Policy, Engineering, Analysis, and Research Support (PEARS)
Contract No. DTFAWA-11-D-00019
Study of Noise Level Reduction (NLR) Variation

L&B

Aviation Planning at the Leading Edge

POLICY, ENGINEERING, ANALYSIS, AND RESEARCH SUPPORT (PEARS)
CONTRACT NO. DTFAWA-11-D-00019

STUDY OF NOISE LEVEL REDUCTION (NLR) VARIATION

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SECTION 1 INTRODUCTION

Noise Level Reduction (NLR) is used in Residential Sound Insulation Programs (RSIP) to determine the indoor Day-Night Average Sound Level or DNL. Acoustical consultants use various testing procedures (aircraft flyovers and artificial noise/loudspeaker) to measure the NLR. The design and implementation of the acoustical testing plan and method is left to the individual acoustical consultant since the Federal Aviation Administration (FAA) does not specify a measurement standard. In addition, the execution of a specific measurement method, may affect the final measurement result. Therefore, the variation of NLR using the different testing methods, and the execution thereof, has not been quantified and has not been fully categorized.

The NLR measurement methods, using aircraft flyovers are generally based on the FAA document, "Guidelines for the Sound Insulation of Residences Exposed to Aircraft Operations", dated October 1992. The NLR measurement methods using an artificial noise source generally follow the American Society for Testing and Materials (ASTM) International Standard E966-10, "Field Measurement of Airborne Sound Attenuation of Building Facades and Facade Elements"[1]. The procedures in E966-10 are often adapted to make them more efficient and practical for RSIP applications. In addition, use of aircraft spectral data and NLR calculations, not covered in the ASTM standard are also incorporated into the procedure. The details of the testing procedures will likely vary among the acoustical consultant firms and the exact details of the procedures are rarely reported in great detail, if at all, in RSIP documents.

Therefore, the NLR variation among the various testing methods and testing parameters is not well determined due to lack of a controlled study. This study is meant to provide a systematic analysis to better quantify the variation of NLR within the constraints of this contract. The following paragraphs provide detail to support the Acoustical Testing Plan for the "Study of Noise Level Reduction (NLR) Variation" based on ATAC's Policy, Engineering, Analysis, and Research Support (PEARS) Contract No. DTFAWA-11-D-00019.

In summary, this study will quantify the variation of the NLR as a result of different:

1. Testing Methods; and
2. Testing Parameters

[1] American Society for Testing and Materials (ASTM) International Standard E966-10, "Field Measurement of Airborne Sound Attenuation of Building Facades and Facade Elements", editorial changes made in April 2011.

SECTION 2 ACOUSTICAL INVENTORY

2.1 Selection of Test Homes

Burlington International Airport (BTV) was chosen as the site for this study due to the on-going property acquisition program and the availability of properties that are now owned by the airport and are in the process of being demolished. Current properties are located between the 65 and 75 DNL 2011 noise contours at BTV. Over 150 properties have either been acquired and demolished, have been acquired and waiting for demolition, or are eligible to be acquired.

Staff from Landrum & Brown (L&B) traveled to Burlington VT on October 24, 2012 to review and select properties that would be candidates for the testing. Many of the properties were already acquired and demolished. Many homes were not considered viable for testing due to the various reasons outlined below:

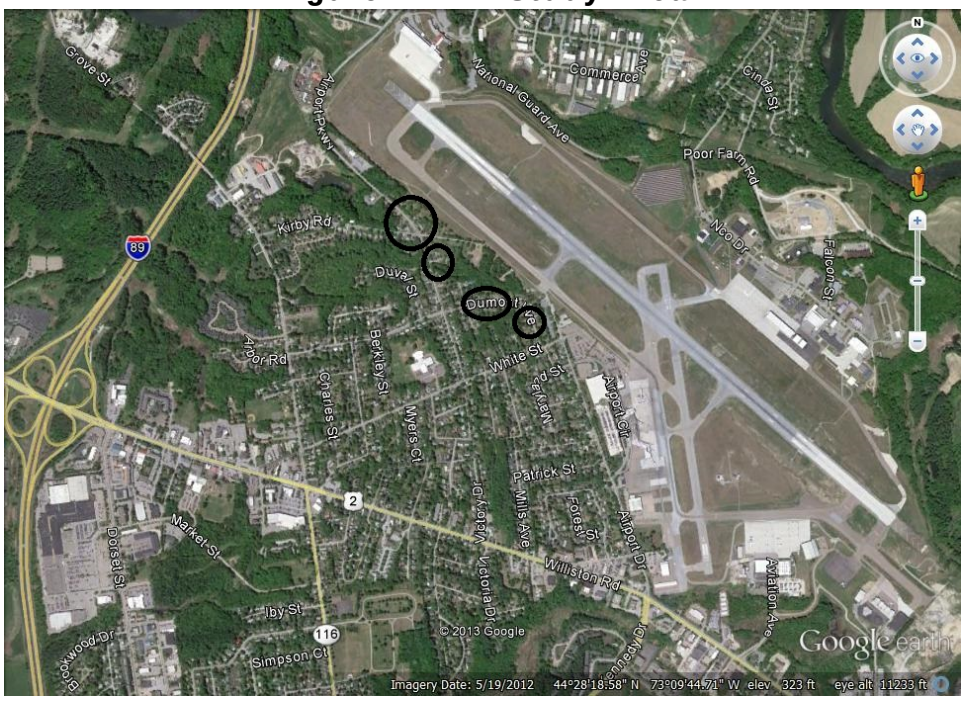
1. Shielding of aircraft operations by the airport terminal/parking structure.
2. Trees that made the use of a crane impractical.
3. Power lines which restricted crane use.
4. High traffic levels on the road which would contaminate noise testing.
5. High traffic levels which would complicate crane placement.
6. Test houses were shielded from the airport by dense vegetation or other structures.
7. Houses that were boarded up due to broken windows.

A total of six properties were selected for the measurement study. Two rooms were selected for testing in each house, with the exception of Site #6 where only one room was measured. At Site #6, the other room in the house with the rear exposure (facing the airport) was shielded by a garage/apartment. The six homes selected for testing are listed below.

- Site #1 - 13 Dumont Avenue
- Site #2 - 57 Dumont Avenue
- Site #3 - 61 Dumont Avenue
- Site #4 - 4 Picard Circle
- Site #5 - 120 Airport Parkway
- Site #6 - 206 Airport Parkway

The BTV study area is shown in **Figure 1** with the general area of the six measurement sites on Dumont Avenue, Picard Circle and Airport Parkway circled in black. A photo and a short description of the houses selected for the study are

Figure 1. BTV Study Area



discussed in the following sections. A site plan of the six homes is included in **Figure 2**. The six properties to be evaluated are shown in black.

2.1.1 Site #1 – 13 Dumont Avenue

Site #1 is located at 13 Dumont Avenue in South Burlington. The home is a one-story Cape-style construction with aluminum siding. The front façade is exposed to aircraft operations. The two rooms that are exposed to aircraft operations include the front kitchen with vinyl floor and the front living room with a wood floor. Both rooms have a corner exposure with two facades exposed to aircraft. A photo of the front façade of the house is presented in **Figure 3**.

2.1.2 Site #2 – 57 Dumont Avenue

Site #2 is located at 57 Dumont Avenue in South Burlington. The home is a one-story Ranch-style construction with aluminum siding. The front façade is exposed to aircraft operations. The two rooms that are exposed to aircraft operations include the front living room and the front bedroom. Both rooms have hardwood floors. The bedroom has a corner exposure with two facades exposed to aircraft. The living room has a single façade exposure. A photo of the front façade of the house is presented in **Figure 4**.

Figure 2. Site Plan of Six Measurement Locations

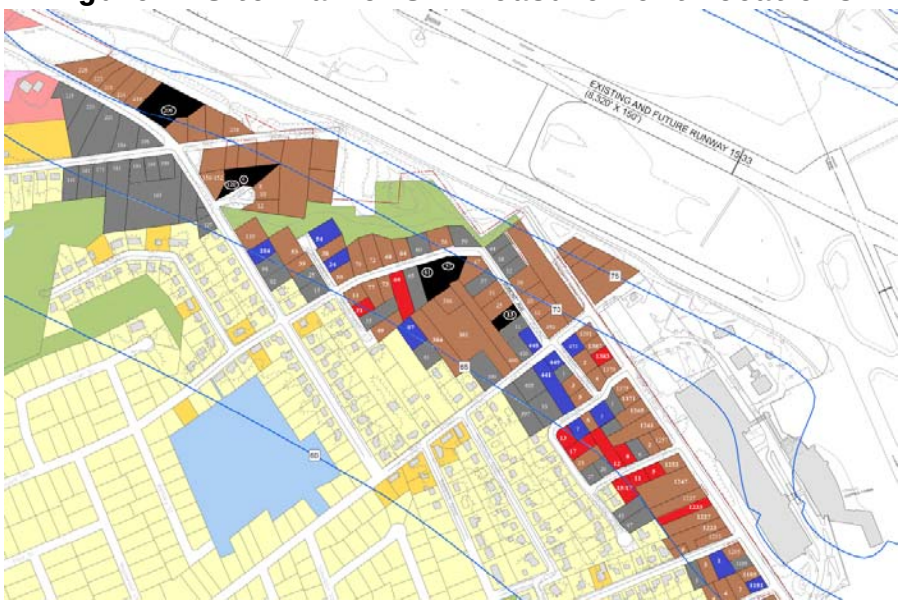


Figure 3. Site #1 – 13 Dumont Avenue

Figure 4. Site #2 – 57 Dumont Avenue

2.1.3 Site #3 – 61 Dumont Avenue

Site #3 is located at 61 Dumont Avenue in South Burlington. This is a one-story Ranch-style construction with aluminum siding. The front façade is exposed to aircraft operations. The two rooms that are exposed to aircraft operations include the front living room and the front bedroom. Both rooms have carpeted floors. The bedroom has a corner exposure with two facades exposed to aircraft. The living room has a single façade exposure. A photo of the front façade of the house is presented in **Figure 5**.

2.1.4 Site #4 – 4 Picard Circle

Site #4 is located at 4 Picard Circle in South Burlington. This is a two-story Contemporary-style home with wood siding. The rear façade is exposed to aircraft operations. The two rooms that are exposed to aircraft operations include the rear upper bedroom and the rear lower dining room. The bedroom had carpeting, while the dining room had just the plywood underlayment for the floor covering. Both rooms have a corner exposure with two facades exposed to aircraft. At the time of the survey, access to the house was not possible due to the buildings being used as part of the local haunted house tour. A photo of the front façade of the house is presented in **Figure 6**.

Figure 5. Site #3 – 61 Dumont Avenue

Figure 6. Site #4 – 4 Picard Circle

2.1.5 Site #5 – 120 Airport Parkway

Site #5 is located at 120 Airport Parkway in South Burlington. This is a one-story Ranch-style home with vinyl siding. The rear façade is exposed to aircraft operations. The two rooms that are exposed to aircraft operations include the rear corner bedroom and the middle kitchen/dining room. The floor in the bedroom was carpeted while floor in the kitchen/dining room was partially carpeted and partially tiled. One room has a corner exposure with two facades exposed to aircraft, while the other room has one façade exposed to aircraft noise. At the time of the survey, access to the house was not possible due to the buildings being used as part of the local haunted house tour. A photo of the front façade of the house is presented in **Figure 7**.

2.1.6 Site #6 – 120 Airport Parkway

Site #6 is located at 206 Airport Parkway in South Burlington. This is a one-story Ranch-style home with vinyl siding. The rear façade is exposed to aircraft operations. The one room exposed to aircraft operations includes the left rear bedroom. An additional test room at this location was not possible due to shielding from a nearby garage. A photo of the front façade of the house is presented in **Figure 8**.

Figure 7. Site #5 – 120 Airport Parkway

Figure 8. Site #6 – 206 Airport Parkway

SECTION 3 ACOUSTICAL MEASUREMENTS

3.1 Acoustical Testing Plan

The Acoustical Testing Plan (ATP) for this study is outlined in the following paragraphs. The objective of the study was to quantify variation of NLR of the existing testing methods and testing parameters. These are discussed in the following sections.

3.1.1 Testing Methods

The testing methods used in this study include the following:

1. Measurement using actual aircraft flyovers; and
2. Measurement using an artificial noise source (loudspeaker)

The artificial noise source measurement method is further broken down, as follows:

1. Exterior microphone measurement method (external flush/external façade)
2. Interior microphone locations (4-feet from elements/room spatial average)
3. Noise source elevation (tripod/crane)
4. Measurement repeatability (same measurement performed twice)

For actual aircraft flyover measurements, the effect of the aircraft type (jet, prop, etc.) on the variation of the NLR was quantified to the extent possible.

3.1.2 Testing Parameters

The identified testing parameters for the measurements that affect the variation in the NLR using an artificial noise source include:

1. Angle of incidence
2. Distance of noise source to façade

3.2 Acoustical Testing

Measurements were conducted using Larson-Davis Model 824 (LD824) Sound Level Meters. The LD824 was calibrated at the beginning of the day of testing and calibration was checked at the end of each day of testing. The list of equipment used in this study is presented in **Appendix A**. Data collected in the field was processed to determine measured NLRs. The outcome from this field test was the result of a statistical analysis of the uncertainties in determining NLR using each testing method with a direct comparison among the different test methodologies.

The testing of the sample of six homes was conducted from Monday November 12 thru Friday November 16. The following structural aspects and room acoustical aspects were varied to assess the influence of these parameters on the NLR:

1. Variation of housing construction types;
2. Variation of room types (corner room/middle room), room size, element size, furnishings and interior acoustics;
3. Variation of room absorption (none-furnished/added absorption).

See details in the test description below.

The tentative daily testing schedule was as follows:

1. Houses were accessed before 6:00 a.m. each day so as to allow the setting up of equipment. This allowed departures operations to be measured during the early morning departure push. Note – the testing times were adjusted accordingly based on traffic flow.
2. Between 9:00 a.m. and approximately 12:00 noon, the rooms were tested using the artificial noise source (loudspeaker) on a tripod.
3. Following a lunch break, a crane was used to allow testing using the elevated artificial noise source. This testing was undertaken between approximately 1:00 p.m. and 3:00 p.m.
4. After 3:00 p.m. time was allocated to fill in where insufficient data was collected during the earlier hours.

Specifics on the various testing methods are outlined in the following paragraphs.

3.2.1 Actual Aircraft

For the flyover testing method using actual aircraft, A-weighted noise levels from aircraft events were collected in the field. The A-weighted Sound Exposure Level (SEL) events were collected simultaneously in two interior rooms and at an exterior location at each house. The SELs were measured and calculated by setting a threshold level on the sound level meters based on the exterior and interior background noise levels at each location. The exterior microphone was located to allow direct line-of-sight between the microphone and the flight path of the aircraft and was located 20 feet from any reflective surface of the house. Due to the close proximity of the house to the runway sideline, the elevation angle to the measured aircraft was quite small, where almost all recorded events were start of take-off rolls and departing to the south, with the exception of the departures on the morning of November 14, when aircraft were departing to the north. The NLR could not be measured for arrivals, because the aircraft levels were not high enough above ambient levels. The two interior microphones were located at least four-feet from any major reflective surface such as walls, ceiling or floors. One microphone was placed opposite a major sound transmitting element within the room. The other microphone was placed in an area of the room, but not the geometric center of the room.

Although the study initially intended to select only two possible aircraft types for the test, that was not possible due to the limited number of aircraft operations (and aircraft types) at BTV. To the maximum extent possible, aircraft events were recoded for departure only or arrivals only. The time of the aircraft event were recorded, as well as the type of event and the aircraft type. Data was entered immediately into a program on a laptop. To the extent possible, the number of aircraft events were logged until the standard deviation of the NLR was within ±1 dB for each room or as close as possible. All aircraft events were logged with the focus primarily on turbine-powered (jet) aircraft. The major aircraft type operating at BTV includes commuter jet aircraft (ERJ & CRJ). Other jet aircraft with limited operations include the A320, F16, business jets and a B727 cargo aircraft.

Various factors affect the event NLR and therefore the NLR differs from event to event. Therefore the number of events needed in the measurement to achieve a reasonable uncertainty level was evaluated on a case-by-case basis. The goal was to collect data until the confidence interval is less than ±1 dB. This was usually achieved with between eight and 15 events. However, sometimes many more events were needed depending on factors such as the exposure of varying flown flight patterns, aircraft types, weather and ambient noise. The impact of aircraft type and flight segment (departure versus approach) selection was studied. It should be noted that for this study, other the variation of the aircraft flight paths relative to the house are expected to be significant due to a significant difference of noise exposure during start of take-off roll, given the close proximity of the houses to the runway.

3.2.2 Artificial Noise Source (on Tripod)

For the outdoor loudspeaker tests, the exterior placement of the loudspeaker was varied (distance & angle of incidence), the exterior microphone placement was varied and the interior microphone placement was varied. The goal of the selected test matrix was to provide sufficient data to quantify the variation affected by the testing parameters.

In addition, variation due to aircraft spectral data and NLR calculation procedures were investigated as well during the data post-processing phase. The measured spectral data of the external actual aircraft NLR measurement method was used for the external spectrum for each home. This allowed for direct comparison of the actual aircraft and artificial noise source measurement methods.

With the loudspeaker on tripod the following variables were introduced into the testing process, to the extent possible. Many of the variables including the loudspeaker angle, loudspeaker distance and exterior microphone measurement location were based on ASTM International E966-10 “Standard Guide for Field Measurement of Airborne Sound Insulation of Building Facades and Façade Elements.” These are as follows:

1. Exterior placement of the loudspeaker
    a. Position the loudspeaker at an angle of incidence of 60-degrees, 45-degrees and 30-degrees from the front or read façade normal.
    b. Locate the loudspeaker at two distances from the façade. This distance depended upon the geometrics of each house and will be determined once on-site.

2. Exterior microphone placement
    a. Outdoor data was collected via spatial average along the exposed façade. This included microphone placement on the façade surface (5 dB adjustment for pressure doubling[2]) and at a distance four-feet away from the façade (2 dB adjustment for energy doubling/reflection[3]).

3. Interior microphone placement
    a. The indoor data was collected via spatial average in the central area of the room. An additional measurement was undertaken four-feet from the most sound transmitting element in the room. The spatial average in the central area of the room was repeated. This allowed analysis of the repeatability of the spatial averaging technique.

It should be noted that these properties are in the process of being demolished so they are devoid of typical furnishings such as furniture, draperies and other wall adornments. Out of the six homes to be included in the testing, access to two homes was not available during the survey trip due to their temporary use as part of the local haunted house tour. Of the four homes that were able to be inspected on the interior, only one house (two rooms) was carpeted. The other three homes had wood or vinyl floors. To replicate a more typical acoustical environment in the interior, L&B staff purchased rolls of fiberglass insulation to be placed within each room during the testing. Two to three rolls of R-30 fiberglass insulation were dispersed within each of the rooms tested. Each roll was approximately 25-feet long, 18-inches wide and 9½-inches thick. The rolls were placed either along a wall, dispersed on the floor, or put in both locations. The exact number of rolls used in each room and whether they were dispersed on the floor or walls is explained in more detail in Appendix B. Reverberation time measurements (RT60) were undertaken to ensure that the reverberation time in each room is in the 0.3 to 0.5 seconds range. This reverberation time would be more typical of a normal room environment. One interior measurement, with the loudspeaker at 45-degrees, exterior faced measurement at four-feet and interior measurement using a central spatial average were undertaken in each room without the absorption/insulation present.

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[2] Previously ASTM E966 used a 6 dB adjustment, however, field measurements showed better agreements with a 5 dB adjustment, and has therefore been changed in ASTM E966-10.
[3] Previously ASTM E966 used a 3 dB adjustment, however, field measurements showed better agreements with a 2 dB adjustment, and has therefore been changed in ASTM E966-10.

3.2.3 Artificial Noise Source (Elevated by Crane)

For the tests using an outdoor loudspeaker elevated by a crane, the placement of the loudspeaker was varied, the exterior microphone placement was varied and the interior microphone placement was varied. The goal of the selected test matrix is to provide sufficient data to quantify the variation affected the by testing parameters. The list below further describes the assumptions for this test.

Variation due to aircraft spectral data and NLR calculation procedures were taken into account for the data post-processing phase. The BTV specifics on the days of testing were used for the post-processing. With the loudspeaker elevated with a crane, the following variables were introduced into the testing process, to the extent possible, including:

1. Exterior placement of the loudspeaker
    a. Position the loudspeaker at an angle of incidence of 45-degrees to the normal of both facades and ceiling for corner rooms or the center of the façade and ceiling.
    b. Position the loudspeaker at two distances from the façade. This distance depended upon the geometrics of each house and was determined once on-site.
2. Exterior microphone placement
    a. The outdoor data was collected via spatial average along the exposed façade. This included microphone placement on the façade surface (5 dB adjustment for pressure doubling); and
    b. At a distance four-feet away from the façade (2 dB adjustment for energy doubling/reflection).
3. Interior microphone placement
    a. The indoor data was collected via spatial average in the central area of the room.
    b. An additional measurement was undertaken four-feet from the most sound transmitting element in the room.
    c. The spatial average in the central area of the room was repeated. This allowed analysis of the repeatability of the spatial averaging technique.

3.3 Acoustical Testing Schedule

Testing at each site was undertaken based on the testing plan outlined in Section 3.1. However, due to various circumstances, the actual acoustical testing was conducted at the six selected sites based on the time and dates as outlined in **Table 1**.

Table 1. Acoustical Test Schedule

Site No.	Address	Testing Date	Approximate Testing Times
1	13 Dumont Avenue	Monday November 12, 2012	5 a.m. to 6 p.m.
2	57 Dumont Avenue	Tuesday November 13, 2012	5 a.m. to 6 p.m.
3	61 Dumont Avenue	Wednesday November 14, 2012	5 a.m. to 5 p.m.
4	4 Picard Circle	Thursday November 15 & Friday November 16, 2012	5 a.m. to 5 p.m.
5	120 Airport Parkway	Thursday November 15 & Friday November 16, 2012	5 a.m. to 7 p.m.
6	206 Airport Parkway	Thursday November 15 & Friday November 16, 2012	5 a.m. to 7 p.m.

3.4 Site-Specific Testing Information

The pictures in the following sections show the general setup of the outdoor microphone location for the actual aircraft measurements. The pictures also show the indoor microphone setup as well as placement of the additional room insulation. **Table 2** presents the background noise levels and reverberation times with and without additional fiberglass insulation.

Table 2. Measured Background Levels and Reverberation Times

Site No.	Address	Room	Exterior Background Level (dBA)	Interior Background Level (dBA)	T_{60} (sec.) w/o Room Insulation	T_{60} (sec.) w/ Room Insulation
1	13 Dumont Avenue	Living Room Kitchen/Dining Room	52.1	35.3 32.7	0.90 0.60	0.45 0.36
2	57 Dumont Avenue	Living Room Front Bedroom	52.0	33.8 33.4	1.04 0.81	0.39 0.31
3	61 Dumont Avenue	Living Room Front Bedroom	53.6	33.9 32.0	0.48 0.41	0.30 0.28
4	4 Picard Circle	Family Room Rear Bedroom	45.9	31.8 29.4	0.92 0.41	0.28 0.29
5	120 Airport Parkway	Kitchen/Dining Room Rear Bedroom	51.1	31.8 29.4	0.80 0.48	0.46 0.29
6	206 Airport Parkway	Rear Bedroom	53.3	40.1	0.61	0.18

3.4.1 Site #1

Figure 9 shows the front façade at 13 Dumont Avenue. The living room tested is on the left with the kitchen area on the right. The living room was approximately 12½-feet by 13½-feet in size with the kitchen about 13½-feet by 12-feet. Exact sizes are presented in Appendix B. Both rooms had two facades of exposure. A picture of the living room is presented in **Figure 10** with the kitchen presented in **Figure 11**.

Figure 9. Site #1 – Front Façade at 13 Dumont Avenue

Figure 10. Site #1 – Living Room at 13 Dumont Avenue

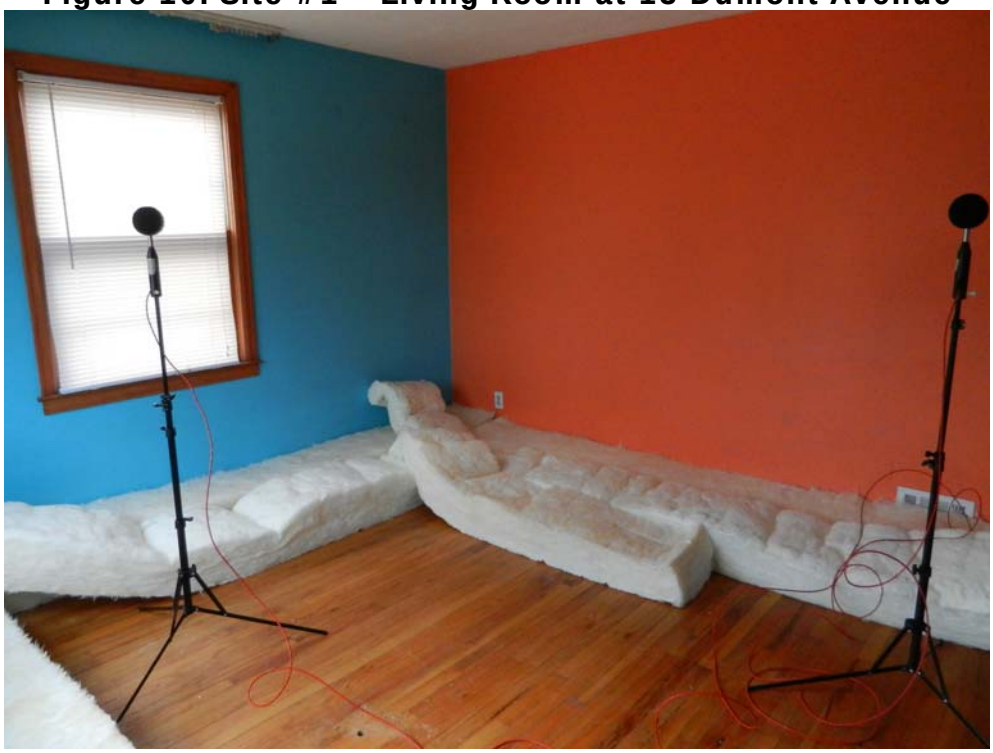


Figure 11. Site #1 – Kitchen at 13 Dumont Avenue

3.4.2 Site #2

Figure 12 shows the front façade at 57 Dumont Avenue. The bedroom tested is on the left with the living room area on the right. The bedroom has two facades of exposure, while the living room has one façade of exposure. The bedroom was approximately 12½-feet by 9½-feet in size with the living room about 25-feet by 11½-feet. Exact dimensions are presented in Appendix B. A picture of the bedroom is presented in **Figure 13** with the living room presented in **Figure 14**.

