Aircraft Noise Spectra used to Estimate Noise Level Reduction (NLR) for Airport Sound Insulation Programs

TRB ADC-40 Summer Meeting

Missoula, Montana

Presented by Christopher Bajdek, Principal Consultant – HMMH

Eugene Reindel, Eric Cox, Brad Nicholas, and Bob Mentzer

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Disclaimer

The work is sponsored by Federal Aviation Administration (FAA).

Any opinions, findings, and conclusions or recommendations expressed in this work are those of the authors and do not necessarily reflect the views of the FAA.

The work, together with other research, may feed into FAA policy development. Please contact FAA directly with policy questions.

Introduction

- Background
- Current Practices
- Sensitivity of Noise Level Reduction (NLR) to aircraft noise spectrum
- Recommendations

Background: Why did the FAA want to investigate this subject?

- Airport sound insulation programs implemented under FAA's Airport Improvement Program require testing to:
  - Determine interior noise levels for eligibility
  - Ensure acoustical goals for noise level reduction are met
- To determine interior noise levels, program sponsors
  - Determine noise level reduction (NLR) of habitable rooms
  - Subtract the NLR from the exterior noise level
- Program sponsors are currently using two methods for determining NLR
  - Actual aircraft noise level measurements
  - Measurements using an artificial noise source

Background: Why investigate? (continued)

- NLR calculations are dependent on
  - The frequency content of the exterior noise source
  - The transmission loss (TL) characteristics of the structure within each frequency band.

- Outdoor/Indoor Noise Reduction (OINR) is calculated by taking the difference between the noise level measured outside and inside the room being tested

- **The aircraft noise spectrum used in the data analysis process plays an important role in determining NLR using the "loudspeaker" method**

FAA Scope of Work

- Survey Airport Sponsors on current practice
  - Obtain noise spectra used in sound insulation programs
  - Understand the **methods** used by sponsor to select and determine a source spectrum
- Evaluate the Methods
  - Supplement methods from survey with additional known methods
  - Evaluate the Sponsor's ability to generate sound source spectra
- Determine Sensitivity of NLR to aircraft noise spectrum
  - Two study airports: INM input data and acoustical test data
  - Spreadsheet to calculate NLR using the input data from each airport – for each of the methods

FAA Scope of Work (continued)

- Results and Recommendations
  - Recommendations for FAA to consider in standardizing use of aircraft sound source spectra for sound insulation programs
  - Technical report

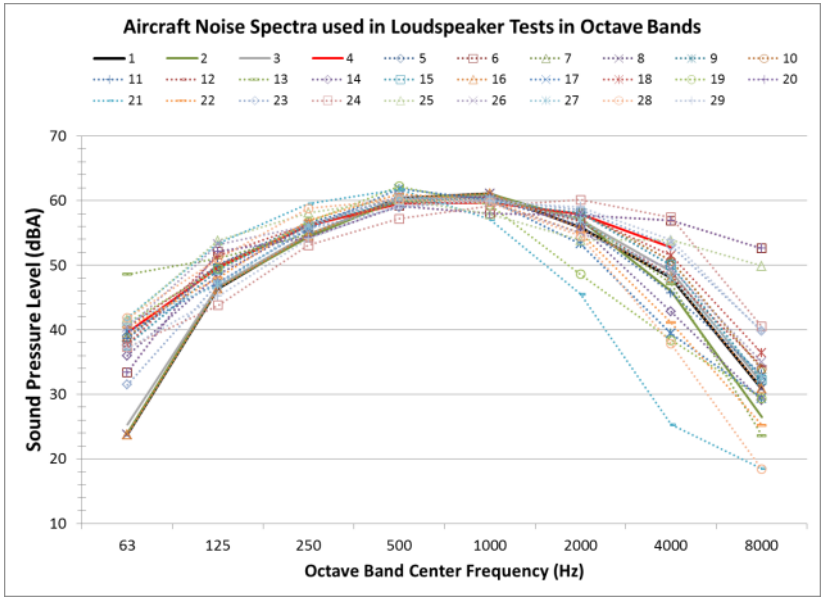
- Provide Sensible Recommendations to FAA
  - Balance the following factors:
    - Technical accuracy
    - Cost
    - Consistency

