TRB ADC40 Mid-Year Meeting 2018

Overview of Noise Level Reduction (NLR) Research

Presented to: ADC40

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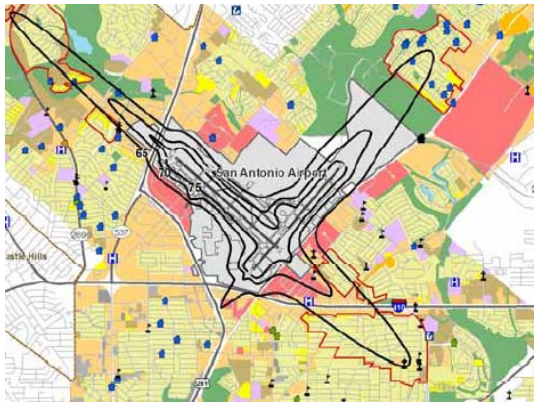
Federal Aviation Administration

Airport sound Insulation programs and NLR

As part of noise management (land use planning), FAA grants were established for Part 150 noise compatibility programs (which includes sound insulation of dwellings)

- More than $10 billion federal grants since 1982
- Dwellings within DNL 65 dB (**and indoor DNL ≥ 45 dB**)
- are eligible for sound insulation



Indoor DNL = Outdoor DNL – **NLR**

NLR: Noise Level Reduction (dB)

NLR variation → tolerance of the indoor DNL requirement

Different methods to measure NLR

Flyover test

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

Loudspeaker - raised

Loudspeaker - on tripod

- More popular now
- "Equivalent to flyover test"
- "Generally follow" ASTM E966
- Actual industry practices may vary, and have not been well documented.

FAA Review of ASTM E966

ASTM E966: "*Field measurement of airborne sound attenuation of building façade and façade elements*

(1) ASTM E966 robust for Residential Sound Insulation Programs (RSIPs)?

No. The standard is referred mostly because it is the only standard available. It provides guidance on loudspeaker test of facade or facade elements.

(2) RSIP acoustic testing practices conform to ASTM E966?

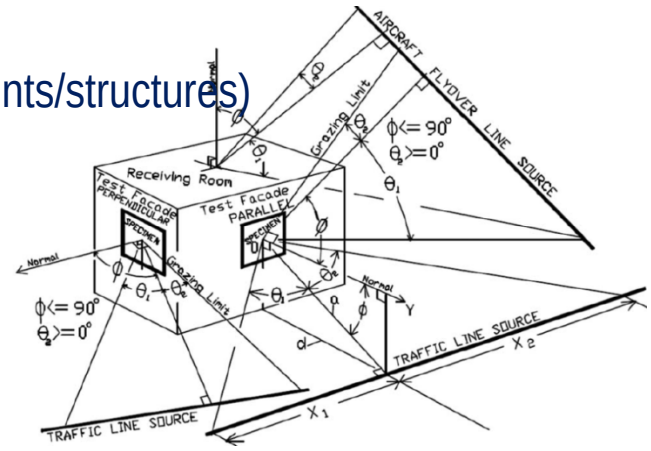
To an extent. The placement of the loudspeaker and outdoor microphones in RSIPs seems to follow ASTM E66 in principle, but not "to the book". On the other hand, the RSIP test procedures include additional topics (i.e. aircraft spectral data, NLR calculation) that are not covered in ASTM E966.

(3) NLR variation likely comes from?