3.4.3 Site #3

Figure 15 shows the front façade at 61 Dumont Avenue. The bedroom tested is on the left with the living room area on the right. The bedroom has two facades of exposure, while the living room has one façade of exposure. The bedroom was approximately 12½-feet by 9½-feet in size with the living room about 25-feet by 11½-feet. Exact dimensions are presented in Appendix B. A picture of the bedroom is presented in **Figure 16** with the living room presented in **Figure 17**.

Figure 12. Site #2 – Front Façade at 57 Dumont Avenue

Figure 13. Site #2 – Bedroom at 57 Dumont Avenue

Figure 14. Site #2 – Living Room at 57 Dumont Avenue

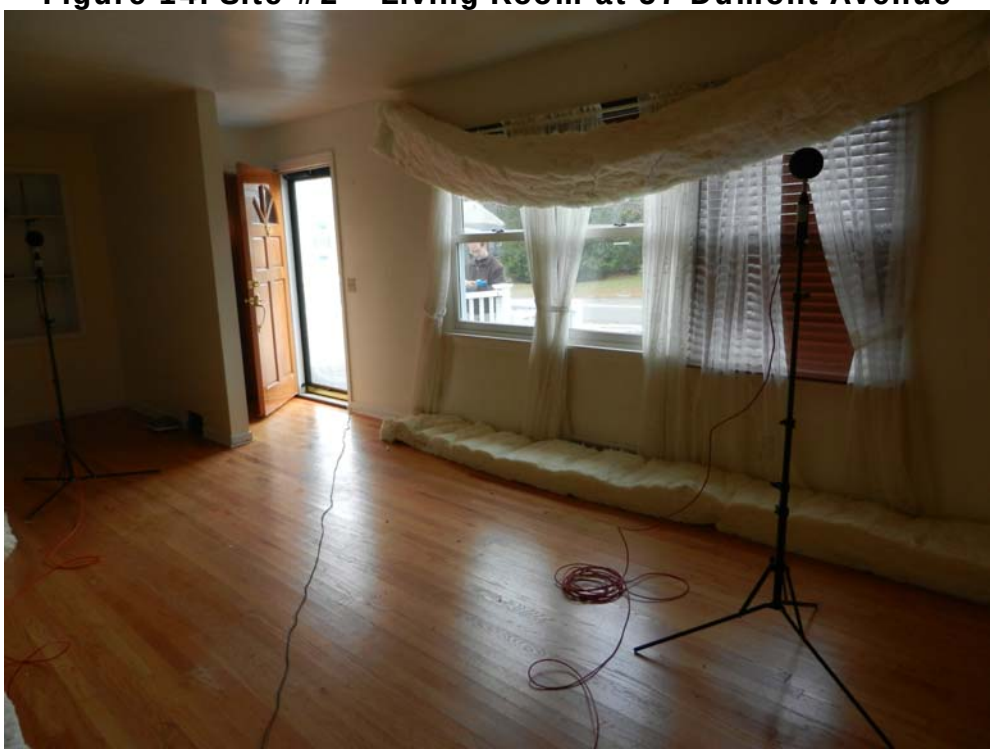


Figure 15. Site #3 – Front Façade at 61 Dumont Avenue

Figure 16. Site #3 – Bedroom at 61 Dumont Avenue

Figure 17. Site #3 – Living Room at 61 Dumont Avenue

3.4.4 Site #4

Figure 18 shows the rear façade at 4 Picard Circle. The bedroom tested is on the 2nd floor left with the dining room on the lower right. Only the dining room had two facades of exposure. The bedroom was approximately 16½-feet by 13-feet in size with the dining room about 11-feet by 13-feet. The exact dimensions are presented in Appendix B. A picture of the bedroom is presented in **Figure 19** with the dining room presented in **Figure 20**.

3.4.5 Site #5

Figure 21 shows the rear façade at 120 Airport Parkway. The bedroom tested is on the left with the kitchen/dining room area in the middle. The bedroom has two facades of exposure, while the kitchen/dining room has one façade of exposure. The bedroom was approximately 15½-feet by 11½-feet in size with the kitchen/dining room about 25-feet by 15-feet. Exact dimensions are presented in Appendix B. A picture of the bedroom is presented in **Figure 22** with the kitchen/dining room presented in **Figure 23**.

3.4.6 Site #6

Figure 24 shows the rear façade at 206 Airport Parkway. The bedroom tested is on the right and has two facades of exposure. The bedroom was approximately 9-feet by 10½-feet in size with the exact dimensions presented in Appendix B. Only one room was tested at this location. A picture of the bedroom is presented in **Figure 25**.

Figure 18. Site #4 – Rear Façade at 4 Picard Circle

Figure 19. Site #4 – Bedroom at 4 Picard Circle

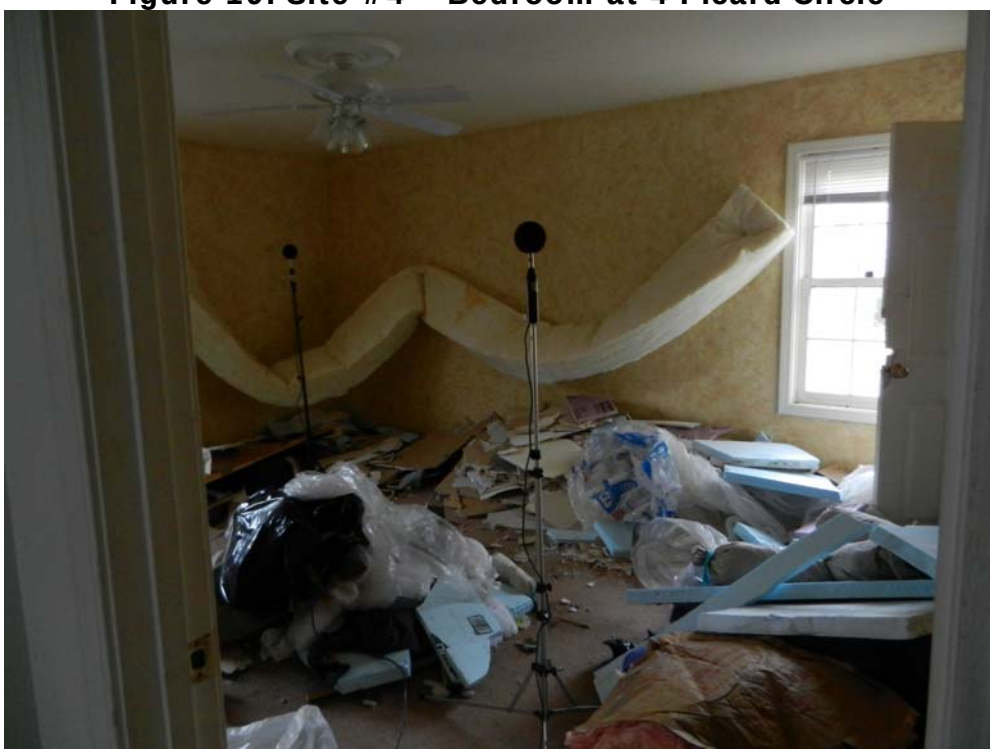


Figure 20. Site #4 – Dining Room at 4 Picard Circle

Figure 21. Site #5 – Rear Façade at 120 Airport Parkway

Figure 22. Site #5 – Bedroom at 120 Airport Parkway

Figure 23. Site #5 – Kitchen/Dining Room at 120 Airport Parkway

Figure 24. Site #6 – Rear Façade at 206 Airport Parkway

Figure 25. Site #6 – Bedroom at 206 Airport Parkway

3.5 Background Data to Acoustical Testing

At each measurement location background information was collected to allow personnel to understand the testing conditions at each house. This data includes the following:

- Microphone setup location inside rooms (actual aircraft only)
- Microphone setup location outside rooms (actual aircraft only)
- House construction information
    - Exterior walls
    - Roof type
- Room information
    - Room dimensions
    - Wall stud dimensions
    - Wall type
    - Wall cavity filling
    - Window dimensions
    - Window type
    - Floor coverings
    - Placement of additional insulation to simulate interior furnishings
- Weather conditions

This background information is summarized further in **Appendix B**.

SECTION 4 ACOUSTICAL TEST RESULTS

4.1 Overview of the Test Results

The NLR acoustical tests were performed starting on Monday November 12, 2012 and continued through Friday November 16, 2012 following the ATP outlined in Section 3. The following sections outline the testing results for the following:

1. Actual Aircraft
2. Artificial Noise Source (On Tripod)
3. Artificial Noise Source (Elevated By Crane)

4.2 Actual Aircraft

4.2.1 Results for Actual Aircraft

The results for the NLR actual aircraft tests are presented in **Table 3**. In Table 3 column one and two describes the site number and the address. The number of aircraft events tested at each location is presented in column three. The mean measured NLR and the 90% confidence interval for testing at room number one at each site are presented in columns four and five. The mean measured NLR and the 90% confidence interval for testing at room number two at each site are presented in columns six and seven. Measurements logs for the actual aircraft measurements for each site are presented in **Appendix C**. The type of aircraft that were measured at each site is presented in **Table 4**.

Table 3. Noise Level Reduction (NLR) Measurements Based on Actual Aircraft Events

Site No.	Location	No. of Events	Room #1 (1)		Room #2 (2)	
			Mean NLR (dB)	90% Confidence Interval (dB)	Mean NLR (dB)	90% Confidence Interval (dB)
1	13 Dumont Avenue	10	23.6	±0.9	25.1	±1.0
2	57 Dumont Avenue	12	27.1	±1.2	27.3	±1.5
3	61 Dumont Avenue	15	28.3	±1.3	28.5	±1.3
4	4 Picard Circle	13	28.5	±1.4	27.3	±1.9
5	120 Airport Parkway	8	24.7	±0.7	23.8	±0.8
6	206 Airport Parkway	13	25.4	±1.6	(3)	(3)

Notes:
(1) Room #1: Living Room (Sites No. 1-3), Family Room (Site No. 4), Kitchen/Dining Room (Site No. 5), Rear Bedroom (Site No. 6)
(2) Room #2: Kitchen/Dining Room (Site No. 1), Front Bedroom (Site No. 2-3), Rear Bedroom (Site No. 4-6)
(3) Only one room was measured at Site #6.

Table 4. Measured Aircraft Types at Each Site

Site No.	Location	Total No. of Events	Aircraft Type & No. of Events								
			E145	E170	E190	CRJ2	CRJ7	A320	C550/ C525/ C750	Other	Unk.
1	13 Dumont Avenue	10	1	0	1	1	1	0	1	2 (1)	3
2	57 Dumont Avenue	12	1	2	0	2	1	1	0	1 (2)	4
3	61 Dumont Avenue	15	3	3	1	0	3	1	2	0	2
4	4 Picard Circle	13	1	4	1	2	3	1	0	0	1
5	120 Airport Parkway	8	1	2	1	2	2	0	0	0	0
6	206 Airport Parkway	13	2	2	1	2	1	0	2	3 (3)	0

Notes:
(1) LJ60 & GL5T
(2) F2TH
(3) BE40, F900 & PA28

4.3 Artificial Noise Source

4.3.1 Background

As mentioned in previous sections, the testing procedures generally follow those outlined in the ASTM International Standard E966-10. The procedures conform to good practice in sound insulation programs. The efficiency and flexibility of the testing procedures are enhanced using methods and theories from other sources such as Leo Beranek's *Noise and Vibration Control*. These are applied to the ASTM standard to achieve the same level of accuracy.

L&B used a specialized field monitoring kit that includes a signal generator, amplifier, and an equalizer to produce a noise source of equal energy in each octave band (known in the acoustics field as "pink noise"). The use of pink noise lends to accurately measuring all octave bands of interest. The noise source was relayed to a loudspeaker and the amplified pink noise was directed at the room of interest. For some tests the loudspeaker was elevated using a crane to perform tests that include exposure of the overall room including the roof structures. For other tests the speaker was placed on a tripod for measurements exposing the wall facades only.

The speaker was directed at the room to be measured, with the goal of having a uniform sound field exposed to all of the surfaces of interest. With the loudspeaker pointed at the room, measurements were made both on the exterior and in the interior of the structure, per the methodology outlined in Section 3. Exterior and interior octave band sound levels were measured and recorded with the speaker in operation. Exterior and interior octave band sound levels were also measured and recorded without the speaker to provide background or ambient sound levels.

Once the measurements have been completed the Outdoor/Indoor Noise Reduction (OINR) of rooms are calculated from the measured exterior and interior sound levels in each octave band, as outlined in ASTM E966-10. The OINR values are then used to compute the outdoor-to-indoor NLR of aircraft noise based on the A-weighted aircraft noise spectrum. This is done by first normalizing the exterior spectrum to an A-weighted level that matches the exterior DNL at the property. The OINR is then subtracted from each octave band to determine the interior A-

weighted spectrum. The NLR is determined by subtracting the A-weighted total interior level from the A-weighted total exterior level. The analysis includes the octave bands from 63 Hz to 8000 Hz. The 63 and 8000 Hz octave bands usually have minimal influence on the NLRs for airport projects due to the A-weighted attenuation of these octave bands. These octave bands are included in the analysis in cases where they do slightly affect the NLR.

Sound levels using the artificial noise source are used to determine the OINR in accordance with ASTM E966-10. With the speaker pointed at the room, measurements are made both on the exterior and in the interior of the room. The exterior measurements are reduced in each octave band based on the measurement location. The definitions according to ASTM E966-10 for room NLR measurements are explained below.

Once the measurements have been completed, the OINR of rooms are calculated from the measured exterior and interior sound levels in each octave band, as outlined in ASTM E966-10. The OINR values are then used to compute the outdoor-to-indoor Noise Level Reduction (NLR) of aircraft noise based on A-weighted aircraft noise spectrum. NLR is a single number rating used for the comparison of the difference in the outdoor-to-indoor noise levels. This number is typically used to judge the overall effectiveness of sound insulation programs.

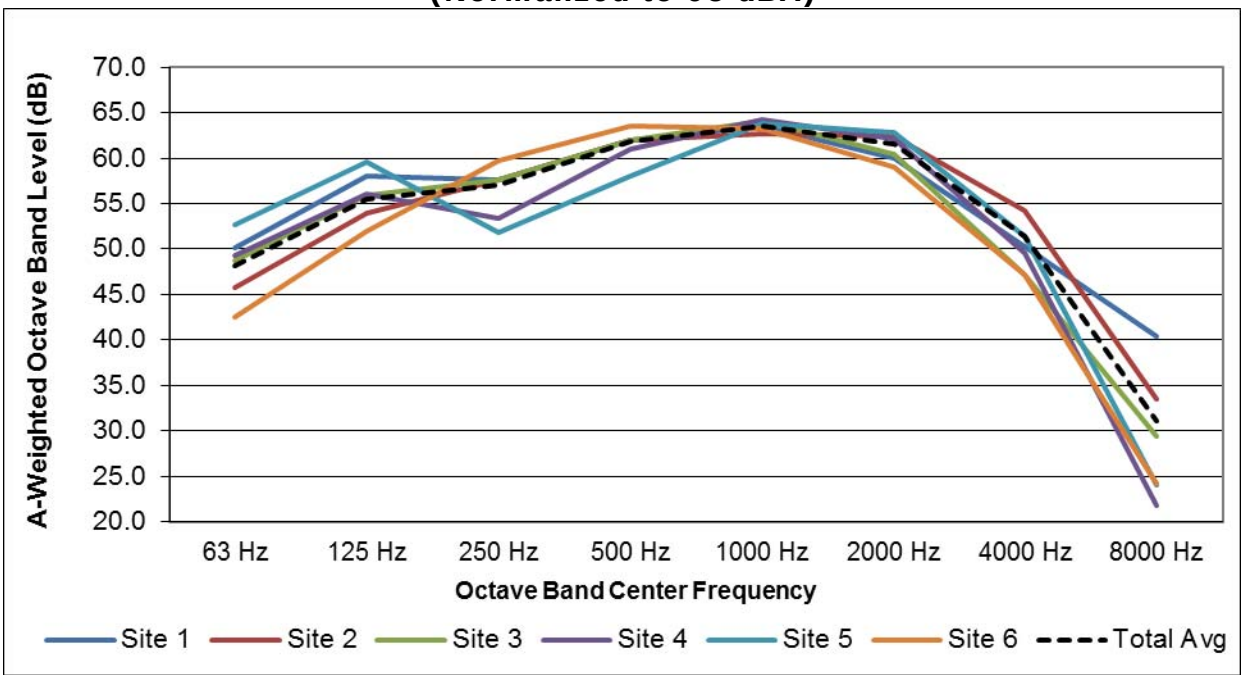
4.3.2 Aircraft Noise Spectra

While the NLR of a room is a property of the façade or facades being measured, it is also dependent upon the exterior noise source spectrum. In aviation sound insulation programs, the NLR is based on aircraft as the noise source. For this study, L&B used the measured spectral data of the external actual aircraft NLR measurements for the external spectrum for each home. The exterior spectra of aircraft at each property was determined using the measured exterior measurements of the actual aircraft measurements. The antilog of the A-weighted SELs divided by 10 were determined for each octave band and the sum was divided by the duration all events together. From this data, the total A-weighed L_{eq} of aircraft events was determined for each property. The exterior spectra measurement logs are included in **Appendix D**. This spectrum is BTV-specific and consistent with the measured aircraft activity of each day of testing at each home. The noise source spectrum of the fleet mix is A-weighted to closely resemble human perception and to be consistent with the FAA guidelines for assessing aircraft noise in communities. The indoor A-weighted noise source spectrum for each room tested in the program is obtained by subtracting the measured OINR from each octave band of the exterior A-weighted noise source spectrum. The A-weighted noise level is obtained by summing the energies in each octave band. The NLR, based on a typical aircraft noise spectrum, is the difference between the outdoor and indoor A-weighted noise levels.

For this study, the exterior noise source spectrum information is from the measured exterior aircraft noise level measurements for the actual aircraft NLR measurements at each specific site. Therefore, six separate average aircraft noise spectrums were developed for each of the six sites measured using an artificial noise source. In

addition, the total average is included, as shows as a dashed line. **Figure 26** shows the exterior source spectrum normalized to 68 dBA.

Figure 26. BTV Site-Specific External Source Spectra (Normalized to 68 dBA)



4.3.3 Results for Artificial Noise Source (On Tripod)

The results for the NLR artificial noise source tests (on tripod) are presented in **Table 5**. In Table 5 column one and two describes the site number and the address. The exterior and interior measurement locations are described in column three and four. The measured NLR at the various distances and façade angles for the two rooms measured are presented in the remaining 12 columns. Detailed logs for the artificial noise source measurements for each site are presented in **Appendix E**.

Table 5. Noise Level Reduction (NLR) Measurements Based on Artificial Noise Source (On Tripod)

Site No.	Location	Exterior Meas. Location (1)	Interior Meas. Location (2)	NLR (dB) Room #1 (3) Façade Distance (5) 25 ft. Façade Angle (degrees) (6)			NLR (dB) Room #1 (3) Façade Distance (5) 50 ft. Façade Angle (degrees) (6)			NLR (dB) Room #2 (4) Façade Distance (5) 25 ft. Façade Angle (degree) (6)			NLR (dB) Room #2 (4) Façade Distance (5) 50 ft. Façade Angle (degree) (6)		
				30	45	60	30	45	60	30	45	60	30	45	60
1	13 Dumont Avenue	EF	SA	22.0	22.4	23.0	21.0	21.4	22.6	23.4	23.4	23.4	23.4	23.7	23.7
		EF	PGL	22.7	22.0	23.0	21.7	21.1	21.6	23.5	23.6	23.7	23.4	23.9	23.6
		EF	SAR	22.8	22.1	23.1	21.8	21.8	22.2	23.5	23.3	23.6	22.9	23.8	23.7
		EFL	SA	22.3	22.5	22.1	22.0	22.8	23.1	23.7	23.8	23.4	24.2	24.6	24.3
		EFL	PGL	22.6	22.3	22.3	22.7	22.6	22.2	23.7	24.0	23.6	24.2	24.9	24.2
		EFL	SAR	22.8	22.3	22.2	22.8	23.0	22.7	23.7	23.8	23.7	23.9	24.9	24.3
2	57 Dumont Avenue	EF	SA	25.9	25.0	23.5	25.5	25.7	26.8	26.8	26.1	26.1	26.6	27.4	26.8
		EF	PGL	25.4	25.2	25.8	24.3	25.5	26.3	26.4	26.2	26.2	27.1	27.4	26.2
		EF	SAR	25.8	25.3	25.2	25.0	25.8	26.9	26.4	26.1	26.2	26.9	27.1	26.4
		EFL	SA	26.5	25.1	24.4	26.9	26.9	27.1	26.1	26.5	26.7	27.7	28.1	27.9
		EFL	PGL	26.2	25.4	25.8	25.9	26.5	26.7	25.7	26.7	26.8	28.3	28.1	27.5
		EFL	SAR	26.6	25.5	25.2	26.6	27.1	27.3	25.7	26.5	26.8	28.0	27.8	27.5
3	61 Dumont Avenue	EF	SA	26.3	24.8	24.9	24.8	24.3	22.7	24.0	24.3	25.3	23.7	24.2	24.8
		EF	PGL	26.0	24.5	24.2	24.7	23.7	22.6	25.3	24.8	24.2	24.0	24.1	24.3
		EF	SAR	26.4	25.3	24.7	25.1	24.1	22.8	24.9	24.5	25.5	23.2	23.6	24.7
		EFL	SA	26.7	25.7	25.1	26.1	25.0	24.3	25.0	25.2	26.4	25.3	25.4	25.5
		EFL	PGL	26.5	25.6	24.5	26.1	24.6	24.3	26.4	25.5	25.5	25.5	25.2	25.0
		EFL	SAR	26.7	26.2	24.8	26.4	24.9	24.4	26.0	25.3	25.6	24.8	24.8	25.3
4	4 Picard Circle	EF	SA	23.9	24.6	24.9	22.5	23.8	24.7	26.6	26.3	26.0	24.4	24.0	23.2
		EF	PGL	24.2	24.7	25.1	23.4	24.2	25.3	26.6	26.2	25.8	24.3	24.0	23.1
		EF	SAR	24.0	24.8	25.2	23.0	24.0	24.9	26.8	26.1	26.4	24.2	24.0	23.6
		EFL	SA	21.0	22.8	22.6	20.2	22.3	23.4	25.6	25.5	25.2	24.0	23.1	22.6
		EFL	PGL	21.2	23.0	23.0	20.6	22.5	24.0	25.6	25.3	25.0	23.7	23.0	22.4
		EFL	SAR	21.0	22.9	23.0	20.6	22.4	23.8	25.9	25.3	25.6	23.8	23.1	23.0
5	120 Airport Parkway	EF	SA	23.5	22.6	22.2	23.3	22.8	22.4	21.1	17.9	19.4	19.0	18.8	18.2
		EF	PGL	20.5	19.9	21.4	21.1	21.3	20.4	20.7	17.4	20.1	18.5	18.4	20.0
		EF	SAR	23.2	22.8	22.1	23.0	22.9	22.2	20.1	18.0	19.1	19.4	18.4	19.4
		EFL	SA	25.7	25.1	22.9	24.6	23.1	22.9	21.8	20.4	20.6	20.4	20.9	19.2
		EFL	PGL	23.1	22.5	21.7	22.3	21.3	21.0	21.3	19.9	21.0	20.1	20.6	19.8
		EFL	SAR	25.4	25.2	23.0	24.2	23.4	23.1	20.8	20.6	20.4	20.8	20.7	19.4
6	206 Airport Parkway	EF	SA	23.1	22.4	24.0	21.8	21.9	22.2	(7)	(7)	(7)	(7)	(7)	(7)
		EF	PGL	22.7	22.9	22.8	21.1	21.7	22.1	(7)	(7)	(7)	(7)	(7)	(7)
		EF	SAR	22.6	22.8	23.6	21.2	21.3	21.9	(7)	(7)	(7)	(7)	(7)	(7)
		EFL	SA	22.9	21.4	23.0	23.0	23.0	21.7	(7)	(7)	(7)	(7)	(7)	(7)
		EFL	PGL	22.5	21.8	21.8	22.2	22.9	21.6	(7)	(7)	(7)	(7)	(7)	(7)
		EFL	SAR	22.4	21.7	22.6	22.4	22.5	21.4	(7)	(7)	(7)	(7)	(7)	(7)

Notes: NLR values reported in A-weighted decibels
(1) EF: External Façade Spatial Average Measurement (4 feet from façade)
EFL: External Flush Measurement (average of 5 measurements flush on the façade)
(2) SA: Spatial Average Taken in Center of Room
PGL: Average Taken 4 feet from Major Sound Transmitting Element
SAR: Spatial Average Taken in Center of Room Repeated
(3) Room #1: Living Room (Sites No. 1-3), Family Room (Site No. 4), Kitchen/Dining Room (Site No. 5), Rear Bedroom (Site No. 6)
(4) Room #2: Kitchen/Dining Room (Site No. 1), Front Bedroom (Site No. 2-3), Rear Bedroom (Site No. 4-6)
(5) Distance is From Closest Corner of Corner Rooms or Center of Non-Corner Rooms
(6) Angle of Incidence to Front Facade
(7) Only one room was measured at Site #6.