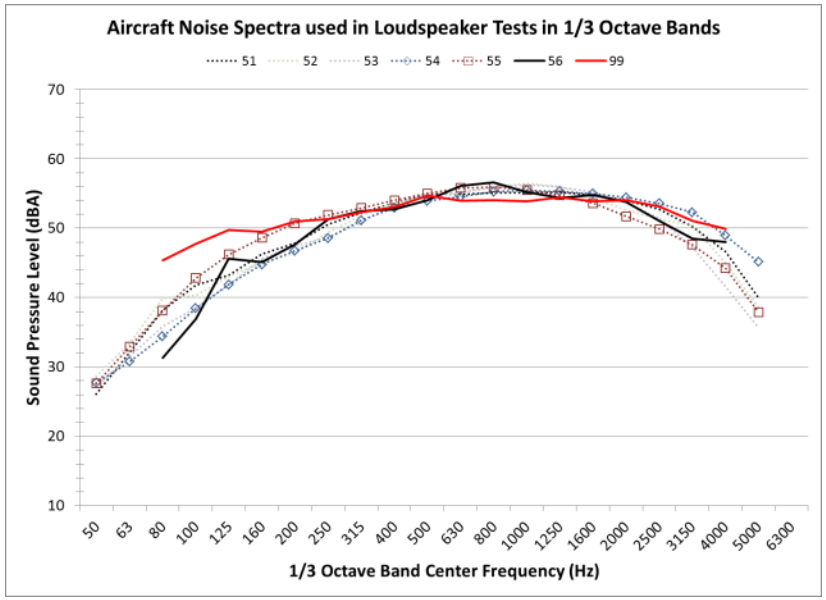
Background: Loudspeaker Method

Current Practice

- 6 out of 7 acoustical consultant responded to a survey
- 35 unique spectra; representing 35 Sound Insulation Programs (SIPs)
- Methods varied:
  - Measurement data adjusted for number of arrivals / departures
  - INM Spectral Class database
  - Standardized spectrum (e.g. ASTM or IBANA)
  - Aircraft noise spectra in octave and 1/3 octave bands
- While spectral data are useful, the prime objective of the survey is to understand the methods

Current Practice: Aircraft Noise Spectra used in Residential Sound Insulation Programs