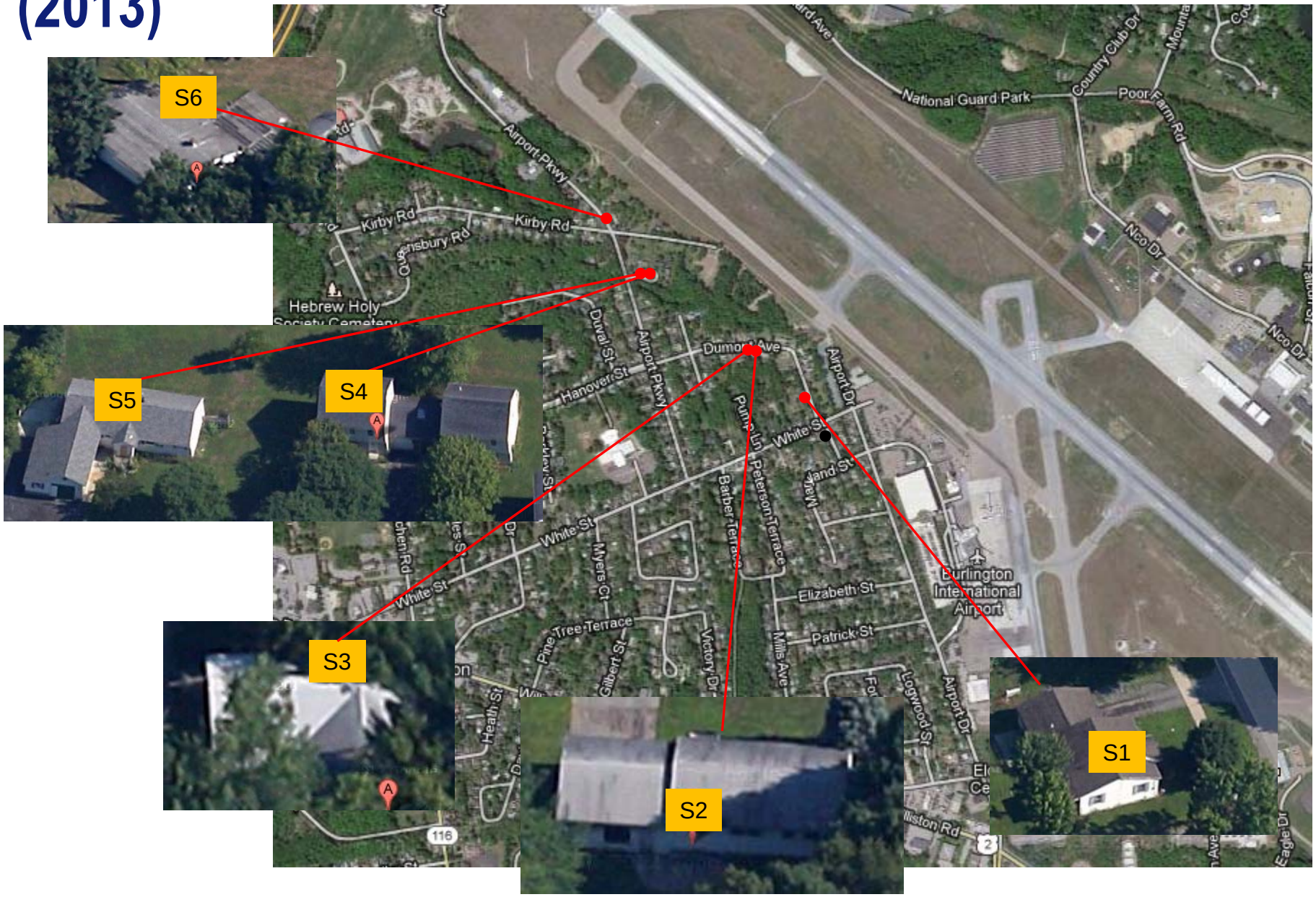
(a) noise source (position, level, spectra, direction);
(b) microphone placement, both outdoors and indoors;
(c) room factors (size and indoor absorption); and
(d) building structure factors (types, unique façade elements/structures)
(e) versions of the standard (2004 vs. 2010)

(4) NLR variation – how much?

Very limited data available as of 2012.
Time to collect data!!!



Burlington Int. Airport (BTV) NLR Data Collection (2013)