The results for the NLR artificial noise source tests (on tripod) are repeated for a limited number of tests in which the rooms had no added room insulation and were devoid of all room furnishings. These tests were undertaken to determine the difference between the tests that were undertaken earlier as presented in Table 5. The artificial noise source tests (on tripod) and with no added room insulation

repeated for the 25-foot distance and the 45-degree façade angle are presented in **Table 6**. In Table 6 column one and two describes the site number and the address. The exterior and interior measurement locations are described in column three and four. The measured NLR at the 25-foot distance and 45-degree façade angles for the two rooms measured are presented in columns 6, 9, 12 and 15. Detailed logs for the artificial noise source measurements for each site are presented in Appendix E.

Table 6. Noise Level Reduction (NLR) Measurements Based on Artificial Noise Source (On Tripod & w/ No Added Room Insulation)

Site No.	Location	Exterior Meas. Location (1)	Interior Meas. Location (2)	NLR (dB) Room #1 (3) Façade Distance (5) 25 ft. Façade Angle (degrees) (6)			NLR (dB) Room #1 (3) Façade Distance (5) 25 ft. (no insulation) Façade Angle (degrees) (6)			NLR (dB) Room #2 (4) Façade Distance (5) 25 ft. Façade Angle (degree) (6)			NLR (dB) Room #2 (4) Façade Distance (5) 25 ft. (no insulation) Façade Angle (degree) (6)		
				30	45	60	30	45	60	30	45	60	30	45	60
1	13 Dumont Avenue	EF	SA	--	22.4	--	--	19.0	--	--	23.4	--	--	21.1	--
2	57 Dumont Avenue	EF	SA	--	25.0	--	--	21.9	--	--	26.1	--	--	21.3	--
3	61 Dumont Avenue	EF	SA	--	24.8	--	--	23.0	--	--	24.3	--	--	21.5	--
4	4 Picard Circle	EF	SA	--	24.6	--	--	21.0	--	--	26.3	--	--	25.3	--
5	120 Airport Parkway	EF	SA	--	22.6	--	--	22.9	--	--	17.9	--	--	17.6	--
6	206 Airport Parkway	EF	SA	--	22.4	--	--	19.0	--	(7)	(7)	(7)	(7)	(7)	(7)

Notes: NLR values reported in A-weighted decibels
(1) EF: External Façade Spatial Average Measurement (4 feet from façade)
EFL: External Flush Measurement (average of 5 measurements flush on the façade)
(2) SA: Spatial Average Taken in Center of Room
PGL: Average Taken 4 feet from Major Sound Transmitting Element
SAR: Spatial Average Taken in Center of Room Repeated
(3) Room #1: Living Room (Sites No. 1-3), Family Room (Site No. 4), Kitchen/Dining Room (Site No. 5), Rear Bedroom (Site No. 6)
(4) Room #2: Kitchen/Dining Room (Site No. 1), Front Bedroom (Site No. 2-3), Rear Bedroom (Site No. 4-6)
(5) Distance is From Closest Corner of Corner Rooms or Center of Non-Corner Rooms
(6) Angle of Incidence to Front Facade
(7) Only one room was measured at Site #6.

4.3.4 Results for Artificial Noise Source (Elevated by Crane)

The results for the NLR artificial noise source tests (elevated by crane) are presented in **Table 7**. In Table 7 column one and two describes the site number and the address. The exterior and interior measurement locations are described in column three and four. The measured NLR at the various distances and 45-degree façade angles for the two rooms measured are presented in columns 6, 9, 12 and 15. Detailed logs for the artificial noise source measurements for each site are presented in Appendix E.

Table 7. Noise Level Reduction (NLR) Measurements Based on Artificial Noise Source (Elevated by Crane)

Site No.	Location	Exterior Meas. Location (1)	Interior Meas. Location (2)	NLR (dB) Room #1 (3) Façade Distance (5) 25 ft. Façade Angle (degrees) (6)			NLR (dB) Room #1 (3) Façade Distance (5) 50 ft. Façade Angle (degrees) (6)			NLR (dB) Room #2 (4) Façade Distance (5) 25 ft. Façade Angle (degree) (6)			NLR (dB) Room #2 (4) Façade Distance (5) 50 ft. Façade Angle (degree) (6)		
				30	45	60	30	45	60	30	45	60	30	45	60
1	13 Dumont Avenue	EF	SA	--	24.7	--	--	22.9	--	--	22.4	--	--	22.0	--
		EF	PGL	--	23.7	--	--	22.3	--	--	22.9	--	--	22.6	--
		EF	SAR	--	25.5	--	--	23.1	--	--	22.9	--	--	22.8	--
		EFL	SA	--	24.6	--	--	23.0	--	--	23.8	--	--	23.5	--
		EFL	PGL	--	23.6	--	--	23.5	--	--	25.2	--	--	25.1	--
		EFL	SAR	--	25.2	--	--	24.2	--	--	25.3	--	--	25.3	--
2	57 Dumont Avenue	EF	SA	--	26.5	--	--	25.4	--	--	28.2	--	--	28.2	--
		EF	PGL	--	26.1	--	--	25.8	--	--	27.9	--	--	28.0	--
		EF	SAR	--	26.0	--	--	25.7	--	--	27.7	--	--	28.4	--
		EFL	SA	--	26.8	--	--	26.7	--	--	25.8	--	--	29.1	--
		EFL	PGL	--	26.3	--	--	27.1	--	--	25.3	--	--	29.0	--
		EFL	SAR	--	26.4	--	--	26.9	--	--	25.6	--	--	29.3	--
3	61 Dumont Avenue	EF	SA	--	25.7	--	--	25.0	--	--	23.9	--	--	23.1	--
		EF	PGL	--	26.0	--	--	25.3	--	--	24.5	--	--	22.1	--
		EF	SAR	--	25.7	--	--	24.5	--	--	24.1	--	--	23.1	--
		EFL	SA	--	25.3	--	--	26.5	--	--	25.1	--	--	24.8	--
		EFL	PGL	--	27.7	--	--	26.7	--	--	25.7	--	--	24.0	--
		EFL	SAR	--	27.3	--	--	26.1	--	--	25.3	--	--	24.8	--
4	4 Picard Circle	EF	SA	--	26.4	--	--	24.9	--	--	26.2	--	--	24.4	--
		EF	PGL	--	24.8	--	--	23.5	--	--	25.4	--	--	23.9	--
		EF	SAR	--	27.0	--	--	25.0	--	--	26.1	--	--	24.0	--
		EFL	SA	--	25.2	--	--	24.9	--	--	25.8	--	--	23.7	--
		EFL	PGL	--	23.6	--	--	23.1	--	--	24.9	--	--	23.0	--
		EFL	SAR	--	25.9	--	--	25.0	--	--	25.6	--	--	23.4	--
5	120 Airport Parkway	EF	SA	--	25.2	--	--	23.9	--	--	21.9	--	--	20.2	--
		EF	PGL	--	22.4	--	--	21.2	--	--	21.0	--	--	20.1	--
		EF	SAR	--	24.2	--	--	23.9	--	--	21.0	--	--	20.4	--
		EFL	SA	--	25.0	--	--	24.4	--	--	22.3	--	--	21.3	--
		EFL	PGL	--	22.5	--	--	21.9	--	--	21.1	--	--	21.0	--
		EFL	SAR	--	24.2	--	--	24.3	--	--	21.4	--	--	21.5	--
6	206 Airport Parkway	EF	SA	--	24.0	--	--	22.9	--	(7)	(7)	(7)	(7)	(7)	(7)
		EF	PGL	--	23.8	--	--	23.1	--	(7)	(7)	(7)	(7)	(7)	(7)
		EF	SAR	--	23.8	--	--	23.0	--	(7)	(7)	(7)	(7)	(7)	(7)
		EFL	SA	--	23.9	--	--	22.9	--	(7)	(7)	(7)	(7)	(7)	(7)
		EFL	PGL	--	23.7	--	--	23.1	--	(7)	(7)	(7)	(7)	(7)	(7)
		EFL	SAR	--	23.7	--	--	23.0	--	(7)	(7)	(7)	(7)	(7)	(7)

Notes: NLR values reported in A-weighted decibels
(1) EF: External Façade Spatial Average Measurement (4 feet from façade)
EFL: External Flush Measurement (average of 5 measurements flush on the façade)
(2) SA: Spatial Average Taken in Center of Room
PGL: Average Taken 4 feet from Major Sound Transmitting Element
SAR: Spatial Average Taken in Center of Room Repeated
(3) Room #1: Living Room (Sites No. 1-3), Family Room (Site No. 4), Kitchen/Dining Room (Site No. 5), Rear Bedroom (Site No. 6)
(4) Room #2: Kitchen/Dining Room (Site No. 1), Front Bedroom (Site No. 2-3), Rear Bedroom (Site No. 4-6)
(5) Distance is From Closest Corner of Corner Rooms or Center of Non-Corner Rooms
(6) Angle of Incidence to Front Facade
(7) Only one room was measured at Site #6.

SECTION 5 STATISTICAL ANALYSIS

This section discusses the statistical analysis of the measured data presented in the previous sections. The statistical analysis is divided into two views, each providing specific information about trends by changing measurement methods or parameters within the measurement methods. The two analytical views are as follows:

1. Comparisons to a reference measurement in a room and defined as follows:
    a. Room with batt insulation;
    b. External façade and internal spatial average measurement method;
    c. 25-foot noise source distance on a tripod; and
    d. Angle of incidence of 45 degrees.
2. General influence of changing measurement methods and parameters of measurement methods.

The first analytical view isolates the effects of a change of a measurement method or a measurement parameter. For example, when comparing the influence of increasing the noise source distance, only measurements that were done at the 50-foot noise source distance on a tripod at 45-degrees angle of incidence are compared to the reference measurement, thereby changing only the noise source distance (one parameter). This analytical view has, therefore, a smaller sample size of 11, representing one sample per room. This analysis is called the "Reference Comparison" in this study.

The second analytical view provides a more practical statistical distribution of the effects of different measurement methods and measurement parameter changes, and better reflects the influence of these changes on the diversity of measurement methods that are performed by various consultants in the field. For example, the analytical sample for comparing the influence of increasing the angle of incidence to 60-degrees includes all measurement methods where the angle of incidence is increased. This includes external flush, external façade, internal spatial averaging and the internal four-foot from elements and the repeated internal spatial averaging measurements. Therefore these sample sizes are varying depending on what is being compared and larger than the sample sizes of the first analytical view. This analysis is called the "General Comparison" in this study.

The following section discusses the statistical analysis of actual aircraft measurement method, artificial measurement method, parameters of the artificial measurement method, and various aspects of building construction.

5.1 Actual Aircraft Measurements

This section presents the variation of NLR measurements pertaining to using real aircraft. The first sub-section focuses on variation within the measurement method using actual aircraft, and the second sub-section compares the actual aircraft measurement method to the artificial noise source measurement method.

5.1.1 Influence of Aircraft Type on Actual Aircraft Measurement Method

Different aircraft types emit different noise spectra. Therefore, the measured NLR varies for various aircraft types, because the noise source spectrum affects the NLR. This sub-section takes a sample of aircraft types and evaluates the influence on the measured NLR. Due the relatively small sample size measured at this airport and having only measured various departing aircraft types, a selection of common aircraft types will be compared to the mean NLRs. The aircraft types that are evaluated include the:

- Airbus A320
- Embraer E145/E170/E190
- Canadair CRJ2/CRJ7

To compare the influence of aircraft type, the NLR for specific aircraft types are subtracted from the average or mean NLR of the room. **Figure 27** shows the frequency distribution of the difference between the NLR measured for various aircraft types and the mean NLRs. The median NLR difference is -0.2 dB, -0.4 dB and 0.0 dB for the A320, E145/E170/E190 and CRJ2/CRJ7; respectively. **Table 8** shows further detailed statistical information. A positive difference indicates the NLR of the specific aircraft types is higher than the mean NLR.

Figure 27. Frequency Distribution of NLR Differences between Various Aircraft Types

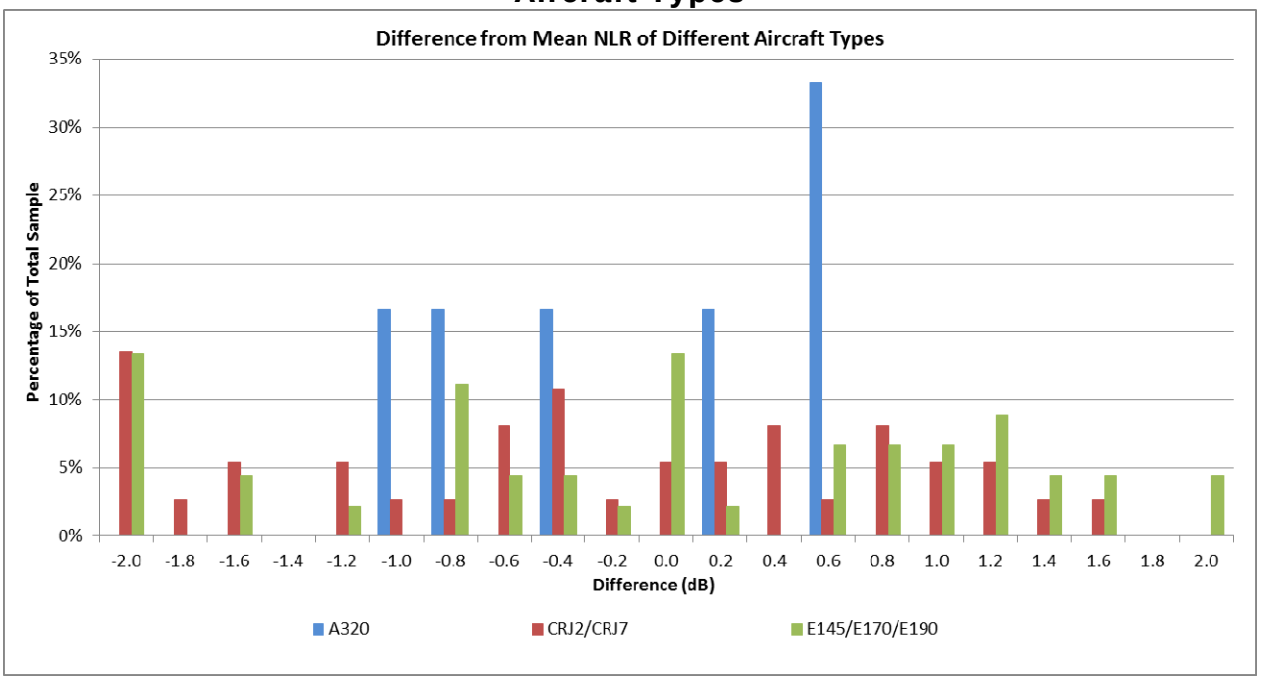


Table 8. NLR Statistical Information for Comparing NLR Differences for Various Aircraft Types

Aircraft Type	Sample Size	NLR Difference (dB)		
		5th Percentile	Median	95th Percentile
A320	6	-1.0	-0.2	0.6
E145/E170/E190	37	-3.3	-0.4	1.2
CRJ2/CRJ7	47	-3.0	0.0	1.9

5.1.2 Actual Aircraft and Artificial Noise Source Measurement Method

This sub-section compares the actual aircraft measurement method to the artificial noise source method outlined in **Section 5**.

Figure 28 shows the frequency distribution of the difference between the actual aircraft measurement method and the artificial noise source method. The median difference is 3.1 dB and 3.4 dB of the reference and general comparison; respectively. A positive difference indicates the measured actual aircraft NLR is higher than that of the artificial noise source measurement method. The median NLR of the actual aircraft measurement method NLR is higher than that of the artificial noise source measurement method. **Table 9** shows further detailed statistical information.

Figure 28. Frequency Distribution of NLR Differences between Actual Aircraft and Artificial Noise Source Measurement Method

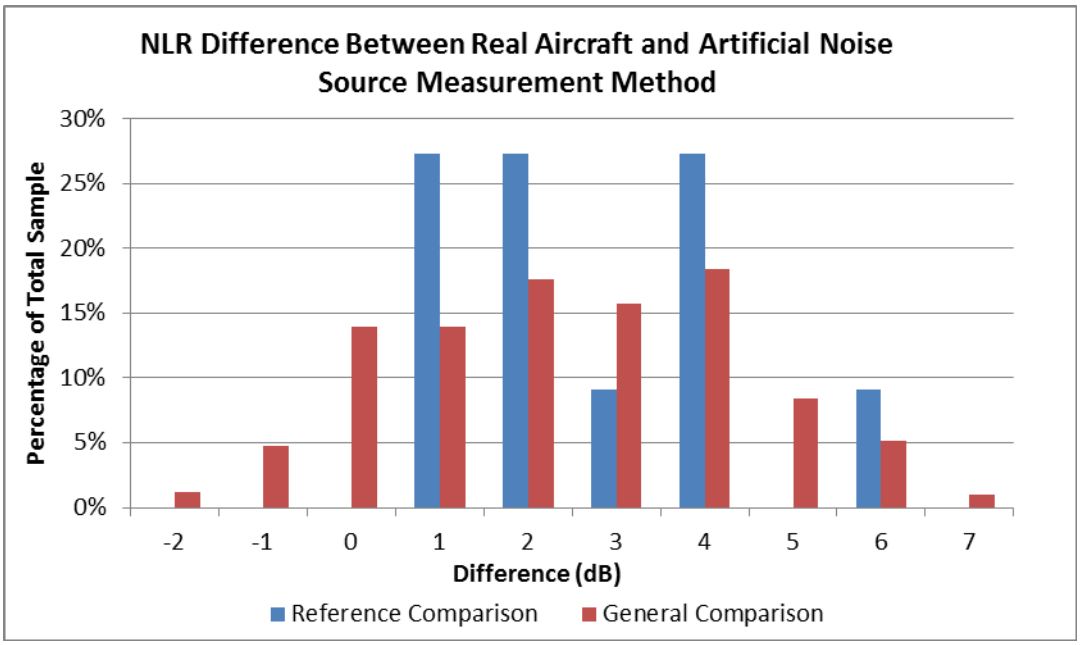


Table 9. NLR Statistical Information for Comparing Differences between Actual Aircraft and Artificial Reference Measurement Method

Comparison	Sample Size	NLR Difference (dB)		
		5th Percentile	Median	95th Percentile
Reference	11	1.1	2.1	5.1
General	528	-0.8	2.4	5.6

5.2 Artificial Noise Source Measurements

This section focuses on the variation on NLR measurements using an artificial noise source. For determining the NLR, two measurements need to be performed; an exterior and an interior measurement. The following sub-section will examine two measurement methods in which the exterior levels have been determined and two methods in which the interior levels have been determined. The second sub-section examines increasing the noise source elevation. The last sub-section evaluates the repeatability of artificial noise source method.

5.2.1 Exterior Measurement Methods Comparisons

This sub-section compares the external flush measurement method to the reference artificial noise source method outlined in **Section 5**, which uses the external façade measurement method. The general comparison also includes crane measurement method at different distances and angles of incidence in the comparison, and the internal four-feet from elements measurement method.

Figure 29 shows the frequency distribution of the difference between the external flush and external façade measurement method. The median difference is 0.1 dB and 0.6 dB for the reference and general comparison; respectively. A positive difference indicates the measured NLR with the external flush measurement method is higher than that of the external facade measurement method. The median NLR with the external flush measurement method is higher than that of the external facade measurement method. **Table 10** shows further detailed statistical information.

Figure 29. Frequency Distribution of NLR Differences between External Flush and External Facade Measurement Method

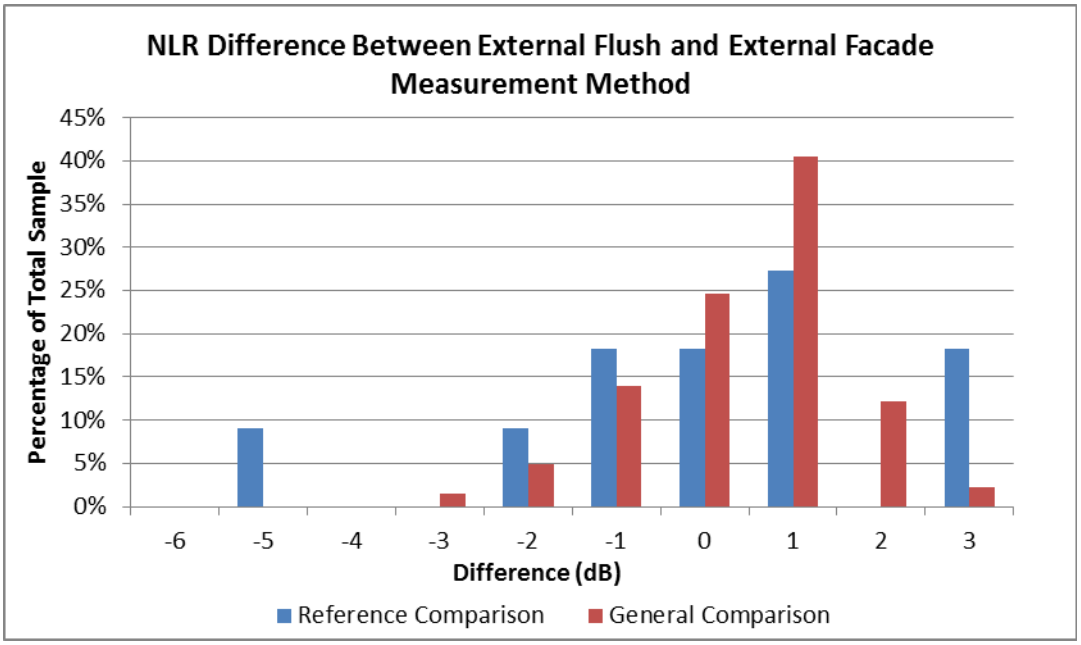


Table 10. NLR Statistical Information for Comparing Differences between External Flush and External Facade Measurement Method

Comparison	Sample Size	NLR Difference (dB)		
		5th Percentile	Median	95th Percentile
Reference	11	-3.5	0.1	2.9
General	264	-1.8	0.6	1.7

5.2.2 Interior Measurement Methods Comparisons

This sub-section compares the internal four-feet from elements measurement method to the reference artificial noise source method outlined in **Section 5**, which uses the internal spatial average measurement method. The general comparison also includes external flush and crane measurement method at different distances and angles of incidence in the comparison.

Figure 30 shows the frequency distribution of the difference between the external flush and external façade measurement method. The median difference is 0.1 dB and -0.2 dB of the reference and general comparison; respectively. A positive difference indicates the measured NLR with the internal four-feet from elements measurement method is higher than that of the internal spatial average measurement method. The internal four-feet from elements measurement method appears to trend towards lower NLRs than the internal spatial averaging measurement method. **Table 11** shows further detailed statistical information.

Figure 30. Frequency Distribution of NLR Differences between Internal Four-Feet from Elements and Spatial Average Measurement Method

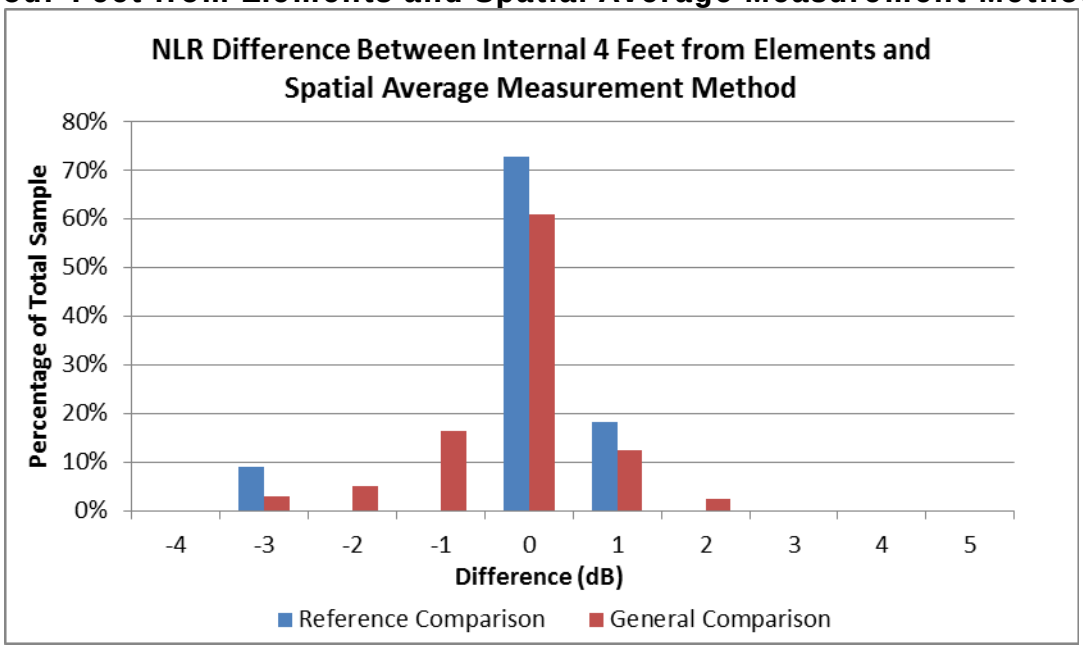


Table 11. NLR Statistical Information for Comparing Differences between Internal Four-Feet from Elements and Spatial Average Measurement Method

Comparison	Sample Size	NLR Difference (dB)		
		5th Percentile	Median	95th Percentile
Reference	11	-1.6	0.1	0.5
General	176	-2.2	-0.2	0.7

5.2.3 Noise Source Elevation Measurement Methods Comparisons

This sub-section compares the elevated on a crane measurement method to the reference artificial noise source method outlined in **Section 5**, which uses the tripod measurement method. The general comparison also includes external flush measurement method at different distances and angles of incidence.

