Low-Frequency Aircraft Noise

LAX Community Noise Roundtable

September 20, 2010

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Low-Frequency Aircraft Noise Overview

- Residences located near runways can experience high levels of low-frequency noise (LFN)
- LFN can induce “feelable” vibrations
- Standard sound insulation does not sufficiently reduce LFN

Low-Frequency Aircraft Noise Studies

- **HMMH Collected data on LFN and associated induced structural vibrations**
- **Measurements were made at MSP, SFO and BWI, listening tests were conducted in an aircraft noise simulator and laboratory studies were conducted**

Low-Frequency Aircraft Noise Studies - Aspects Examined

- **Measured sound, vibration, insulation efficacy and resident's judgments**
- **For each takeoff, determined:**
  - **Sound Level (A- and C- Weighted)**
  - **Induced Vibration Levels**
  - **Resident's "Rating" of sound**
- **Correlated Sound Levels with Vibration Levels and Resident Ratings**

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Low-Frequency Aircraft Noise Studies - Measurement Locations

- **LFN levels may produce perceptible vibrations at considerable distances from the runway end**
  - **Only in limited directions due to the directional sound pattern produced by jet engines**
  - **Vibrations could occur 7,000 to 8,000 feet from the start-of-takeoff-roll**
    - **Well outside the 65 DNL (CNEL) contour**

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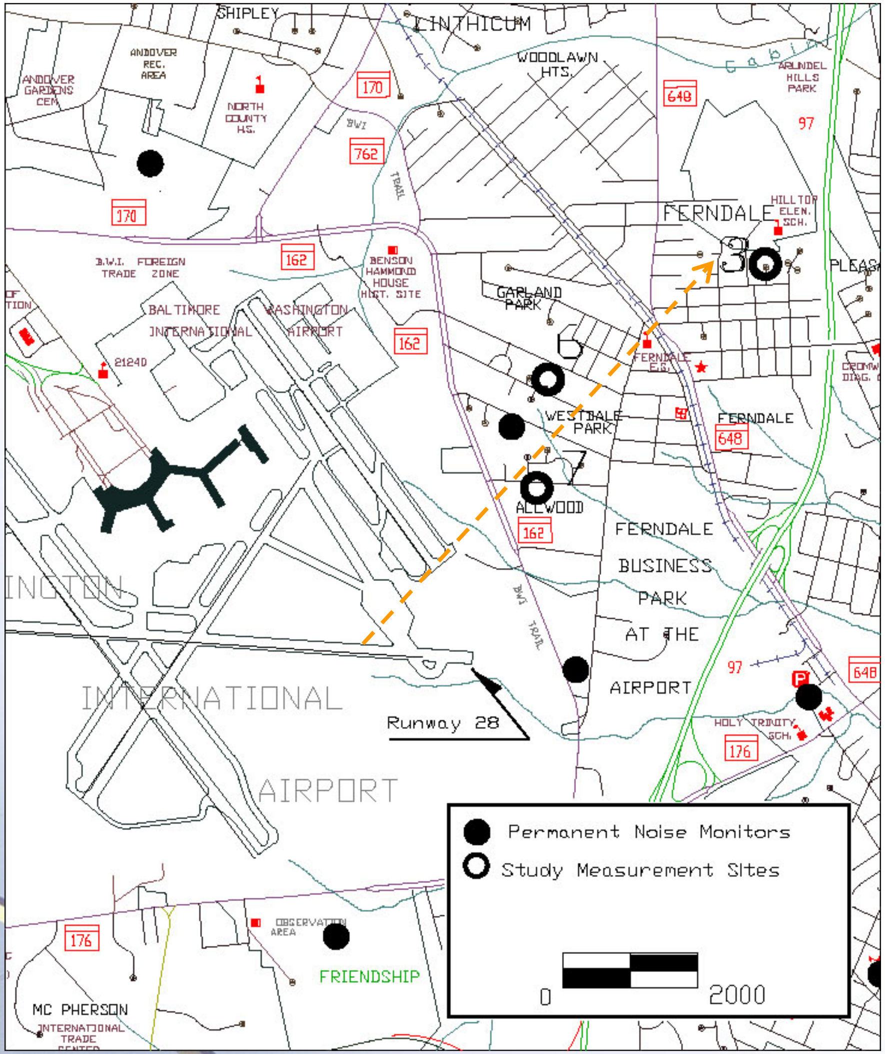
Low-Frequency Aircraft Noise Study
Measurement Locations – BWI Takeoffs



