Portable Noise Monitoring Report

August 15 - October 11, 2013

Woodland Park Elementary School

Vancouver Airport Authority

December 4, 2013

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INTRODUCTION

This report summarizes the results from the deployment of the Vancouver Airport Authority's portable noise monitoring equipment in North Surrey from August 15 through to October 11, 2013. The monitoring site, located at Woodland Park Elementary (specifically 9025-158 Street, Surrey, BC), was selected in consultation with a North Surrey resident who had expressed concerns about aircraft noise in the area.

The portable Noise Monitoring Terminal ("NMT") is a Brüel & Kjær Environmental Monitoring Unit 2 (EMU), which is linked to the Vancouver Airport Authority's Aircraft Noise and Operations Management System ("ANOMS"). The portable NMT was placed on the roof of the school in a secure location.

OBJECTIVES

The objective of this noise monitoring study is to help residents understand aircraft noise exposure in their community. It will also allow the Airport Authority to augment their dataset of aircraft and community noise measured at other sites around the Lower Mainland with the portable equipment, as well as the network of fixed noise monitoring terminals. While this study follows the same methodology as in previous monitoring work, this report includes the addition of supplementary noise metrics to better explain noise levels in the community. This format provides a level of consistency in the analysis of community noise levels between previous works, but adds further information on noise in the community.

Results of this study are not meant to initiate changes to aircraft procedures or to the airspace system. In addition, the results are not meant to be used for the purpose of compliance with aircraft noise regulations because all aircraft operating in Canada meet noise standards prescribed by the International Civil Aviation Organization.

NORTH SURREY: AIRCRAFT OPERATIONS

Figures 1 and 2 illustrate the typical flight patterns over the monitoring location in North Surrey. The figures represent radar flight tracks over a typical four-hour period (10:00AM-2:00PM) of westerly operations (runway 26 active) and easterly operations (runway 08 active) at YVR.

The GREEN tracks represent YVR departures, the RED tracks represent YVR arrivals, and the YELLOW tracks represent aircraft operating from other airports in the region. Aircraft arrivals are often lower than departures over this location. Arrivals have an average altitude of approximately 4,000 feet above sea level and departures have an average altitude of 8,000 feet above sea level.

In general, arrival activity (runway 26 active) is more common over the location during the spring and summer months and departure active is more common during the fall and winter months. This is due to the seasonality of wind conditions at the airport, which will dictate the active runway as aircraft must land and take-off into the wind for safety.