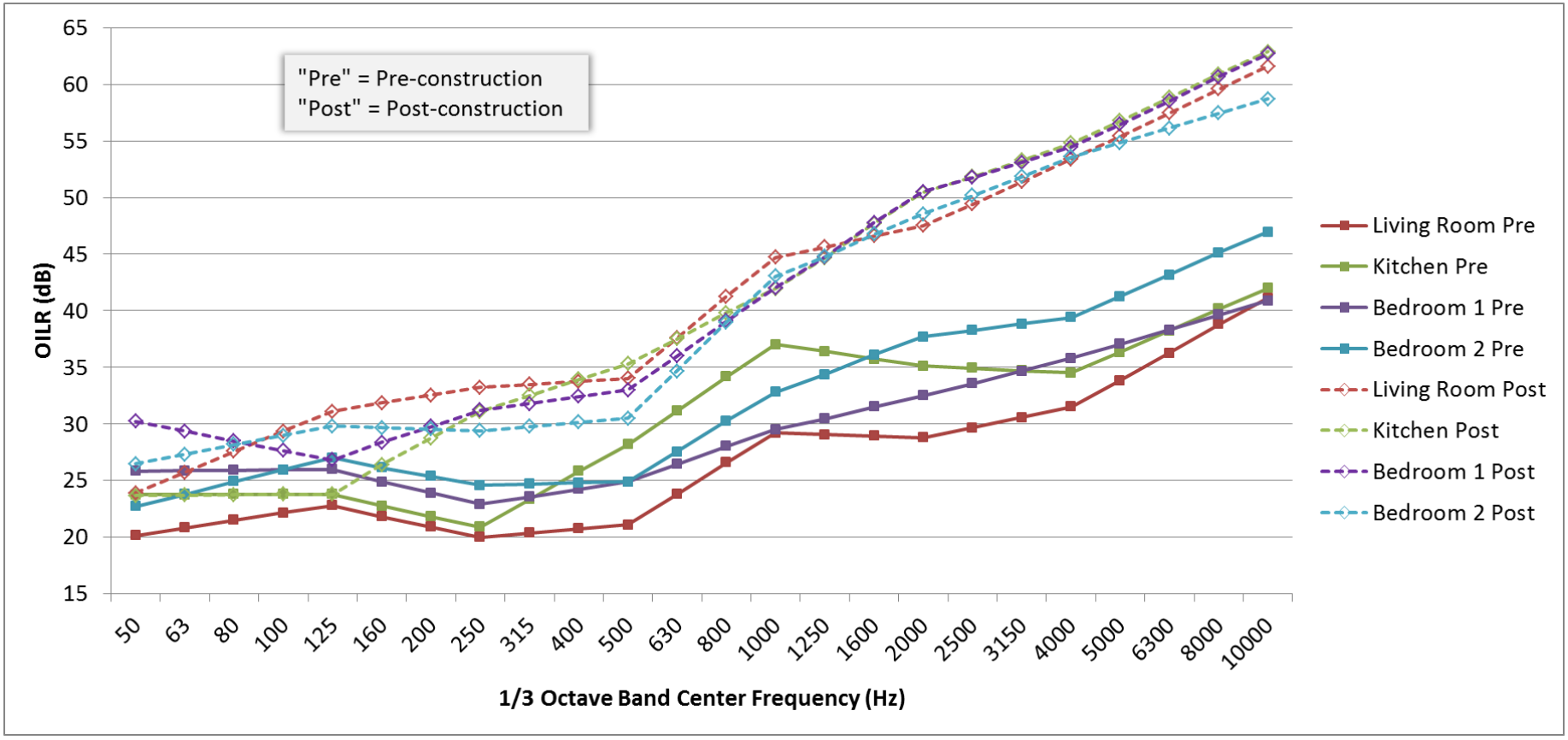


- Significant variations in spectra → significant variation in NLR
- What is the sensitivity of NLR to choice of aircraft noise spectrum?