Low-Frequency Aircraft Noise Studies
Principal Findings

- **Start-of-takeoff-roll, acceleration and thrust reversal generate high levels of LFN**
  - **Aircraft ground operations**
- **LFN below 200 Hz**
  - **Human hearing range is from 20 Hz – 20,000 Hz**
- **Low-frequency sounds propagate further and with less reduction due to their longer wavelength**
- **Standard A-weighting is unlikely to relate people's reactions to these low-frequency sounds**

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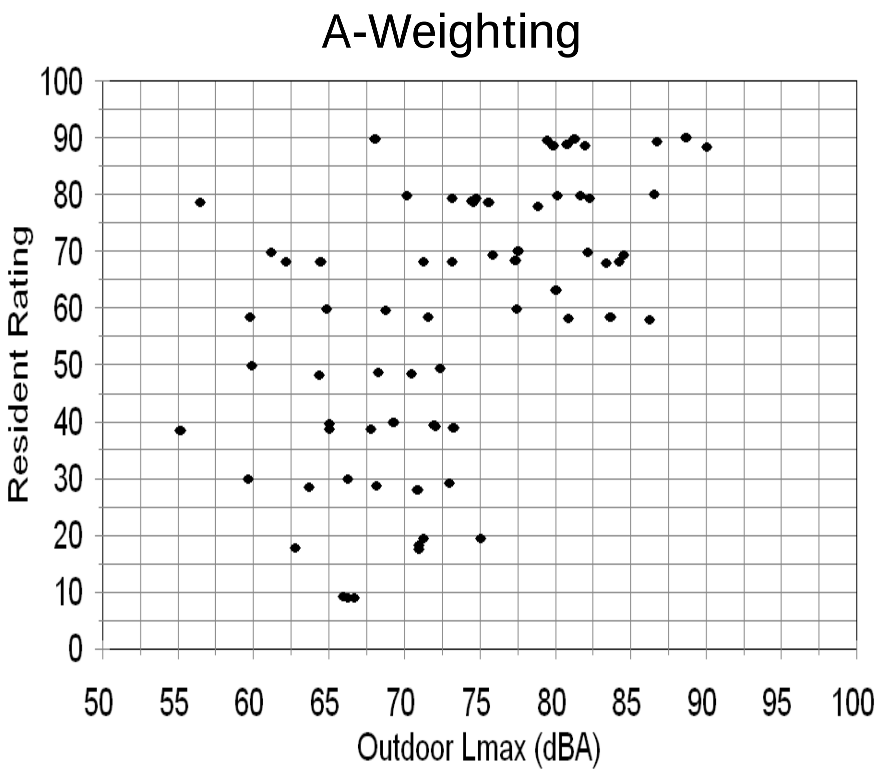
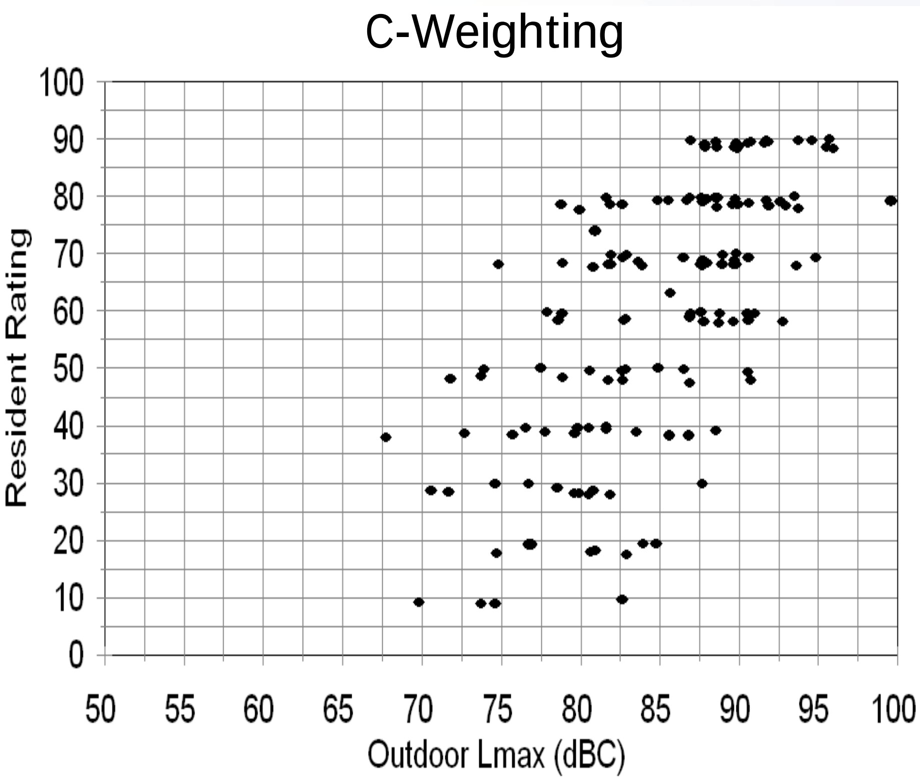
Low-Frequency Aircraft Noise Study Results – Resident Ratings (BWI)