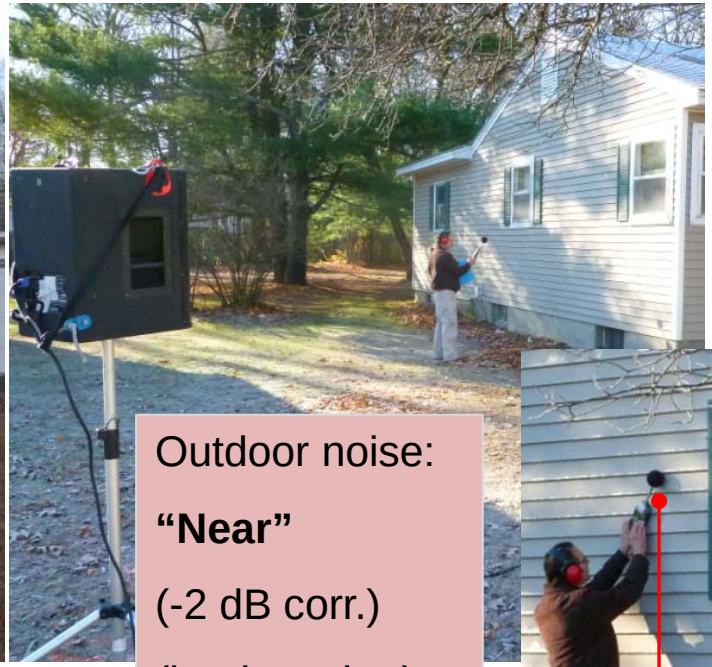


BTV NLR Data Collection - Test Setup

Outdoor noise:

“Free field”

(aircraft flyover)



Outdoor noise:

“Near”

(-2 dB corr.)

(loudspeaker)

Outdoor noise:

“Flush”

(-5 dB corr.)

(loudspeaker)

Indoor noise

“fixed or roving”

BTV NLR Data Collection - Findings

Factors shown as of secondary importance

- Loudspeaker distance to the house
- Loudspeaker angle
- Outdoor noise measurement: “Near” vs. “Flush”
- Indoor noise measurement: - fixed mic. vs. roving

Factors shown as of primary importance

- Room absorption
  - NLR 2-3 dB lower in empty rooms (minimum absorption)
- Method-to-method difference (!)
  - Loudspeaker tests yields lower NLR (ref. a/c test which is closer to “actual experience”)
    - 3 dB lower (ldspkr on tripod
    - 2 dB lower (ldspkr is raised)
- Aircraft spectra (!)

Subsequent research topics and funding venues

A. Method-to-method differences in NLR testing

B. Aircraft noise spectra in loudspeaker NLR tests

C. Evaluate use of models in estimating NLR

Airport Technology Research (ATR) program

D. Alternative testing methods (i.e. indoor loudspeaker)

ACRP 02-51 Evaluating Methods for Determining Interior Noise Levels Used in Airport Sound Insulation Programs

- CSDA Design Group completed final report in 2016
- Measured 14 homes at two airports (SAN and BOS) using various measurement techniques
- Results largely similar to findings from the BTV study, with further quantification of measurement uncertainties.
- Also explored indoor speaker/modeling methods
- Outcome includes method selection decision matrix, uncertainties and best practices
- Some, but limited, efforts to study differences among testing methods

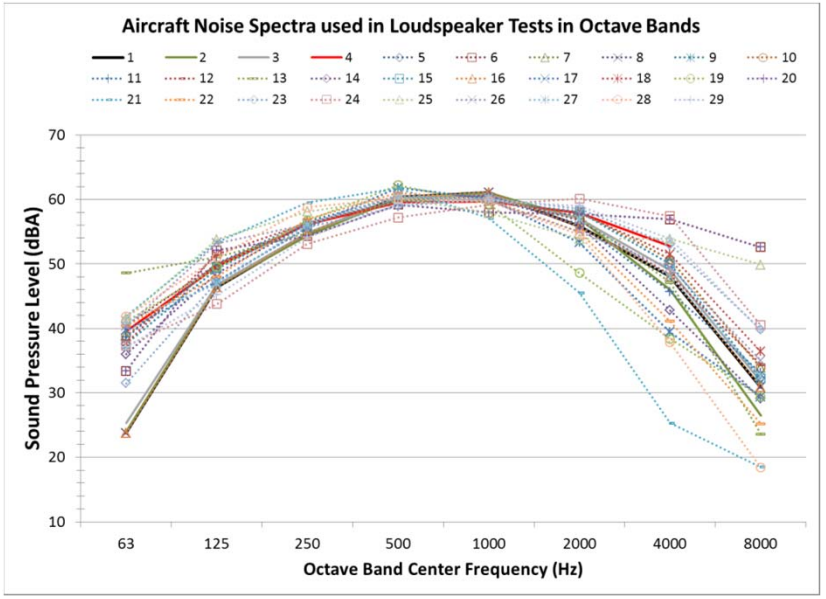
Frequency Spectra Study

HMMH completed final report in 2016 - contract via ARP/ATR

1. Surveyed current industry practices in the selection of frequency spectra data
2. Conducted sensitivity analysis and recommended intermediate approach

Findings:

1. Surveyed current industry practices: wide range → several dB variation in NLR
2. Identified 7 methods to focus for sensitivity study
3. Recommended an interim approach – use spectrum of most frequently operating aircraft at an airport.
4. Proposed a long-term solution – spreadsheet based estimation method to account for fleet mix, aircraft spectral class information, etc.



