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

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Supporting Organizations

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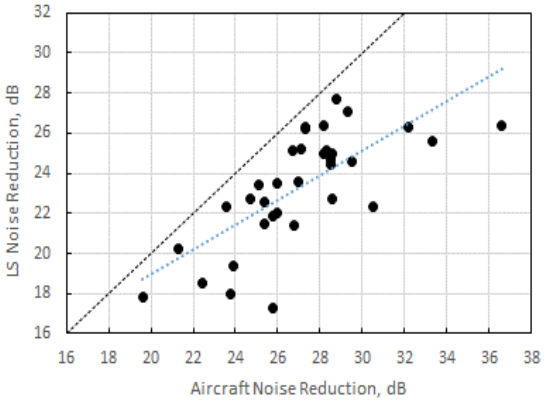
- **Eric Cox and Hayden Jubara, HMMH – Field measurements**
- **Dr. Charlie Zheng, Univ. of Kansas – Noise Modeling**

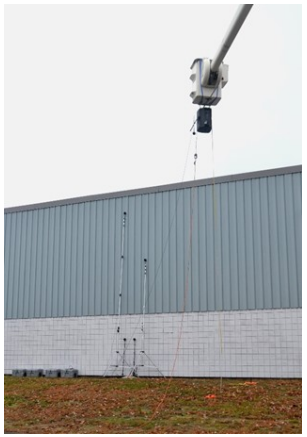
Background

- 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?



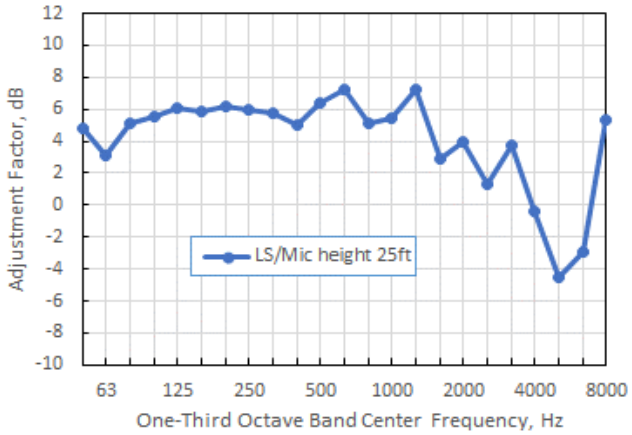
Loudspeaker/Microphone Test Configuration

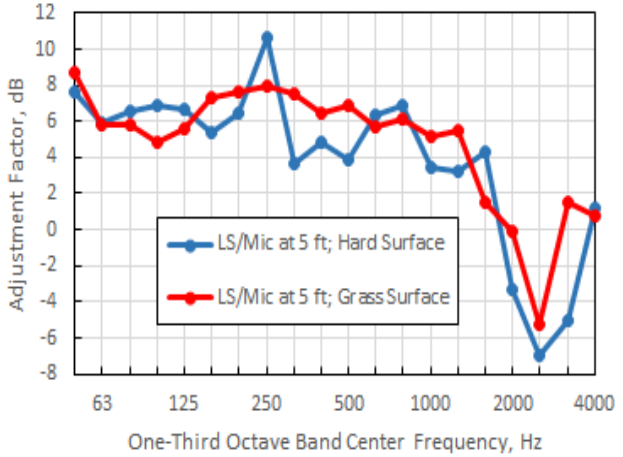
- **ASTM E966-10 Standard allows for two methods for measurement of exterior sound level generated by a loudspeaker:**
  - **Flush to the façade (with 5 dB adjustment) – average of 5 positions on the façade.**
  - **Near-façade, 1.5 to 2.5m (with 2 dB adjustment) – average of 5 positions at random positions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



Flush Measurement

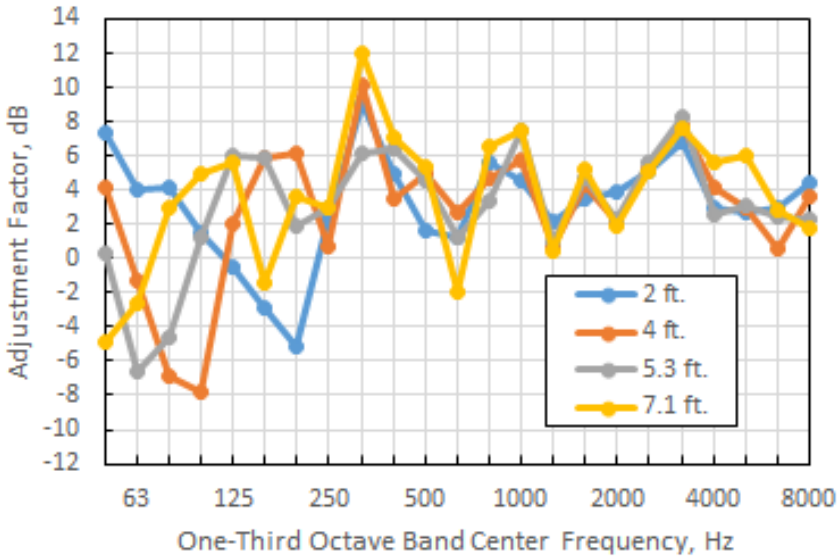
- Adjustment factor is the difference between free-field level and level measured close to the façade (<1.5")
- Adjustment factor is 6 dB over frequency range of interest.
- Deviations at high frequencies due to façade reflection interference.
- Deviation at mid-frequencies due to slight change in ground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





