Sound Insulation Measurements for Buildings Near Airports

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Key West, Florida

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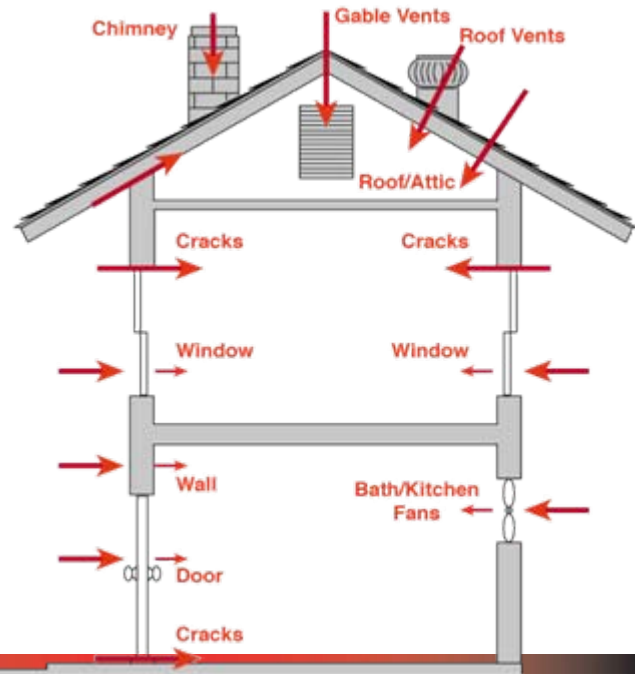
Measurement Principals

- Diffuse exterior sound source
- Individual building elements radiating sound to interior space
- Measure the reverberant sound field in the space
- The noise level reduction:

$$NLR = L_{out} - L_{in}$$



Major Paths for Noise Transmission into House in Order of Importance:

Gaps/Cracks
Windows/Doors
Walls/Roof

Sound Insulation Criteria (FAA)

Airport Improvement Program (AIP) Handbook

- **Order 5100.38C**
- **Maximum interior noise exposure of 45 dB (DNL)**
  - **Requires minimum 20 dB NLR (within 65 DNL contour)**
- **Minimum 5 dB improvement in Noise Level Reduction (NLR)**
  - **Provides noticeable improvement to habitants**

Standards and Protocols

- **Airport Improvement Program (AIP) Handbook – design criteria**
- **ASTM E966 – *Measurement of sound insulation of building facades***
- **ASTM E366 – *Measurement of sound insulation of buildings***
- **ANSI S12.9 – *Quantities and procedures for environmental sound***

Measurement Methods

- Actual Aircraft Sound Source

- Artificial Sound Source

Measurement Method – Actual Aircraft Source

- Measure inside two rooms and exterior simultaneously to capture around 20 aircraft noise events
- Difference in measured Sound Exposure Level from inside to outside provides NLR directly

Measurement Method – Artificial Sound Source

- Measure inside two rooms – obtain room and element information within a couple of minutes
- Measure outside rooms and elements at façade with steady pink noise source
- Difference in measured Equivalent Sound Level from inside to outside provides OILR – NLR determined using representative aircraft noise spectrum

Comparison of Methods

Aircraft Source

- Logistics
  - No need for speaker/hoist
  - Homeowner credibility
    - Speaker is not an aircraft…
  - No added noise
- Technical
  - Consistent results
  - Statistical results