FIGURE 1

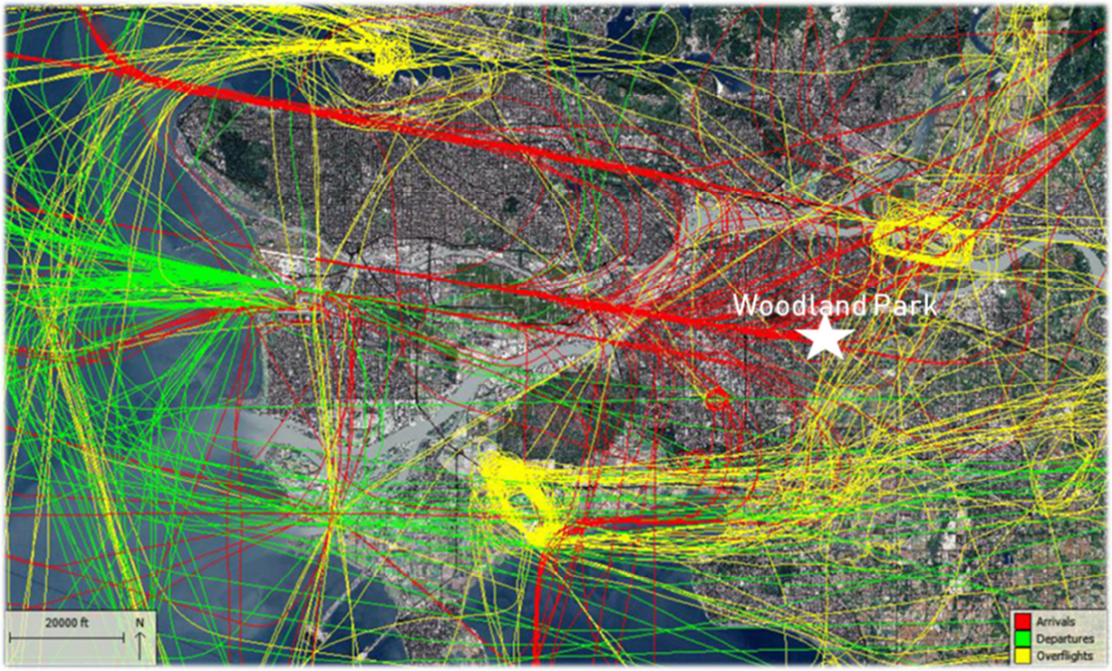
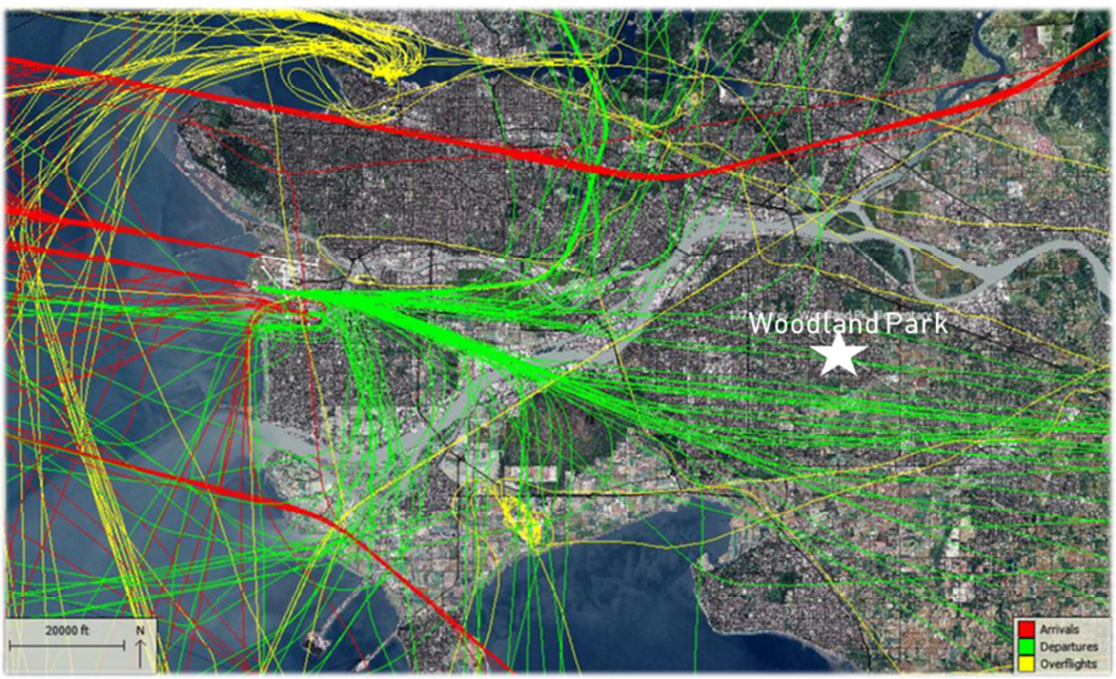


FIGURE 2



METHODOLOGY

INSTRUMENTATION SET-UP AND CALIBRATION

The portable NMT was set up on the roof of Woodland Elementary School and positioned away from any large sound reflecting surfaces such as walls, trees, and other significant sources of community noise (See Figures 3 and 4). The microphone was fitted with a windscreen and set on top a tripod at a height of approximately 1.5 metres. The NMT was stored in a locked waterproof case adjacent to the microphone and power was supplied from the school. An initial calibration was performed at the beginning of monitoring as is standard practice. The portable NMT was calibrated and adjusted for 0.1 dBA of drift. An automatic calibration was also performed on a nightly basis throughout the monitoring period.

MONITORING

The collection of noise data commenced August 15 and ceased on October 11, 2013[1], a period of 58 days. The NMT is designed to continually measure sound levels from all sources at the location, including vehicles, aircraft, and all other community sources.