Though the noise source elevation could be considered a parameter change of the artificial measurement method, a number of parameters change when increasing the elevation such that the structure is exposed with an angle of incidence in the horizontal direction as well as the vertical direction. Therefore we are considering elevating the noise source on a crane a measurement method.

Figure 31 shows the frequency distribution of the difference between the crane and tripod measurement method. The median difference is 1.6 dB and 0.9 dB of the reference and general comparison; respectively. A positive difference indicates the measured NLR with the elevated measurement method is higher than that of the tripod measurement method. The median NLR with the elevated measurement

method is higher than that of the tripod measurement method. **Table 12** shows further detailed statistical information.

Figure 31. Frequency Distribution of NLR Differences between Elevated and Tripod Measurement Method

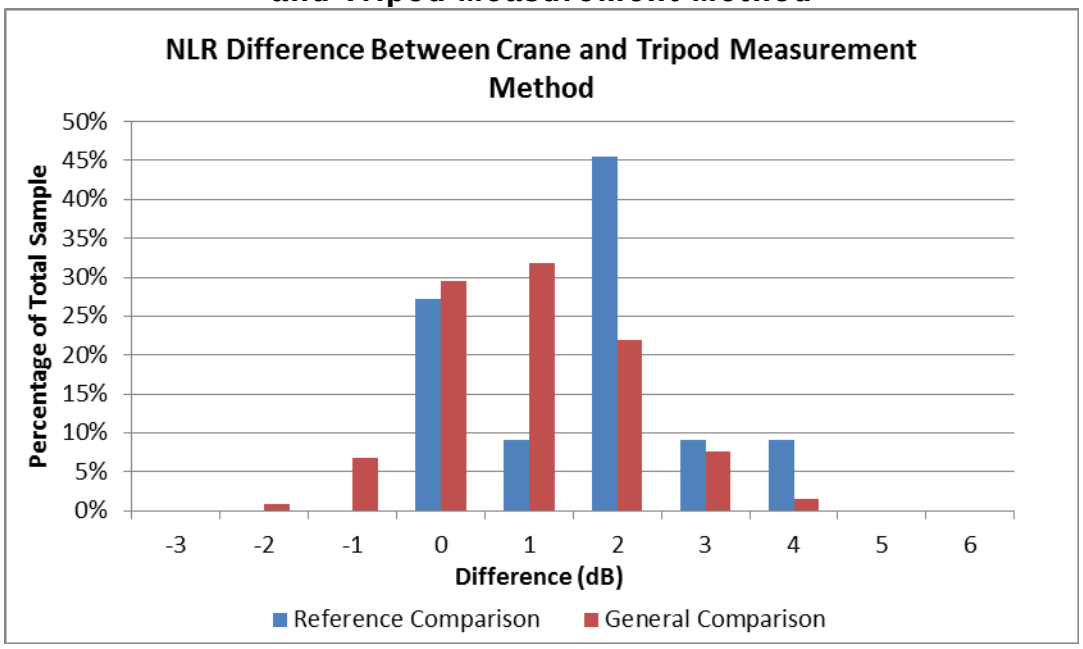


Table 12. NLR Statistical Information for Comparing Differences between Elevated and Tripod Measurement Method

Comparison	Sample Size	NLR Difference (dB)		
		5th Percentile	Median	95th Percentile
Reference	11	-0.3	1.6	3.3
General	132	-0.7	0.9	2.6

5.2.4 Artificial Noise Source Repeatability Evaluation

This sub-section compares the repeated internal spatial average measurements method of the reference artificial noise source method outlined in **Section 5**. The general comparison also includes external flush and crane measurement method at different distances and angles of incidence in the comparison. The sample gives an indication of the repeatability of performing a measurement, such as an internal spatial average.

Figure 32 shows the frequency distribution of the difference between the repeated and initial internal spatial average measurement method. The median difference is 0.2 dB and 0.1 dB of the reference and general comparison; respectively. A positive difference indicates the repeated internal spatial average NLR measurement method is higher than that of the initial internal spatial average measurement method. Approximately 80% of the repeated measurements differ less than ±0.5 dB from the initial measurement. **Table 13** shows further detailed statistical information.

Figure 32. Frequency Distribution of NLR Differences between Initial and Repeated Internal Spatial Average Measurement

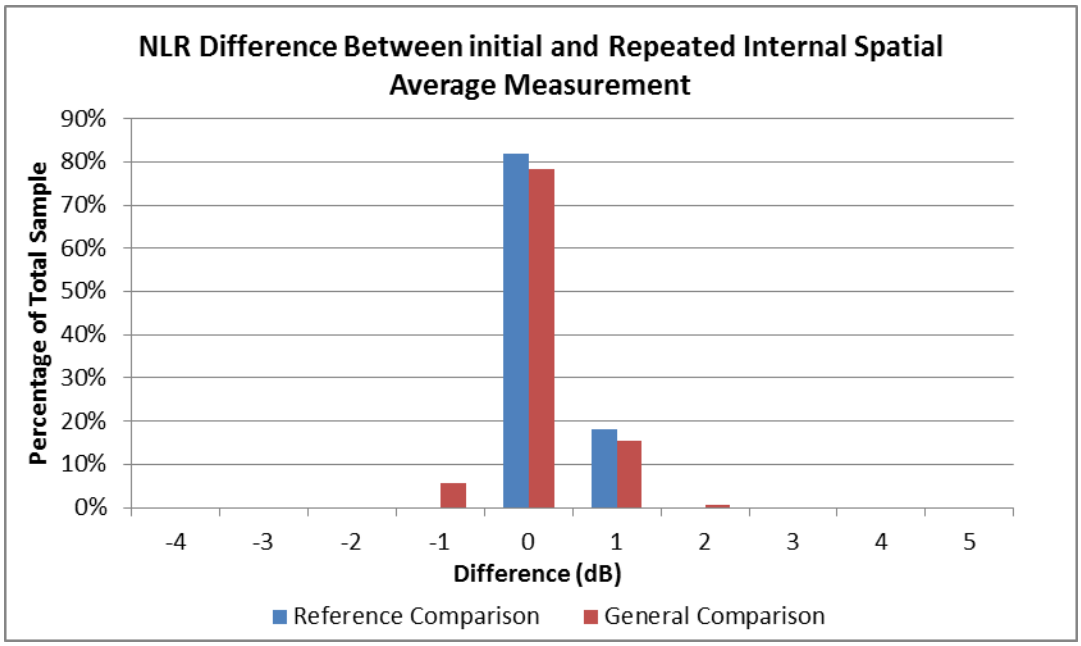


Table 13. NLR Statistical Information for Comparing Differences between Initial and Repeated Internal Spatial Average Measurement

Comparison	Sample Size	NLR Difference (dB)		
		5th Percentile	Median	95th Percentile
Reference	11	-0.2	0.2	0.5
General	176	-0.6	0.1	0.8

5.3 Parameter Changes of Artificial Noise Source Measurements

This section focuses on the variation of parameters on NLR measurements using an artificial noise source. The angle of incidence is decreased and increased 15-degrees from 45-degrees, and the distance is increased to 50-feet from 25-feet in the following three sub-sections.

5.3.1 Decreasing Angle of Incidence

This sub-section compares decreasing the angle of incidence to 30-degrees to the reference artificial noise source method outlined in **Section 5**, which uses and angle of incidence of 45-degrees. The general comparison also includes the repeated measurement, external flush and internal four-feet from elements measurement methods at different distances in the comparison.

Figure 33 shows the frequency distribution of the difference between the external flush and external façade measurement method. The median difference is 0.7 dB and 0.2 dB of the reference and general comparison; respectively. A positive difference indicates the NLR measured at 30-degrees angle of incidence is higher

than that measured at 45-degrees. **Table 14** shows further detailed statistical information.

Figure 33. Frequency Distribution of NLR Differences between 30- and 45-Degrees Angle of Incidence

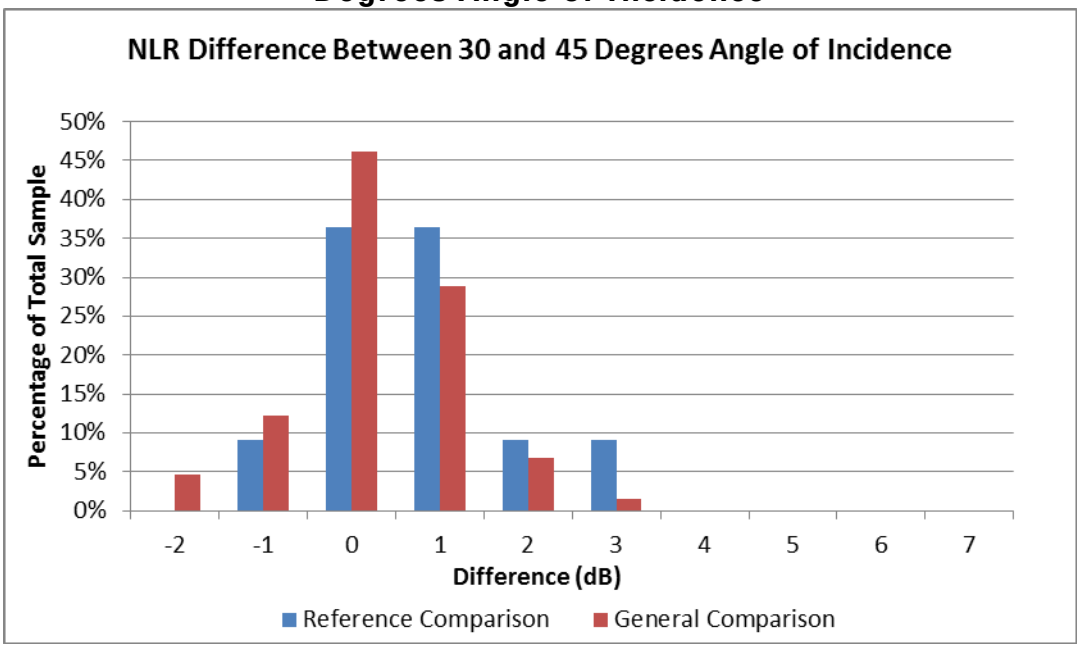


Table 14. NLR Statistical Information for Comparing Differences between 30- and 45-Degrees Angle of Incidence

Comparison	Sample Size	NLR Difference (dB)		
		5th Percentile	Median	95th Percentile
Reference	11	-0.6	0.7	2.4
General	132	-1.2	0.2	1.5

5.3.2 Increasing Angle of Incidence

This sub-section compares increasing the angle of incidence to 60-degrees to the reference artificial noise source method outlined in Section 5, which uses an angle of incidence of 45-degrees. The general comparison also includes the repeated measurement, external flush and internal four-feet from elements measurement methods at different distances in the comparison.

Figure 34 shows the frequency distribution of the difference between the external flush and external façade measurement method. The median difference is 0.1 dB and 0.0 dB of the reference and general comparison; respectively. A positive difference indicates the NLR measured at 60-degrees angle of incidence is higher than that measured at 45-degrees. **Table 15** shows further detailed statistical information.

Figure 34. Frequency Distribution of NLR Differences between 60- and 45-Degrees Angle of Incidence

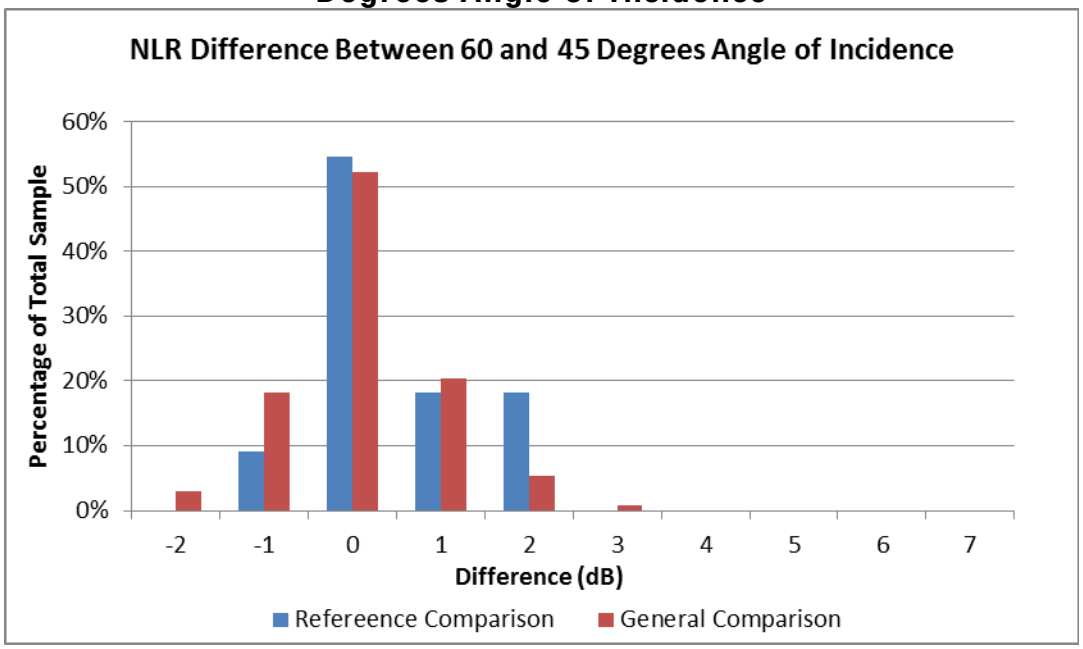


Table 15. NLR Statistical Information for Comparing Differences between 60- and 45-Degrees Angle of Incidence

Comparison	Sample Size	NLR Difference (dB)		
		5th Percentile	Median	95th Percentile
Reference	11	-1.0	0.1	1.6
General	132	-1.3	0.0	1.4

5.3.3 Increasing Noise Source Distance

This sub-section compares increasing the noise source distance to 50-feet to the reference artificial noise source method outlined in Section 5, which uses a noise source distance of 25-feet. The general comparison also includes the repeated measurement, external flush and internal four-feet from elements measurement methods at different angles of incidence in the comparison.

Figure 35 shows the frequency distribution of the difference between the external flush and external façade measurement method. The median difference is -0.1 dB and -0.4 dB of the reference and general comparison; respectively. A positive difference indicates the NLR measured at 50-feet noise source distance is higher than that measured at 25-feet. **Table 16** shows further detailed statistical information.

Figure 35. Frequency Distribution of NLR Differences between 50- and 25-Feet Noise Source Distance

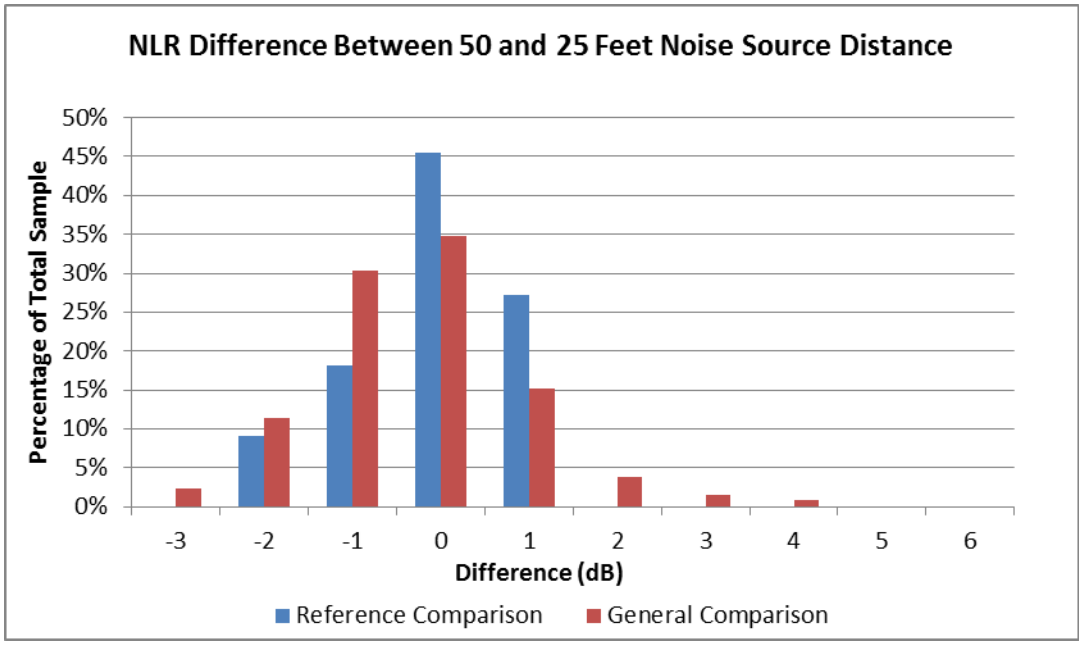


Table 16. NLR Statistical Information for Comparing Differences between 50- and 25-Feet Noise Source Distance

Comparison	Sample Size	NLR Difference (dB)		
		5th Percentile	Median	95th Percentile
Reference	11	-1.7	-0.1	1.1
General	264	-2.2	-0.4	-1.6

5.4 Evaluation of Building Structures

This section focuses on the influence of the building structure and interior acoustical conditions on the NLR. A total of 11 rooms were evaluated, which provides a limited sample to evaluate these aspects in detail. To increase the sample size, L&B also included the general comparison. The following sub-sections will evaluate the following:

- Construction types and room location;
- Window Styles; and
- Difference of the interior absorptive properties of rooms.

5.4.1 Construction Types

This sub-section compares various building structure types and compares to the reference measurements. The general comparison includes all measurement methods and parameters changes and only excludes measurements where batt insulation has been removed from the rooms. Three general construction types were categorized as described below:

1. Aluminum-sided one-story residential structure (Site 1, 2 and 3)
2. Wood-sided two-story residential structure (Site 4)
3. Vinyl-sided one-story residential structure (Site 5 and 6)

Two different window styles were observed at the six sites; Site 1, 3 and 6 had single-glazed windows with storms. Sites 2, 4 and 5 had double-glazed insulated windows. The window styles will be evaluated in the following sub-section

Figure 36 shows the frequency distribution of the three construction types. For this comparison, the average external spectrum was applied to the analysis. The median reference NLR is 24.6 dB, 25.6 dB, and 21.9 dB of the aluminum-sided, wood-sided and vinyl-sided structures; respectively. **Table 17** shows further detailed statistical information. The bar colors reflect the construction style and the shade reflects the reference/general comparison. Aluminum siding is reflected in blue, vinyl siding in green and wood siding in brown. Reference comparisons have a light shade, and the general comparisons have a darker shade.

Figure 36. Frequency Distribution of NLRs of Rooms with Different Construction Types

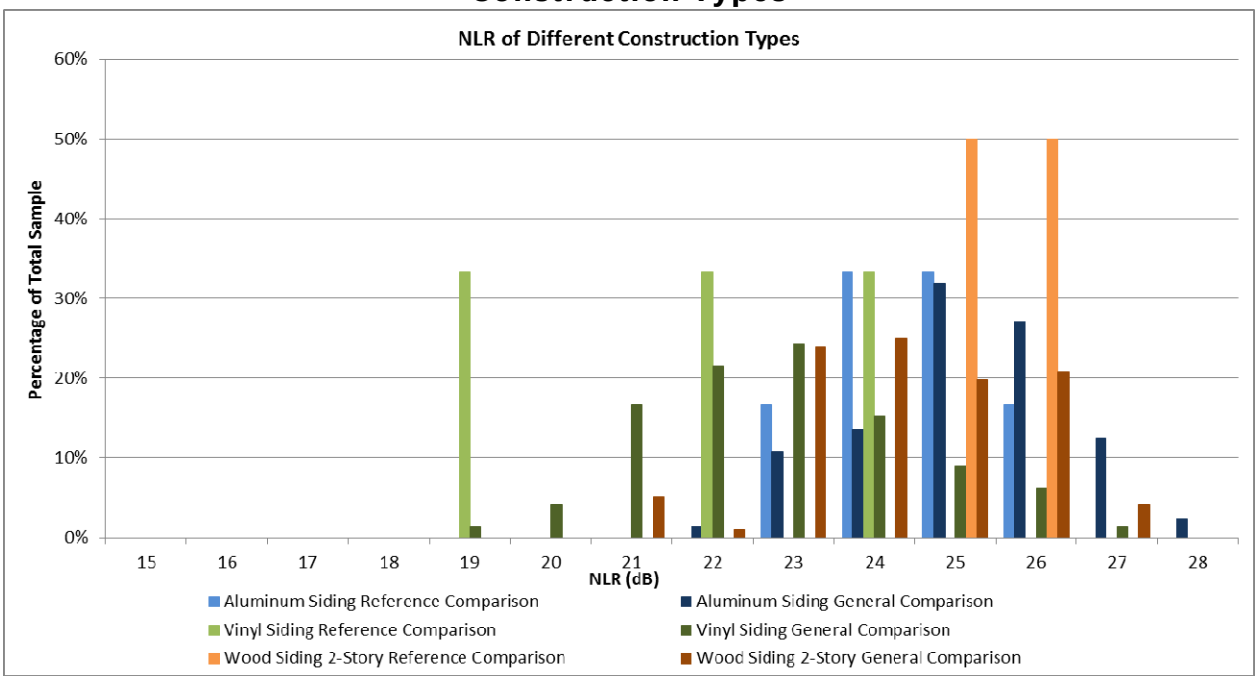


Table 17. NLR Statistical Information for NLRs of Rooms with Different Construction Types

Structure Type	Comparison	Sample Size	NLR Difference (dB)		
			5th Percentile	Median	95th Percentile
Aluminum-Sided	Reference	6	23.6	24.6	25.7
	General	288	22.8	25.2	27.1
Wood-Sided (2-Story)	Reference	2	24.9	25.6	26.2
	General	96	21.5	24.2	26.4
Vinyl-Sided	Reference	3	19.7	21.9	23.0
	General	144	20.4	22.8	25.7

5.4.2 Window Styles

This sub-section compares two window styles and the reference measurements for comparison. The general comparison includes all measurement methods and parameters changes and only excludes measurements where batt insulation has been removed from the rooms. Two window styles were categorized as described below:

1. Single-glazed windows with exterior storms (Site 1, 3 and 6)
2. Double-glazed insulated windows (Site 2, 4 and 5)

Figure 37 shows the frequency distribution of the two observed window styles. For this comparison, the average external spectrum was applied to the analysis. The median reference NLR is 24.3 dB, and 24.6 dB with single-glazed windows with storms and double-glazed insulated glazed windows; respectively. **Table 18** shows further detailed statistical information. The bar colors reflect the construction style and the shade reflects the reference/general comparison. Single glazed windows with storms are reflected in blue and insulated glazed windows are reflected in green. Reference comparisons have a light shade, and the general comparisons have a darker shade.

Figure 37. Frequency Distribution of Measured NLRs of Rooms with Different Window Styles

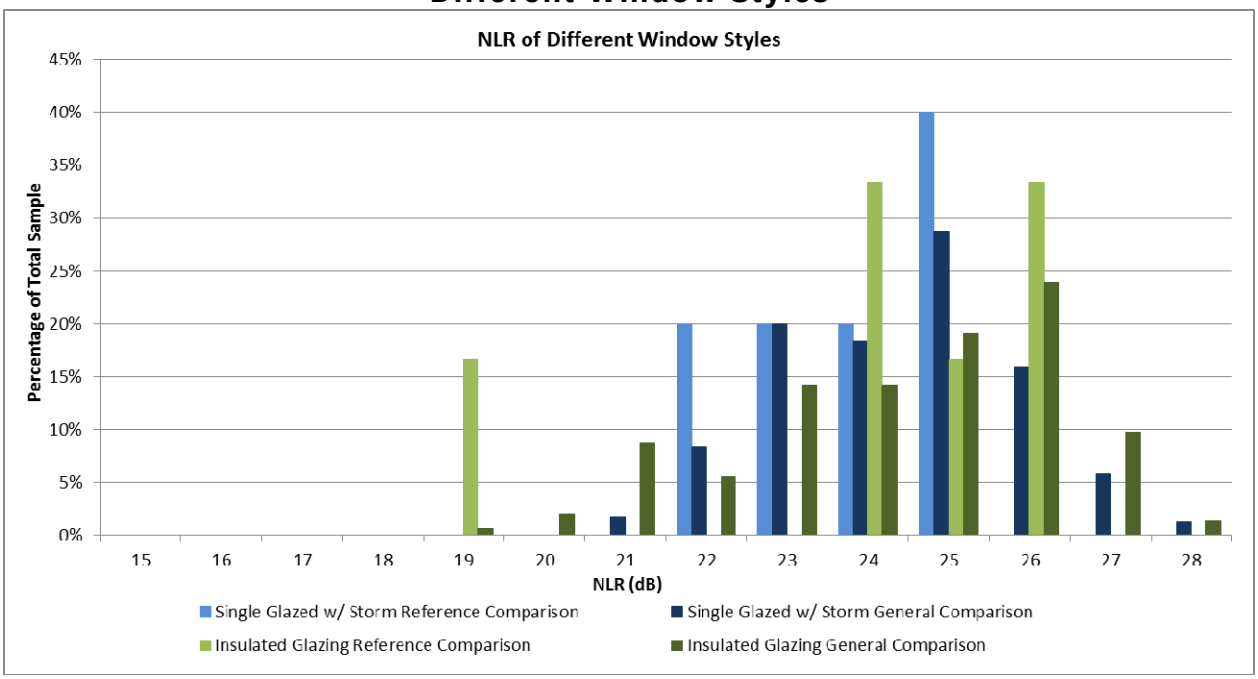


Table 18. NLR Statistical Information for Measured NLRs of Rooms with Different Window Styles

Window Style	Comparison	Sample Size	NLR Difference (dB)		
			5th Percentile	Median	95th Percentile
Single-Glazed (w/ Storm)	Reference	5	22.2	24.3	25.1
	General	240	22.0	24.5	26.7
Double-Glazed (Insulated)	Reference	6	20.6	24.6	26.2
	General	288	20.8	24.8	27.0

5.4.3 Reducing Room Absorption

This sub-section compares removing the batt absorption to the reference artificial noise source method outlined in Section 5, which has batt insulation on the walls and floors. The general comparisons are not appropriate for this comparison.

