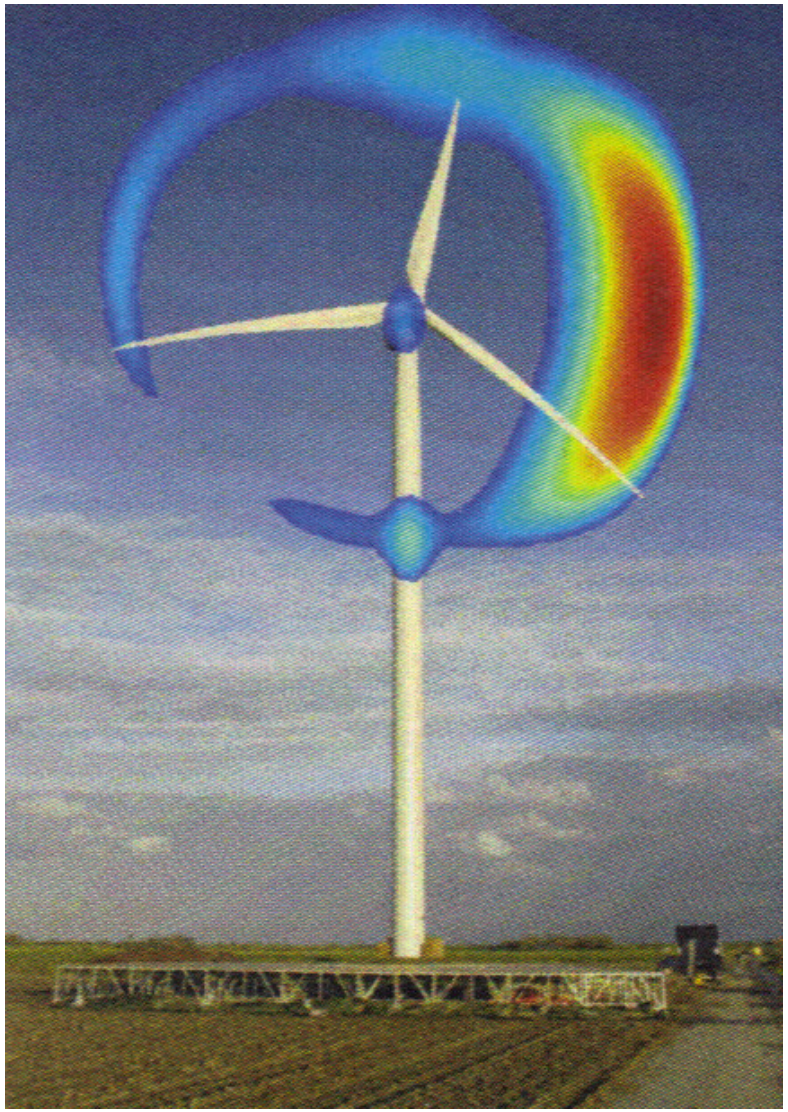
Werner Richarz
Echologics Engineering
wricharz@echologics.com

Mueller Co.