Figure 3

Figure 4

[1] The monitoring period began on August 15 at 0000 hours and ended at 2359 hours on October 11, 2013.

DEFINING NOISE EVENTS

A noise event is captured by the NMT when the sound level exceeds a predefined threshold for a set duration of time. In the case of these measurements, the event thresholds were set at:

Time Period	Sound level Threshold	Event Duration
7:00AM – 10:00PM	65 dBA or greater	6 seconds
10:00PM-7:00AM	55 dBA or greater	6 seconds

The sound thresholds are set according to the ambient background noise level in the community, and the lower threshold at night accounts for the reduced ambient background noise. Noise events can be caused by either aircraft or non-aircraft sources. The ANOMS system will use a system of algorithms to correlate those noise events caused by aircraft flying in close vicinity to the NMT location using radar data supplied by NAV CANADA. This allows the Airport Authority to determine the contribution of aircraft noise in the area compared to other community noise sources.

RESULTS

NOISE EVENTS

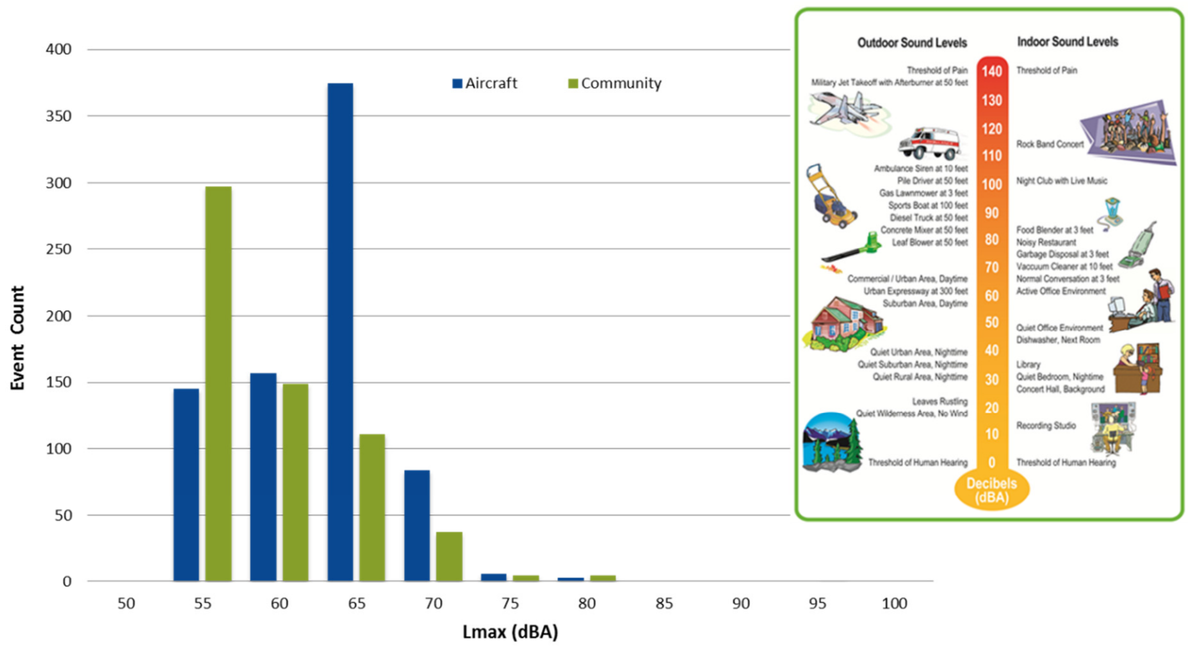
During the 58-day monitoring period, a total of 1,357 noise events were measured at the site. Of these events, 51% (n=688) were related to YVR aircraft, 5% (n=70) were related to non-YVR aircraft, and the remaining 44% (n=599) were associated with other community sources. A summary of the 1,357 noise events is provided in Table 1 below. Of the 758 aircraft noise events, 73% (n=553) are associated with aircraft arrivals, 18% (n=135) are associated with aircraft departures, and the remaining 9% (n=70) are associated with non-YVR aircraft.

