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MONITORING AND ASSESSMENT OF AIRCRAFT NOISE IN AN AIRPORT'S NEIGHBORHOOD

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Abstract

Airports have grown continually worldwide and nearly unabated since the mid-1960s. This persistent growth has frequently been accompanied by a negative community reaction and created turmoil between airports, municipalities, and the surrounding communities. In recent years, there has been a significant increase in air traffic internationally. Airports are constantly seeking to expand their capacity. In the quest for expansion of services, it becomes vitally important for airports and communities to collaborate with mutual benefits in mind, especially regarding land use. This research examines land-use decisions and their relation to airport noise concerns and complaints. In an effort to gain a better perspective of the actual noise exposure of individuals who frequently complain about aircraft noise, noise data in these neighborhoods were recorded and analyzed. Access was granted within the homes of two frequent complainants and one non-complainant. A continuous set of 24-hour noise data was recorded both inside and outside each of these homes. A series of noise data samples was also taken simultaneously at various locations through affected neighborhoods over several days. This noise data will provide a better understanding of the actual noise experienced in the locations of the affected communities and provide a baseline comparison to future noise data samples and noise complaint patterns.

1. INTRODUCTION

Concern over airport noise and its impact on neighboring communities has been heightened due to a significant increase in air traffic as well as rapid urban development in many countries. During the past 40 years, there has been extensive assessment of aircraft noise in neighborhoods located near airports.[1-7] These assessments involve measuring and/or calculating noise levels and estimating any adverse impact upon residents. Many field studies[8-10] have been conducted to investigate the relationship between noise exposures associated with different transportation noise sources and their induced annoyance to the exposed populations. Empirical formulas for dosage-response relationships have developed.[10] These formulas are used for predicting the human annoyance as a function of noise exposure level. A popular metric known as the Day-Night Equivalent Level (DNL) was proposed as a convenient and universal single parameter to describe the possible impact of noise on communities in the vicinity of an airport. The basic assumption of DNL implies that a person's annoyance level is the same whether they are exposed to a small number of short, high-level noise events or a large number of long, low-level noise events. However, the DNL's reliance on equal energy supposition to explain an individual's and a community's response to airport noise makes the DNL an incomplete metric to describe the sporadic pass-by events of aircraft.

This paper describes a field study aiming to quantity the noise levels of a neighborhood community in the vicinity of an airport. The field study was carried out in 2006 at neighborhood communities adjacent to Orlando-Sanford International Airport, Florida. Noise levels at different locations around the airport were monitored. Measured data, which was obtained from the noise survey, was analyzed in terms of their temporal and spatial characteristics. The primary objective of the current study is to examine the suitability of DNL as a metric to assess the human annoyance to airport noise at different locations in the vicinity of airports. Preliminary measured results and some discussions are presented as follows.