# OVERVIEW

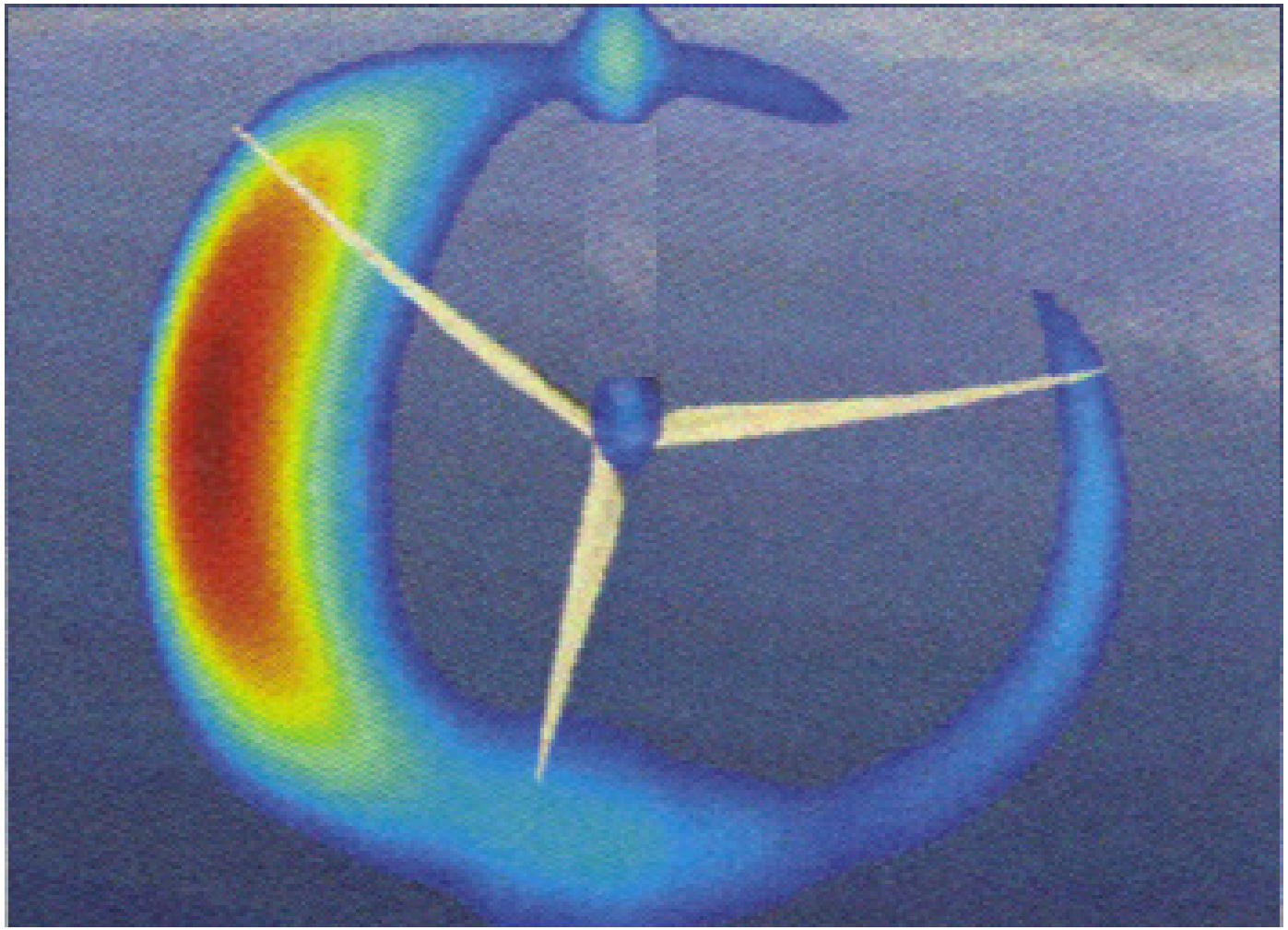
- Acoustic Characteristics of Wind-Turbines
- Challenges of Outdoor Measurement
- Performance Measurement
- Compliance Measurement
- Un-attended Monitoring
- Data Interpretation
- Concluding Remarks

# WIND-TURBINE SOUND



- Rotational:
  - blade passage+harmonics
  - wind-shear
  - wake-tower interaction
- Broadband:
  - boundary layer+trailing edge noise
  - ingested atmospheric turbulence