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Low-Frequency Aircraft Noise Studies - Principal Findings

- Vibration/rattle due to LFN
  - Hubbard exterior sound level criteria
- C-Weighted Lmax correlated better with wall vibration and with resident ratings
- HMMH work for BWI and SFO suggest 75 dB to 85 dB maximum C-weighted levels result in perceptible window and wall vibrations
- C-Weighted levels preferable for estimating resulting vibration and annoyance potential

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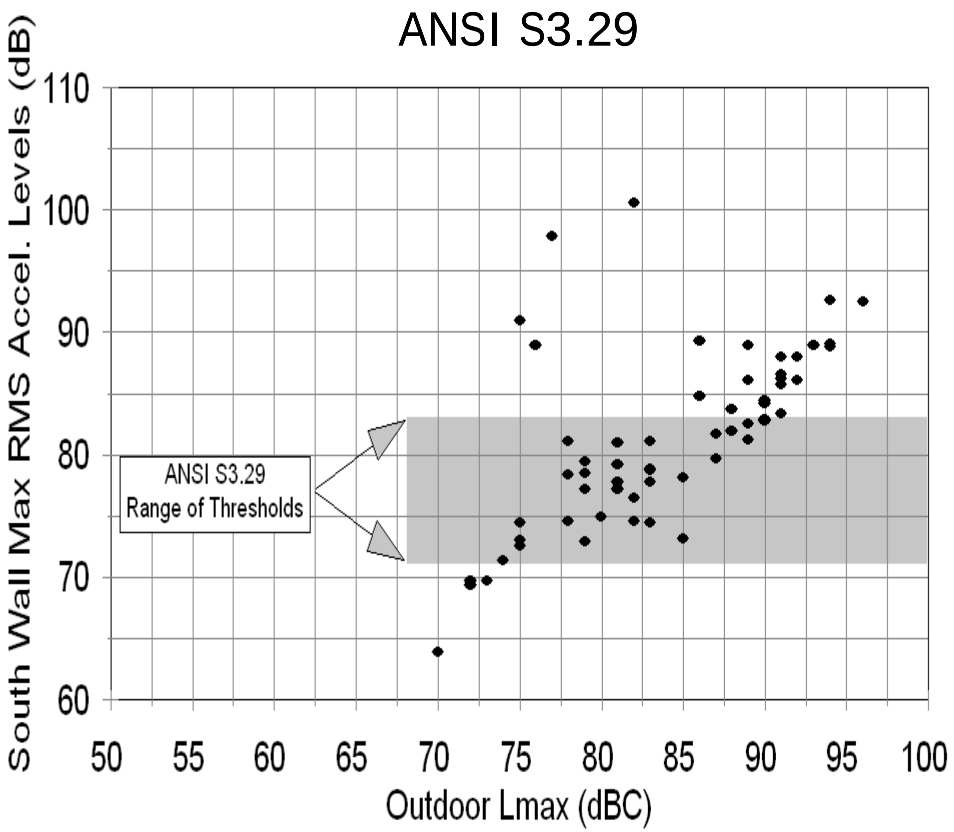
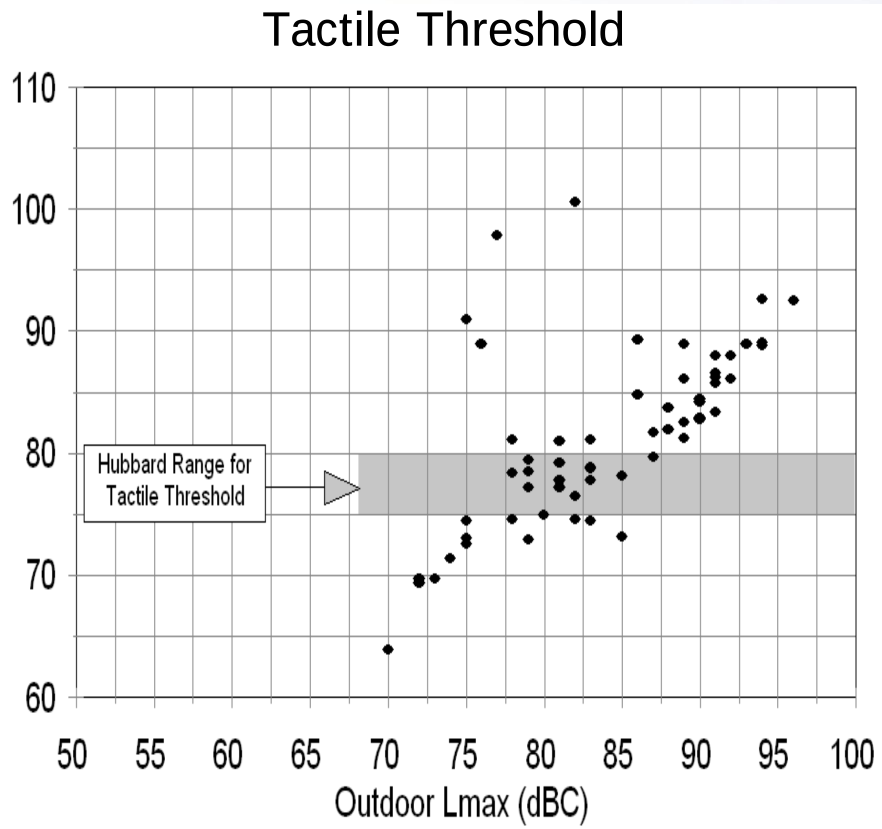
Low-Frequency Aircraft Noise Studies Results – Vibration vs Maximum Sound Level