Table 1: Noise events at Woodland Park

<table>
<tr><td rowspan="3">Number of Noise Events</td><td rowspan="3">1,357</td><td>Community Events</td><td>599</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Aircraft Events</td><td rowspan="2">758</td><td>YVR aircraft</td><td>688</td></tr>
<tr><td>Non-YVR aircraft</td><td>70</td></tr>
</table>

Figure 5 categorizes the 1,357 noise events according to the maximum sound level (Lmax) measured during the event and illustrates a comparison of typical indoor and outdoor sound levels, for example a sound level of 70 dBA is equivalent to a vacuum cleaner at 10 feet.

FIGURE 5



Aircraft Movements and Noise Events

Table 2 below provides information on YVR aircraft movement data, including the number of aircraft operating in the vicinity of the NMT (within a one kilometre radius), number of aircraft noise events, and the number of non-aircraft noise events identified during the monitoring period. Aircraft noise events identified during this monitoring assessment had an average duration of 17 seconds, with the longest aircraft event lasting 90 seconds (a non-YVR Cessna 172 aircraft) and the shortest events lasting 6 seconds. Non-aircraft related noise events had an average duration of 18 second, with the longest event lasting 120 seconds and the shortest event lasting 6 seconds.

Table 2: Aircraft movement and noise data at Woodland Park

WEEK	Total # YVR Aircraft Operations	# Aircraft over Portable NMT location	# of Aircraft Noise Events at NMT	# of Non-aircraft Noise Events at NMT	# of events related to YVR Aircraft	# of events related to non-YVR Aircraft
1	6,776	395	83	67	77	6
2	6,587	508	103	80	91	12
3	6,113	529	90	81	82	8
4	5,827	610	92	42	79	13
5	5,760	411	58	35	54	4
6	5,850	431	90	73	81	9
7	5,581	163	52	119	47	5
8	5,652	528	132	93	127	7
9*	1,707	218	58	9	52	6

*Week 9 only involved two full days whereas the preceding weeks included a full seven days.

METRICS

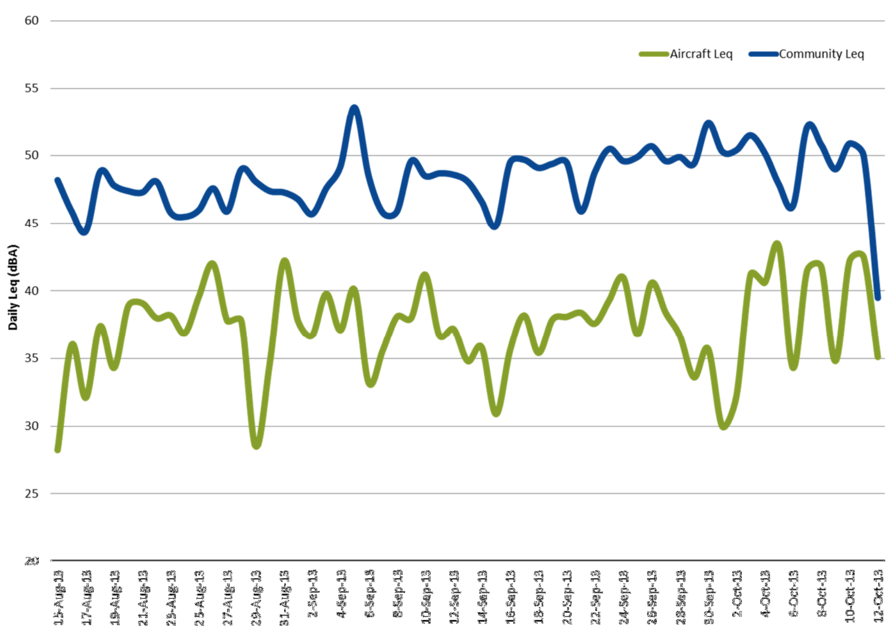
There are a number of different metrics used to describe aircraft noise. For the purpose of this study, the Equivalent Continuous Sound Pressure Level (Leq), Exceedance Level (L10 and L90), and Day Night Average Sound Level (DNL) are presented. The properties, measurement, and presentation of noise involve specialized terminology that is often difficult to understand. To provide a basic reference on the metrics used, a definition is provided for each at the end of the document.