# Source image when array is above the WT



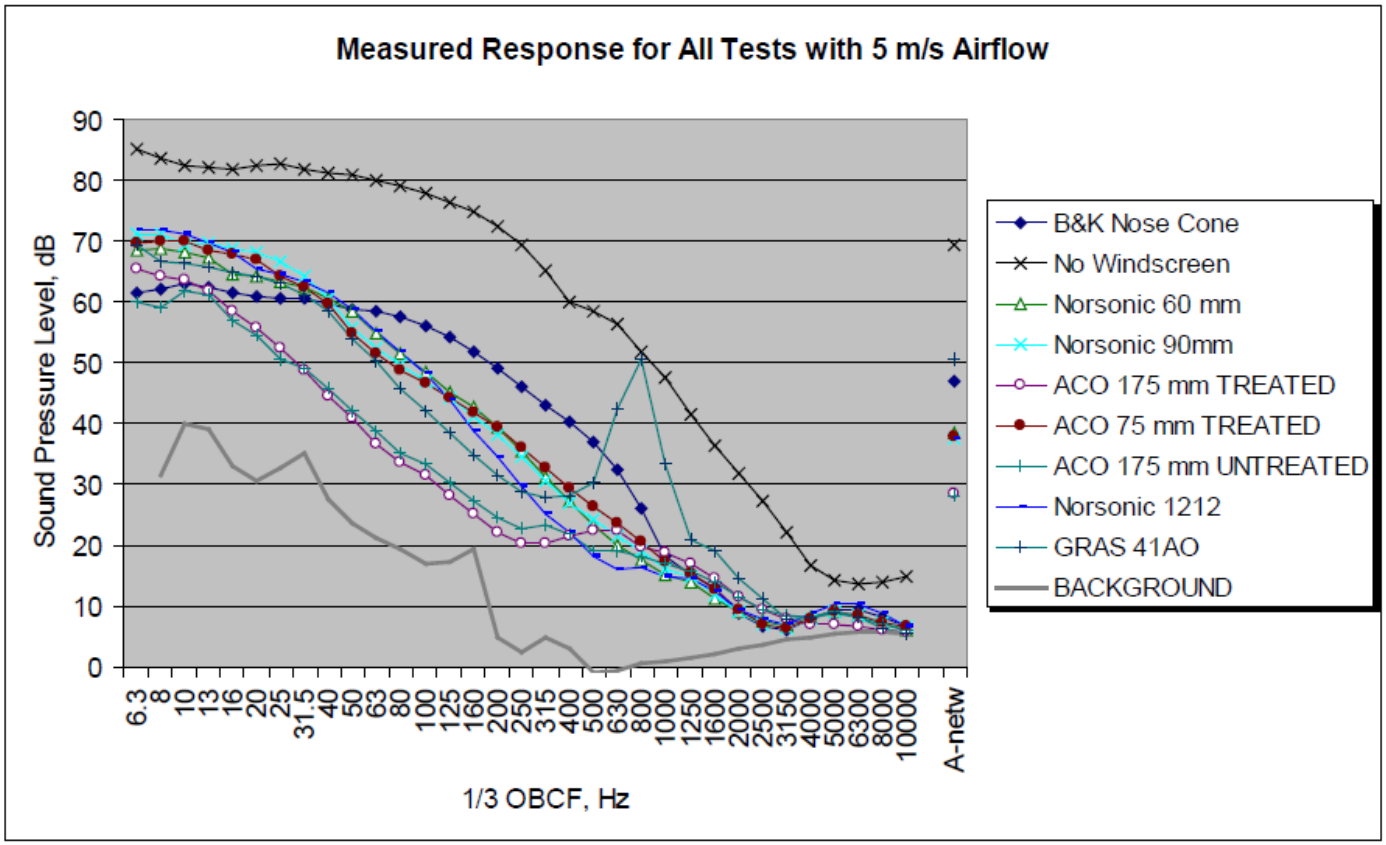
# Outdoor Measurements cope with

- Weather
  - Wind
  - Rain
  - Snow
  - Temperature
- Wildlife
- Frogs, birds, crickets
- Vegetation

# Wind

- Microphones cannot distinguish between pseudo-sound and real sound
- Windscreens provides some protection by suppressing small scale eddies
  - Performance not well documented
- Special hemi-spherical units are favoured
- In-ground systems based on long-lost sonic boom experience

# Typical Wind-Screens




# Wildlife

- Frogs, birds, crickets sounds are audible over large distances
- Add spurious contributions to single number indicators
- Spectrum analysis and special filters may be used if signals are clearly identifiable and not in the bands where WT sound is observable

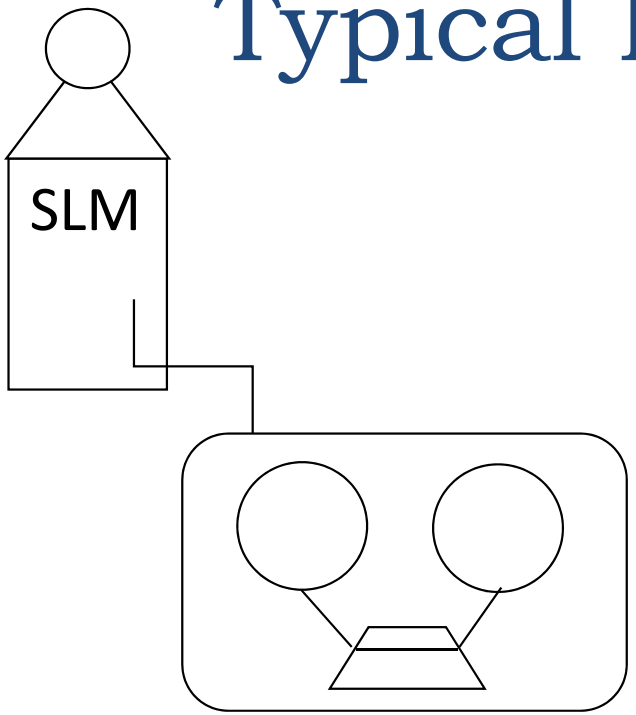
# Performance Measurements

- Conducted according to prescribed standards
  - IEC 61400-11
- Octave and 1/3 Octave band used to determine dBA
- Narrow-band spectra used to determine ‘tonality’ and adjustments to dBA
- Ideal conditions ←→lowest sound power