Figure 38 shows the frequency distribution of the difference between from removing batt insulation. The median difference is -2.8 dB. The NLR reduces when batt insulation is removed. A positive difference indicates the NLR measured with the batt insulation removed is higher than that measured with batt insulation in the rooms. **Table 19** shows further detailed statistical information.

Figure 38. Frequency Distribution of NLR Differences from Removing Batt Insulation

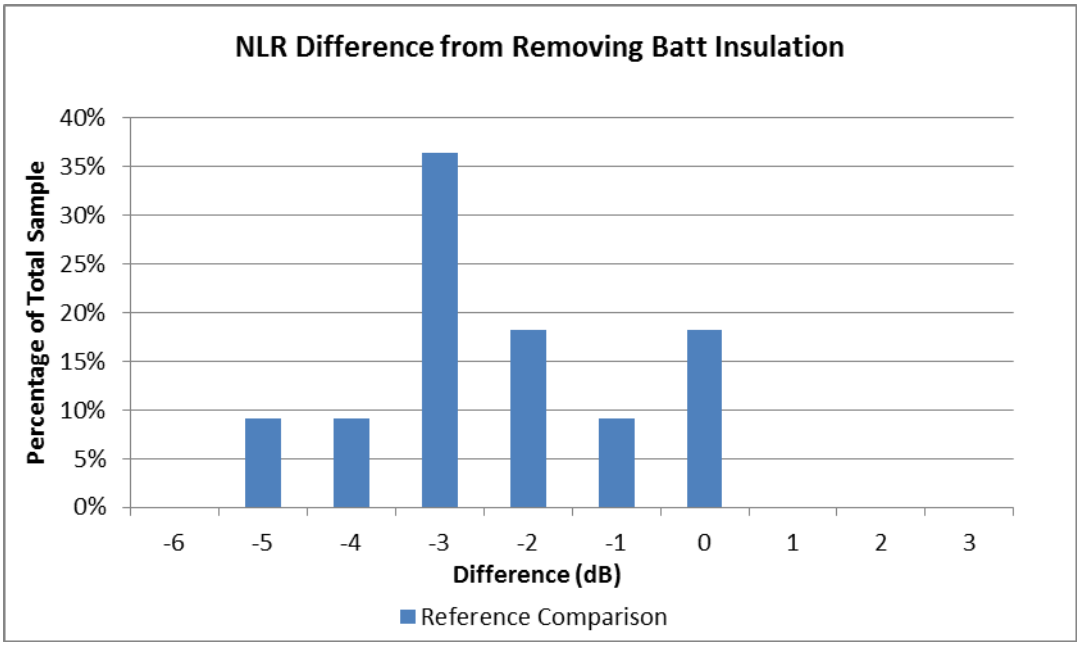


Table 19. NLR Statistical Information for Comparing Differences from Removing Batt Insulation

Comparison	Sample Size	NLR Difference (dB)		
		5th Percentile	Median	95th Percentile
Reference	11	-4.2	-2.8	0.0

SECTION 6 DISCUSSION

6.1 General Comparisons

This section discusses the results of the statistical analysis presented in the previous sections. A number of primary causes that contribute to the NLR variation are described first. The following sections will discuss the relation of statistical measurement information to the various causes of the NLR variation. Due to the limited scope of this study, not all causes that contribute to the NLR variations are included in this study.

Primary contributions to the variation of NLR measurements that should be considered are broken down as follows:

1. *Actual Aircraft Measurement Method –* Using actual aircraft for the noise source will produce different NLR results than using an artificial noise source. Differences are summarized as follows:

   a) *Aircraft Types:* The aircraft type influences the measured NLR differently. The sample of aircraft measured during a specific window of time may not necessarily reflect the actual annual aircraft mix.

   b) *Aircraft Operations (departures/arrivals/start-of-takeoff roll):* The operation may have an influence on the measured NLR. The measured samples in this study do not include any arrivals due to the location of the housing selection. Therefore, this study did not lend to accurate NLR measurements for arrivals. In addition, the departures measured in this study tended to be on the ground or low to the horizon.

   c) *Flight Path Location:* The flight path location in relation to the building will affect the exposure of the structure. Different parts of a building envelope usually perform differently acoustically and, therefore, the NLR may vary. Also, the spectrum of the noise exposure fluctuates throughout the duration of an aircraft over flight which also contributes to variations in the NLRs.

   d) *Weather:* Wind and temperature inversions affect the noise propagation that may affect the noise exposure and, ultimately, may influence the NLR.

   e) *Variation in Microphone Placement:* There are a number of sources that specify the microphone locations for measuring NLRs. For example, one option specified in the Wyle Research Report WR89-7 is four-feet from the most sound transmitting element. A room with multiple windows and perhaps an exterior door leaves a consultant to choose the location of the microphone. The exterior microphone location specifications also leave consultants with freedom in selecting locations depending on the environment.

   f) *Data Acquisition Setup:* To automate the data acquisition, consultants may choose to set sound level triggers on the sound level meters for starting and stopping aircraft events recordings. They may also perform these actions using software back in an office. Differences in the setup of sound level meters may affect the final measured NLR.

2. *Artificial Noise Source Measurement Method –* Using an artificial noise source for performing NLR measurements may produce different NLRs than by using actual aircraft. This is further influenced by the measurement method with the artificial noise source, as well as the influence of human judgments and performance of the measurements. Finally, the exterior noise source spectrum that the NLR measurement is based on will affect the final results.

   a) *Human Variations:* Every consultant performs measurements differently and, therefore, there are variations not only caused by a consultant performing measurements slightly differently, but also when measurements are performed by different consultants.

      i) Data Acquisition: The repeatability of performing spatial averages and exterior spatial averages, location selections for external flush measurements is affected by how the consultant executes the measurements.

      ii) Noise Source Location Selection: The ASTM E966-10 standard only specifies minimum noise source distance to facades. Consultants have the freedom to increase this distance, thereby introducing variations in the NLR measurements. Also, limitations of the environment may not make it possible to position the noise source at the minimum distance per ASTM E966-10 standard. The accuracy of positioning the noise source at 45-degrees is limited, thereby also introducing variations in NLR measurements. An even sound distribution over the façade (as would often be the case during real aircraft exposure) is improved as the noise source is placed further away.

   b) *Measurement Method:* The measurement method that consultants chose affects the final NLR results. The consultant has three main external measurement methods to choose from and two internal measurements. In addition, a consultant may choose to perform a moving spatial average or select multiple static microphone locations. Also the consultant may choose to elevate the noise source using a crane instead of a tripod.

      i) Noise Source Elevation: The noise source can be elevated using a crane or a tripod, where each measurement method exposes the facades differently, and thereby causing a NLR variation.

      ii) External Free Field: This measurement is sometimes affected by nearby objects, or differences in the noise propagation to the façade to be measured and the location where the free field measurement is taken.

      iii) External Façade: This measurement may be affected by the absorptive properties of the structure, and sometimes the transmission loss, where not a true 100% of the sound is reflected.

      iv) External Flush: As with the external façade measurement method, the external flush method adjustment may not be quite accurate, depending on the absorptive surfaces and transmission loss of the façade. In addition, a moving spatial average is not possible, and a limited number

of microphone locations are selected that will affect the exterior measurement result depending on where the microphones are positioned.

v) Internal Spatial Averaging: Depending on whether a moving or static spatial average is performed, variances in the microphone locations affect the interior measurement.

vi) Internal Four-Feet from Elements: Depending on whether a moving or static four-feet from element measurement is performed, variances in the microphone locations affect the interior measurement.

c) *Exterior Noise Source Spectrum:* Whether the consultant chooses to shape the noise source spectrum to represent aircraft noise and measure A-weighted levels, or measure a flat spectrum and shape the exterior spectrum using software, to calculate A-weighted levels, both ultimately result in applying an exterior noise spectrum to base the NLR calculations on. The exterior noise spectrum affects the NLR calculations.

3. *Building Construction -* The building construction influences the measured NLR. This includes the window styles/sizes, doors, wall construction and roof construction. Sound insulation programs focus on replacing certain elements (windows, doors, etc.) to increase the NLR. The pre- to post-construction NLR differences are affected by the existing building construction.

4. *Room Absorption -* The furnishings of a room affect the measured NLR. This can be important when consultants are comparing pre- and post-construction measurements. When the furnishings significantly change, it will affect the computed pre-post construction NLR change in addition to the change due to the installation of new acoustical products.

6.2 Actual Aircraft and Artificial Noise Source Measurements

Consultant may choose to perform NLR measurements using actual aircraft or an artificial noise source. Section 5.1.2 shows the median NLR of the actual aircraft measurement method measuring is higher than that of the artificial noise source method. Approximately 90% of the differences are within a 6.4 dB range from the actual aircraft measurement methods (general comparison). In general, the median NLR of actual aircraft measurement method is 2.4 dB higher than using an artificial noise source.

The causes for the difference can only be speculated at this time. One possibility is the difference of aircraft noise exposure compared to using an artificial noise source. Actual aircraft noise exposure changes and exposes different parts of the building envelope differently over the course of time during an over flight. The artificial noise source exposes all the facades continuously and represents a worse case exposure, which is the case only for a brief period during an actual over flight.

6.3 Influence of Aircraft Noise Exposure on Actual Aircraft Measurement Method

Section 5.1.1 and Appendix C show variation between individual aircraft. The median 90% confidence intervals of the NLRs of the 11 rooms measured in Table 3 is ±1.3 dB. However, additional measurements would be required to quantify differences in measured NLRs for different aircraft types more accurately, because the sample size that was measured for this study was too small. Therefore, it is not certain whether the NLR variations of different aircraft are due to differences of elevation between different aircraft causing the exposure to vary. Given that the homes were located to the side of the runway, differences in aircraft elevation may be significant.

From past experience, we have observed clear NLR differences for arriving props/turbo props, small regional jets (such as CRJ), commercial jets (such as B737), and wide body commercial jets (such as B747). Only departures have been measured in this evaluation and, therefore, to quantify any NLR differences for aircraft types for arrivals would require additional measurements.

This study does not include the NLR variations caused by location of flight path in relation to the buildings (sideline versus overhead) and variations due to different weather conditions.

6.4 Artificial Noise Source Measurements Methods

For this study, two external and two internal measurement methods have been evaluated. Depending on the two measurement methods a consultant chooses, the internal and external measurement method NLR differences can increase, decrease or partially cancel out each other. This is a result of the way the NLR is computed, where the interior levels are subtracted from the exterior levels. In addition, the elevated measurement method is discussed.

In general, the median NLR using the external flush measurement method is 0.6 dB higher than the external façade method. The slight trend does seem to be conclusive. It is not certain if this is related to the five chosen static microphone locations that limited the coverage of the exposed facades. For rooms with two exposed façades one microphone was placed near the ground where the ground propagation attenuation may be higher compared to the microphone positions higher up on the walls. This difference is emphasized even more during elevated measurements, where most of the microphones are closer to the elevated noise source. When comparing the results to the reference measurement, the median NLR is only 0.1 dB higher using the external flush measurement method.

The internal four-feet from elements measurement method is not showing a conclusive difference, despite the general median NLR of the internal four-feet from elements measurement method being 0.1 dB lower than the internal spatial average measurement method. A larger difference was expected. Although we added batt insulation to rooms and measured the reverberation times to match that of furnished rooms, it may not have been completely sufficient in the larger rooms.

In general using a crane to elevate the noise source increases the median NLR by 0.9 dB compared to using a tripod to elevate the noise source. Compared to the reference measurement, the difference is 1.6 dB. This difference supports the possible explanation of the external flush measurement method microphone locations having more higher than lower locations for rooms with two exposed facades.

6.5 Human Causes to NLR Variation

There are two parts to performing NLR measurements; (1) measurement setup and, (2) data acquisition. For variation caused by differences in measurement setups, this study evaluates varying angles of incidence and varying the distance noise of the noise source. This study only includes the NLR variation from repeating the internal spatial average measurement less than 10 minutes after the initial measurement by the same consultant.

Section 5.2.4 shows that 80% of the repeated internal spatial average NLR measurement differences are within ±0.5 dB from the initial measurements. Almost all repeated NLR measurement differences are within ±1.0 dB from the initial NLR measurements.

The variation from repeating external façade and external flush measurements and internal four-feet from elements measurements are not included in this study. Therefore, the additional variation due to a second measurement cannot be determined. The NLR is calculated by subtracting the exterior and interior measurements, each having a certain variation that are additive.

The variation of the noise source angle of incidence and distance are also additive variations. The angles of incidence evaluated in this study are ±15 degrees from 45 degrees. Section 5.3.1 and Section 5.3.2 show that in general, the median NLR difference from a 45-degree angle is 0.2 dB and 0.0 dB when decreasing and increasing the angle of incidence by 15-degrees; respectively. Although the transmission loss continuously decreases as the angle of incidence decreases from 90-degrees, many rooms had two exposed façades. As the angle of incidence is reduced in relation to the front façade, it is simultaneously increased in relation to the side façade. Therefore, in general the NLR variation from changing the angle of incidence is not conclusive in the sample of rooms measured in this study.

Section 5.3.3 shows that in general, the median difference from increasing the distance of the noise source is -0.4 dB. The NLR in general decreases as the noise source is moved further away. This difference is conclusive. In a number of rooms that were open to adjacent rooms, noise was observed coming from the adjacent rooms, as a result of a more even noise exposure of multiple rooms.

6.6 Building Construction

NLR variation evaluation from different building construction is limited in this study, due to the relatively small sample size. This study evaluates the NLR variation from rooms with different wall construction and different window styles.

Section 5.4.1 shows the median NLRs are 24.6 dB, 25.5 dB, and 22.4 dB for the aluminum-sided, wood-sided and vinyl-sided structures. The sample size of 11 rooms is too small to be conclusive. Observations from experience on different programs have shown buildings with brick facades to have higher NLR than others.

Section 5.4.1 evaluates the two observed window styles: single-glazed with storms and double-glazed insulated (newer) windows. The median reference NLR is 23.4 dB, and 24.8 dB with single-glazed windows with storms and double-glazed insulated windows; respectively. The single-glazed windows with storms have a larger airspace that increases the transmission loss and lowers the resonance frequency. The double-glazed insulated windows generally seal better and in this study, where installed, are showing 1.4 dB higher median NLR than single-glazed windows with storms.

6.7 Room Absorption

NLR variation from differences in furnishings was simulated using batt insulation. Section 5.4.4 shows that the median NLR difference from removing batt insulation is -2.8 dB. The interior levels in a room consist of direct sound coming from the exposed facades and perhaps some single reflections, and the reverberation level. Adding absorption mainly decreases the reverberation levels, and thereby the interior levels too. This increases the difference between the exterior and interior levels that increases the NLR. Therefore it is important to have the furnishings for pre- and post-construction testing as much the same as possible to determine the NLR increase as a result of the modifications.

6.8 Final Statements

Figure 39 and **Figure 40** summarize the measured variations as a result from various measurement methods, parameter changes, and absorption changes. The total variation of NLR measurements is comprised of many causes, each introducing their own variations to the total. This study includes a subset of a number of possible causes that contribute to the total NLR variation. Section 6.1 listed various aspects that contribute to the NLR variation. To quantify the total NLR variation, the variation of individual components that contribute to the total NLR needs to be quantified separately.

For artificial noise source sound insulation measurements, the main variation components are:

1. Human Variation
    a. Data Acquisition
    b. Measurement Setup
2. Measurement Method
    a. External
    b. Internal

c. Noise Source Height

3. Analysis Method

a. Exterior Spectrum

The relation of these variations is mathematically described below:

Var(NLR Measured) = Var(Data Acquisition) + Var(Setup) + Var(Measurement Method) + Var(Analysis)

Var(Data Acquisition) = Var(Internal Measurement) + Var(External Measurement)

Var(Setup) = Var(Angle of Incidence) + Var(Noise Source Distance)

Var(Measurement Method) = Var(Exterior Method) + Var(Interior Method)

Further studies could be broken down into a number of separate studies, each focusing on a separate category that contributes to the NLR variation. These study categories can be broken down as:

1. Human Variation:

a) Data Acquisition –

i) A focus on the variations of repeatability when performing the external as well as internal measurements can be quantified.

ii) Also it is useful to determine variations between different instruments. This can be as detailed as quantifying the differences between the microphones, pre-amps and the sound level meter itself. Studies on instrument variations have most likely already been done in the past and can be referred to.

b) Measurement Setup – To gain a better understanding of factors pertaining to the noise source setup that contribute to the NLR variations, the following main aspects can be further analyzed.

i) The external levels at various locations of the façade and internal levels at various locations in the room can be compared to the noise source distance and frequency. The use of waterfall graphs showing levels as a function of noise source distance and octave band may reveal the influence of reflections and interference patterns.

ii) The external levels at various locations of the façade and internal levels at various locations in the room can be compared to angle of incidence and frequency. These measurements can be plotted in waterfall graphs showing the levels as a function of angle of incidence and octave bands.

2. Measurement Method:

a) External - A detailed comparison of external flush and external façade measurements at various locations of a façade can be compared directly with two microphone positions; one flush and one at four feet from the façade.

b) Internal - A detailed comparison of the levels at different locations throughout the room can be directly compared to locations four feet from weaker elements.

c) Noise Source Height – Having the noise source elevated above the roof changes the exposure of the property. The differences can be analyzed in further detail to further understand the variation between measurement methods.

3. Analysis Method:

a) Exterior Spectrum - Depending on how the data is analyzed, the NLR varies. Some consultants measure A-weighted exterior and interior levels of a noise source producing simulated aircraft spectrum. Other consultants measure spectral data and apply certain aircraft of pink noise spectra to the analysis, producing different results.

Additional studies can further quantify differences between actual noise source and artificial aircraft by choosing an airport and locations with more typical aircraft noise exposure. The properties can be chosen such that exposures with different flight paths, and differences between departures and arrivals can be quantified and compared to measurements using an artificial noise source. By collecting spectral data as a function of time, the NLR can be analyzed as different parts of the property are exposed during an over-flight.

For real aircraft sound insulation measurements, the main aspects that contribute to NLR variation are:

1. Conditional
    a. Aircraft Types
    b. Flight Path Location
    c. Aircraft Operation
2. Environmental
    a. Weather
        i. Wind Speed/Direction
        ii. Temperature (and Temperature Inversions)
    b. Geographic - these are uncommon, however, as an example, sometimes large buildings are constructed near residential structures that change the acoustics of the environment and possibly the aircraft noise exposure.
3. Measurement Setup
    a. Interior as well as exterior microphone location selections
    b. Data acquisition setup

The relation of the most common variations is mathematically described below:

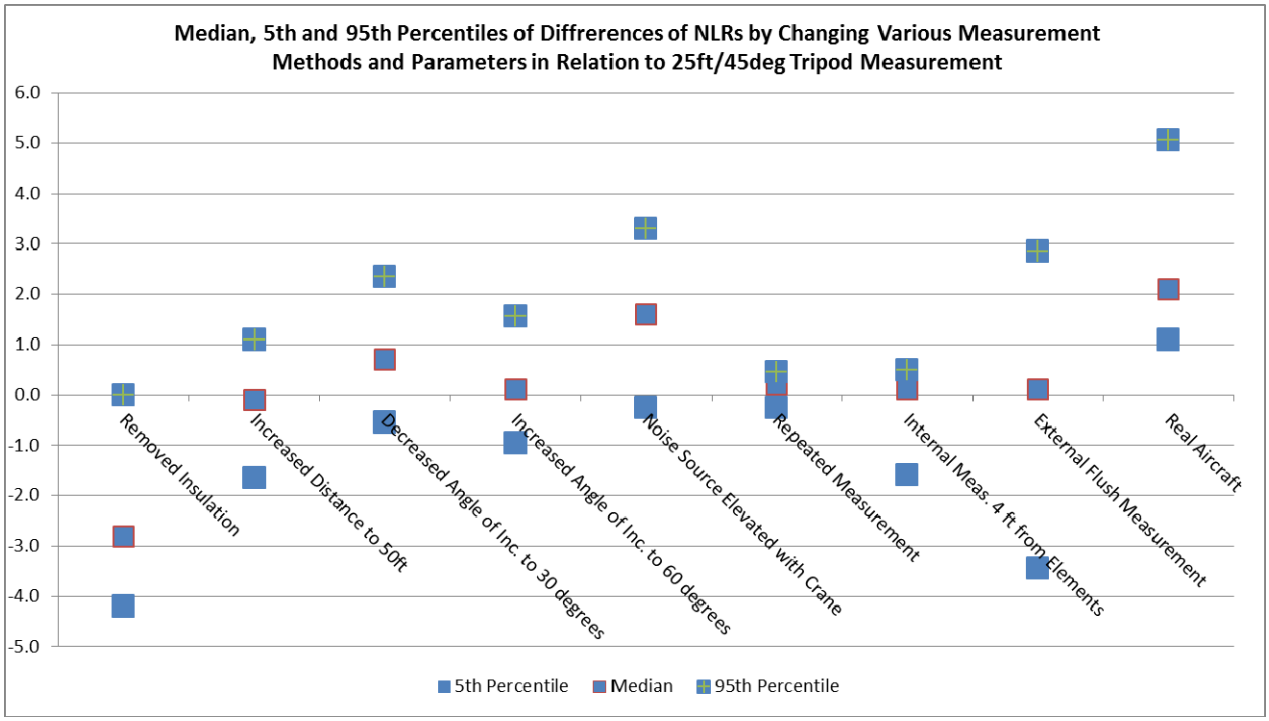
Var(NLR Measured) = Var(Data Acquisition) + Var(Aircraft Type) + Var(Weather) + Var(Aircraft Operation)

Var(Data Acquisition) = Var(Exterior Measurement Location) + Var(Interior Measurement Location) + Var(Data Acquisition Setup)

Further studies could be broken down into a number of separate studies, each focusing on a separate category that contributes to the NLR variation. These study categories can be broken down as:

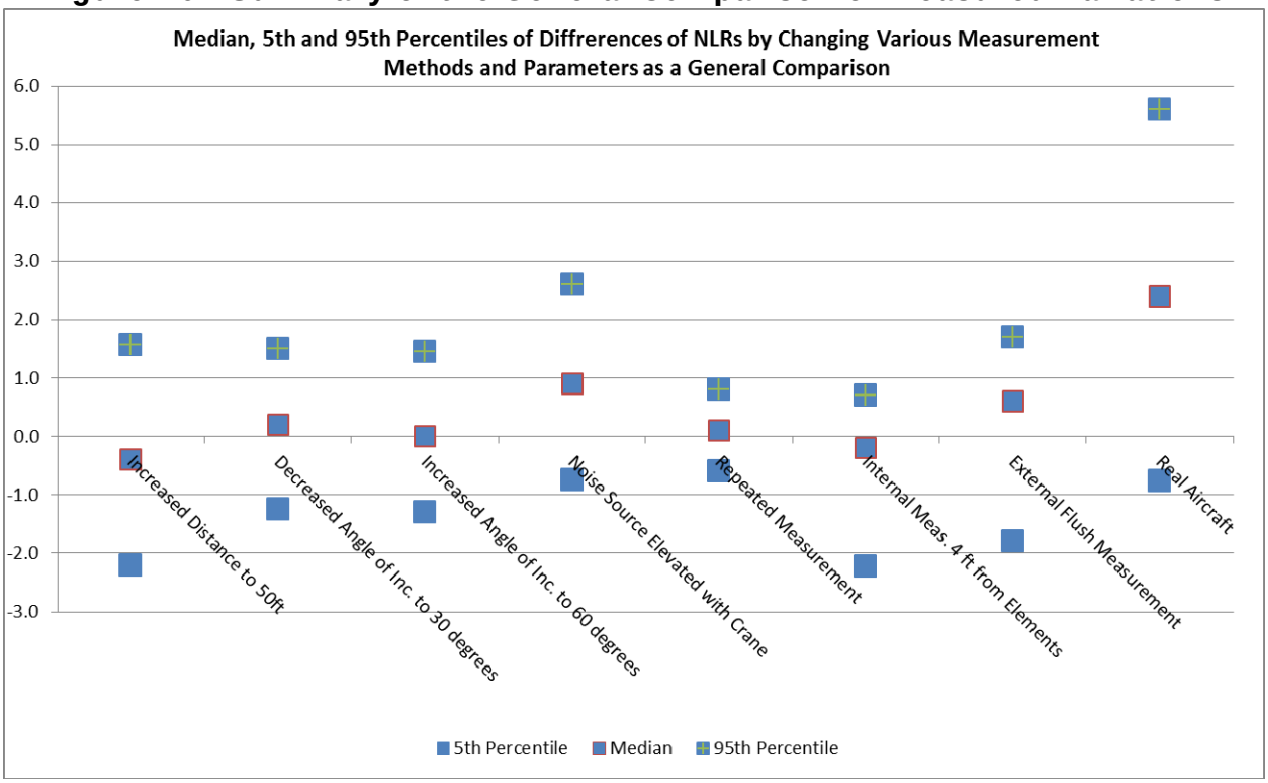
1. Conditional:
    a. Spectral data as a function of time of aircraft types can be measured externally and internally, that can help explain variations in the measured NLR.
    b. By selecting multiple homes at different locations in relation to the flight path and measuring the frequency content as a function of time externally and internally, the difference between NLR measurements using real aircraft and artificial noise source can be further understood. Although, usually, flight paths do not change significantly, and may not be a significant source of NLR variation.
    c. The exposure of departures and arrivals are different. Therefore it would be useful to understand how this difference affects the NLR.
2. Environmental:
    a. The NLR can be measured during different weather conditions and compared. Determining temperature inversions might not be feasible; however, the influence of wind and temperature on the exterior and interior levels and frequency content can provide useful information about how the NLR changes due to weather conditions.
3. Measurement Setup:
    a. Different exterior and interior microphone locations can affect measured levels. The NLR variation resulting from different microphone locations is important for determining the NLR variation using real aircraft.
    b. Different trigger levels and settings of the instruments can be compared to understand the influence of instrument settings.