2. METHODOLOGY

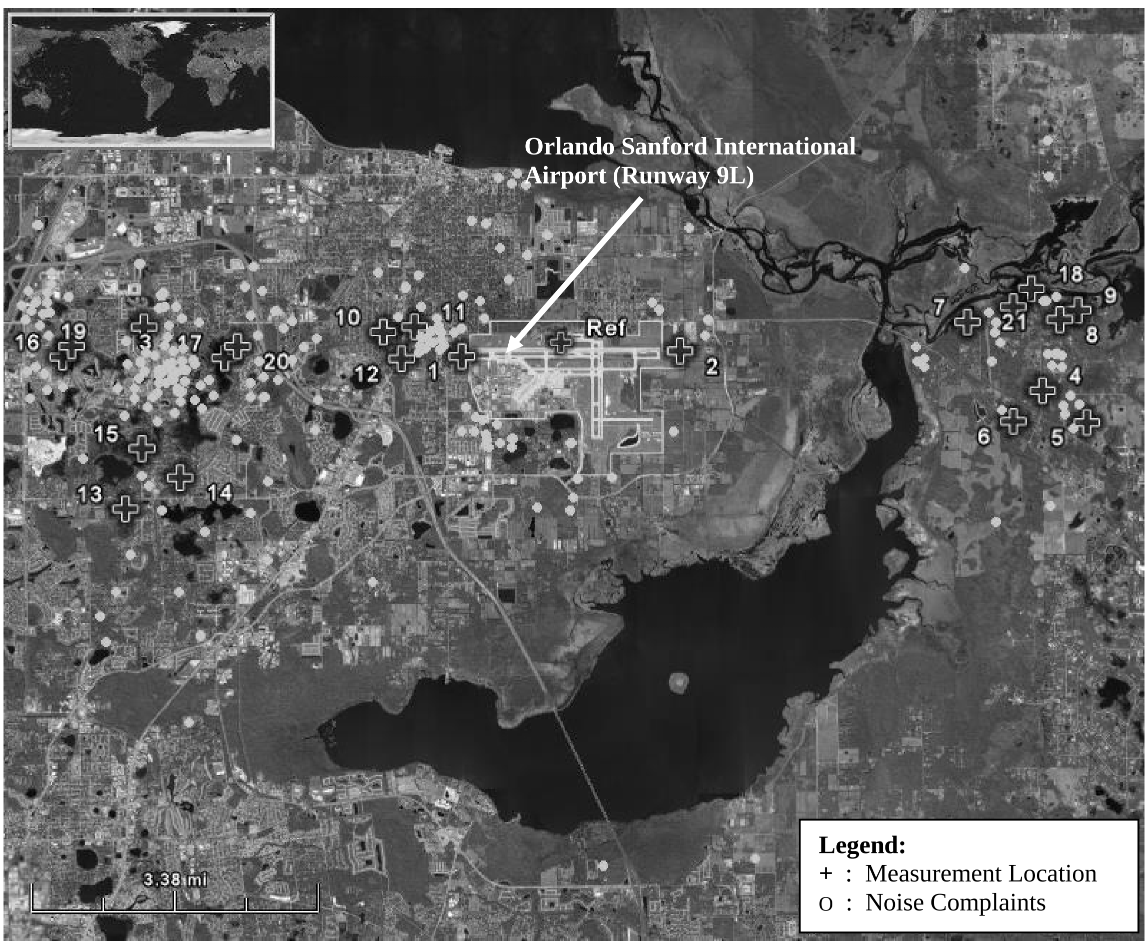


Photo 1. Noise Measurement Locations

Measurement was conducted at various locations around Orlando-Sanford International Airport (SFB) in Florida. The majority of noise complaints received by SFB come from populated residential communities west of the airport. Many residents complained about low and loud aircraft noise in recent years. The noise measurements were conducted over a seven-day period in the summer of 2006. The duration was selected as a period for a typical week of operations in the selected airport. The measurement was conducted at 21 locations, 18 of which were outdoors and 3 indoors. Outdoor locations were selected to be roughly along a line oriented parallel to the Runway 9L, see **Photo 1** above. The two closest locations to Runway 9L were used to monitor the noise levels of aircraft over-flights at the sides of departure and arrival, respectively. For the indoor measurements, access was granted to the house of two frequent noise complainants and one resident who chose not to complain. A continuous set of 24-hour noise data was recorded both inside and outside of each of these three houses. A B&K binaural head was also set up for noise recording near the indoor microphone. Noise signals were measured by two condenser microphones placed at both ear positions of the binaural head. **Table 1** summarizes various measuring locations of the present study.

Type 1 Sound level meters were used for measuring noise continuously over a time period of three hours at various selected locations in the region close to the airport. Three B&K Model 3639E Noise Monitoring Terminals were used for measuring noise continuously over the 7-day period at three fixed locations. A-weighted instantaneous sound levels were sampled at an interval of 1 second. The data were stored for subsequent analysis. The data from B&K Noise Monitoring Terminal gave the day-night average sound level (DNL) for each of the seven 24-hour period of measurements. A B&K Pulse system was installed inside the three residents' houses to record the 24-hour continuous time-series noise signals with the possibility of obtaining spectral information of aircraft noise for subsequent processing of data. Three sets of 24-hour noise data were recorded separately at these three separate measurement sites. The first set of data was recorded in a noise non-complainant's house, and the other two were recorded in the two noise complainants' houses. Noise monitoring equipments were calibrated at the start and end of each measurement period.