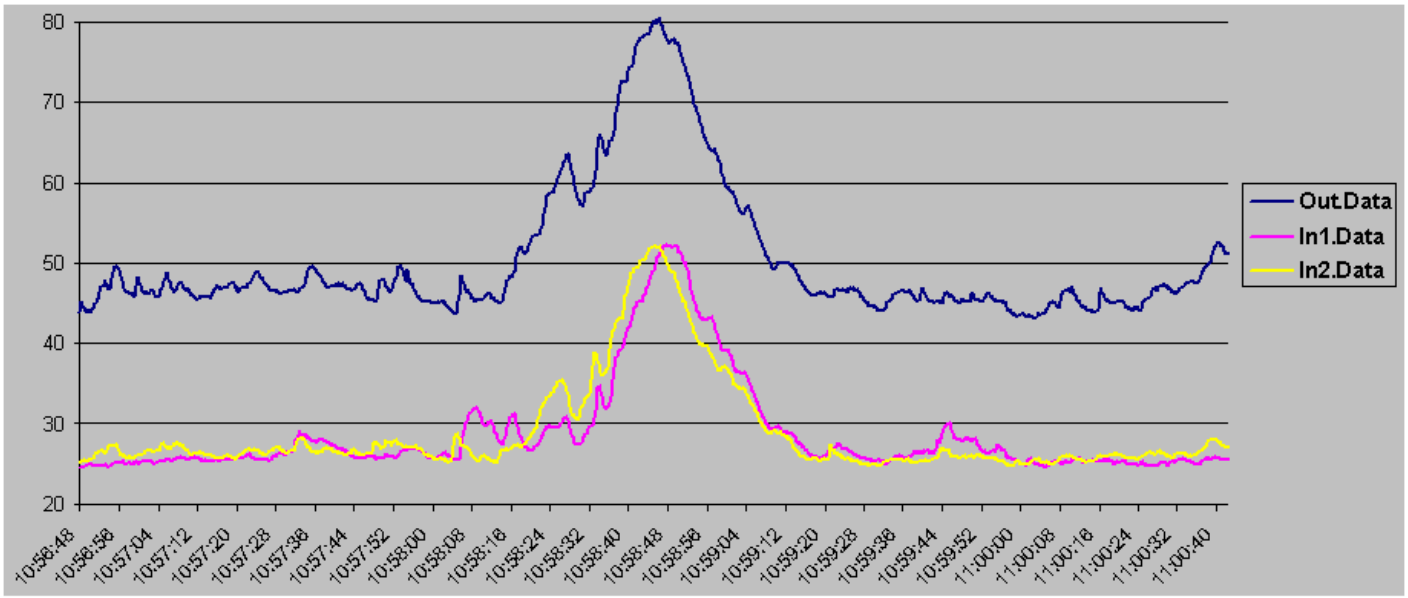
Artificial Source

- Logistics
  - Quick
  - Efficient
  - No waiting for aircraft
  - Fewer occupant issues
- Technical
  - Repeatable
  - Spectral data included
  - Diagnostics available
    - Including element specifics

Comparison of Methods
Data Analysis – Aircraft Source

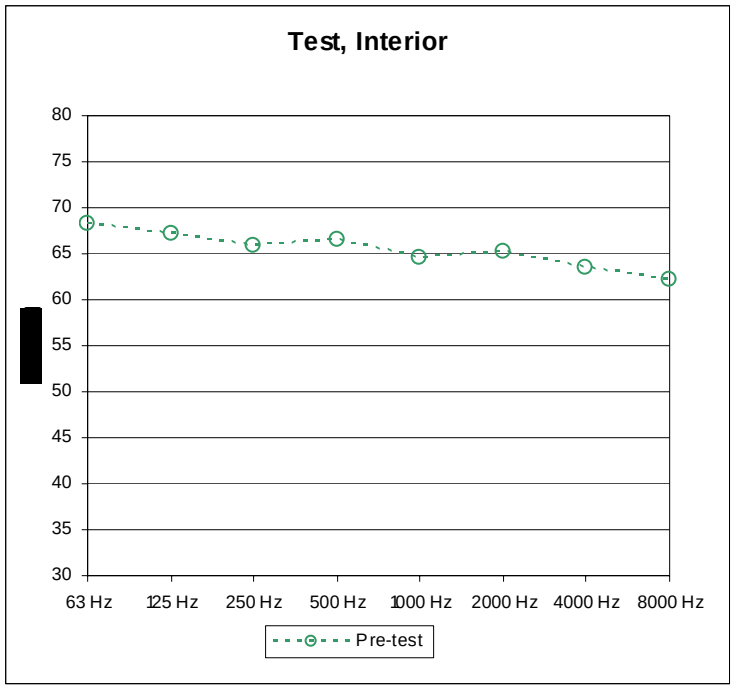
Provides:

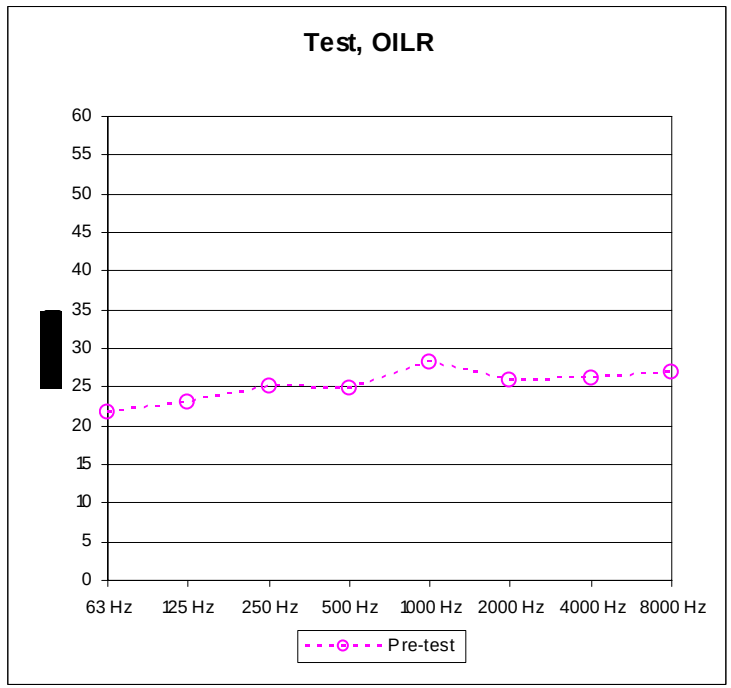
- **Time history noise event data of exterior and interior measurements**



Comparison of Methods
Data Analysis – Artificial Source

- Provides:
  - Octave band interior level
  - Octave band Outdoor-to-Indoor Level Reduction (OILR)





Comparison of Methods
Noise Level Reduction Results

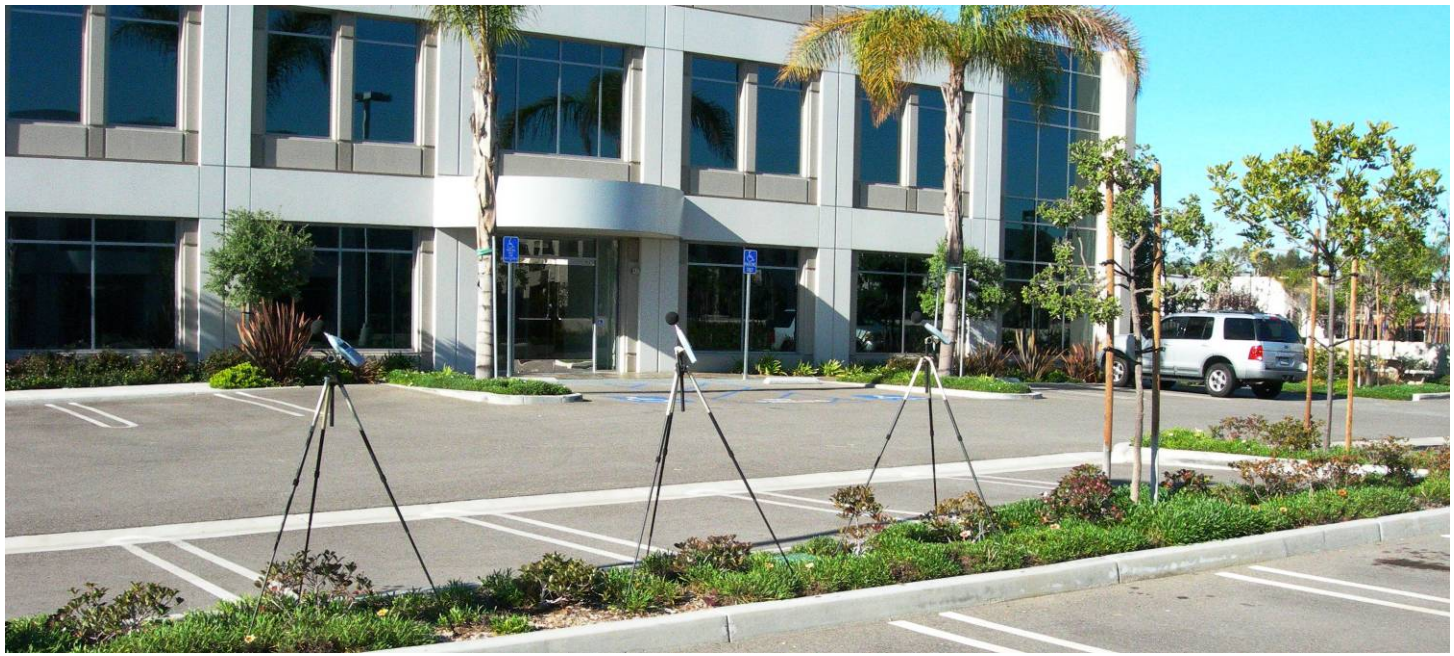
- Measurement results at a single residential structure in San Diego, California
  - NLR (Speaker): 24 dB
  - NLR (Aircraft): 26 dB
  - Difference of just over 2 dB (rounding)