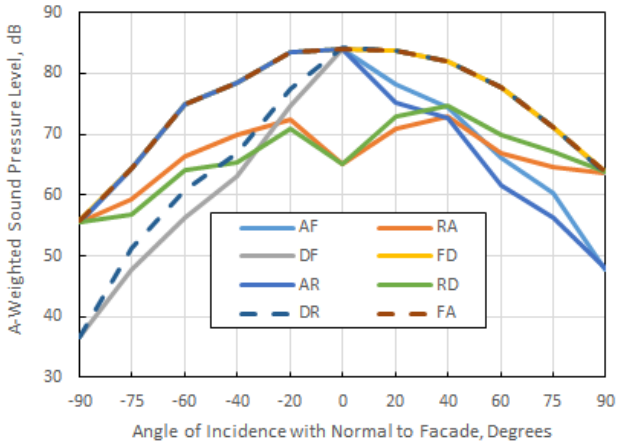
Near-Façade Measurement

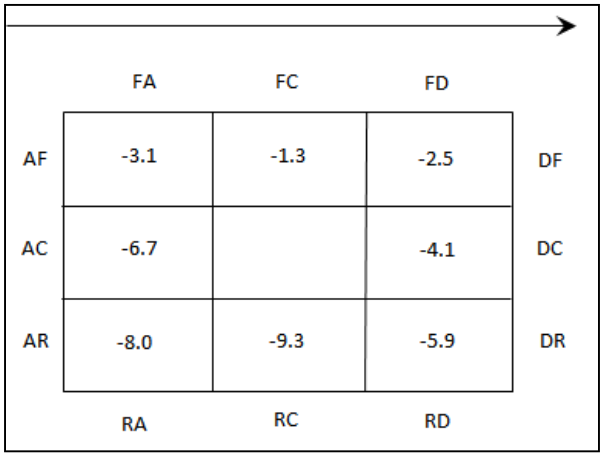
- Measurement of adjustment factor for different distances of microphone to façade (2, 4, 5.3, 7.1 ft).
- Large variations due to façade reflection interference effects.
- Interference frequency decreases as façade-microphone distance increases
- Average adjustment factor is 3.5 dB over frequency range of interest.



Aircraft vs Loudspeaker Measurements

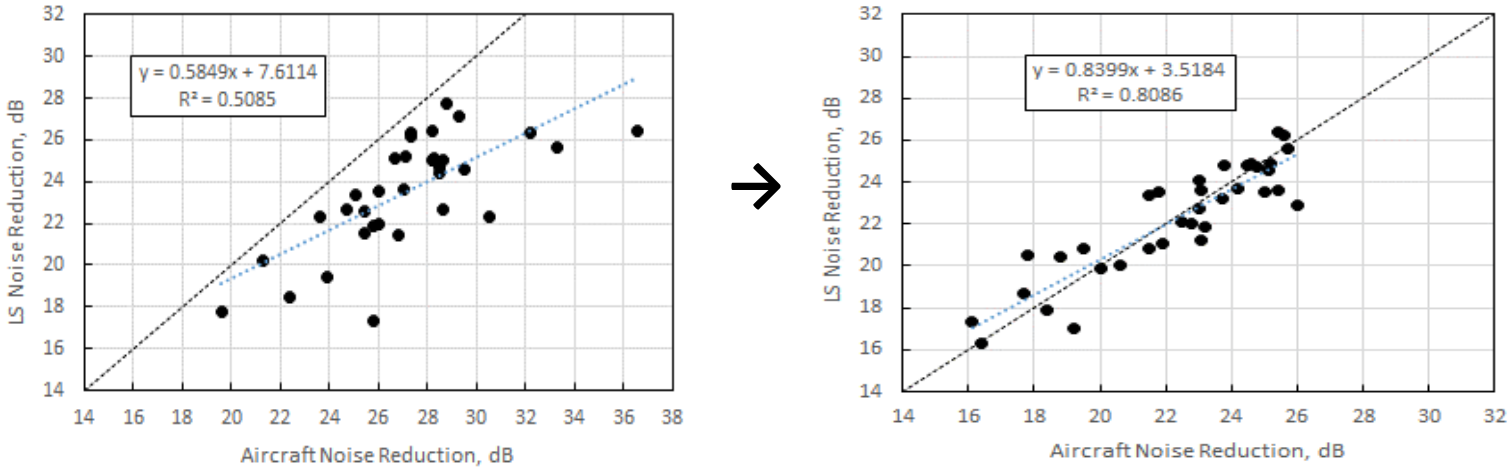
- **Values of NLR measured with a loudspeaker are 2 to 3 dB less than those measured for an aircraft overflight as a result of:**
  - **Shielding effects**
  - **Angle of incidence**
- **A time-domain simulation model was exercised to calculate the shielding of building surfaces to an aircraft noise 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.**