Figure 39. Summary of the Variations Compared to the Reference Measurement



Note: Reference measurement is defined as a room with batt insulation, artificial noise source on a tripod, external façade and internal spatial average measurement method, 25-foot noise source distance and angle of incidence of 45 degrees.

Figure 40. Summary of the General Comparison of Measured Variations



APPENDIX A
EQUIPMENT USED FOR NLR MEASUREMENTS

- Actual Aircraft
  - Larson Davis 824 Sound Level Meter/One Third Octave Band Analyzer

- Artificial Noise Source (On Tripod) & (Elevated By Crane)
  - Larson Davis 824 Sound Level Meter/One Third Octave Band Analyzer
  - McCauley AC95-1 Coaxial Loudspeaker
  - Crown XLS 202 Power Amplifier
  - Rolls REQ215 31 Band Graphic Equalizer
  - Goldline PN3B Noise Generator

APPENDIX B
MEASUREMENT SITE BACKGROUND INFORMATION

date	11/12/2012
ADDRESS	13 dumont ave
MICROPHPONE set	4 feet in from each wall. 2 MICS in each room. SET 5 FT HIGH; Kicthen and front room facing airport; 65 degrees NE x E
MICROPHONE OUT FRONT	20 ft from front of house; 20 ft from NE corner; 5 FT HIGH
INSULATION PALCEMENT	3 ROLLS ON FLOOR AROUND PERIMETER OF EXTERIOR WALLS IN LIVING ROOM; 2 ROLLS IN KITCHEN
EXTERIOR	aluminum siding
WALL STUD SEPARATION	16 INCH STUD ON PLASTER WALLS AT LEAST 1 INCH THICK 8 FEET HIGH CEILING
WALL TYPE	PLASTER
CAVITY FILLING	BATTED FACED FIBERGLASS INSULATION
ROOF TYPE	shingle - poor condition, curled, 1 LAYER
NUMBER LAYERS	1 layer
WINDOW TYPE	SINGLE PANE W SOTRM WINDOWS. SOME UP SOME DOWN. COULDN'T CHANGE THEIR POSITION
KITCHEN L X W X H	150X160X96
kitchen windows HxW	48x60 facing 65 degrees NE x E; 20x38 FACING 340 DEGREE NORTH
lliving room lxwXH inches	163x146X 96
living room windows	48x60 facing 65 degrees NE x E, 36 X 54 FACING 174 DEGREE SOUTH
living room door	36x80 facing 65 degrees NE x E
WIND	SOUTH X SOUTHWEST 20 MPH GUSTING TO 35MPH; TEMPERATURE 58 DEGREES AT 6:34 AM
TAKEOFF EVENTS	SOUTH FLOW ALL DAY 6:45 PROP; 7:07 JET; 7:31 jet; 1 small and 1 large jet @7:47 am; 7:53jet; 8:02 prop did NOT taxi to runway end. Short take off; 8:35 TWO SEATER PROP LANDING; 9:00 JET; NO EVENTS NOTED TIL 9:54 JET; 12:04 ARR; 12:07 ARR; 12:36 RR; 1243 DEP PROP; 12:45 DEP JET HJ;
LANDING EVENTS	7:21

	SET #1	SET #2	SET #3	SET #4	SET #5	SET #6	SET #7	SET #8	SET #9	SET #10	SET #11	SET #12
DATE	11/12/2012	1/12/2012	11/12/2012	11/12/2012	11/12/2012	11/12/2012	11/12/2012	1/12/2012	11/12/2012	11/12/2012	11/12/2012	11/12/2012
TIME	9:31 AM	10:02 AM	10:16 AM	10:30 AM	10:45 AM	10:58 AM	11:08 AM	11:24 AM	11:30 AM	11:38 AM	11:45 AM	11:53 AM
SPEAKER FACING	W NW	N NW	N NW	W NW	N NW	N NW	SW	SW	SW	SW	SW	SW
SPEAKER HEIGHT FEET	5	5	5	5	5	5	5	5	5	5	5	5
DEGREE FROM CORNER OF HOUSE	45	60	30	45	60	30	45	60	30	45	60	30
SPEAKER ANGLE DEGREES	290	275	305	290	275	305	215	240	200	215	240	200
DISTANCE FROM HOUSE	25	25	25	50	50	50	25	25	25	50	50	50
WIND SPEED MPH	18	18	17	18	18	17	18	18	17	18	18	17
WIND DIRECTION DEGREES	190	190	190	190	190	190	190	190	190	190	190	190
VERTICAL MESUREMENTS	SET#1	SET#2	SET#4	SET#3								
TIME	1:23	1:35	2:05	1:49								
SPEAKER FACING	SW	SW	N NW	N NW								
SPEAKER HEIGHT FEET	39	25	39	25								
DEGREE FROM CORNER OF HOUSE	45	45	45	45								
SPEAKER ANGLE DEGREES	215	215	290	290								
DISTANCE FROM HOUSE	29 X 29	15X15	29X29	15X15								
WIND SPEED MPH	21	21	21	21								
WIND DIRECTION DEGREES	190	190	190	190								

WITHOUT INSULATION	SET#1	SET#2
TIME	16:43	
SPEAKER FACING	N NW	SW
SPEAKER HEIGHT FEET	5	5
DEGREE FROM CORNER OF HOUSE	45	45
SPEAKER ANGLE DEGREES	215	290
DISTANCE FROM HOUSE	25	25
WIND SPEED MPH	17	17
WIND DIRECTION DEGREES	190	190

date	11/13/2012
ADDRESS	57 dumont ave
microphone set	4 feet in from each wall. 2 MICS in each room. SET 5 FT HIGH; bedroom and front room facing airport;
microphone out front	20 ft from front of house; 20 ft from E corner; 5 FT HIGH
INSULATION PALCEMENT	1 roll draped and nailed to north wall; 2 rolls on floor; 1 roll draped and ndailed to 3 walls and 1 roll on floor in bedroom
EXTERIOR	aluminum siding
WALL STUD SEPARATION	16 INCH 8 FEET HIG CEILING
WALL TYPE	PLASTER
CAVITY FILLING	FIBERGLASS BATTED/FACED INSULATION
WINDOW TYPE	DOUBLE PANED GLASS NO STORM WINDOWS
ROOF TYPE	shingle - GOOD condition 1 LAYER
NUMBER LAYERS	1 layer
BEDROOM L X W	148X116
BEDROOM windows HxW	48X36 FACING 90 DEGREES E AND 48X36 FACING 0 DEGREES N
lliving room lxwXH inches	300 X 138
living room windows	118X60 FACING 0 DEGREE N, 36 X 54 FACING 0 DEGREE N
living room door	36X80 FACING 0 DEGREE N
WIND	RAINING AT 0600; WIND 7 MPH FROM NW; 46 DEGREES FAHRENHEIT; ;740 STOPPED RAINING ; 805 RAIN AGAIN
TAKEOFF EVENTS	NORTH FLOW; 6:10 JET; 615 JET; 6:17 JET: 6:24 JET; 6:32 RJ/CESSNA; 731 JET; 756 JET TAXI DID NOT SEE DEP;
LANDING EVENTS	7:20 AM SOUTH FLOW JET ARR; ;
DOUBLE PANED WINDOWS WITH NO STORM WINDOWS	

	SET #1	SET #2	SET #3	SET #7	SET #8	SET #9	SET #4	SET #5	SET #6	SET #10	SET #11	SET #12
DATE	11/13/2012	11/13/2012	11/13/2012	11/13/2012	11/13/2012	11/13/2012	11/13/2012	11/13/2012	11/13/2012	11:05	11/13/2012	11/13/2012
TIME	9:15 AM	9:25 AM	9:35 AM	10:25 AM	10:50 AM	11:00 AM	9:45 AM	9:55 AM	10:05 AM	11:10 AM	11:20 AM	11:30 AM
SPEAKER FACING	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
SPEAKER HEIGHT FEET	5	5	5	5	5	5	5	5	5	5	5	5
DEGREE FROM CORNER OF HOUSE	45	60	30	45	60	30	45	60	30	45	60	30
SPEAKER ANGLE DEGREES	225	240	210	220	235	205	225	240	210	220	235	205
DISTANCE FROM HOUSE	25	25	25	50	50	50	25	25	25	50	50	50
WIND SPEED MPH	Calm	Calm	8	Calm	Calm	Calm	8	8	8	18	18	18
WIND DIRECTION DEGREES	Calm	Calm	W	Calm	Calm	Calm	W	W	W	NW	NW	NW
VERTICAL MESUREMENTS	SET#1	SET#2	SET#3	SET#4								
TIME	12:24	12:55	1:05	1:20								
SPEAKER FACING	SW	SW	SW	SW								
SPEAKER HEIGHT FEET	39	25	39	25								
DEGREE FROM CORNER OF HOUSE	45	45	45	45								
SPEAKER ANGLE DEGREES	225	225	225	225								
DISTANCE FROM HOUSE	29 X 29	15X15	29X29	15X15								
WIND SPEED MPH	18	15	21	21								
WIND DIRECTION DEGREES	NW 315	NE 40	NE 40	NE 40								

WITHOUT INSULATION	SET#1	SET#2
TIME	16:43	16:58
SPEAKER FACING	N NW	SW
SPEAKER HEIGHT FEET	5	5
DEGREE FROM CORNER OF HOUSE	45	45
SPEAKER ANGLE DEGREES	225	290
DISTANCE FROM HOUSE	25	25
WIND SPEED MPH	15	15
WIND DIRECTION DEGREES	190	190

date	11/13/2012
ADDRESS	61 dumonT ave
microphone set	4 feet in from each wall. 2 MICs in each room. SET 5 FT HIGH; bedroom and front room facing airport;
microphone out front	20 ft from front of house; 20 ft from E corner; 5 FT HIGH
INSULATION PALCEMENT	1 roll draped and nailed to NORTH wall; 2 rolls on floor; 1 roll draped and nailed to 3 walls and 1 roll on floor in bedroom
EXTERIOR	aluminum siding
WALL STUD SEPARATION	16 INCH 8 FEET HIGH CEILING
WALL TYPE	1 INCH THICK DRYWALL
CAVITY FILLING	FIBERGLASS BATTED/FACED INSULATION
WINDOW TYPE	SINGLE PANE W SOTRM WINDOWS. SOME UP SOME DOWN. COULDN'T CHANGE THEIR POSITION
ROOF TYPE	shingle - GOOD condition 1 LAYER
NUMBER LAYERS	1 layer
BEDROOM L X W	148X116
BEDROOM windows HxW	48X36 FACING 90 DEGREES E AND 48X36 FACING 0 DEGREES N
lliving room lxwXH inches	300 X 138
living room windows	120X60 FACING 0 DEGREE N, 72 X 54 FACING 0 DEGREE N
living room door	36X80 FACING 0 DEGREE N
WIND	CLEAR SKIES, 25 DEGREES, NO WIND
TAKEOFF EVENTS	540 DEP S; 553 DEP S; DID NOT NOTE ANY DEPS(STARBUCKS) TILL 633 DEP S; 635 DEP S; 724 DEP S;
LANDING EVENTS	744 FEDEX; 747 SMALL JET; 755 SMALL JET; 807 SMALL PROP
DOUBLE PANED WINDOWS WITH NO STORM WINDOWS	

	SET #1	SET #2	SET #3	SET #7	SET #8	SET #9	SET #4	SET #5	SET #6	SET #10	SET #11	SET #12
DATE	11/14/2012	11/14/2012	11/14/2012	11/14/2012	11/14/2012	11/14/2012	11/14/2012	11/14/2012	11/14/2012	11/14/2012	11/14/2012	11/14/2012
TIME	9:15 AM	9:25 AM	9:33 AM	10:15 AM	10:23 AM	10:32 AM	9:46 AM	9:55 AM	10:05 AM	10:47 AM	10:57 AM	11:05 AM
SPEAKER FACING	SW	SW	SW	NE	NE	NE	SW	SW	SW	NE	NE	NE
SPEAKER HEIGHT FEET	5	5	5	5	5	5	5	5	5	5	5	5
DEGREE FROM CORNER OF HOUSE	45	60	30	45	60	30	45	60	30	45	60	30
SPEAKER ANGLE DEGREES	225	240	210	135	150	120	225	240	210	135	150	120
DISTANCE FROM HOUSE	25	25	25	25	25	25	50	50	50	50	50	50
WIND SPEED MPH	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm
WIND DIRECTION DEGREES	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm
VERTICAL MESUREMENTS	SET#2	SET#1	SET#4	SET#3								
TIME	2:06	1:52	2:55	2:37								
SPEAKER FACING	SW	SW	NE	NE								
SPEAKER HEIGHT FEET	39	25	39	25								
DEGREE FROM CORNER OF HOUSE	45	45	45	45								
SPEAKER ANGLE DEGREES	225	225	135	135								
DISTANCE FROM HOUSE	29 X 29	15X15	29X29	15X15								
WIND SPEED MPH												
WIND DIRECTION DEGREES												

WITHOUT INSULATION	SET#1	SET#2
TIME	3:20	3:30
SPEAKER FACING	NE	SW
SPEAKER HEIGHT FEET	5	5
DEGREE FROM CORNER OF HOUSE	45	45
SPEAKER ANGLE DEGREES	135	225
DISTANCE FROM HOUSE	25	25
WIND SPEED MPH	CALM	CALM
WIND DIRECTION DEGREES	CALM	CALM

SITE NO.	4
DATE	11/15/2012
ADDRESS	4 PICARD CIRCLE
MICROPHONE SETUP INSIDE	2 microphones in each room - 4 feet in from each wall, set 5 feet high. 2nd floor Bedroom and 1st floor Dining Room facing airport; facing 0 degrees N
MICROPHONE SETUP OUTSIDE	20 FT from N corner toward middle of building and 20 feet from back of house
INSULATION PLACEMENT	1 roll draped and nailed to north and west wall in Dining Room; 1 roll on west and south wall draped in living room & 1 roll on floor & 1 roll draped on north and west wall
EXTERIOR WALLS	Wood siding
WALL STUD SEPARATION	16-inch on-center studs
WALL TYPE	½-inch drywall
CAVITY FILLING	Faced fiberglass batt insulation
ROOF TYPE	Shingles, 1-layer, fair condition
WINDOW TYPE	Double-glazed sliders facing 0 degrees N
BEDROOM SIZE (LxWxH) (inches)	198x150x96
BEDROOM WINDOWS (HxW) (inches)	28x54 facing W & 28x54 facing N
BEDROOM FLOOR	Carpeting
DINING ROOM (LxWxH) (inches)	132x154x96
DINING ROOM WINDOWS (HxW) (inches)	72x80 slider facing N
DINING ROOM FLOOR	Plywood Underlayment
WEATHER	Calm wind and partly cloudy skies

	SET #1	SET #2	SET #3	SET #4	SET #5	SET #6
DATE	11/15/2012	11/15/2012	11/15/2012	11/15/2012	11/15/2012	11/15/2012
TIME	9:00 AM	9:20 AM	9:40 AM	10:05 AM	10:25 AM	10:50 AM
SPEAKER FACING	SE	SE	SE	SE	SE	SE
SPEAKER HEIGHT FEET	7	7	7	7	7	7
DEGREE FROM CORNER OF HOUSE	45	60	30	45	60	30
SPEAKER ANGLE DEGREES	135	150	120	135	150	120
DISTANCE FROM HOUSE	25	25	25	50	50	50
WIND SPEED MPH	Calm	Calm	Calm	Calm	Calm	Calm
WIND DIRECTION DEGREES	Calm	Calm	Calm	Calm	Calm	Calm
VERTICAL MESUREMENTS	SET#1	SET#2	SET#3	SET#4	YES THE HEIGHTS ARE NOT IN SAME ORDER BUT	
TIME	12:45	1:00	1:15	1:30	THEY ARE CORRECT AS LISTED	
SPEAKER FACING	SE	SE	SE	SE	ALL ENREIS CRRECT	
SPEAKER HEIGHT FEET	39	49	35	25		
DEGREE FROM CORNER OF HOUSE	45	45	45	45		
SPEAKER ANGLE DEGREES	135	135	135	135		
DISTANCE FROM HOUSE	29 X 29	29X29	15X15	15X15		
WIND SPEED MPH	CALM	CALM	CALM	CALM		
CALM	CALM	CALM	CALM	CALM		

WITHOUT INSULATION	SET#1	31 DEGREEES AT 10:50 ON 11-16-12				
DATE	11/16/2012					
TIME	10:50					
SPEAKER FACING	SE					
SPEAKER HEIGHT FEET	7					
DEGREE FROM CORNER OF HOUSE	45					
SPEAKER ANGLE DEGREES	135					
DISTANCE FROM HOUSE	25					
WIND SPEED MPH	CALM					
WIND DIRECTION DEGREES	CALM					

SITE NO.	5
DATE	11/15/2012
ADDRESS	120 AIRPORT PKWY
MICROPHONE SETUP INSIDE	2 microphones in each room - 4 feet in from each wall, set 5 feet high. Bedroom and Kitchen facing airport; 0 degrees N
MICROPHONE SETUP OUTSIDE	20 ft from rear of house; 20 ft from S corner; 5 ft high
INSULATION PLACEMENT	1 roll draped and nailed to west wall & 1 roll on floor in Kitchen; 1 roll draped and nailed to 2 walls and 1 roll draped to 1 wall and 1 roll on floor in bedroom
EXTERIOR WALLS	Vinyl siding
WALL STUD SEPARATION	16-inch on-center studs
WALL TYPE	⅝-inch drywall
CAVITY FILLING	Faced fiberglass batt insulaiton
ROOF TYPE	Shingles, 1-layer, good condition
WINDOW TYPE	Double glazed double hung windows w/ slider out facing 0 degrees N
BEDROOM SIZE (LxWxH) (inches)	186x140x96
BEDROOM WINDOWS (HxW) (inches)	36x38 facing N; 36x38 facing S
BEDROOM FLOORS	Carpeting
KITCHEN/DINING ROOM (LxWxH) (inches)	180x300x96
KITCHEN/DINING ROOM WINDOWS (HxW) (inches)	One slider 72x80 facing 0 degree N; One window 36x38 facing S
KITCHEN/DINING ROOM FLOORS	Tile/Carpeting
WEATHER	Wind out of east/southeast at 3 mph; temperature 20 degrees

	SET #1	SET #2	SET #3	SET #7	SET #8	SET #9	SET #4	SET #5	SET #6	SET #10	SET #11	SET #12
DATE	11/16/2012	11/16/2012	11/16/2012	11/16/2012	11/16/2012	11/16/2012	11/16/2012	11/16/2012	11/16/2012	11/16/2012	11/16/2012	11/16/2012
TIME	7:50 AM	8:00 AM	8:10 AM	8:55 AM	9:05 AM	9:15 AM	8:20 AM	8:30 AM	8:40 AM	9:25 AM	9:35 AM	9:45 AM
SPEAKER FACING	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
SPEAKER HEIGHT FEET	5	5	5	5	5	5	5	5	5	5	5	5
DEGREE FROM CORNER OF HOUSE	45	60	30	45	60	30	45	60	30	45	60	30
SPEAKER ANGLE DEGREES	225	240	210	225	240	210	225	240	210	225	240	210
DISTANCE FROM HOUSE	25	25	25	25	25	25	50	50	50	50	50	50
	BEDROOM	BEDROOM	BEDROOM	KITCHEN	KITCHEN	KITCHEN	BEDROOM	BEDROOM	BEDROOM	KITCHEN	KITCHEN	KITCHEN
WIND SPEED MPH	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm
WIND DIRECTION DEGREES	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm
VERTICAL MESUREMENTS	SET#1	SET#2	SET#3	SET#4								
DATE NOT SAME AS SPEAKER DATE	11/15/2012	11/15/2012	11/15/2012	11/15/2012		WE DID THE VERTICALS ON 11-15-12 SAME DAY AS 4 PICARD						
TIME	2:30	2:40	2:50	3:00		AND WE ALSO DID 206 AIRPORT PARKWAY 11-15-12 AS WELL						
SPEAKER FACING	SW	SW	SW	SW		JUST THE VERTICALS						
SPEAKER HEIGHT FEET	25	39	25	39								
DEGREE FROM CORNER OF HOUSE	45	45	45	45								
SPEAKER ANGLE DEGREES	225	225	225	225		ALL PCTURES OF SPEAKER SETS ON 11-16 FOR THIS HOUES ARE FROM MY CAMERA						
DISTANCE FROM HOUSE	15X15	29X29	15X15	29X29		SO THEY WILL B NUMBERED DIFFERENTLY THAN ERICS.						
WIND SPEED MPH	Calm	Calm	Calm	Calm		HIS CAMERA WOJULD NOT WORK TODAY						
WIND DIRECTION DEGREES	Calm	Calm	Calm	Calm								

WITHOUT INSULATION	SET#1	SET#2
TIME	10:25	10:32
SPEAKER FACING	SW	SW
SPEAKER HEIGHT FEET	5	5
DEGREE FROM CORNER OF HOUSE	45	45
SPEAKER ANGLE DEGREES	225	225
DISTANCE FROM HOUSE	25	25
WIND SPEED MPH	CALM	CALM
WIND DIRECTION DEGREES	CALM	CALM

SITE NO.	6
DATE	11/16/2012
ADDRESS	206 AIRPORT PARKWAY
MICROPHONE SETUP INSIDE	2 microphones in each room - 4 feet in from each wall, set 5 ft high. Bedroom facing airport
MICROPHONE SETUP OUTSIDE	20 ft from rear of house & 20 ft from N corner; 5 ft high w/ an extra 20-inches of ground clearence due to being on deck
INSULATION PLACEMENT	1 roll draped on west, north and east walls and 1 roll on floor
EXTERIOR WALLS	Vinyl siding
WALL STUD SEPARATION	16-inch on-center studs
WALL TYPE	
CAVITY FILLING	Faced fiberglass batt insulation (1-inch thick) & additional shredded material
ROOF TYPE	Shingles, 1-layer, fair condition
WINDOW TYPE	Single Glazed w/ storm windows. Poor condition
BEDROOM SIZE (LxWxH) (inches)	110x128x96
BEDROOM WINDOWS (HxW) (inches)	48x28 facing NE and 48x28 facing NW
BEDROOM FLOORS	Hardwood
WEATHER	Winds out of the north at 6 mph

30,45,60 MEASUREMENTS TAKEN 11-16-12
40 DEGREES FAHRENHEIT

	SET #1	SET #2	SET #3	SET #4	SET #5	SET #6
DATE	11/16/2012	11/16/2012	11/16/2012	11/16/2012	11/16/2012	11/16/2012
TIME	1:30	1:45	1:55	2:05	2:15	2:25
SPEAKER FACING	SE	SE	SE	SE	SE	SE
SPEAKER HEIGHT FEET	5	5	5	5	5	5
DEGREE FROM CORNER OF HOUSE	45	60	30	45	60	30
SPEAKER ANGLE DEGREES	170	155	185	170	155	185
DISTANCE FROM HOUSE	25	25	25	50	50	50
WIND SPEED MPH	6	6	6	6	6	6
WIND DIRECTION DEGREES	10 N	10 N	10 N	10 N	10 N	10 N
VERTICAL MESUREMENTS	SET#1	SET#2				
DATE	11/15/2012	11/15/2012				
TIME	4:05	4:20				
SPEAKER FACING	S	S				
SPEAKER HEIGHT FEET	25	39				
DEGREE FROM CORNER OF HOUSE	45	45				
SPEAKER ANGLE DEGREES	170	170				
DISTANCE FROM HOUSE	15X15	29X29				
WIND SPEED MPH	CALM	CALM				
WIND DIRECTION DEGREES	CALM	CALM				

WITHOUT INSULATION	SET#1
TIME	3:37
SPEAKER FACING	SE
SPEAKER HEIGHT FEET	5
DEGREE FROM CORNER OF HOUSE	45
SPEAKER ANGLE DEGREES	135
DISTANCE FROM HOUSE	25
WIND SPEED MPH	6
WIND DIRECTION DEGREES	10N

APPENDIX C
ACTUAL AIRCRAFT MEASUREMENTS LOGS

Resident	
Address	13 Dumont Ave.
City, State	Burlington, VT
Date - Time	11/12/2012
Project #	
Site #	1
Airport	BTV
Consultant	ERS

Pre-Test						0	0	0	0		
m	SEL ext (dBA)	SEL int 1a (dBA)	SEL int 1b (dBA)	SEL int 2a (dBA)	SEL int 2b (dBA)	SEL int 1	SEL int 2	NLR 1 (dB)	NLR 2 (dB)	Ext Leq	Duration
1	81.2	58.9	59.5	55.9	57.6	59.2	56.8	21.9	24.3	66.4	29.9
2	81.3	57.6	58.0	56.8	56.9	57.8	56.9	23.4	24.4	66.0	33.5
3	86.1	61.0	62.0	59.5	59.7	61.5	59.6	24.6	26.5	69.9	41.8
4	80.9	56.2	57.1	55.0	56.3	56.7	55.7	24.2	25.2	67.0	24.5
5	82.2	59.4	60.0	58.3	59.0	59.7	58.7	22.4	23.5	66.2	39.4
6	78.1	53.3	53.9	51.0	52.2	53.6	51.6	24.5	26.5	64.1	25.4
7	77.5	53.3	54.2	50.3	50.5	53.8	50.4	23.8	27.1	66.8	11.9
8	74.5	49.7	49.6	49.4	50.4	49.7	49.9	24.9	24.6	60.8	23.6
9	86.1	61.9	62.1	60.5	61.1	62.0	60.8	24.1	25.3	72.8	21.4
10	82.8	60.6	60.1	57.8	58.8	60.4	58.3	22.5	24.5	66.5	42.8
11											
12											
13											
14											
15											
Measurement Done		0		0		Notes					
n - 1 = m		9		9							
$t(m,\alpha)$		1.833		1.833							
var NLR		0.230065104		0.292947388							
90% Conf. interval NLR lower limit (dB)		22.7		24.1							
90% Conf. interval NLR upper limit (dB)		24.5		26.1							
90% Confidence interval (dB)		1.8		2.0							
Mean NLR (dB)		23.6		25.1							