Measurement Issues with Aircraft Method

- Sampling rate of measurements
  - 100ms, 200ms, or 1s
- Dynamic range of meter
- Number of aircraft events statistically required to know NLR with some certainty

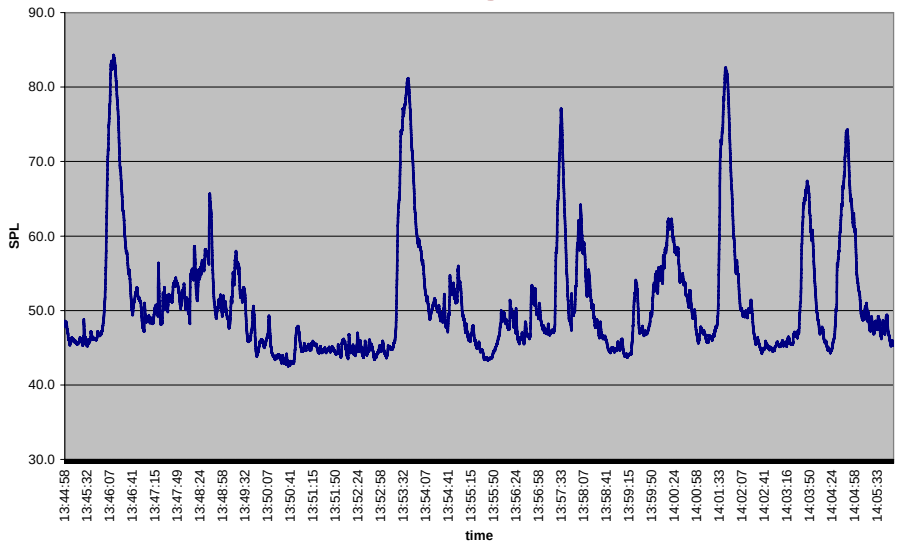
Measurement Issues with Aircraft Method Instrumentation and Process Check

- Identical meters, calibrated and synchronized
- Similar terrain and structure reflections
- Simultaneous measurement of aircraft departures at a single airport