# Compliance Measurements

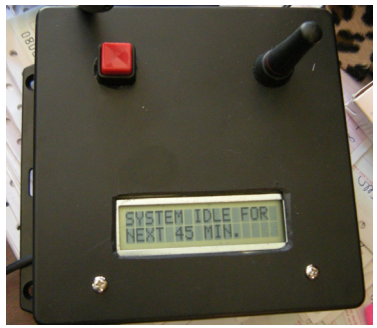
- Independent audit to establish sound levels under actual operating conditions
- Measurement procedure not standardized in many jurisdictions
- Ontario regulations are somewhat cumbersome and permit extensive data management that effectively lowers the reported sound levels

# Typical Field Kit circa 1980



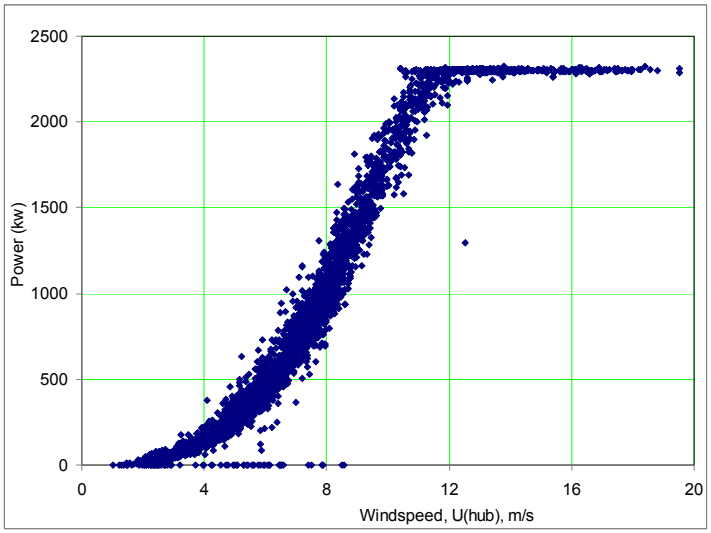

- Portable SLM+Tape Recorder
- Data Analysis via Spectrum Analyzer+Level Recorder
- Permits source identification
- Fair weather system

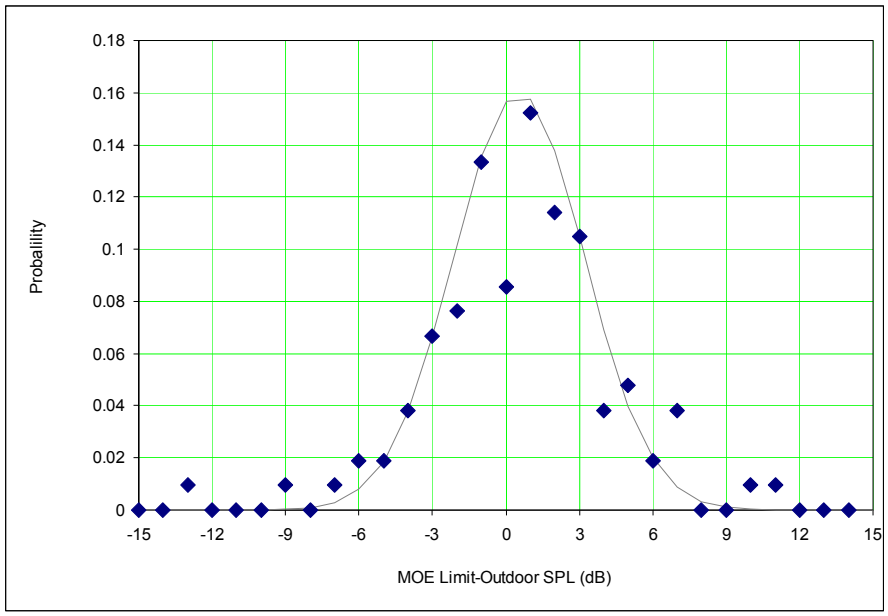
# Experimental Field Kit circa 2004-6









# Modern Portable Sound Analyzers

- Compact
- Moderate power consumption
- Programmable
- On event recording
- Convenience options