NLR Prediction/Modeling

L&B completed final report in 2016 – contract via ARP/ATR

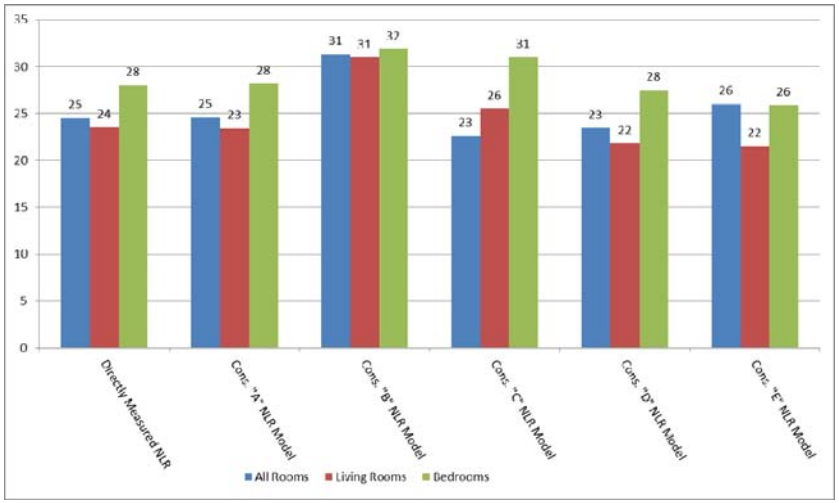
1. Surveyed current industry practices in the models used and modeling practices.

2. Evaluated consistency among various prediction models ("round robin test") and recommended best modeling practices.

Findings:

Surveyed current industry practices: wide range → several dB variation

1. **Variations among firms are caused by both modeling input and modeling itself.**
2. **When similar modeling input/modeling practices are followed, output variation reduces.**
3. **Premature to use modeling as alternative to testing – particularly with leaks in building structures .**



ASTM E966 Adjustment Factors (ongoing)

Objectives: Understand robustness of the ASTM E966 adjustment factor and causes of differences between aircraft and loudspeaker tests. Recommend practices to reduce the differences, and approaches to develop a new (version of) industry standard.

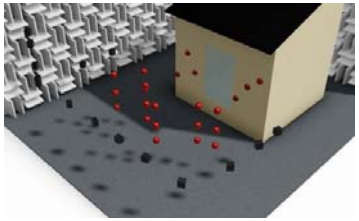
Preliminary findings: Phase I research report will be available soon.

Research Teams: CSRA (& Ben Sharp Acoustics/U. Kansas/HMMH)

Funding Source: ARP/ATR

Other related projects

- (completed) University research (COE) – modeling/validation/exploration
  - Funding stopped in 2015
  - Key findings include
    - As window is improved, walls start to contribute to NLR
    - New energy efficient wall types might lead to lower NLR
    - Acoustic array offers new opportunities in NLR testing



- ACRP 02-31 “Aging effect” of sound insulation – Effect is found to be limited

Concluding Remarks on the NLR Research

- A research program developed to address NLR estimation issues
- Identified various gaps and peeled the onion. The upfront evaluation and the BTV study built a solid foundation (and scope) for subsequent studies.
- Leveraged different funding sources and maintained coordination (including sourcing, project management, technical reviews, publications, etc.).
- Research findings incorporated into a guidance document.
- Ongoing research to further understand the difference between the aircraft flyover noise and loudspeaker noise testing.
- The research program is expected to lead to update of a new (version of) industry standard.

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NLR research reports can be found at

http://www.faa.gov/about/office_org/headquarters_offices/apl/research/science_integrated_modeling/noise_mitigation/

https://ascent.aero/project/estimate-of-noise-level-reduction/

http://www.trb.org/Main/Home.aspx