15

25.98076

Resident	
Address	57 Dumont Ave.
City, State	Burlington, VT
Date - Time	11/13/2012
Project #	
Site #	2
Airport	BTV
Consultant	ERS

Pre-Test						0	0	0	0		
m	SEL ext (dBA)	SEL int 1a (dBA)	SEL int 1b (dBA)	SEL int 2a (dBA)	SEL int 2b (dBA)	SEL int 1	SEL int 2	NLR 1 (dB)	NLR 2 (dB)	Ext Leq	Duration
1	83.1	55.5	55.3	55.0	54.7	55.4	54.9	27.7	28.2	70.4	18.6
2	88.7	62.6	63.1	61.4	60.7	62.9	61.1	25.8	27.6	73.7	31.6
3	83.3	56.4	54.1	54.7	54.4	55.4	54.6	27.9	28.8	69.8	22.5
4	90.7	63.3	62.7	63.6	62.9	63.0	63.3	27.7	27.5	76.0	29.6
5	86.3	55.8	56.4	54.7	55.1	56.1	54.9	30.2	31.4	72.5	24.1
6	85.0	56.4	55.0	55.5	54.9	55.8	55.2	29.2	29.8	70.6	27.5
7	81.6	54.3	53.6	53.9	54.9	54.0	54.4	27.6	27.1	70.0	14.4
8	85.7	59.6	61.7	60.7	59.8	60.8	60.3	24.9	25.4	70.9	30.1
9	85.2	55.5	57.0	56.1	55.7	56.3	55.9	28.9	29.3	71.1	25.9
10	81.6	53.1	52.2	53.6	52.1	52.7	52.9	28.9	28.7	69.4	16.6
11	91.0	64.5	64.2	65.1	65.1	64.4	65.1	26.6	25.9	76.5	27.9
12	86.9	60.9	59.9	60.8	60.0	60.4	60.4	26.5	26.5	73.4	22.4
13											
14											
15											
Another Event Required		0		0		Notes					
n - 1 = m		11		11							
t(m,α)		1.796		1.796							
var NLR		0.455726231		0.684966022							
90% Conf. interval NLR lower limit (dB)		25.9		25.8							
90% Conf. interval NLR upper limit (dB)		28.3		28.8							
90% Confidence interval (dB)		2.4		3.0							
Mean NLR (dB)		27.1		27.3							

15

25.98076

Resident	
Address	61 Dumont Ave.
City, State	Burlington, VT
Date - Time	11/14/2012
Project #	
Site #	3
Airport	BTV
Consultant	ERS

Pre-Test						0	0	0	0		
m	SEL ext (dBA)	SEL int 1a (dBA)	SEL int 1b (dBA)	SEL int 2a (dBA)	SEL int 2b (dBA)	SEL int 1	SEL int 2	NLR 1 (dB)	NLR 2 (dB)	Ext Leq	Duration
1	81.2	52.9	52.8	52.9	52.8	52.9	52.9	28.4	28.4	69.1	16.3
2	86.2	54.4	53.1	54.2	54.1	53.8	54.2	32.4	32.0	73.2	19.9
3	84.9	57.8	57.2	57.4	57.1	57.5	57.3	27.4	27.7	71.3	23.1
4	79.1	53.6	54.2	53.5	54.4	53.9	54.0	25.2	25.2	66.8	17.1
5	85.5	58.6	58.1	57.8	57.9	58.4	57.9	27.2	27.7	71.0	28.4
6	81.1	53.5	54.4	53.9	54.5	54.0	54.2	27.1	26.9	67.1	25.1
7	84.4	52.1	51.4	52.0	51.3	51.8	51.7	32.6	32.7	71.2	20.9
8	83.0	57.0	56.8	56.8	56.7	56.9	56.8	26.1	26.3	68.2	30.4
9	85.6	57.8	55.4	56.9	54.8	56.8	56.0	28.8	29.6	70.2	34.4
10	82.0	55.1	53.2	54.8	52.9	54.3	54.0	27.8	28.1	68.0	25.4
11	76.3	50.8	47.8	53.0	50.0	49.6	51.8	26.8	24.6	63.2	20.5
12	78.6	55.5	49.7	53.0	53.4	53.5	53.2	25.1	25.4	68.8	9.6
13	81.4	53.4	50.4	52.5	50.3	52.2	51.5	29.2	29.8	67.7	23.4
14	84.6	56.6	54.3	55.6	54.4	55.6	55.0	29.0	29.6	71.0	23.1
15	79.8	53.0	49.5	51.7	48.9	51.6	50.5	28.2	29.3	66.8	20.1
Measurement Done		0		0		Notes					
n - 1 = m		14		14							
t(m,α)		1.761		1.761							
var NLR		0.498751164		0.557505526							
90% Conf. interval NLR lower limit (dB)		27.0		27.2							
90% Conf. interval NLR upper limit (dB)		29.5		29.8							
90% Confidence interval (dB)		2.5		2.6							
Mean NLR (dB)		28.3		28.5							

15

25.98076

Resident	
Address	4 Picard Circle
City, State	Burlington, VT
Date - Time	11/15/2012
Project #	
Site #	4
Airport	BTV
Consultant	ERS

Pre-Test						0	0	0	0		
m	SEL ext (dBA)	SEL int 1a (dBA)	SEL int 1b (dBA)	SEL int 2a (dBA)	SEL int 2b (dBA)	SEL int 1	SEL int 2	NLR 1 (dB)	NLR 2 (dB)	Ext Leq	Duration
1	84.2	55.4	54.0	56.9	58.1	54.8	57.5	29.5	26.7	71.8	17.5
2	85.8	56.6	55.7	57.3	58.8	56.2	58.1	29.7	27.7	71.7	25.9
3	80.9	56.2	55.0	57.3	59.3	55.6	58.4	25.2	22.4	69.6	13.4
4	86.7	58.5	57.6	60.1	60.1	58.1	60.1	28.6	26.6	73.4	21.4
5	92.6	64.2	62.8	65.8	65.9	63.6	65.9	29.1	26.8	76.3	42.9
6	84.4	56.0	55.4	58.2	57.8	55.7	58.0	28.7	26.4	69.4	31.4
7	89.1	60.7	59.6	62.5	62.4	60.2	62.5	29.0	26.7	74.5	29.1
8	86.9	59.8	58.7	61.1	61.6	59.3	61.4	27.6	25.6	71.9	31.9
9	96.4	67.6	66.5	67.2	68.1	67.1	67.7	29.3	28.7	82.7	23.4
10	86.5	60.5	59.5	62.8	63.2	60.0	63.0	26.5	23.5	71.4	32.4
11	83.2	58.7	57.1	59.1	59.9	58.0	59.5	25.2	23.7	69.1	25.6
12	92.7	64.6	65.2	64.1	64.3	64.9	64.2	27.8	28.5	76.7	39.5
13	88.6	61.4	60.3	58.3	60.3	60.9	59.4	27.7	29.1	74.6	24.9
14											
15											
Another Event Required		0		0		Notes					
n - 1 = m		12		12							
$t(m,\alpha)$		1.782		1.782							
var NLR		0.553647578		1.101282644							
90% Conf. interval NLR lower limit (dB)		27.2		25.4							
90% Conf. interval NLR upper limit (dB)		29.8		29.2							
90% Confidence interval (dB)		2.7		3.7							
Mean NLR (dB)		28.5		27.3							

15

25.98076

Resident	
Address	120 Airport Pkwy (2 Picard Cir)
City, State	Burlington, VT
Date - Time	11/16.12
Project #	
Site #	5
Airport	BTV
Consultant	ERS

Pre-Test						0	0	0	0			
m	SEL ext (dBA)	SEL int 1a (dBA)	SEL int 1b (dBA)	SEL int 2a (dBA)	SEL int 2b (dBA)	SEL int 1	SEL int 2	NLR 1 (dB)	NLR 2 (dB)	Ext Leq	Duration	
1	79.2	54.9	52.0	55.5	53.7	53.7	54.7	25.5	24.5	64.7	28.3	
2	82.2	57.4	54.5	57.7	55.7	56.2	56.8	26.1	25.4	66.1	41.1	
3	83.3	58.8	56.3	58.8	56.6	57.7	57.8	25.6	25.5	69.3	25.1	
4	87.2	63.2	61.7	63.7	62.9	62.5	63.3	24.6	23.8	70.5	46.4	15
5	85.2	61.3	59.6	62.0	60.8	60.5	61.4	24.6	23.7	68.5	46.4	
6	86.7	63.2	61.2	63.9	62.8	62.3	63.4	24.4	23.3	70.9	37.9	25.98076
7	83.1	59.7	57.7	60.6	59.2	58.8	60.0	24.3	23.1	67.7	34.6	
8	88.9	65.0	63.2	65.7	64.5	64.2	65.1	24.7	23.7	72.6	42.4	
9												
10												
11												
12												
13												
14												
15												
Measurement Done		0		0		Notes						
n - 1 = m		7		7								
t(m,α)		1.895		1.895								
var NLR		0.094624095		0.181978158								
90% Conf. interval NLR lower limit (dB)		24.2		23.0								
90% Conf. interval NLR upper limit (dB)		25.3		24.7								
90% Confidence interval (dB)		1.2		1.6								
Mean NLR (dB)		24.7		23.8								

Resident	
Address	206 Airport Pkwy
City, State	Burlington, VT
Date - Time	11/16.12
Project #	
Site #	6
Airport	BTV
Consultant	ERS

Pre-Test						0	0	0	0		
m	SEL ext (dBA)	SEL int 1a (dBA)	SEL int 1b (dBA)	SEL int 2a (dBA)	SEL int 2b (dBA)	SEL int 1	SEL int 2	NLR 1 (dB)	NLR 2 (dB)	Ext Leq	Duration
1	91.6	65.3	64.8			65.1		26.5		76.8	30.1
2	82.3	58.5	57.6			58.1		24.2		70.5	15.0
3	84.7	61.3	61.9			61.6		23.1		72.2	17.9
4	93.2	68.0	69.4			68.8		24.5		77.1	40.9
5	82.7	55.4	57.2			56.4		26.3		69.7	19.8
6	84.0	59.0	60.5			59.8		24.2		71.3	18.8
7	89.7	62.3	63.9			63.2		26.5		75.5	26.4
8	88.6	61.5	62.9			62.3		26.3		74.5	25.5
9	82.1	56.6	53.0			55.2		27.0		68.9	21.1
10	78.0	56.6	57.8			57.2		20.8		67.4	11.5
11	81.0	55.3	56.4			55.9		25.2		67.8	21.1
12	85.7	58.3	58.5			58.4		27.3		69.8	38.8
13	82.3	55.7	57.3			56.6		25.8		69.2	20.6
14											
15											
Another Event Required		0		0		Notes					
n - 1 = m		12		-1							
t(m,α)		1.782									
var NLR		0.741043845		#VALUE!							
90% Conf. interval NLR lower limit (dB)		23.8									
90% Conf. interval NLR upper limit (dB)		26.9									
90% Confidence interval (dB)		3.1		#VALUE!							
Mean NLR (dB)		25.4									

APPENDIX D
EXTERIOR SPECTRUM MEASUREMENT LOGS

	Site 1							
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
A-Weighted Ext Spectrum	63.9	71.8	71.3	75.8	77.4	73.8	64.0	54.3
Duration	Leq							
0:00:21	65.0	72.1	67.7	70.3	68.7	62.9	50.8	43.4
0:00:30	76.4	73.0	63.9	61.7	57.8	53.9	43.7	36.0
0:00:30	79.8	75.3	65.2	60.9	61.1	59.2	49.8	41.4
0:00:34	70.2	72.4	66.5	64.1	61.3	55.7	45.7	34.5
0:00:42	77.3	75.4	67.9	67.1	65.6	61.7	50.4	40.1
0:00:24	60.7	71.8	64.4	63.9	63.7	55.4	43.1	32.7
0:00:24	67.3	68.5	59.4	54.0	53.8	48.4	36.6	34.6
0:00:28	72.2	68.6	59.8	57.9	56.8	52.9	47.8	41.2
0:00:27	70.4	68.0	60.6	57.9	57.6	52.2	46.0	39.3
0:00:39	77.9	75.5	66.1	63.5	60.5	55.7	50.9	44.9

	Site 2							
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
A-Weighted Ext Spectrum	67.6	75.8	79.4	83.8	84.5	84.1	76.0	55.3
Duration	Leq							
0:00:19	71.5	68.8	72.1	68.2	65.1	61.0	56.2	44.0
0:00:32	80.8	74.0	76.0	72.0	67.9	64.2	56.3	39.6
0:00:23	76.7	75.6	70.3	67.0	64.6	61.7	53.3	39.0
0:00:30	83.4	79.5	73.5	74.7	70.6	67.5	59.0	44.0
0:00:24	68.7	66.6	69.8	68.1	69.0	65.8	57.7	45.3
0:00:20	89.2	87.2	79.1	77.6	80.1	80.1	72.2	50.5
0:00:28	76.6	75.4	70.9	68.1	65.5	61.8	55.5	44.7
0:00:32	72.1	74.3	70.4	65.7	60.2	48.3	31.8	29.2
0:00:30	70.2	72.2	74.5	70.8	64.0	56.0	34.5	20.9
0:00:26	68.0	72.2	72.2	70.8	66.6	55.9	31.3	25.3
0:00:17	71.7	71.7	66.3	69.0	64.7	59.2	50.2	27.7
0:00:28	65.0	78.9	76.7	78.0	70.4	59.3	39.4	22.2
0:00:22	67.7	72.8	75.1	75.4	66.2	53.7	33.8	26.6

	Site 3							
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
A-Weighted Ext Spectrum	64.0	71.2	72.8	77.2	79.3	75.7	62.5	44.7
Duration	Leq							
0:00:16	77.4	72.9	65.7	64.2	66.6	60.0	51.5	24.6
0:00:20	70.1	73.7	69.4	70.0	70.3	64.3	53.4	25.3
0:00:23	79.4	76.4	70.1	67.1	68.0	62.9	50.8	24.2
0:00:17	79.5	74.1	65.8	62.0	63.1	58.1	44.2	21.2
0:00:28	80.7	75.9	68.9	64.5	67.2	65.0	49.3	27.2
0:00:25	78.6	72.8	64.5	62.6	64.5	57.6	45.6	32.2
0:00:21	68.8	70.1	67.5	67.1	68.8	62.6	49.0	25.6
0:00:30	78.4	75.0	68.5	65.1	62.6	61.1	48.0	23.4
0:00:34	74.6	74.7	68.9	68.7	64.7	62.8	45.2	32.5
0:00:25	76.2	74.0	67.3	68.2	62.3	54.2	39.0	34.7
0:00:21	72.6	67.7	65.8	59.1	56.8	54.2	49.1	40.5
0:00:10	67.1	76.3	69.7	67.8	63.4	56.0	43.8	35.0
0:00:23	70.6	71.3	66.3	66.7	63.9	55.3	43.3	33.2
0:00:23	75.1	73.8	70.1	70.4	66.7	59.7	43.9	25.8
0:00:20	70.8	70.8	65.0	65.7	63.0	54.6	37.5	29.1

	Site 4							
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
A-Weighted Ext Spectrum	70.8	77.7	74.9	82.6	85.7	83.6	71.1	43.4
Duration	Leq							
0:00:17	82.2	78.2	61.1	66.4	68.6	64.5	53.1	28.8
0:00:26	80.7	75.8	62.5	68.3	68.8	62.7	52.4	28.7
0:00:13	73.6	67.8	71.5	68.1	65.0	58.0	46.8	23.7
0:00:21	86.3	80.2	65.2	69.0	70.5	64.7	53.0	26.6
0:00:43	85.3	81.1	64.4	71.7	72.9	69.1	56.0	34.7
0:00:31	83.3	76.7	60.0	64.8	66.0	61.4	49.1	25.3
0:00:29	84.5	81.6	64.6	69.5	71.0	67.3	55.8	29.2
0:00:32	82.7	81.0	63.7	64.5	67.3	66.3	53.8	27.6
0:00:23	82.2	81.1	70.1	75.7	79.5	77.5	64.3	34.3
0:00:32	84.5	82.9	67.7	63.0	65.7	64.6	55.7	29.4
0:00:25	76.7	75.0	64.7	61.4	61.4	57.1	49.1	27.8
0:00:26	80.0	79.8	69.2	61.3	62.2	62.2	54.9	27.8
0:00:40	62.4	72.2	75.5	77.0	72.1	62.4	48.8	27.7
0:00:25	79.9	77.1	72.5	74.6	69.7	64.4	53.0	30.3

	Site 5							
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
A-Weighted Ext Spectrum	70.2	77.1	69.4	75.6	81.3	80.3	68.9	41.6
Duration	Leq							
0:00:28	78.0	73.7	56.9	58.7	61.2	56.5	46.0	22.7
0:00:41	77.1	72.6	58.3	60.7	62.8	58.7	46.3	23.7
0:00:25	78.8	74.9	58.2	63.2	65.7	63.4	52.1	26.6
0:00:46	81.1	78.7	62.2	63.3	65.7	65.4	52.4	23.7
0:00:46	80.8	76.2	63.0	62.8	64.6	61.3	53.5	32.2
0:00:38	82.4	79.7	62.2	63.5	66.8	64.8	50.9	23.0
0:00:35	81.3	76.1	60.1	61.6	64.3	60.0	45.1	21.1
0:00:42	81.7	80.3	66.6	65.9	68.4	66.4	56.5	27.2

	Site 6							
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
A-Weighted Ext Spectrum	62.0	71.6	79.3	83.1	82.7	78.5	66.8	43.7
Duration	Leq							
0:00:30	77.0	73.7	76.6	75.4	72.0	68.6	56.0	33.1
0:00:16	76.2	71.4	70.9	69.8	65.8	59.2	47.5	26.5
0:00:18	61.2	80.2	74.7	70.4	65.9	57.6	44.8	26.6
0:00:41	71.0	75.1	78.8	75.9	72.7	66.1	52.3	31.0
0:00:20	67.7	67.8	68.9	68.0	65.8	60.0	50.4	24.9
0:00:39	74.0	68.3	71.5	67.9	65.2	59.5	52.0	26.3
0:00:26	78.8	76.2	72.4	75.2	70.9	65.9	55.8	33.5
0:00:26	77.2	74.5	71.9	73.6	70.2	65.4	53.4	28.8
0:00:21	64.1	68.6	69.1	67.1	64.8	59.2	52.2	23.6
0:00:11	71.6	76.4	71.4	63.8	61.5	55.3	40.3	28.8
0:00:21	70.5	64.8	68.7	66.8	63.2	55.9	44.6	30.9
0:00:39	71.5	71.4	73.5	69.2	63.7	51.0	36.1	32.9
0:00:21	73.9	69.9	68.0	68.7	65.0	57.5	43.1	33.7

APPENDIX E
ARTIFICIAL NOISE SOURCE MEASUREMENTS LOGS

Site #	1
Address	13 Dumont
City, State	Burlington, VT
Room	LR
Date	11/12/12
Airport	BTV
Consultant	EBS/CLL

Reverberation	SLM Log	RT60 (s)
No Insulation	002	0.90
With Insulation	004	0.45
Background	**SLM Log**	**Leq (dBA)**
Exerior	014	52.1
Interior	015	35.3
Ext. Spectrum Logs	006-013/125/163	

Artificial Noise Source on Tripod - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
30 Degrees	25 ft	Ext Façade	040	92.4	Spatial Avg. (a)	041	62.9
		Ext. Flush 1/5 (a)	035	92.7	4ft from Elements	042	63.5
		Ext. Flush 5/5 (e)	039	93.3	Spatial Avg. (b)	043	63.1
	50 ft	Ext Façade	070	87.2	Spatial Avg. (a)	062	58.4
		Ext. Flush 1/5 (a)	065	89.0	4ft from Elements	063	57.8
		Ext. Flush 5/5 (e)	069	88.4	Spatial Avg. (b)	064	59.0
45 Degrees	25 ft	Ext Façade	016	92.9	Spatial Avg. (a)	022	63.7
		Ext. Flush 1/5 (a)	017	93.7	4ft from Elements	024	63.7
		Ext. Flush 5/5 (e)	021	93.1	Spatial Avg. (b)	025	63.8
	50 ft	Ext Façade	047	87.0	Spatial Avg. (a)	044	57.8
		Ext. Flush 1/5 (a)	048	89.8	4ft from Elements	045	58.0
		Ext. Flush 5/5 (e)	052	88.1	Spatial Avg. (b)	046	57.6
60 Degrees	25 ft	Ext Façade	029	92.6	Spatial Avg. (a)	026	63.0
		Ext. Flush 1/5 (a)	030	93.9	4ft from Elements	027	63.0
		Ext. Flush 5/5 (e)	034	92.1	Spatial Avg. (b)	028	63.0
	50 ft	Ext Façade	053	86.2	Spatial Avg. (a)	059	57.4
		Ext. Flush 1/5 (a)	054	89.7	4ft from Elements	060	58.1
		Ext. Flush 5/5 (e)	058	87.1	Spatial Avg. (b)	061	57.7

Artificial Noise Source on Tripod - No Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25 ft	Ext Façade	172	91.8	Spatial Avg.	171	65.6

Artificial Noise Source on Crane - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25 ft	Ext Façade	148	91.4	Spatial Avg. (a)	145	60.9
		Ext. Flush 1/5 (a)	149	90.0	4ft from Elements	146	61.5
		Ext. Flush 5/5 (e)	153	92.1	Spatial Avg. (b)	147	61.0
	50 ft	Ext Façade	154	86.4	Spatial Avg. (a)	160	57.0
		Ext. Flush 1/5 (a)	155	85.2	4ft from Elements	161	57.4
		Ext. Flush 5/5 (e)	159	87.8	Spatial Avg. (b)	162	56.9

Site #	1
Address	13 Dumont
City, State	Burlington, VT
Room	K/DR
Date	11/12/12
Airport	BTV
Consultant	EBS/CLL

Reverberation	SLM Log	RT60 (s)
No Insulation	021	0.60
With Insulation	003	0.36
Background	**SLM Log**	**Leq (dBA)**
Exerior	014	52.1
Interior	126	32.7
Ext. Spectrum Logs		

Artificial Noise Source on Tripod - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
30 Degrees	25 ft	Ext Façade	089	92.8	Spatial Avg. (a)	095	62.4
		Ext. Flush 1/5 (a)	090	92.5	4ft from Elements	096	63.2
		Ext. Flush 5/5 (e)	094	95.3	Spatial Avg. (b)	097	62.5
	50 ft	Ext Façade	119	86.9	Spatial Avg. (a)	116	55.8
		Ext. Flush 1/5 (a)	120	87.5	4ft from Elements	117	56.3
		Ext. Flush 5/5 (e)	124	88.1	Spatial Avg. (b)	118	56.0
45 Degrees	25 ft	Ext Façade	071	93.1	Spatial Avg. (a)	077	62.8
		Ext. Flush 1/5 (a)	072	93.0	4ft from Elements	078	63.1
		Ext. Flush 5/5 (e)	076	95.3	Spatial Avg. (b)	079	62.7
	50 ft	Ext Façade	101	87.6	Spatial Avg. (a)	098	56.4
		Ext. Flush 1/5 (a)	102	88.9	4ft from Elements	099	56.8
		Ext. Flush 5/5 (e)	106	91.7	Spatial Avg. (b)	100	56.2
60 Degrees	25 ft	Ext Façade	083	93.4	Spatial Avg. (a)	080	62.5
		Ext. Flush 1/5 (a)	084	94.0	4ft from Elements	081	62.4
		Ext. Flush 5/5 (e)	088	94.6	Spatial Avg. (b)	082	62.3
	50 ft	Ext Façade	107	87.5	Spatial Avg. (a)	113	55.6
		Ext. Flush 1/5 (a)	108		4ft from Elements	114	56.0
		Ext. Flush 5/5 (e)	112		Spatial Avg. (b)	115	55.5

Artificial Noise Source on Tripod - No Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25 ft	Ext Façade	174	93.7	Spatial Avg.	173	65.7

Artificial Noise Source on Crane - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25 ft	Ext Façade	136	91.8	Spatial Avg. (a)	142	60.8
		Ext. Flush 1/5 (a)	137	91.2	4ft from Elements	143	60.9
		Ext. Flush 5/5 (e)	141	94.5	Spatial Avg. (b)	144	60.4
	50 ft	Ext Façade	130	87.0	Spatial Avg. (a)	127	56.8
		Ext. Flush 1/5 (a)	131	86.4	4ft from Elements	128	56.9
		Ext. Flush 5/5 (e)	135	90.2	Spatial Avg. (b)	129	56.0

Site #	2
Address	57 Dumont Ave
City, State	Burlington, VT
Room	LR
Date	11/13/12
Airport	BTV
Consultant	ERS/CLL

F16
330
100.2 dBA

Reverberation	SLM Log	RT60 (s)
No Insulation	351	1.04
With Insulation	294	0.39
Background	**SLM Log**	**Leq (dBA)**
Exerior	182	52.0
Interior	183	33.8
Ext. Spectrum Logs	175-181/341-346	

