Updated Procedure for the Measurement of Noise Level Reduction of Buildings Exposed to Aircraft Noise

Ben H. Sharp
Ben Sharp Acoustics, LLC

Transportation-Related Noise and Vibration Committee Summer Conference

June 25, 2018
Supporting Organizations

The work described in this presentation was supported by the following organizations:

- Eric Cox and Hayden Jubara, HMMH – Field measurements
- Dr. Charlie Zheng, Univ. of Kansas – Noise Modeling
Background

- FAA eligibility requirement for participation in an Airport Sound Insulation Program requires an absolute measurement of Noise Level Reduction (NLR).
- Preferred method of measuring NLR uses a loudspeaker as the noise source in accordance with ASTM E 966-10 Standard.
- NLR is a measure of Insertion Loss = Incident sound level – interior room sound level.

- E 966 contains adjustments to measured exterior sound level to account for sound reflection from the façade.
- Issues to be resolved:
  - Are the adjustment factors correct?
  - Why are aircraft and loudspeaker measurements of NLR different?
Loudspeaker/Microphone Test Configuration

- ASTM E966-10 Standard allows for two methods for measurement of exterior sound level generated by a loudspeaker:
  - Flush to the façade (with 5 dB adjustment) – average of 5 positions on the façade.
  - Near-façade, 1.5 to 2.5m (with 2 dB adjustment) – average of 5 positions at random positions across the façade.

- Field tests conducted to validate adjustment factors
Flush Measurement

- Adjustment factor is the difference between free-field level and level measured close to the façade (<1.5")
- Adjustment factor is 6 dB over frequency range of interest.
- Deviations at high frequencies due to façade reflection interference.
- Deviation at mid-frequencies due to slight change in ground reflection interference.
Near-Façade Measurement

- Measurement of adjustment factor for different distances of microphone to façade (2, 4, 5.3, 7.1 ft).

- Large variations due to façade reflection interference effects.

- Interference frequency decreases as façade-microphone distance increases.

- Average adjustment factor is 3.5 dB over frequency range of interest.
Aircraft vs Loudspeaker Measurements

- Values of NLR measured with a loudspeaker are 2 to 3 dB less than those measured for an aircraft overflight as a result of:
  - Shielding effects
  - Angle of incidence

- A time-domain simulation model was exercised to calculate the shielding of building surfaces to an aircraft noise source.

- Noise level histories calculated for each building surface for an aircraft overflight and compared to free-field levels to develop adjustments for building orientation.
Application to Existing Data

- Calculated adjustments applied to existing measured data to account for
  - Updated adjustment factors for wall reflection.
  - Shielding
  - Angle of incidence

![Graph 1](attachment:image1.png)  

\[ y = 0.5849x + 7.6114 \quad R^2 = 0.5085 \]

![Graph 2](attachment:image2.png)  

\[ y = 0.8399x + 3.5184 \quad R^2 = 0.8086 \]
Loudspeaker Placement

- Large variation of noise levels over façade with a 6 ft. loudspeaker due to ground reflection.

- Ground reflection interference frequency a function of loudspeaker/microphone configuration.

- The goal is to minimize variation of sound level over the façade and expose each element equally.
Loudspeaker Placement (cont.)

- Loudspeaker placement alternatives (Loudspeaker/microphone heights):
  - Elevated (25/5) – Interference frequency below range of interest (80 Hz).
  - Ground (0/5) – Interference frequency above range of interest (2500 Hz).

- Traditional mid-level placement (5/5) is worst possible case.

- Adjustment factor for a ground loudspeaker is 6 dB.
Summary

- The adjustment factor for a flush mounted microphone should be the theoretical value of 6 dB, and not 5 dB as in ASTM E966-10.

- The adjustment factor for near-façade microphones varies considerably with frequency and with the loudspeaker/microphone configuration. The average factor is 3.5 dB, and not 2 dB as in ASTM E966-10.

- Close agreement between flush and near-façade measurements of NR with updated adjustment factors.

- Application of adjustments to measured data resolves the differences between aircraft and loudspeaker measurements of NR.