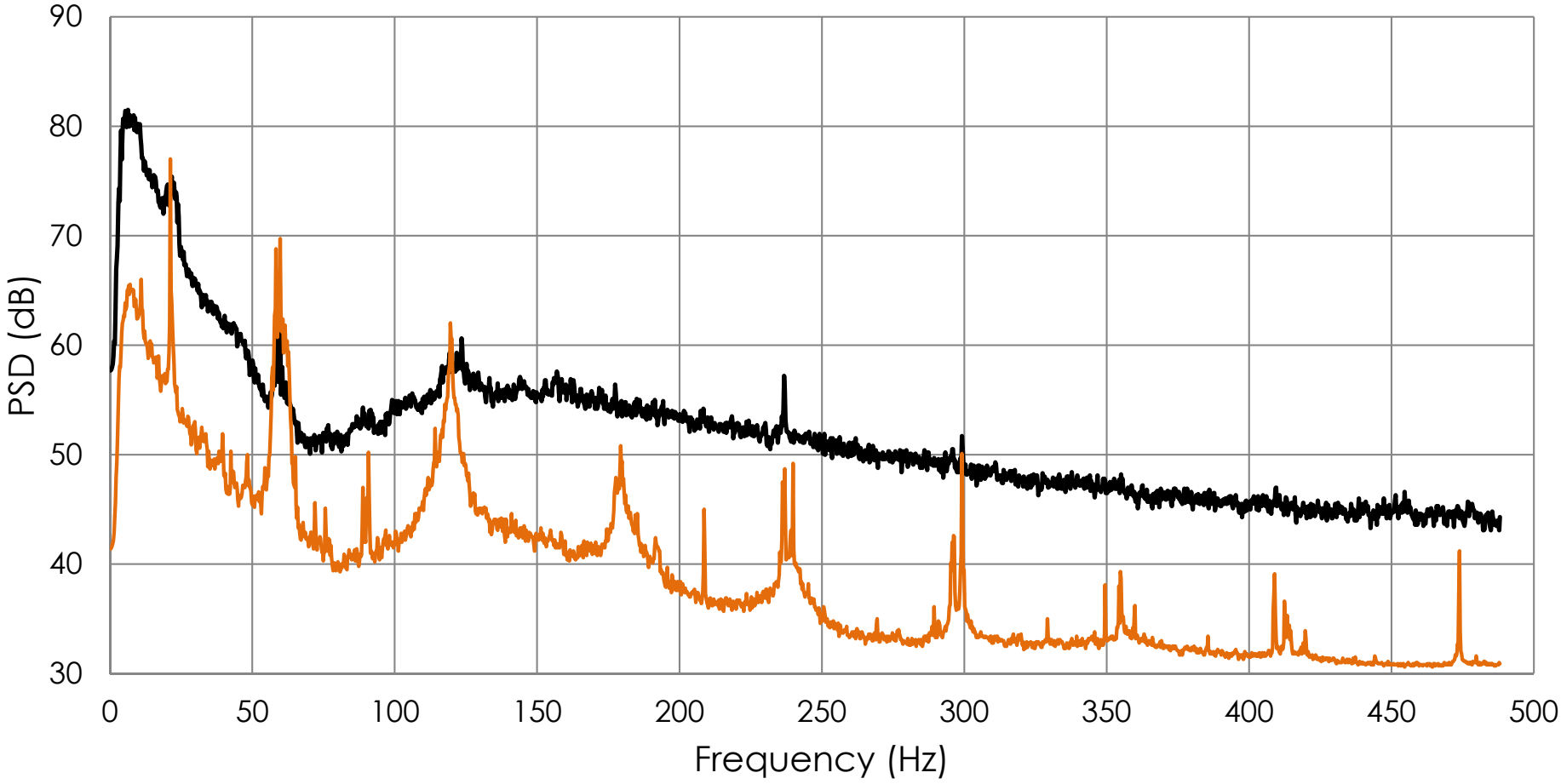
# Basic Features of a Field Kit

- Single channel commonly used in WT noise assessment
- Extended monitoring requires large capacity power supplies (marine batteries)
- Solar panel charging may extend operating period
- Weatherproofing equipment ‘black art’
  - Condensation, extreme hot, cold
- Data retrieval “easy”
  - Memory card
  - Internet, cellular networks
- Internet, cellular networks are attractive options