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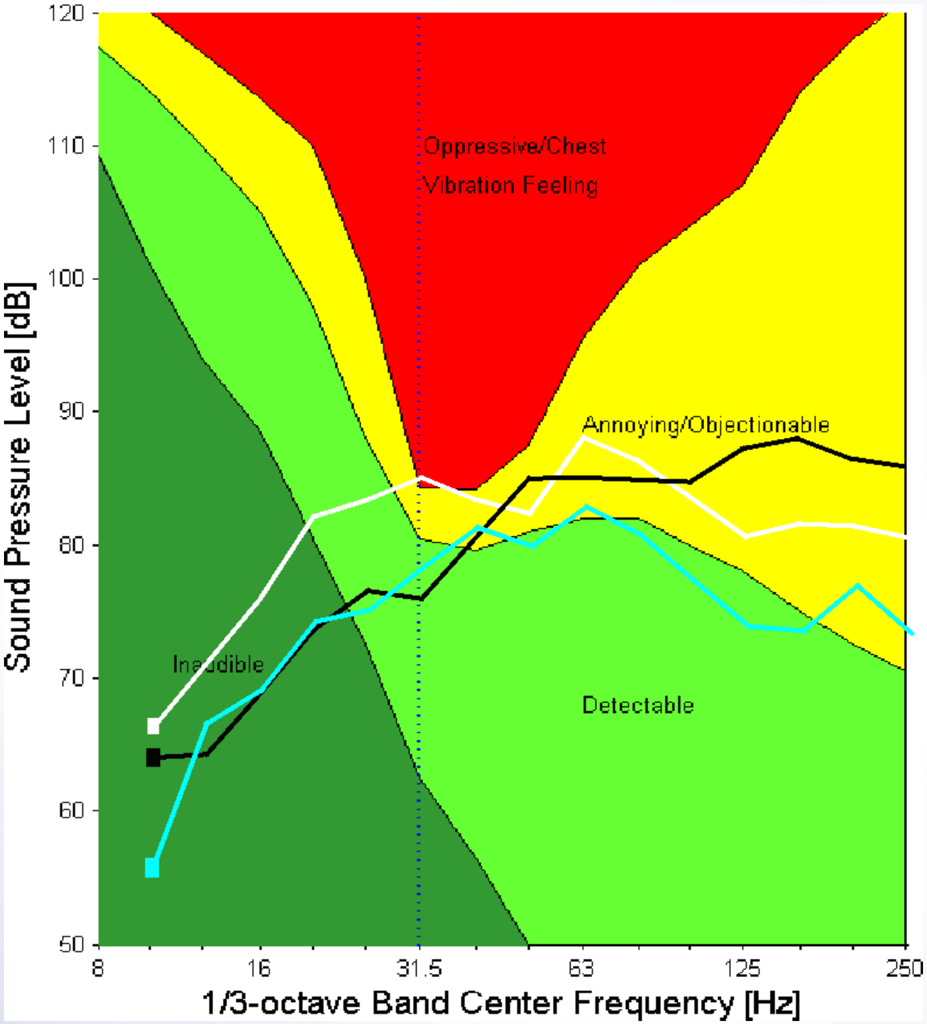
Low-Frequency Aircraft Noise Studies - Comparison with Human Judgments

- **Event 2 Indoors - Rating 90, Cmax = 82 dB**
- **Event 1 Indoors - Rating 80, Cmax = 83 dB**
- **Event 3 Indoors - Rating 30, Cmax = 76 dB**



(Tokita & Nakamura thresholds)

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Conclusions From PARTNER LFN Study

- Low-frequency sounds propagate further than high-frequency sounds and can annoy people far from the runway
- The Hubbard criteria work well for screening for vibration/rattle due to LFN
- A-Weighted and C-Weighted maximum noise levels work for predicting laboratory response at lower A-weighted noise levels (60 dB – 80 dB)
- For high levels use C-Weighted maximum levels or Tokita & Nakamura thresholds

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Low-Frequency Aircraft Noise Studies - Conclusions

- C-Weighted maximums are most effective metric for screening for possible LFN problems
- Use C-Weighted maximum of 80 dB as screening threshold
- If possible, also measure associated A-Weighted maximum levels for additional screening information
  - C-Weighted minus A-Weighted indicates significance of LFN

Low-Frequency Aircraft Takeoff Noise Study Conclusions

- **C-Weighted better correlated with induced vibrations and resident ratings than A-Weighted**
- **Perceptible wall vibrations likely to occur for C-Weighted Lmax exceeding 75 dB – 85 dB**
- **C-Weighted Lmax possible predictor of subjective judgments of takeoff noise**

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Questions?

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