Measurement Issues with Aircraft Method Instrumentation – Sampling Rate

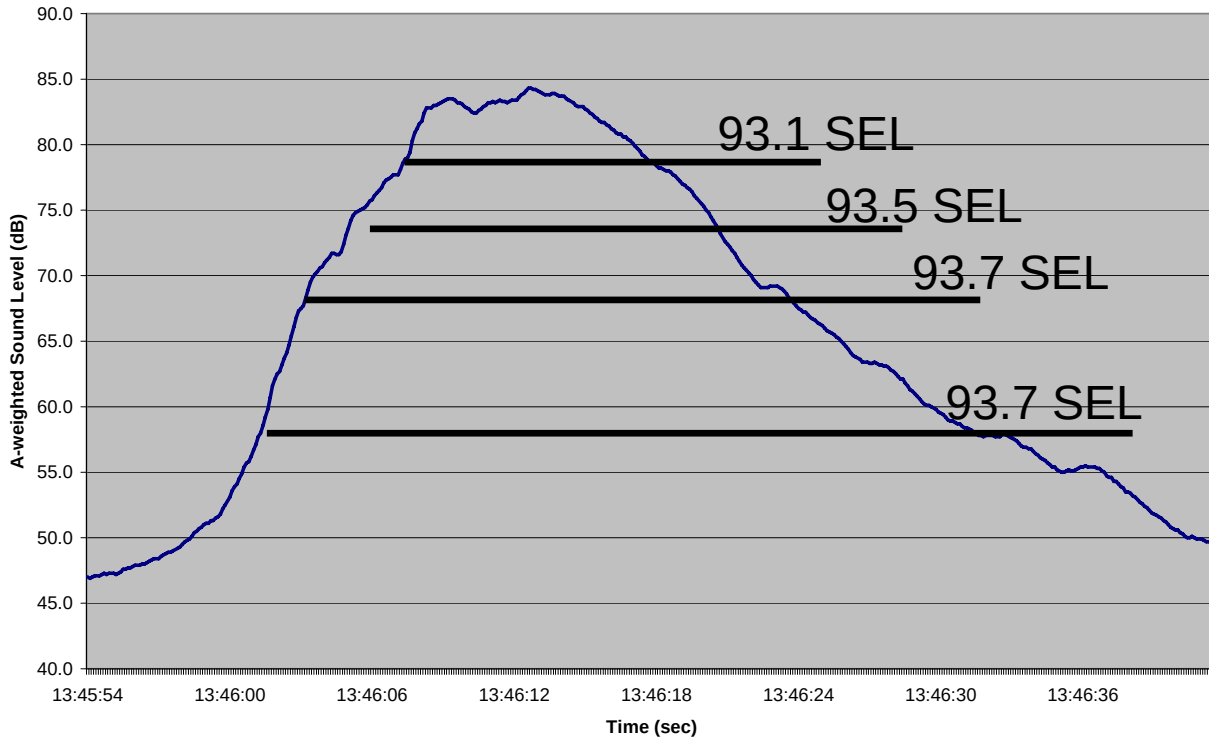
- Six aircraft noise events sampled at 100ms
- Compared results at different sampling rates
- One-second sampling rate introduces no more than 0.2 dB of error
  - Within tolerance for these programs