# Portable (?) field kit

# Field team takes a break

# Measured Spectra

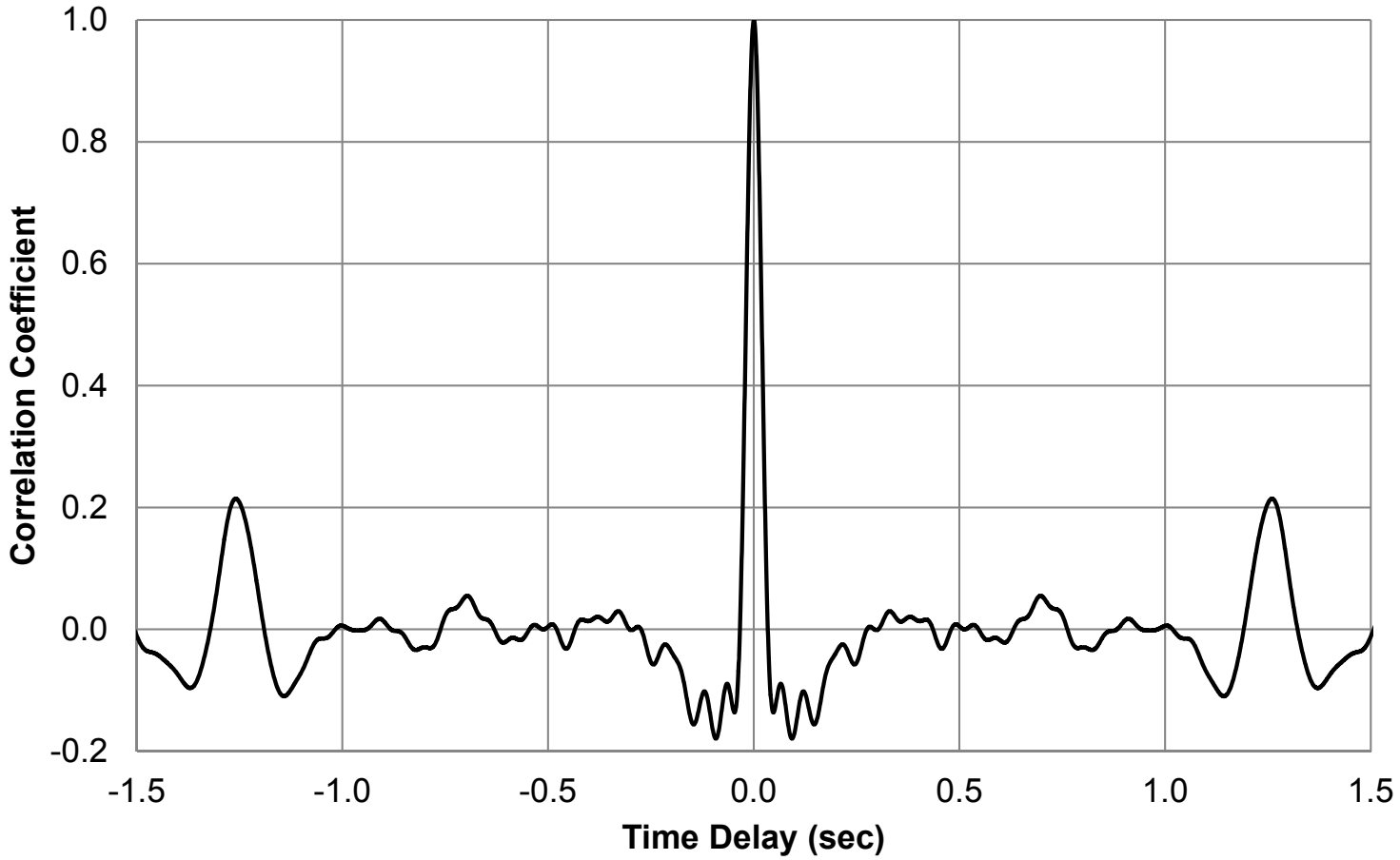


# Data Interpretation

- Collected data still needs to be reviewed with care
- File affected by extremes of weather easily identified with weather station
- ‘Filtering’ according to wind state performed manually or via software.  No standards set at this time.
- Despite massive data base, there is usually not enough data in the ‘critical’ ranges.