Artificial Noise Source on Tripod - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
30 Degrees	25ft	Ext Façade	207	95.9	Spatial Avg. (a)	203	62.3
		Ext. Flush 1/5 (a)	208	94.8	4ft from Elements	204	62.8
		Ext. Flush 5/5 (e)	212	97.2	Spatial Avg. (b)	205	62.1
	50ft	Ext Façade	231	89.1	Spatial Avg. (a)	237	54.9
		Ext. Flush 1/5 (a)	232	89.3	4ft from Elements	238	55.7
		Ext. Flush 5/5 (e)	236	89.7	Spatial Avg. (b)	239	55.0
45 Degrees	25ft	Ext Façade	188	94.9	Spatial Avg. (a)	185	61.9
		Ext. Flush 1/5 (a)	189	93.2	4ft from Elements	186	61.8
		Ext. Flush 5/5 (e)	193	95.4	Spatial Avg. (b)	187	61.4
	50ft	Ext Façade	213	89.9	Spatial Avg. (a)	219	55.5
		Ext. Flush 1/5 (a)	214	89.9	4ft from Elements	220	56.1
		Ext. Flush 5/5 (e)	118	90.6	Spatial Avg. (b)	221	55.3
60 Degrees	25ft	Ext Façade	194	94.4	Spatial Avg. (a)	200	62.2
		Ext. Flush 1/5 (a)	195	93.5	4ft from Elements	201	61.6
		Ext. Flush 5/5 (e)	199	95.8	Spatial Avg. (b)	202	62.0
	50ft	Ext Façade	225	89.7	Spatial Avg. (a)	222	55.2
		Ext. Flush 1/5 (a)	226	90.2	4ft from Elements	223	56.0
		Ext. Flush 5/5 (e)	230	90.8	Spatial Avg. (b)	224	54.9

Artificial Noise Source on Tripod - No Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25ft	Ext Façade	348	94.8	Spatial Avg.	347	66.9

Artificial Noise Source on Crane - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25ft	Ext Façade	334	92.7	Spatial Avg. (a)	331	59.3
		Ext. Flush 1/5 (a)	335	93.3	4ft from Elements	332	59.9
		Ext. Flush 5/5 (e)	339	93.9	Spatial Avg. (b)	333	59.4
	50ft	Ext Façade	326	87.6	Spatial Avg. (a)	327	55.1
		Ext. Flush 1/5 (a)	321	88.8	4ft from Elements	328	55.0
		Ext. Flush 5/5 (e)	325	89.4	Spatial Avg. (b)	329	55.0

Site #	2
Address	57 Dumont Ave
City, State	Burlington, VT
Room	FBB
Date	11/13/12
Airport	BTV
Consultant	EAS/CLL

Reverberation	SLM Log	RT60 (s)
No Insulation	352	0.81
With Insulation	295	0.31
Background	**SLM Log**	**Leq (dBA)**
Exerior	182	52.0
Interior	184	33.4
Ext. Spectrum Logs		

Artificial Noise Source on Tripod - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
30 Degrees	25ft	Ext Façade	258	92.6	Spatial Avg. (a)	264	58.6
		Ext. Flush 1/5 (a)	259	92.9	4ft from Elements	265	58.6
		Ext. Flush 5/5 (e)	263	92.2	Spatial Avg. (b)	266	58.4
	50ft	Ext Façade	288	86.2	Spatial Avg. (a)	285	53.4
		Ext. Flush 1/5 (a)	289	87.6	4ft from Elements	286	52.7
		Ext. Flush 5/5 (e)	293	89.4	Spatial Avg. (b)	287	53.1
45 Degrees	25ft	Ext Façade	243	92.2	Spatial Avg. (a)	240	58.7
		Ext. Flush 1/5 (a)	244	90.4	4ft from Elements	241	58.0
		Ext. Flush 5/5 (e)	248	93.7	Spatial Avg. (b)	242	58.1
	50ft	Ext Façade	270	87.5	Spatial Avg. (a)	267	53.2
		Ext. Flush 1/5 (a)	271	87.6	4ft from Elements	268	53.4
		Ext. Flush 5/5 (e)	275	90.8	Spatial Avg. (b)	269	53.3
60 Degrees	25ft	Ext Façade	252	91.1	Spatial Avg. (a)	249	57.8
		Ext. Flush 1/5 (a)	253	91.8	4ft from Elements	250	57.5
		Ext. Flush 5/5 (e)	257	93.4	Spatial Avg. (b)	251	57.4
	50ft	Ext Façade	276	85.8	Spatial Avg. (a)	282	51.9
		Ext. Flush 1/5 (a)	277	87.4	4ft from Elements	283	52.0
		Ext. Flush 5/5 (e)	281	88.0	Spatial Avg. (b)	284	52.0

Artificial Noise Source on Tripod - No Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25ft	Ext Façade	349	91.5	Spatial Avg.	350	64.5

Artificial Noise Source on Crane - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25t	Ext Façade	314	90.6	Spatial Avg. (a)	311	55.6
		Ext. Flush 1/5 (a)	315	89.5	4ft from Elements	312	55.8
		Ext. Flush 5/5 (e)	319	92.7	Spatial Avg. (b)	313	55.7
	50ft	Ext Façade	302	86.1	Spatial Avg. (a)	308	51.5
		Ext. Flush 1/5 (a)	303	84.9	4ft from Elements	309	51.0
		Ext. Flush 5/5 (e)	307	89.3	Spatial Avg. (b)	310	51.2

Site #	3
Address	61 Dumont Ave
City, State	Burlington, VT
Room	LR
Date	11/14/12
Airport	BTV
Consultant	EBS/CCL

Reverberation	SLM Log	RT60 (s)
No Insulation	530	0.48
With Insulation	369	0.30
Background	**SLM Log**	**Leq (dBA)**
Exerior	366	53.6
Interior	364	33.9
Ext. Spectrum	353-362/479-489	

Artificial Noise Source on Tripod - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
30 Degrees	25ft	Ext Façade	443	94.1	Spatial Avg. (a)	449	58.5
		Ext. Flush 1/5 (a)	444	94.4	4ft from Elements	450	58.8
		Ext. Flush 5/5 (e)	448	93.0	Spatial Avg. (b)	451	58.6
	50ft	Ext Façade	470	88.1	Spatial Avg. (a)	476	54.2
		Ext. Flush 1/5 (a)	471	91.3	4ft from Elements	477	54.2
		Ext. Flush 5/5 (e)	475	87.8	Spatial Avg. (b)	478	53.8
45 Degrees	25ft	Ext Façade	428	93.4	Spatial Avg. (a)	425	59.2
		Ext. Flush 1/5 (a)	429	93.9	4ft from Elements	426	59.2
		Ext. Flush 5/5 (e)	433	92.5	Spatial Avg. (b)	427	58.9
	50ft	Ext Façade	452	88.2	Spatial Avg. (a)	458	[illegible]
		Ext. Flush 1/5 (a)	453	90.0	4ft from Elements	459	54.1
		Ext. Flush 5/5 (e)	457	85.6	Spatial Avg. (b)	460	53.7
60 Degrees	25ft	Ext Façade	434	93.6	Spatial Avg. (a)	440	58.7
		Ext. Flush 1/5 (a)	435	94.6	4ft from Elements	441	59.1
		Ext. Flush 5/5 (e)	439	90.6	Spatial Avg. (b)	442	59.0
	50ft	Ext Façade	461	87.5	Spatial Avg. (a)	467	54.2
		Ext. Flush 1/5 (a)	462	89.5	4ft from Elements	468	54.4
		Ext. Flush 5/5 (e)	466	85.9	Spatial Avg. (b)	469	54.1

Artificial Noise Source on Tripod - No Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25ft	Ext Façade	527	93.8	Spatial Avg.	526	60.4

Artificial Noise Source on Crane - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25ft	Ext Façade	511	92.3	Spatial Avg. (a)	508	56.7
		Ext. Flush 1/5 (a)	512	93.7	4ft from Elements	509	56.2
		Ext. Flush 5/5 (e)	516	89.9	Spatial Avg. (b)	510	56.4
	50ft	Ext Façade	517	88.2	Spatial Avg. (a)	523	52.7
		Ext. Flush 1/5 (a)	518	89.8	4ft from Elements	524	53.1
		Ext. Flush 5/5 (e)	522	87.2	Spatial Avg. (b)	525	52.8

Site #	3
Address	61 Dumont Ave
City, State	Burlington, VT
Room	FBB
Date	11/14/12
Airport	BTV
Consultant	ERS/CLL

Reverberation	SLM Log	RT60 (s)
No Insulation	531	0.41
With Insulation	368	0.28
Background	**SLM Log**	**Leq (dBA)**
Exerior	367	50.2
Interior	365	32.0
Ext. Spectrum	354-360/474-483/486-489	

Artificial Noise Source on Tripod - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
30 Degrees	25ft	Ext Façade	389	93.4	Spatial Avg. (a)	395	59.6
		Ext. Flush 1/5 (a)	390	95.1	4ft from Elements	396	60.2
		Ext. Flush 5/5 (e)	394	96.0	Spatial Avg. (b)	397	59.5
	50ft	Ext Façade	416	87.9	Spatial Avg. (a)	422	55.0
		Ext. Flush 1/5 (a)	417	90.9	4ft from Elements	423	55.9
		Ext. Flush 5/5 (e)	421	91.1	Spatial Avg. (b)	424	55.7
45 Degrees	25ft	Ext Façade	373	93.8	Spatial Avg. (a)	370	59.3
		Ext. Flush 1/5 (a)	375	94.4	4ft from Elements	371	60.6
		Ext. Flush 5/5 (e)	379	95.7	Spatial Avg. (b)	372	59.4
	50ft	Ext Façade	398	88.5	Spatial Avg. (a)	404	54.7
		Ext. Flush 1/5 (a)	399	88.7	4ft from Elements	405	55.6
		Ext. Flush 5/5 (e)	403	90.7	Spatial Avg. (b)	406	55.3
60 Degrees	25ft	Ext Façade	380	93.5	Spatial Avg. (a)	386	59.2
		Ext. Flush 1/5 (a)	381	93.5	4ft from Elements	387	59.6
		Ext. Flush 5/5 (e)	385	96.5	Spatial Avg. (b)	388	59.3
	50ft	Ext Façade	407	88.0	Spatial Avg. (a)	413	53.3
		Ext. Flush 1/5 (a)	408	86.3	4ft from Elements	414	54.3
		Ext. Flush 5/5 (e)	412	90.9	Spatial Avg. (b)	415	54.0

Artificial Noise Source on Tripod - No Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25ft	Ext Façade	529	93.3	Spatial Avg.	528	62.0

Artificial Noise Source on Crane - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25ft	Ext Façade	493	92.0	Spatial Avg. (a)	490	56.2
		Ext. Flush 1/5 (a)	494	91.8	4ft from Elements	491	56.6
		Ext. Flush 5/5 (e)	498	93.9	Spatial Avg. (b)	492	56.3
	50ft	Ext Façade	499	87.3	Spatial Avg. (a)	505	52.3
		Ext. Flush 1/5 (a)	500	88.4	4ft from Elements	506	53.1
		Ext. Flush 5/5 (e)	504	89.2	Spatial Avg. (b)	507	52.3

Site #	4
Address	4 Pic and Civ
City, State	Burlington, VT
Room	FR
Date	11/15/12
Airport	BTV
Consultant	EHS/CLL

Reverberation	SLM Log	RT60 (s)
No Insulation	162	0.92
With Insulation	160	0.28
Background	**SLM Log**	**Leq (dBA)**
Exerior	119	45.9
Interior	165	31.8
Ext. Spectrum	1-10/120-123	

Artificial Noise Source on Tripod - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
30 Degrees	25 ft	Ext Façade	047	94.4	Spatial Avg. (a)	059	60.1
		Ext. Flush 1/5 (a)	046	94.2	4ft from Elements	060	66.5
		Ext. Flush 5/5 (e)	052	93.6	Spatial Avg. (b)	061	66.3
	50 ft	Ext Façade	101	87.9	Spatial Avg. (a)	113	60.4
		Ext. Flush 1/5 (a)	102	90.3	4ft from Elements	114	60.5
		Ext. Flush 5/5 (e)	106	88.5	Spatial Avg. (b)	115	60.4
45 Degrees	25 ft	Ext Façade	011	94.5	Spatial Avg. (a)	023	66.3
		Ext. Flush 1/5 (a)	012	94.6	4ft from Elements	024	66.7
		Ext. Flush 5/5 (e)	016	94.0	Spatial Avg. (b)	025	66.0
	50 ft	Ext Façade	065	88.4	Spatial Avg. (a)	077	61.4
		Ext. Flush 1/5 (a)	066	90.0	4ft from Elements	078	61.4
		Ext. Flush 5/5 (e)	070	89.7	Spatial Avg. (b)	079	61.3
60 Degrees	25 ft	Ext Façade	024	94.3	Spatial Avg. (a)	041	66.4
		Ext. Flush 1/5 (a)	030	94.8	4ft from Elements	042	66.2
		Ext. Flush 5/5 (e)	034	92.4	Spatial Avg. (b)	043	60.0
	50 ft	Ext Façade	083	88.4	Spatial Avg. (a)	095	60.2
		Ext. Flush 1/5 (a)	084	90.5	4ft from Elements	096	59.8
		Ext. Flush 5/5 (e)	088	89.1	Spatial Avg. (b)	097	59.6

Artificial Noise Source on Tripod - No Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25 ft	Ext Façade	351	93.3	Spatial Avg.	353	68.8

Artificial Noise Source on Crane - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25 ft	Ext Façade	151	93.4	Spatial Avg. (a)	157	64.1
		Ext. Flush 1/5 (a)	152	94.2	4ft from Elements	158	63.7
		Ext. Flush 5/5 (e)	156	94.0	Spatial Avg. (b)	159	63.3
	50 ft	Ext Façade	124	88.3	Spatial Avg. (a)	130	59.5
		Ext. Flush 1/5 (a)	125	89.9	4ft from Elements	131	61.8
		Ext. Flush 5/5 (e)	129	90.4	Spatial Avg. (b)	132	59.3

Site #	4
Address	4 Pine 2nd Cir
City, State	Burlington, VT
Room	BBR
Date	11/15/12
Airport	BTV
Consultant	EBS/CLL

Reverberation	SLM Log	RT60 (s)
No Insulation	163	0.41
With Insulation	161	0.29
Background	**SLM Log**	**Leq (dBA)**
Exerior	119	45.9
Interior	164	29.4
Ext. Spectrum		

Artificial Noise Source on Tripod - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
30 Degrees	25ft	Ext Façade	058	93.7	Spatial Avg. (a)	062	63.0
		Ext. Flush 1/5 (a)	053	91.9	4ft from Elements	063	63.2
		Ext. Flush 5/5 (e)	057	93.4	Spatial Avg. (b)	064	62.2
	50ft	Ext Façade	107	87.1	Spatial Avg. (a)	115	57.9
		Ext. Flush 1/5 (a)	108	92.3	4ft from Elements	117	58.7
		Ext. Flush 5/5 (e)	112	88.6	Spatial Avg. (b)	116	58.0
45 Degrees	25ft	Ext Façade	017	93.7	Spatial Avg. (a)	026	63.3
		Ext. Flush 1/5 (a)	010	92.1	4ft from Elements	027	63.6
		Ext. Flush 5/5 (e)	022	92.4	Spatial Avg. (b)	028	63.2
	50ft	Ext Façade	076	88.0	Spatial Avg. (a)	080	59.1
		Ext. Flush 1/5 (a)	071	88.3	4ft from Elements	081	59.5
		Ext. Flush 5/5 (e)	075	88.3	Spatial Avg. (b)	082	59.3
60 Degrees	25ft	Ext Façade	035	93.0	Spatial Avg. (a)	044	63.0
		Ext. Flush 1/5 (a)	036	93.0	4ft from Elements	045	63.3
		Ext. Flush 5/5 (e)	040	91.6	Spatial Avg. (b)	046	62.3
	50ft	Ext Façade	089	88.0	Spatial Avg. (a)	098	58.8
		Ext. Flush 1/5 (a)	090	87.9	4ft from Elements	099	59.4
		Ext. Flush 5/5 (e)	094	87.7	Spatial Avg. (b)	100	58.5

Artificial Noise Source on Tripod - No Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25ft	Ext Façade	352	92.4	Spatial Avg.	354	63.1

Artificial Noise Source on Crane - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25ft	Ext Façade	145	91.8	Spatial Avg. (a)	142	62.7
		Ext. Flush 1/5 (a)	146	92.5	4ft from Elements	143	61.2
		Ext. Flush 5/5 (e)	150	90.7	Spatial Avg. (b)	144	62.4
	50ft	Ext Façade	136	87.5	Spatial Avg. (a)	133	58.9
		Ext. Flush 1/5 (a)	137	87.2	4ft from Elements	134	59.8
		Ext. Flush 5/5 (e)	141	87.9	Spatial Avg. (b)	135	58.7

Site #	5
Address	120 Airport Pkwy
City, State	Burlington, VT
Room	K/DR
Date	11/16/12
Airport	BTV
Consultant	EBS/CLL

Reverberation	SLM Log	RT60 (s)
No Insulation	345	0.80
With Insulation	343	0.46
Background	**SLM Log**	**Leq (dBA)**
Exerior	230	51.1
Interior	165	31.8
Ext. Spectrum Logs	221-227/229	

Artificial Noise Source on Tripod - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
30 Degrees	25ft	Ext Façade	307	96.6	Spatial Avg. (a)	313	64.3
		Ext. Flush 1/5 (a)	308	98.4	4ft from Elements	314	66.3
		Ext. Flush 5/5 (e)	312	95.5	Spatial Avg. (b)	315	64.4
	50 ft	Ext Façade	334	90.9	Spatial Avg. (a)	340	59.3
		Ext. Flush 1/5 (a)	335	92.1	4ft from Elements	341	61.4
		Ext. Flush 5/5 (e)	339	91.8	Spatial Avg. (b)	342	59.4
45 Degrees	25 ft	Ext Façade	289	96.8	Spatial Avg. (a)	295	64.1
		Ext. Flush 1/5 (a)	290	97.1	4ft from Elements	296	66.5
		Ext. Flush 5/5 (e)	294	95.8	Spatial Avg. (b)	297	64.0
	50 ft	Ext Façade	316	91.6	Spatial Avg. (a)	322	60.2
		Ext. Flush 1/5 (a)	317	92.6	4ft from Elements	323	62.2
		Ext. Flush 5/5 (e)	321	89.7	Spatial Avg. (b)	324	59.9
60 Degrees	25ft	Ext Façade	289	96.0	Spatial Avg. (a)	304	64.3
		Ext. Flush 1/5 (a)	299	96.5	4ft from Elements	305	63.6
		Ext. Flush 5/5 (e)	303	94.0	Spatial Avg. (b)	306	64.1
	50 ft	Ext Façade	325	90.9	Spatial Avg. (a)	331	59.7
		Ext. Flush 1/5 (a)	326	92.6	4ft from Elements	332	61.5
		Ext. Flush 5/5 (e)	330	89.5	Spatial Avg. (b)	333	59.3

Artificial Noise Source on Tripod - No Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25ft	Ext Façade	349	96.3	Spatial Avg.	350	66.2

Artificial Noise Source on Crane - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25ft	Ext Façade	194	93.2	Spatial Avg. (a)	200	62.0
		Ext. Flush 1/5 (a)	195	93.1	4ft from Elements	201	64.3
		Ext. Flush 5/5 (e)	199	92.6	Spatial Avg. (b)	202	62.3
	50 ft	Ext Façade	184	88.3	Spatial Avg. (a)	193	58.1
		Ext. Flush 1/5 (a)	185	88.9	4ft from Elements	191	60.4
		Ext. Flush 5/5 (e)	189	87.7	Spatial Avg. (b)	192	58.1

Site #	5
Address	120 Airport Pkwy
City, State	Burlington, VT
Room	BBR
Date	11/6/12
Airport	BTV
Consultant	EBS/CLL

Reverberation	SLM Log	RT60 (s)
No Insulation	346	0.48
With Insulation	344	0.29
Background	**SLM Log**	**Leq (dBA)**
Exerior		
Interior	164	29.4
Ext. Spectrum Logs		

Artificial Noise Source on Tripod - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
30 Degrees	25 ft	Ext Façade	253	92.9	Spatial Avg. (a)	259	65.5
		Ext. Flush 1/5 (a)	254	91.7	4ft from Elements	260	65.8
		Ext. Flush 5/5 (e)	258	94.2	Spatial Avg. (b)	261	66.4
	50 ft	Ext Façade	280	86.9	Spatial Avg. (a)	286	60.3
		Ext. Flush 1/5 (a)	281	88.0	4ft from Elements	287	60.6
		Ext. Flush 5/5 (e)	285	90.0	Spatial Avg. (b)	288	60.5
45 Degrees	25 ft	Ext Façade	237	91.5	Spatial Avg. (a)	234	66.5
		Ext. Flush 1/5 (a)	239	92.7	4ft from Elements	235	66.3
		Ext. Flush 5/5 (e)	243	93.9	Spatial Avg. (b)	236	66.4
	50 ft	Ext Façade	262	87.9	Spatial Avg. (a)	268	61.1
		Ext. Flush 1/5 (a)	263	88.9	4ft from Elements	269	61.1
		Ext. Flush 5/5 (e)	267	90.2	Spatial Avg. (b)	270	60.7
60 Degrees	25 ft	Ext Façade	244	93.6	Spatial Avg. (a)	250	67.0
		Ext. Flush 1/5 (a)	245	92.7	4ft from Elements	251	67.3
		Ext. Flush 5/5 (e)	249	93.3	Spatial Avg. (b)	252	67.1
	50 ft	Ext Façade	271	87.8	Spatial Avg. (a)	277	60.2
		Ext. Flush 1/5 (a)	272	89.4	4ft from Elements	278	60.4
		Ext. Flush 5/5 (e)	276	89.0	Spatial Avg. (b)	279	59.7

Artificial Noise Source on Tripod - No Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25 ft	Ext Façade	347	93.1	Spatial Avg.	348	68.3

Artificial Noise Source on Crane - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25 ft	Ext Façade	169	92.2	Spatial Avg. (a)	166	62.3
		Ext. Flush 1/5 (a)	170	92.6	4ft from Elements	167	63.1
		Ext. Flush 5/5 (e)	174	92.0	Spatial Avg. (b)	168	62.4
	50 ft	Ext Façade	175	87.5	Spatial Avg. (a)	181	58.4
		Ext. Flush 1/5 (a)	176	87.4	4ft from Elements	182	59.1
		Ext. Flush 5/5 (e)	180	88.3	Spatial Avg. (b)	183	58.2

Site #	6
Address	204 Airport Pkwy
City, State	Burlington, VT
Room	RBR
Date	11/16/12
Airport	BTV
Consultant	ERS/CLL

357 → F16

Reverberation	SLM Log	RT60 (s)
No Insulation	433	0.61
With Insulation	355	0.18
Background	**SLM Log**	**Leq (dBA)**
Exerior	368	53.3
Interior	367	40.1
Ext. Spectrum	~~[illegible]~~	

356/358 → 363/365/366/425/427/428/429

Artificial Noise Source on Tripod - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
30 Degrees	25 ft	Ext Façade	388	93.4	Spatial Avg. (a)	394	64.4
		Ext. Flush 1/5 (a)	389	91.5	4ft from Elements	395	65.2
		Ext. Flush 5/5 (e)	393	94.2	Spatial Avg. (b)	396	65.3
	50 ft	Ext Façade	415	87.1	Spatial Avg. (a)	421	59.5
		Ext. Flush 1/5 (a)	416	88.1	4ft from Elements	422	60.2
		Ext. Flush 5/5 (e)	420	88.7	Spatial Avg. (b)	423	60.2
45 Degrees	25 ft	Ext Façade	372	93.1	Spatial Avg. (a)	369	65.4
		Ext. Flush 1/5 (a)	373	93.8	4ft from Elements	370	65.2
		Ext. Flush 5/5 (e)	377	93.7	Spatial Avg. (b)	371	65.1
	50 ft	Ext Façade	397	88.1	Spatial Avg. (a)	403	61.4
		Ext. Flush 1/5 (a)	398	71.1	4ft from Elements	404	61.5
		Ext. Flush 5/5 (e)	402	91.3	Spatial Avg. (b)	405	61.8
60 Degrees	25 ft	Ext Façade	378	93.7	Spatial Avg. (a)	384	64.2
		Ext. Flush 1/5 (a)	379	94.6	4ft from Elements	385	65.3
		Ext. Flush 5/5 (e)	383	92.2	Spatial Avg. (b)	386	64.5
	50 ft	Ext Façade	406	88.2	Spatial Avg. (a)	412	65.6
		Ext. Flush 1/5 (a)	407	89.3	4ft from Elements	413	60.6
		Ext. Flush 5/5 (e)	411	88.3	Spatial Avg. (b)	414	60.9

Artificial Noise Source on Tripod - No Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log 432	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25	Ext Façade	~~[illegible]~~	93.4	Spatial Avg.	431	69.3

Artificial Noise Source on Crane - With Insulation

Angle of Incidence	Distance to Façade	Exterior Meas.	SLM Log	Leq (dBA)	Interior Meas.	SLM Log	Leq (dBA)
45 Degrees	25	Ext Façade	203	91.3	Spatial Avg. (a)	209	61.4
		Ext. Flush 1/5 (a)	204	91.7	4ft from Elements	210	61.5
		Ext. Flush 5/5 (e)	208	92.4	Spatial Avg. (b)	211	61.7
	50	Ext Façade	215	87.0	Spatial Avg. (a)	212	58.1
		Ext. Flush 1/5 (a)	216	88.0	4ft from Elements	213	58.1
		Ext. Flush 5/5 (e)	220	88.0	Spatial Avg. (b)	214	58.1