1. DAILY EQUIVALENT CONTINUOUS SOUND PRESSURE LEVEL (LEQ)

Figure 7 provides a graph of the daily LAeq values, in units of dBA, for the monitoring period. The average 'Community'[2] Leq at the site over the entire monitoring period was determined to be 49.0 dBA. The 'Aircraft'[3] Leq related specifically to the 758 aircraft events was determined to be 38.4 dBA. The difference between these values indicates that aircraft are not a significant contributor to the *overall* noise environment at this location.

To explain further using time as a descriptor, the total cumulative duration of the aircraft noise events was equivalent to a total of 222 minutes out of the 58 days of monitoring – 0.2% of the total monitoring duration. This does not mean that the location does not experience aircraft noise events, but it does indicate that non-aircraft related noise dominates the overall noise environment. Noise events from aircraft, while louder than many community noise events, constitute a small amount of exposure during a given day and other community noise source minimizes its influence on the noise environment.

Figure 7



[2] Community noise is defined is all noise with the exception of aircraft noise.
[3] Aircraft noise is defined as all noise identified as aircraft. The ANOMS system is designed to identify aircraft noise events.

Table 3 helps illustrate the contribution of aircraft noise at this location by time of day. As illustrated, there is a 03 dBA and a 0.5dBA difference between the Community Leq and the Total[4] Leq values for the day and night periods respectively. These minor differences further indicate that aircraft noise within the community is not a significant contributor to the overall noise environment.

Table 4: Averaged Hourly Noise Levels Leq (dBA)

	Day-time (7:00AM-10:00PM)	Night-time (10:00PM-7:00AM)
Community Leq	49.1	44.4
Aircraft Leq	38.7	35.4
Total Leq	49.4	44.9

2. Exceedance Level (L90 and L10)

Measured noise levels at the monitoring location will vary over time, and may be quantified in terms of the noise level value that is exceeded for a certain percentile (N%) of total measurement time. This value is identified as LN. For example, the L90 is the noise level that was exceeded 90% of the time during the monitoring period. The L90 is generally referred to as the background noise levels and indicates the relative "*noticeability*" of all types of noise events at the site. Alternatively, the L10 is the noise level that was exceeded for 10% of the time during the monitoring period. The L10 does not represent the maximum sound at a location, but it does represent the upper limits of the environmental noise at a location.

Figure 8 illustrates the daily values of the L10 and L90 during the monitoring period. Assessing these percentile values provides an indication of the degree in fluctuations in noise readings. As illustrated, the daily L10 and L90 values vary at a minimum of 2 dBA and a maximum of 6dBA on a day-to-day basis. There is minimal to moderate fluctuations with these two values and they are often indistinguishable from one another. When L10 and L90 values differ between 5 and 15 dBA this is considered an environment where there are moderate fluctuations in sound. Many residential neighbourhoods fall within the range of moderate fluctuations.

Table 4 provides further analysis of the monthly L99, L90, L10, and L1 values during monitoring period. The L1 and L99 values are the upper (max) and lower (min) noise levels measured during the monitoring period. The L1 values for the monitoring period ranges between 59.7 and 60.1 dBA, meaning that only 1% of all noise levels measured during the monitoring period exceeded these values. Alternatively, the L99 values range between 31.0 and 34.2 dBA meaning that 99% of all noise exceeded these values.

[4] Total noise is all community and aircraft noise combined.