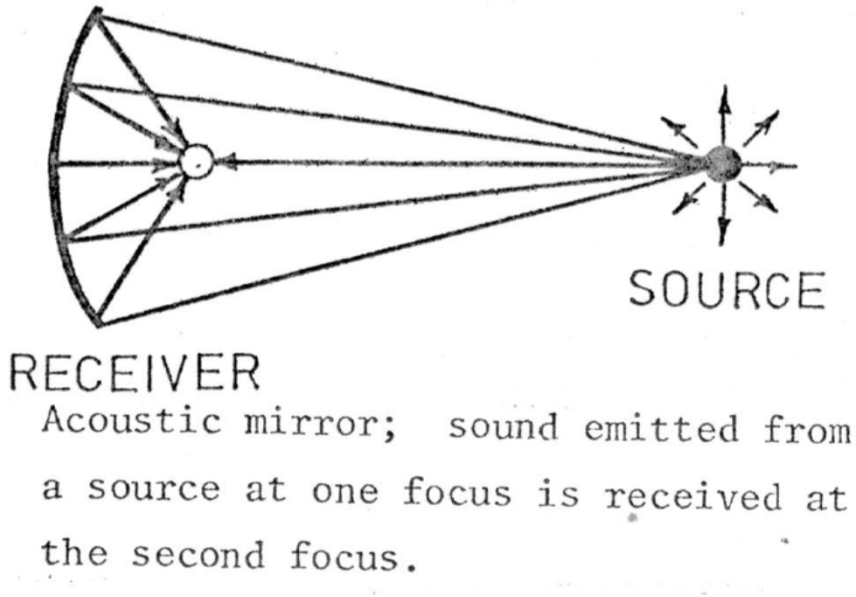
# Alternative Analysis

## Autocorrelations identify periodic patterns



# Wish-list

- Affordable imaging for source location




- Old sat. dish: not user-friendly

# Multiple Elements

Not for the ‘average’ consultant

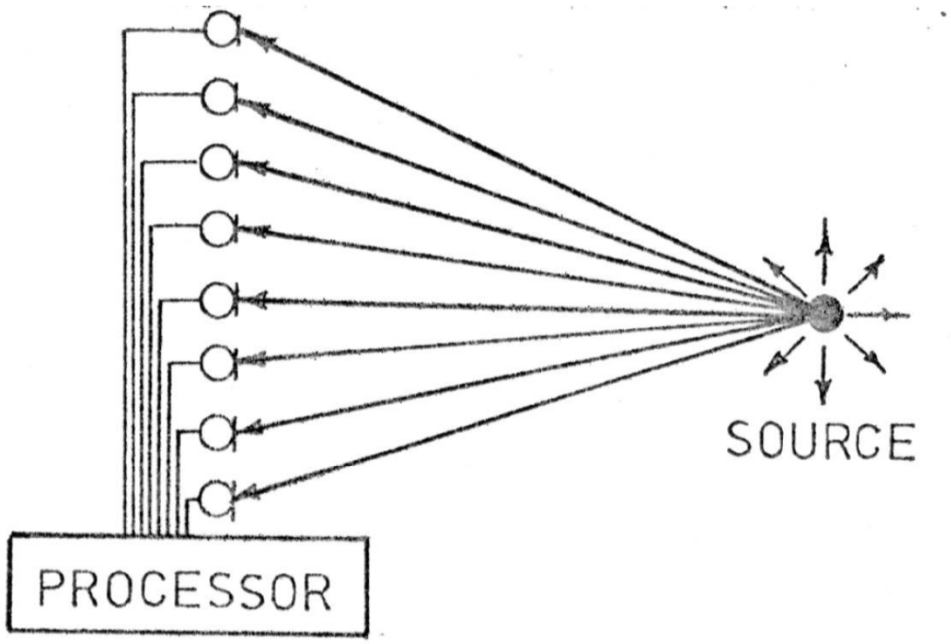
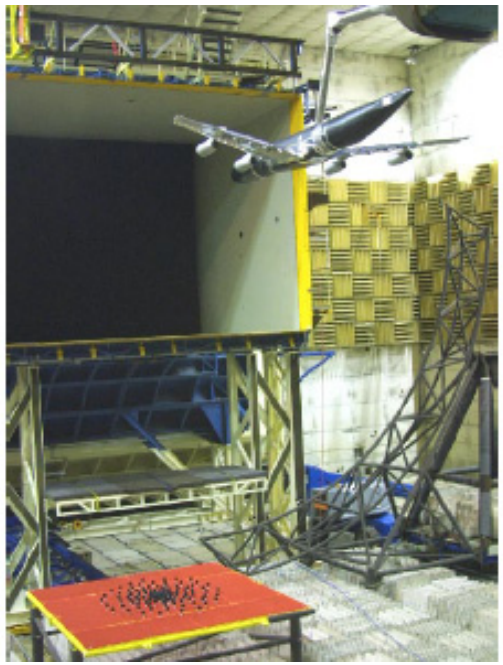
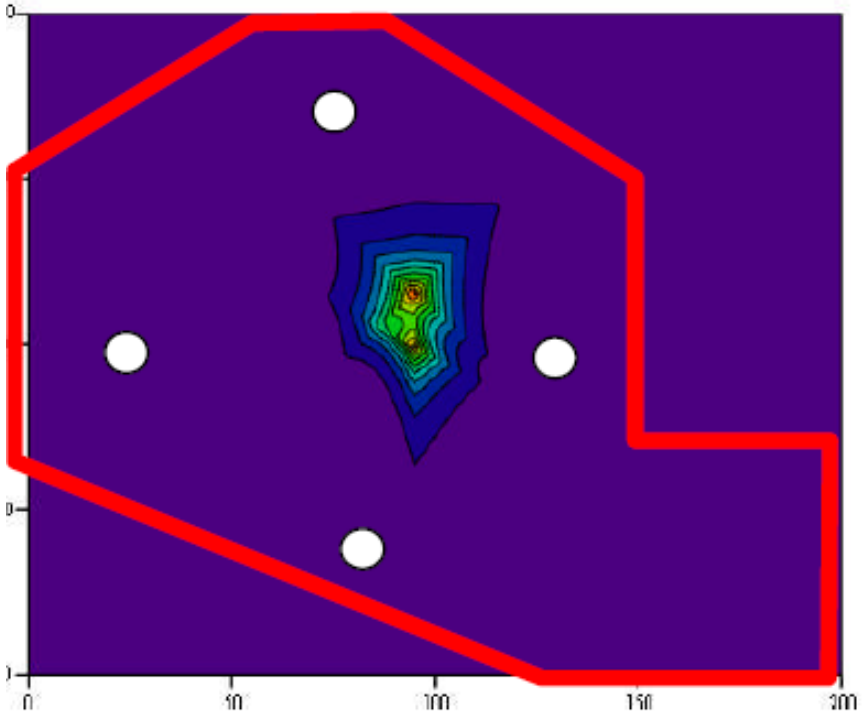