Measurement Issues with Aircraft Method Instrumentation – Dynamic Range

A single B-757 departure analyzed

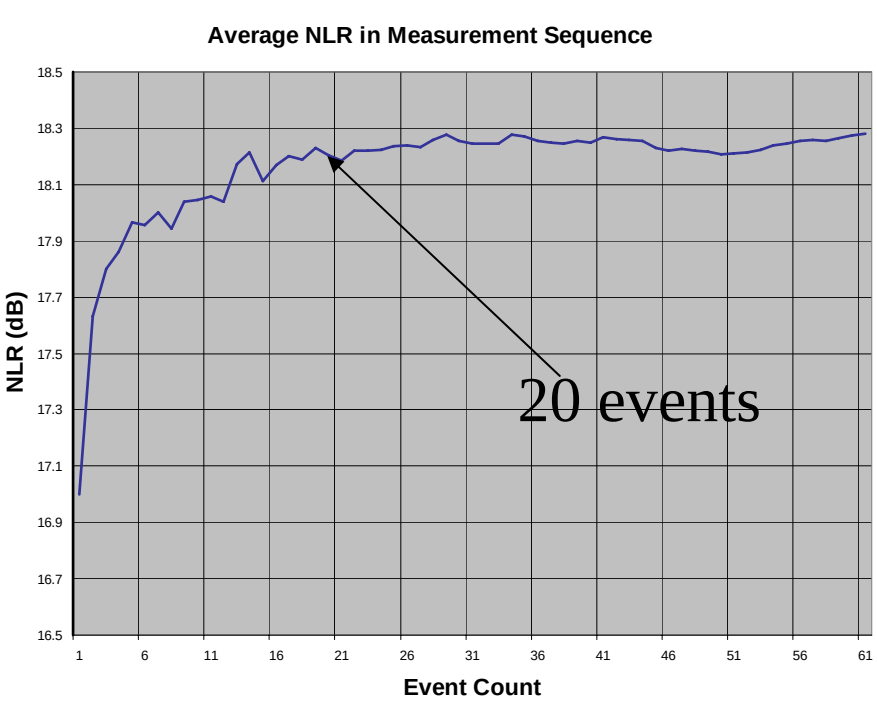
- **Various measurement thresholds evaluated to determine the results of measurement at various dynamic ranges.**
- **10 dB – 15 dB dynamic range is sufficient for 0.2 dB SEL results**

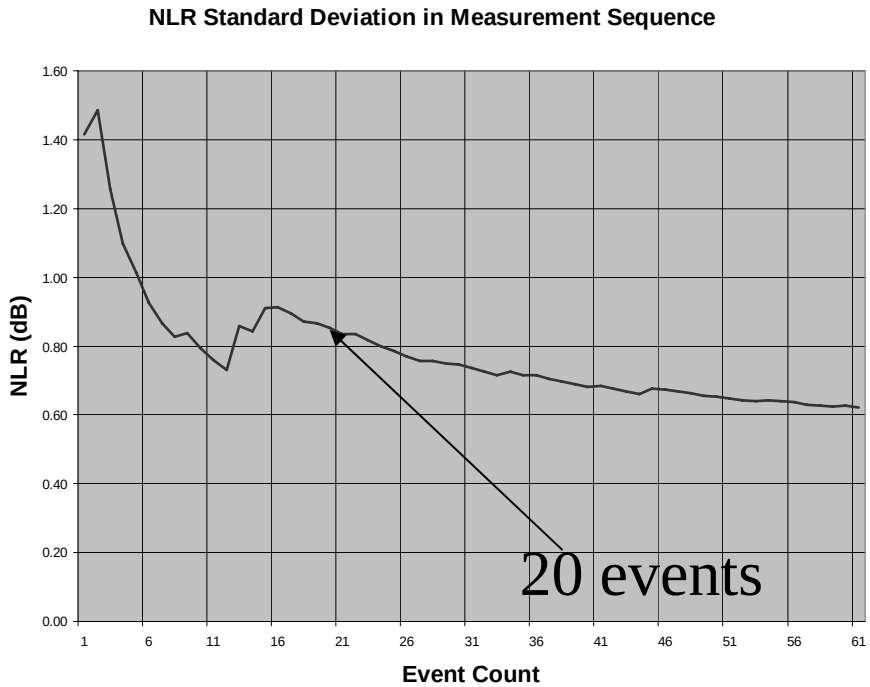


Measurement Issues with Aircraft Method Number of Events Required

We try to obtain 20 events as we found

- **NLR average is within 0.1 dB**
- **Standard deviation is around 0.8 dB**





Conclusions

- Both artificial or flyover source methods are effective
- The volume of aircraft activity may dictate the method used
- Artificial source gives useful spectral and diagnostic information, but may not replicate aircraft directivity well
- Flyover method gives good statistical information, but results vary among individual aircraft flyover events
- Both methods offer good information to the Airport and the FAA to demonstrate an effective noise insulation program

Thank you

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