Table 1: Study Locations

Location	Location	Measuring system*	Miles from airport reference point
1	North Patrol Road, Sanford, FL	NMT	1.16
2	Beardall Avenue, Sanford, FL	NMT	1.42
3	Dorchester Square, Sanford, FL	NMT	4.92
4	Tabatha Drive, Geneva, FL	SOLO	5.7
5	Tabatha Drive, Geneva, FL	SOLO	6.33
6	Tabatha Drive, Geneva, FL	SOLO	5.39
7	Shad Lane., Geneva, FL	SOLO	4.81
8	Shad Lane., Geneva, FL	SOLO	5.9
9	Shad Lane., Geneva, FL	SOLO	6.18
10	Briarcliffe Street, Sanford, FL	SOLO	2.16
11	Briarcliffe Street, Sanford, FL	SOLO	1.76
12	Briarcliffe Street, Sanford, FL	SOLO	1.93
13	West Lake Mary Boulevard, Lake Mary, FL	SOLO	5.55
14	West Lake Mary Boulevard, Lake Mary, FL	SOLO	4.77
15	West Lake Mary Boulevard, Lake Mary, FL	SOLO	5.14
16	Eagle Claw Court, Lake Mary FL	PULSE	5.83
17	Alena Place, Lake Mary, FL	PULSE	3.71
18	Shad Lane., Geneva, FL	PULSE	5.01
19	Eagle Claw Court, Lake Mary, FL (Indoor)	PULSE	5.4
20	Alena Place, Lake Mary, FL (Indoor)	PULSE	3.71
21	Shad Lane., Geneva, FL (Indoor)	PULSE	5.33

*SOLO - Data logging integrating sound level meter; NMT - Noise monitoring terminal; PULSE - Pulse measuring system

3. RESULTS

In addition to the aircraft noise, the monitoring station also recorded overall contributions from other environmental noise sources, such as human conversation noise indoors during the period of recording. The DNL at Locations 1, 2 and 3 are shown in **Table 2** below. It was computed from the hourly average sound levels (L_{eq}_hourly). In Table 2, average of the daily sound energy from the DNL data was obtained to estimate average DNL for the monitoring period.

Table 2: Daily and Average DNL at Locations 1 – 3.

Location	Day 1 dB(A)	Day 2 dB(A)	Day 3 dB(A)	Day 4 dB(A)	Day 5 dB(A)	Day 6 dB(A)	Day 7 dB(A)	Average dB(A)
1	56.7	60.1	57.5	59.3	60.4	61.7	54.8	58.6
2	58.2	64.5	56.1	59.2	60.6	64	60.4	60.4
3	51.2	52.3	50.5	50.6	54.2	53.5	54.4	52.4

Indoor and outdoor noise data were recorded with a B&K Pulse system at Locations 16 – 21 in three separate residents' houses. A continuous recording of spectral data of 24 hours was recorded respectively at these locations. From these recorded data, the DNL at each location was computed and summarized in **Table 3**. Outdoor-measured DNL at various locations showed several decibels differences: the highest outdoor DNL level was 64.1 dB(A) at Location 17, where it was situated at a distance of 3.7 miles from the airport. In **Table 3**, we also showed the corresponding indoor noise levels measured by a microphone mounted on a stand and a pair of microphones placed at the binaural head. Typically, indoor noise levels showed an average of about 5 dB(A) lower than those measured at the corresponding outdoor locations. Recorded noise signals at the binaural heads showed rather similar results with the indoor microphones placed at the respective houses.