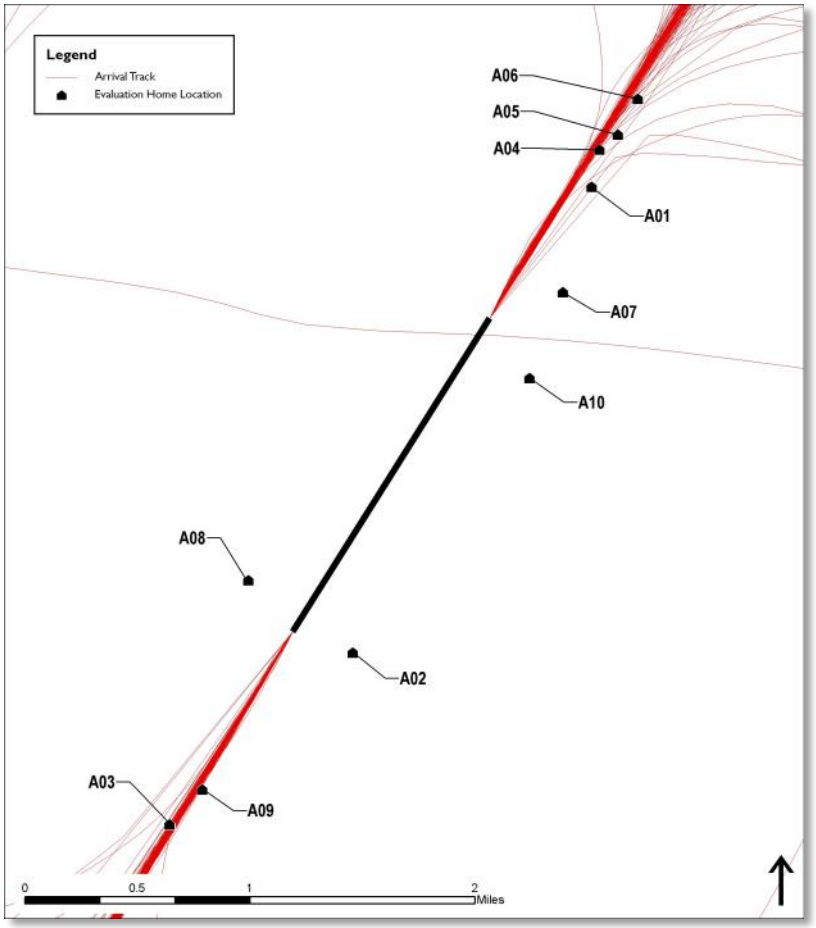
Methods to Evaluate

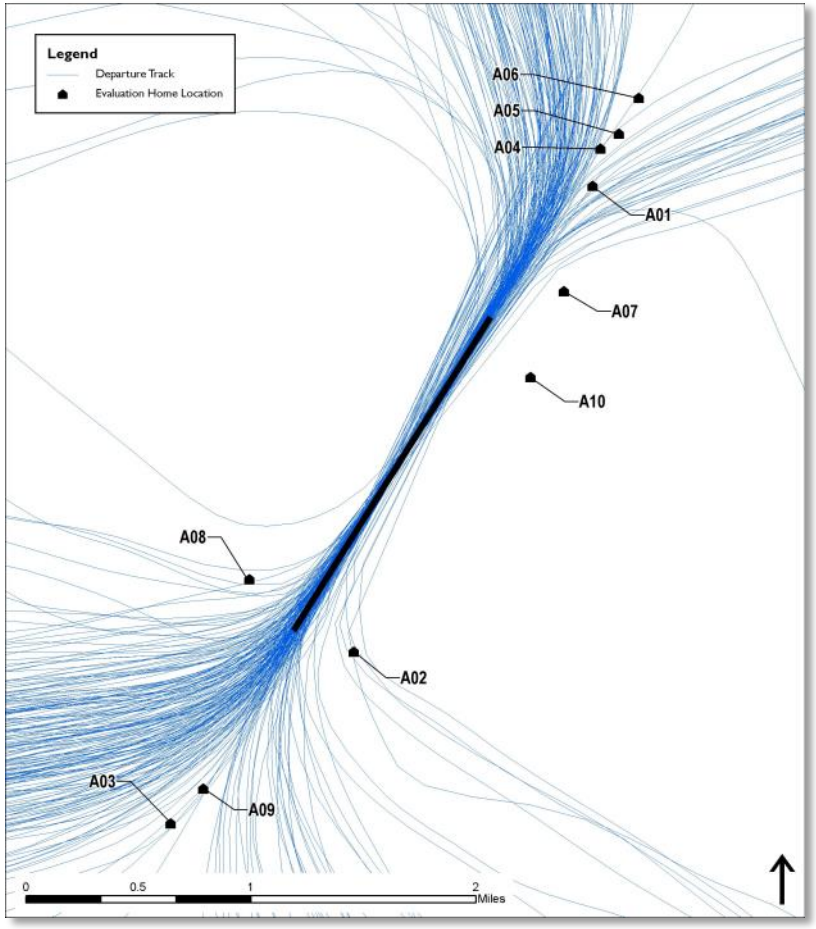
1. Loudest aircraft
2. Most frequently operating aircraft
3. Largest single aircraft contributor to the exterior Day-Night Average Sound Level (DNL)
4. Generalized spectrum for aircraft groupings
5. Standardized spectrum (e.g. ASTM)
6. Average exterior aircraft noise spectrum
7. Calculated NLR based on noise spectra for all aircraft operations at an airport (the reference method)
8. Simulated aircraft noise measurements

Measured OINR by Room (Representative Home at Study Airport A)