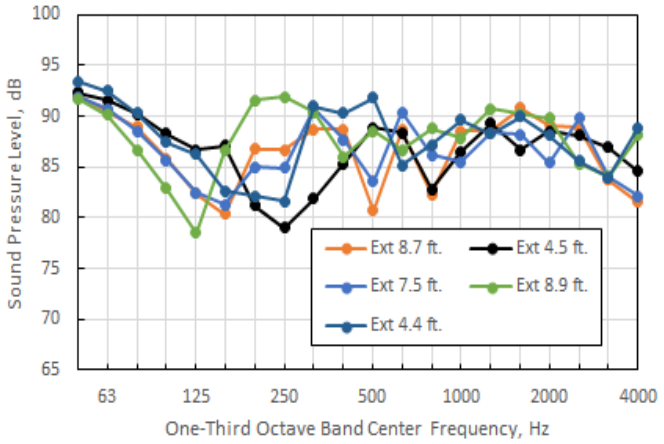
Application to Existing Data

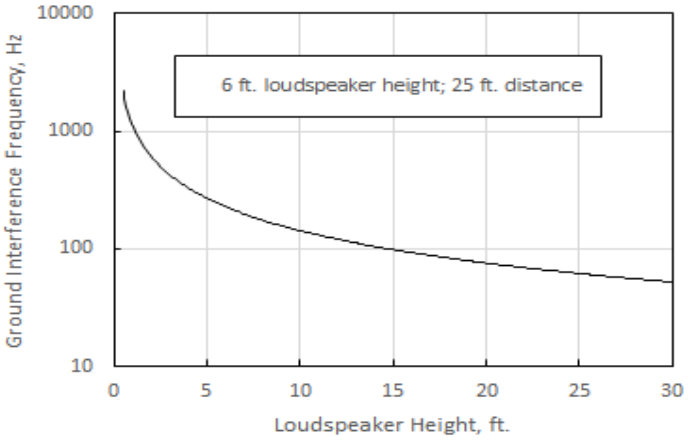
- **Calculated adjustments applied to existing measured data to account for**
  - **Updated adjustment factors for wall reflection.**
  - **Shielding**
  - **Angle of incidence**



Loudspeaker Placement

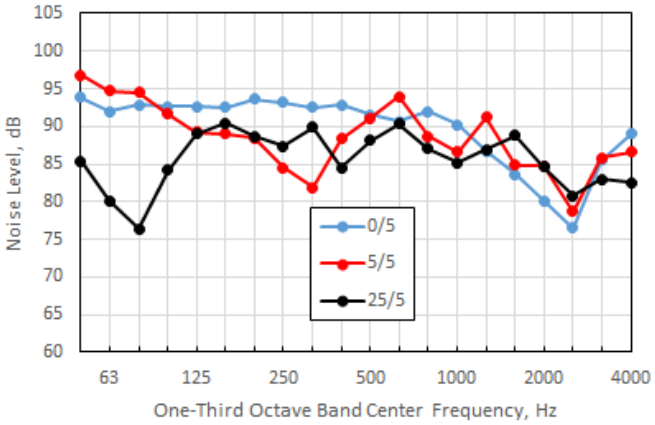
- Large variation of noise levels over façade with a 6 ft. loudspeaker due to ground reflection.
- Ground reflection interference frequency a function of loudspeaker/microphone configuration.
- The goal is to minimize variation of sound level over the façade and expose each element equally.

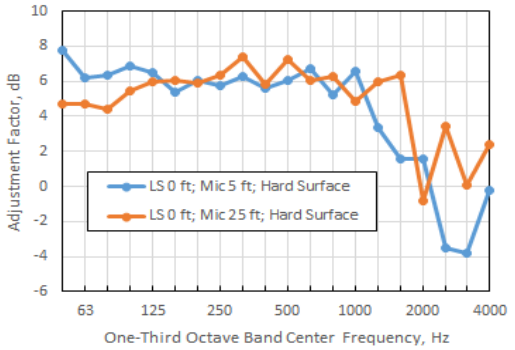




Loudspeaker Placement (cont.)

- **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**