Table 3: Daily DNL at Locations 16 – 21

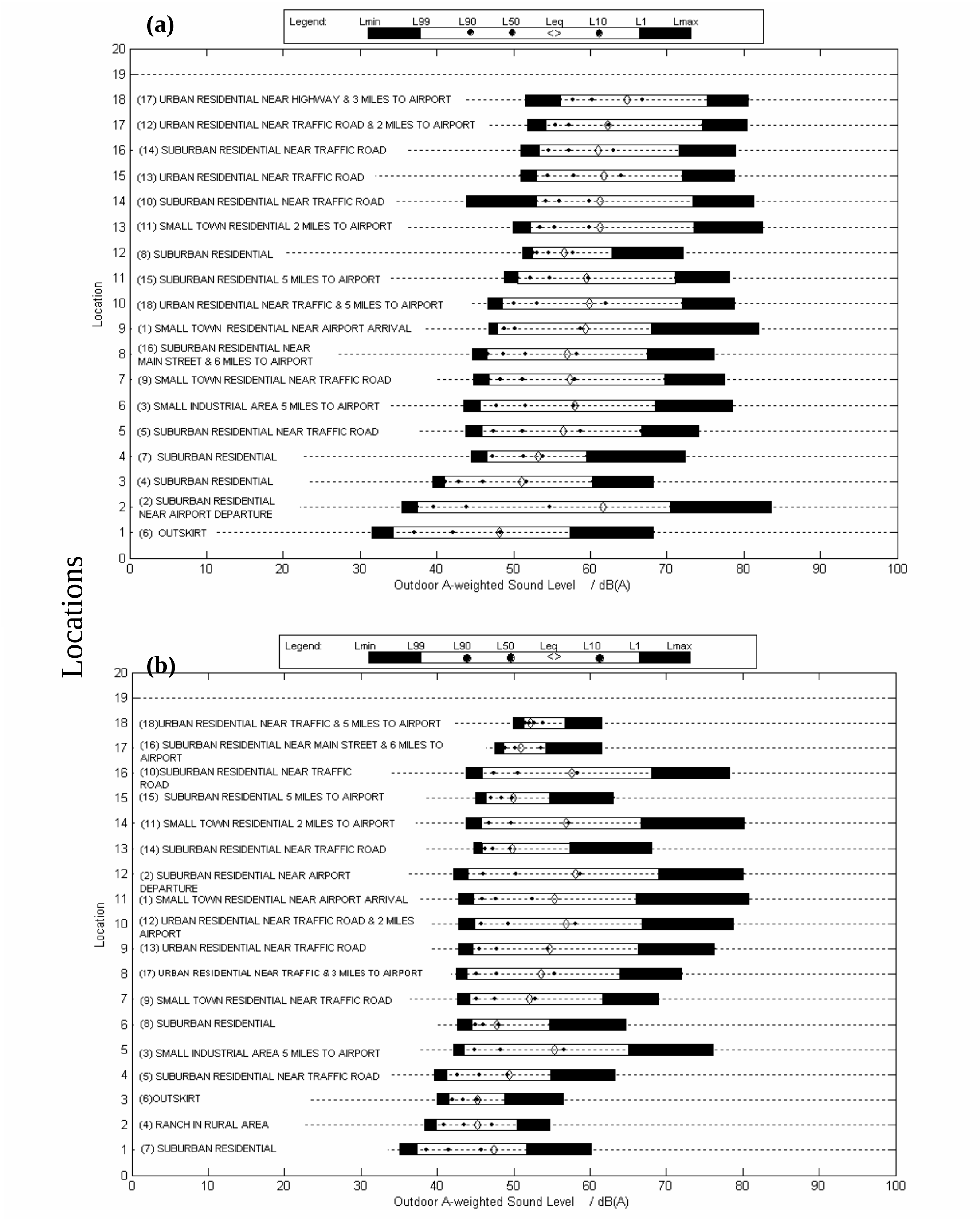
Locations	Outdoor dB(A)	Indoor dB(A)	Indoor (Left ear) dB(A)	Indoor (Right ear) dB(A)
16 / 19	60.5	55.0	56.2	55.3
17 / 20	64.1	55.9	56.9	56.3
18 / 21	58.3	53.3	53.6	52.9

The monitoring noise levels at various locations were generally well below 65 DNL. As we conducted a noise survey in a 'typical' week, it is assumed that this noise level closely represents a yearly-based DNL level. As a result, the residential areas in the neighborhood communities of SFB are expected to be classified as regions of compatible land use in the vicinity of the airport. However, there were still many occasions where local residents submitted noise complaints to the airport authority. One of the main reasons for this apparent lack of consistency is due to fact that DNL has used an inherent assumption of 'equal energy' basis. Other acoustic parameters such as the characteristics of ambient noise, duration and fluctuations in noise level are ignored in the assessments. In the following paragraphs, various acoustic factors in relation to the noise levels are analyzed and presented in order to examine the adequacy of DNL as a single parameter to assess the human annoyance to airport noise.