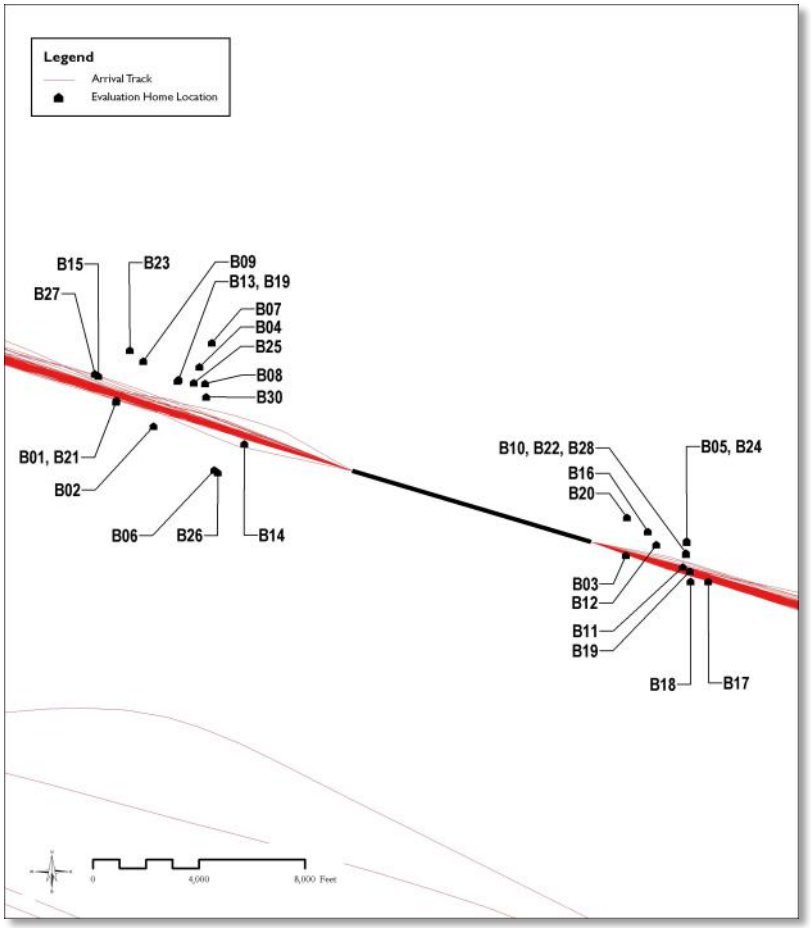


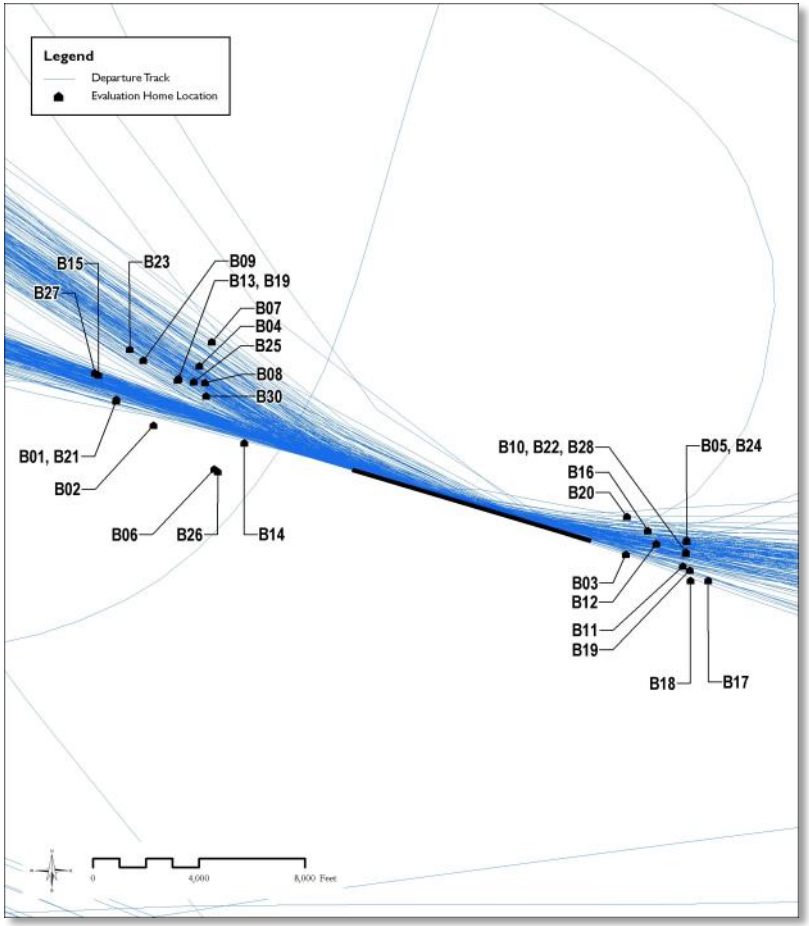
Study Airport A: Arrivals and Departures





Study Airport B: Arrivals and Departures





Distributions of Pre-construction "Offsets"

Pre Construction

Offset (dB)	1A1	1A2	1B	2A1	2A2	2B1	2B2	3A	3B	4A1	4A2	4A3	4A4	4A5	4A6	4A7	4A8	4A9	4A10	4A11	4A12	5	6A	6B	6C	6D	8_1	8_2
-10	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
-9	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
-8	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
-7	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
-6	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
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Distributions of Post-construction "Offsets"