Figure 8

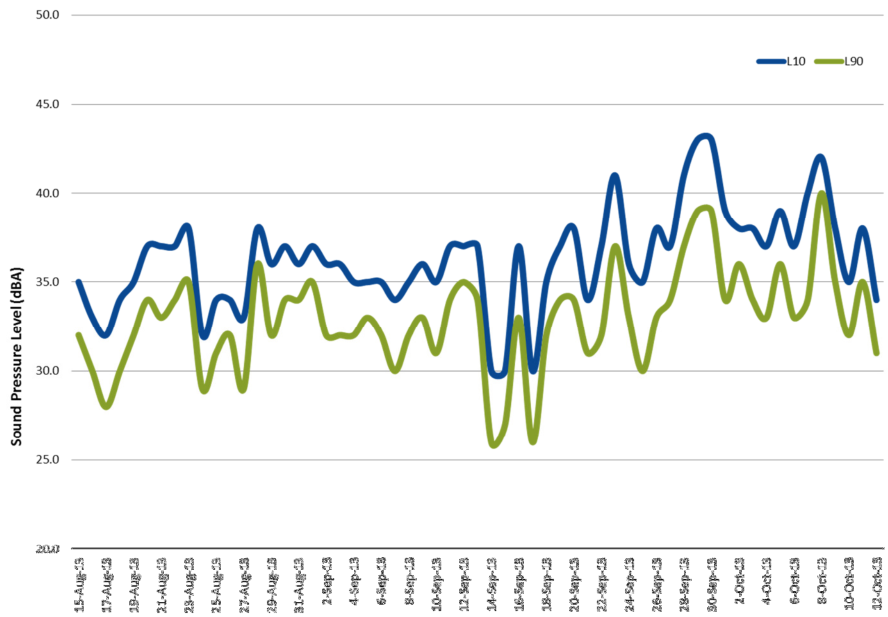


Table 4: LN monthly values

Sound Pressure Level (dBA)	L99	L90	L10	L1
August*	31	38.2	49.4	59.9
September	30.1	36.3	51.9	59.7
October+	34.2	38.3	52.8	60.1

*Monitoring began on August 15, 2013 at 00:00 hours
+Monitoring ceased on October 11, 2013 at 23:59 hours

3. Day-Night Average Sound Level (DNL)

The DNL is a cumulative time weighted cumulative noise metric with each individual aircraft noise event adding to the total noise exposure. The metric was developed to predict annoyance and assist with compatible land use planning in the vicinity of airports. To calculate the DNL, the 24-hour day is divided into two parts, day-time (between 7:00Am-10:00PM) and night-time (10:00PM-7:00AM). Noise events occurring at night are assigned a 10 dBA penalty to account for increased annoyance to noise at night.

The measured aircraft DNL at the monitoring location was determined to be 42.9 dBA. This is significantly lower than the DNL level of 65 dBA that the US Federal Aviation Administration has set to define the threshold of significant aviation noise exposure.

CONCLUSION

The noise measurements obtained at the Woodland Park Elementary location in North Surrey characterizes noise levels that are typical of an urban residential environment. While the number of aircraft noise events at this location is often louder than community noise events, aircraft noise does not contribute significantly to this area because aircraft events are small in number and duration. Other noise sources in the community have a far greater contribution to the overall noise levels.

Aircraft is audible, distinguishable, and sporadic at this location. These characteristics can lead to the perception that they contribute significantly to the overall noise environment, when in fact they have a minor contribution.

DEFINITIONS

The Decibel

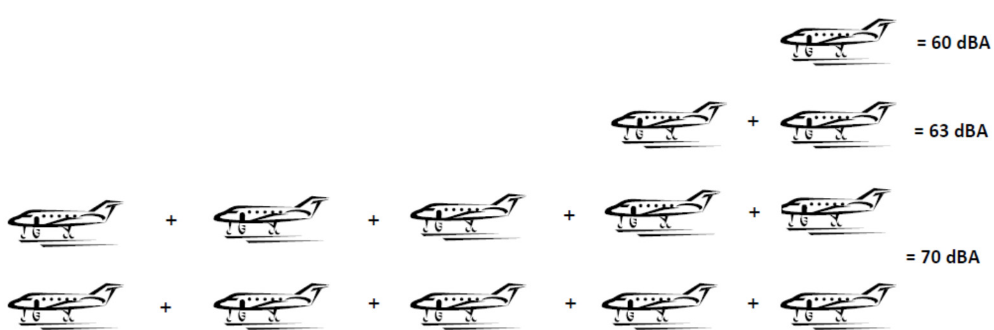
The basic unit of sound is the decibel (dB) and the normal extent of the human ear aural experience (from threshold of hearing to threshold of pain) falls within the range from 0 to 130dB. Decibels are sound pressure measurements. Sound pressure level is a measure of the sound pressure of a given noise source relative to a standard reference value. As mentioned above, dB are logarithmic quantities, relating the sound pressure level of a noise source to the reference pressure level. The reference pressure value is typical of the quietest sound that a young person with good hearing is able to detect.