3.1 Spatial Variations in Measured Noise Levels

Figure 1 shows the results of outdoor noise measurements conducted at various locations spanning rural to suburban areas. Data are presented as the arithmetic averages of the different hourly A-weighted noise levels of the periods for day time (Fig. 1(a)) and for night time (Fig.

1(b)). In addition to L_{eq}, parametric values of L_{max}, L_{99}, L_{90}, L_{50}, L_{10}, L_1 and L_{min} are also shown. The variations in noise level and the sporadic character of noise at all locations are demonstrated. As expected, the noise climates (L_{10}-L_{90}) at different locations vary considerably. The over-flight of aircraft often leads to a significant variation in noise levels.



Overall A-weighted sound levels

Figure 1: Measurement of A-weighted sound levels at various locations in the vicinity of Orlando-Sanford International airport (a) Day time, (b) Night time.

Figure 2 gives the measured noise levels at Location 17 over a 24-hour period. It can be observed that the noise climate varies with time considerably. This fluctuation is probably one of the most important parameters causing intermittent noise complaints. The parameter, L_1, is indicated as the highest percentile level which corresponds to noise levels due to an over-flight of aircraft in the region around airports.

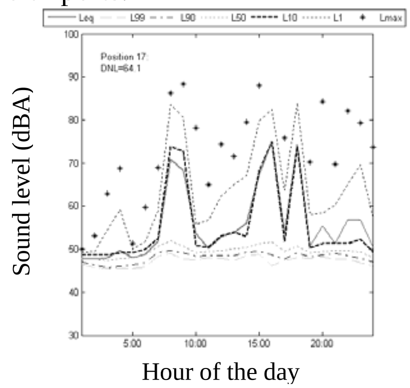


Figure 2: Variations of L_{eq} and percentile levels throughout the 24 hour periods recorded at Location 17.

3.2 Comparisons of Indoor and Outdoor Noise Measurement

Figure 3 shows the histograms of the distribution of A-weighted sound levels measured outside (Location 18) and inside (Location 21) a noise complainant's house. The plots indicate that the measured noise levels shift from higher levels at outdoors to lower levels at indoors. This also reveals statistically the change of noise pattern from outdoors to indoors. Similar results were also recorded at other households.

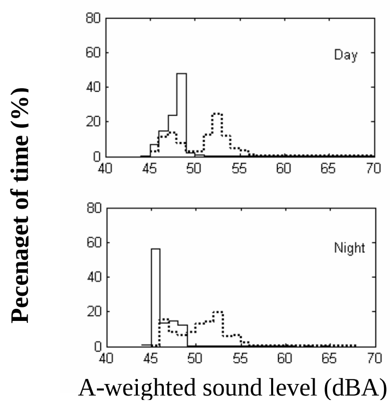


Figure 3: Histograms showing the distribution of A-weighted sound levels measured at outside (Location 18) and inside (Location 21) positions of a noise complainant house: inside (——) and outside (------).

The average hourly L_{eq} (at outdoor and indoor locations) measured at three indoor locations is shown in Figure 4. As expected, the outdoor measured L_{eq} are generally higher than those measured indoors.

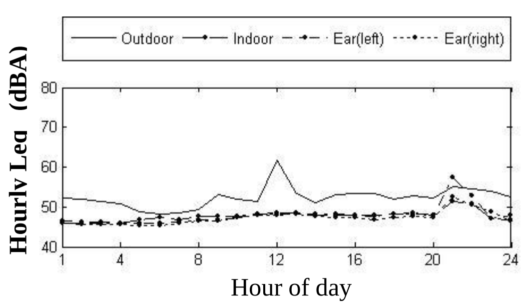


Figure 4: Comparison of indoor (Location 21) and outdoor (Location 18) measured hourly A-weighted equivalent continuous sound levels at a noise-complainant house.

Figure 5 shows the statistical distribution pattern of measured noise levels indoors and outdoors. It can be seen that sound levels recorded at the three locations show irregular shape of distribution patterns. We note that there were occasionally more than one noise source during the period of recording. At many instances, the acoustic environments at these three positions are composed of at least two distinct dominant noise sources. The recorded outdoor sound levels, during both day and night times, also revealed the presence of other noise sources.