Post Construction

Offset (dB)	1A1	1A2	1B	2A1	2A2	2B1	2B2	3A	3B	4A1	4A2	4A3	4A4	4A5	4A6	4A7	4A8	4A9	4A10	4A11	4A12	5	6A	6B	6C	6D	8_1	8_2
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Report Findings

- Interim Approach: uses the most frequently operating aircraft at an airport by runway end (a variation of Method 2)
  - Relatively straight-forward and requires a low level of effort to implement
  - Yields reasonably accurate results for airports dominated by frequent commercial jet operations and may be used immediately

Report Findings: (continued)

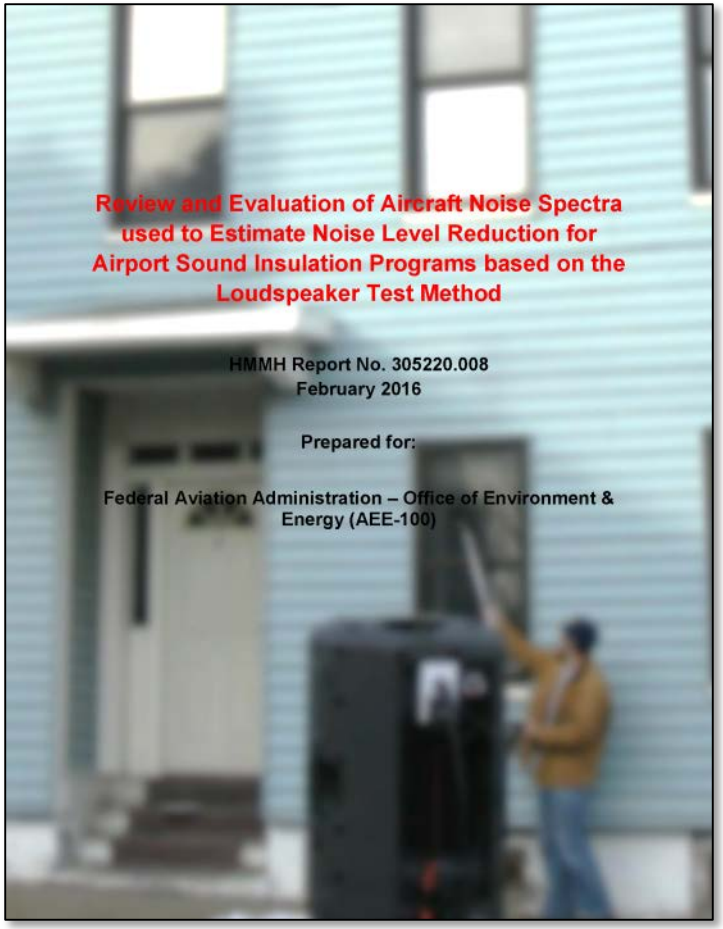
- The Long-term Approach: based on a calculation of the average exterior aircraft noise spectrum (Method 6)
  - Medium-high to high level of effort to implement and yields more accurate results
  - While this approach could be implemented for immediate use, HMMH believes the development of a stand-alone spreadsheet tool and/or future revisions to AEDT, as directed by FAA, would provide consistent and repeatable results

Acknowledgments

- HMMH
  - Sean Doyle, Analyst (now with FAA)
  - Michael Hamilton, GIS specialist
- FAA
  - Dr. Hua (“Bill”) He, FAA Office of Environment & Energy (AEE-100)
  - Mr. James Byers, FAA Airport Planning and Environmental Division (APP-400), email jim.byers@faa.gov
- Participants in the data collection effort
  - Acentech, Andrew S. Harris, BridgeNet International, CSDA Design Group, and Landrum & Brown

Closing Remarks

- The report will soon be available on the FAA web site
- Questions?



Thank you!

Chris Bajdek

781.229.0707 x3128

cbajdek@hmmh.com

www.hmmh.com

Method 7: Reference or Baseline (Best Estimate of "Overall" NLR)

- One (1) year of aircraft operations
- Determine NLR for each aircraft operation:
  - Exterior sound exposure level (SEL), in 1/3 octave bands
  - Apply OINR
  - Interior SEL, in 1/3 octave bands
  - One NLR per operation per room
- To evaluate the other methods, derive a composite NLR (for each residence) by averaging over all aircraft operations (and rooms)