Several filters have been developed that match the sensitivity of our ear and thus help us to judge the relative loudness of various sounds made up of many different frequencies. The "A" filter is the best measure for most environmental noise sources, including aircraft noise. Sound pressure levels measured through this filter are referred to as A-weighted levels, and are measured in A-weighted decibels or (dBA). For this assessment A-weighted decibels will be used for analysis.

Loudness and the Decibel Scale

The human ear is capable of sensing an enormous range of sound intensities. Analogous to the familiar Richter scale of earthquake magnitude, a logarithmic scale of sound levels has been developed to compress the large range of human hearing – ranging from 10^{-12} W/m^2 to 1 W/m^2 or 0Bb to 120dB.

The nature of dB logarithmic scale is such that the individual sound level for different noise sources cannot be added directly to give the combined sound level of these sources. The result of the logarithmic basis for the scale is that increasing a sound intensity by a factor of 10 raises its level by 10 dB; increasing it by a factor of 100 raises its level by 20 dB; by 1,000, 30 dB and so on. When two equal noise sources radiate twice the sound energy as one noise source the human ear does not perceive the resulting noise as being twice as loud, but only recognizes it as being noticeably louder. The decibel scale functions in a similar way. For example, two small propeller aircraft each producing 70 dBA at a given distance is observed flying together at equal distances from the observer, they would produce approximately 73 dBA, not 140 dBA.



This 3 dBA increase in noise level, achieved by doubling equal noise sources, is only just perceptible by the receiver. Similarly, a 6 dBA increase in noise level would be clearly perceived, and a 10dBA increase would be perceived as being twice as loud. Thus, an aircraft that produces a noise level of 80 dBA at the receiver location would be typically judged to be twice as loud as one that produces 70 dBA at the same receiver location, but only half as loud as aircraft that produces 90 dBA. Most people have difficulty distinguishing the louder of two noise sources if they differ by less than 2.0 dBA.

Equivalent Continuous Sound Pressure Level (Leq)

Community noise from road, rail, aircraft and other local sources are rarely steady. Sound varies in intensity from second to second, minute to minute or hour to hour. When attempting to describe the overall noise exposure of a community over a period of time, it is necessary to average the sound level in some way. The most commonly used average noise-level descriptor is the Equivalent Sound Level (Leq). The Leq is a measure of the average exposure resulting from the accumulation of A-weighted decibel sound levels over a particular time period (e.g., 1 hour, 8 hour, 24-hour). Variations in the "average" sound level suggested by Leq are not an arithmetic value, but a logarithmic ("energy-averaged") sound level. As a consequence, loud events will dominate sound levels measured.

Exceedance Level (LN)

Human response depends directly upon the range with which noise levels vary in a given environment. For a given Leq, one would find a higher, more steady level tolerable than a lower background level with frequent noise intrusions. Exceedance levels are those noise levels that exceed for a given percentage 'N' of the monitoring time. L90 is the noise level that was exceeded for 90% of the time whereas L10 is the noise level that was exceeded 10% of the time. L90 is used to estimate the residual background sound environment.

Aircraft Day-Night Average Sound Level (DNL)

The aircraft DNL is a daily average noise metric in which events occurring at night (between 10:00PM and 7:00AM) are penalized by 10 dBA. This night-time weighting treats one nighttime noise event as equivalent to 10 day-time events of the same magnitude, and is intended to account for the greater community annoyance with night-time noise.

The US Federal Aviation Agency has guidelines for compatible land uses and environmental sound levels based on the DNL metric. These guidelines are found in the Airport Noise Compatibility Program, found in Part 150 of the Federal Aviation Regulations. The FAA has identified a DNL of 65 dBA as the threshold level of aviation noise which is deemed as significant.