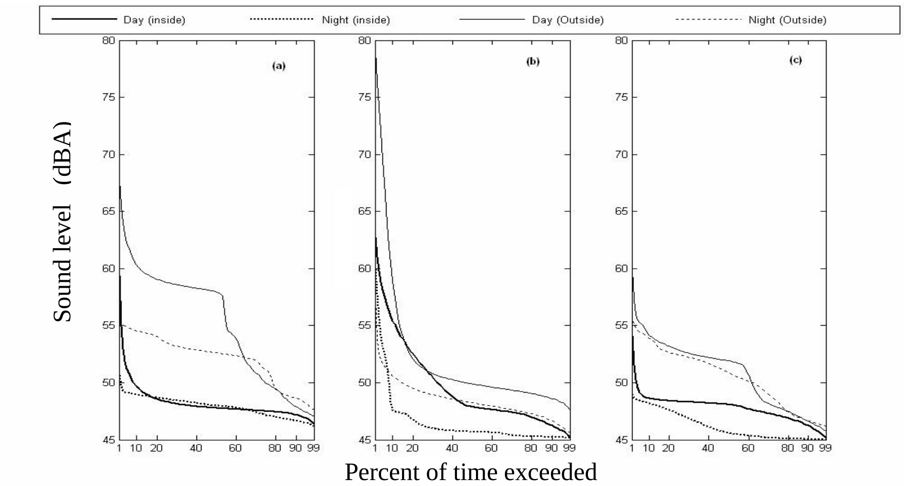


Figure 5: Statistical distribution patterns of A-weighted sound levels.

The indoor noise levels result from the ingress of noise from the outside environment as well as the noise produced internally. Although many community noise surveys use outdoor measurements to infer the noise indoors (to which the local residents are really exposed), the measured results at the three typical household presented in this section shows considerable discrepancy in noise levels.

3.3 Variations in Measured Noise Levels with Time of Day

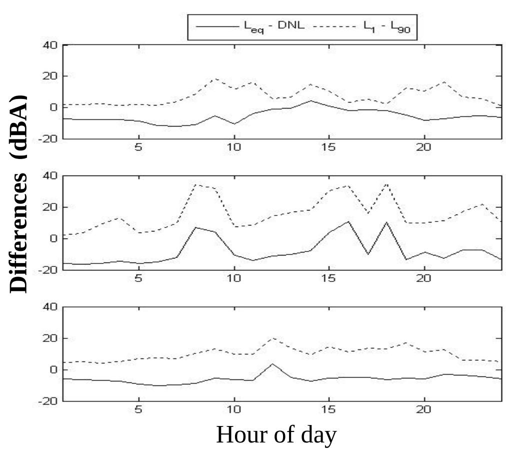


Figure 6. Difference between hourly Leq and DNL versus time of day.

Figure 6 shows the difference between the hourly L_{eq} and DNL plotted for each hour of the day at the outdoor locations of the three residents' houses. The figure also shows the hourly noise climate (where the noise climate is defined as $L_1 - L_{90}$). The figures show considerable variations of hourly noise climate with the time of day. This pattern of variation was correlated directly with the time pattern of human activities in the house. The results from the two complainants reveal considerable differences for each hour of the day and suggest that these fluctuations in levels often lead to a complainant's immediate prevalence of annoyance. The plots also reveal that the DNL based upon the 'equal energy' hypothesis may lack the ability to account for the fluctuation of noise levels throughout the day. There is a notable similarity in patterns between the variation in L_{eq} and noise climates for each hour of the day. This unsteady noise exposure throughout the day, which cannot be predicted by DNL, may sometimes trigger an action by a resident to file a noise complaint.

4. CONCLUSION

This research explored the acoustical characteristics for a neighborhood community near an airport. Preliminary data analyses conducted by this study suggest three basic results: (1) the use of 'equal' energy assumption in DNL cannot be used to explain the sporadic character of noise levels due to pass-by aircraft in the vicinity of airports; (2) measured outdoor noise levels and their spectral contents may not be a good indicator of the actual indoor noise levels and their corresponding spectral contents; and (3) the variation of noise levels throughout the day provides important information for assessing the human annoyance to airport noise.

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

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