Fig. 2 Acoustic telescope; processor samples the output of the array in a specified manner to 'focus' on the source region.

# Two microphones

- Requires a little post-processing
- Robust



- Potential application to WT

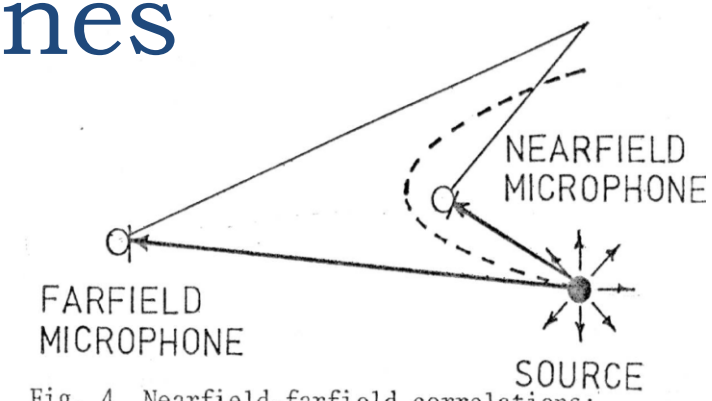
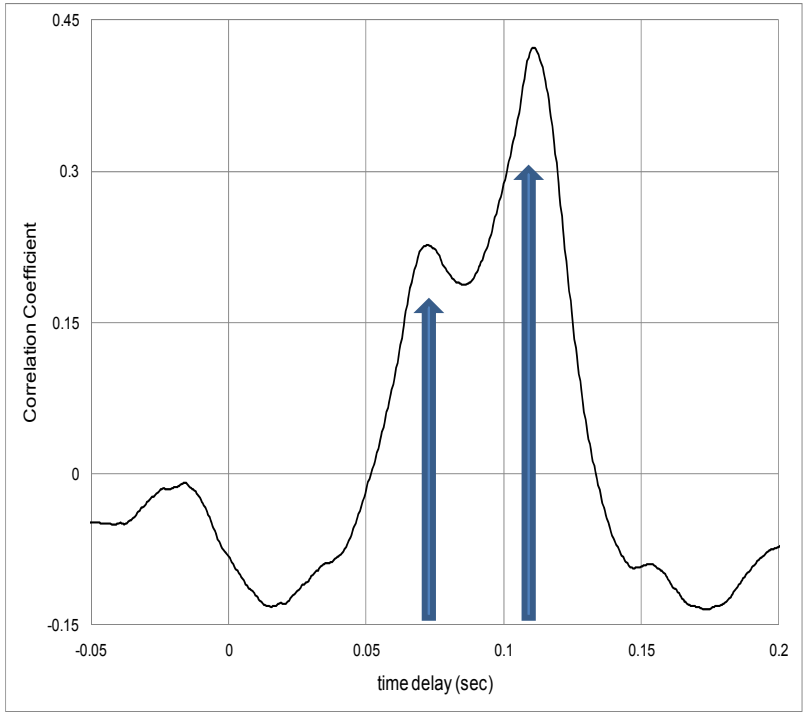



Fig. 4 Nearfield-farfield correlations; time delay between signal reception by the two observers allows construction of source location hyperbola (---).



# Now its' your turn!

**Thanks to:**

Rob Stevens (HGC)

Tony Gambino (Aercoustics Engineering)

Bruce Robertson (Aercoustics Engineering)

Tim Preager (Aercoustics Engineering)

Ian McLean (UTIAS, 1980)

Werner Richarz – wricharz@echologics.com