Aircraft Noise Measurement Report

Kilimanjaro Road

Columbia, MD 21045

Prepared by Harris Miller Miller & Hanson, Inc.

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1. INTRODUCTION

This memorandum presents the measured aircraft noise levels for the period of January 5 to January 19, 2015 at Kilimanjaro Road Columbia, MD 21045. This residence is located approximately 8.7 miles west-northwest of the western end of Runway 10/28 of Baltimore-Washington International Thurgood Marshall Airport (BWI Marshall). Figure 1 shows the location of the measurement site (marked as BW224) relative to BWI Marshall. Measurement data were collected on behalf of the Maryland Aviation Administration (MAA) by Harris Miller Miller & Hanson (HMMH) and Straughan Environmental (SE). The equipment was regularly checked for function and calibrated during the measurements. With the exception of brief periods during calibration, noise levels were monitored continuously throughout the measurement period.

At the conclusion of the measurement period, data were uploaded to the MAA's Noise and Operations Monitoring System (NOMS). The NOMS compared the times of loud noise events to its database of aircraft radar flight paths. Loud noise events which occurred while aircraft were passing within the vicinity were identified as aircraft noise. This matching of noise events to individual aircraft events makes possible the calculation of the total aircraft noise exposure over a particular hour or day as well as the full measurement period. Additionally, the relative contribution of different aircraft types (e.g. jet aircraft, propeller aircraft, helicopters) or operations (e.g. arrivals, departures) to the total noise exposure can be computed.

Section 1 of this memorandum describes the measurement location. Section 2 presents information about the aircraft operations during the measurement period. Section 3 summarizes the measured noise levels. The appendix titled "How Do We Describe Aircraft Noise" provides background information on acoustical terms used in this memorandum.

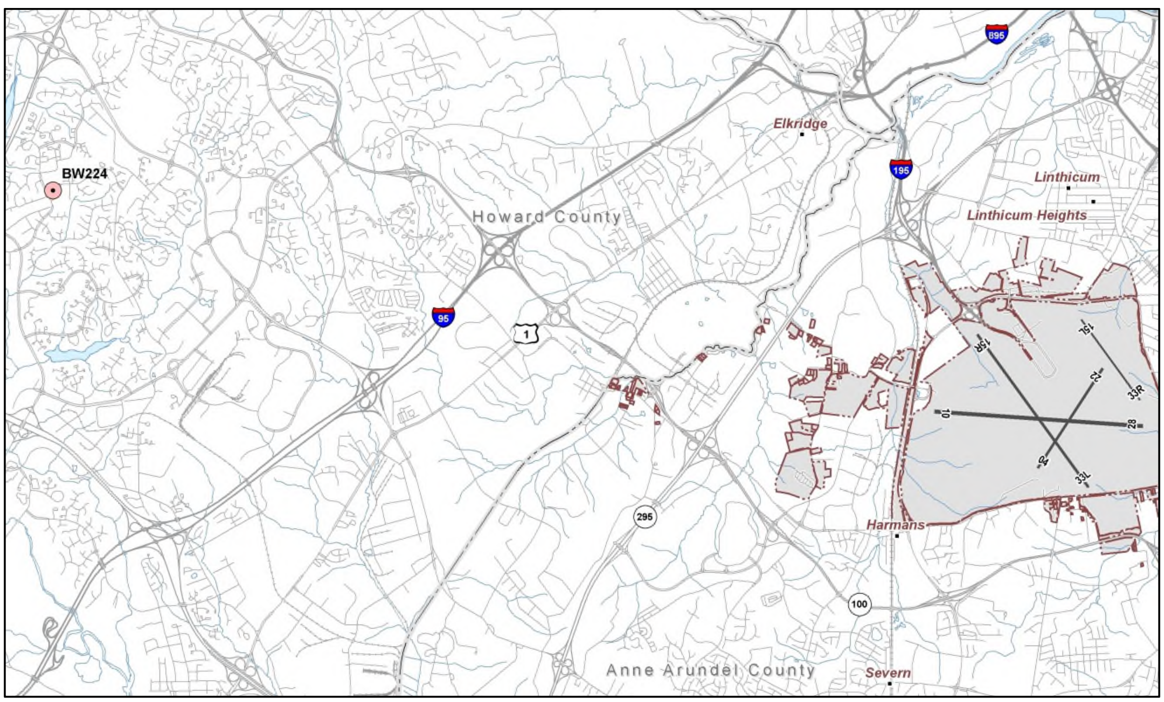

Figure 1. Noise Monitoring Location Map

2. MEASUREMENT SITE

Aircraft noise levels were measured from the afternoon of January 5 to the afternoon of January 19, 2015 at Kilimanjaro Road in Columbia. The noise monitor was placed in the backyard of the residence. Figure 2 shows the placement of the noise monitoring equipment.

The noise monitor is a Type I sound level meter and is regularly calibrated. Additionally, the system was calibrated every two to three days during the measurements during equipment checks. The equipment experienced no malfunctions and the meter was only stopped briefly for the periodic calibration checks.

Notable noise sources at this site include aircraft overflights, primarily departures from BWI Marshall Runway 28 and arrivals to BWI Marshall Runway 10, and typical suburban sounds such as local street traffic, dogs, and the PA system of the adjacent school.

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Figure 2. Noise Measurement Microphone

3. AIRCRAFT OPERATIONS

The measurement site is located to the west-northwest of BWI Marshall, north of the extended centerline of Runway 10/28. The primary aircraft noise events for this site are from departures from Runway 28. Other less common aircraft noise events are due to arrivals to Runway 10 and other aircraft overflights not associated with BWI Marshall.

Figure 3 displays all departure flight tracks for Runway 28 from the measurement period. The location of the measurement site is marked with its unique identifier in the NOMS, “BW224”. Figure 4 displays the same Runway 28 departure flight tracks at a larger scale. Again, the text “BW224” shows the location of the measurement site. Aircraft departing from Runway 28 were typically at an altitude of 4,900 ft to 7,400 ft above ground level at their point of closest approach to the measurement site. The most common altitude was 5,700 ft.

Figure 5 displays all arrival flight tracks for Runway 10 from the measurement period. Figure 6 displays the same arrival flight tracks for Runway 10 at a larger scale. Aircraft arriving to Runway 10 were typically at an altitude of 1,500 ft to 2,300 ft above ground level at their point of closest approach to the measurement site. The most common altitude was 1,600 ft.

During the measurement period, BWI Marshall operated in three configurations: departures on Runway 28 and arrivals on Runway 33L; departures on Runway 15R and arrivals on Runway 10; or both departures and arrivals on Runway 28. The most common configuration, departures on Runway 28 and arrivals on Runway 33L, was active for ten days during the measurement period. The configuration with departures on Runway 15R and arrivals on Runway 10 was active for one day during the measurement period. The configuration with both departures and arrivals on Runway 28 was also active for one day during the measurement period. On three days, BWI Marshall operated in combinations of these configurations during different portions of the day. Table 1 in the Measured Noise Levels section includes a description of the primary arrival and departure runways for each day.

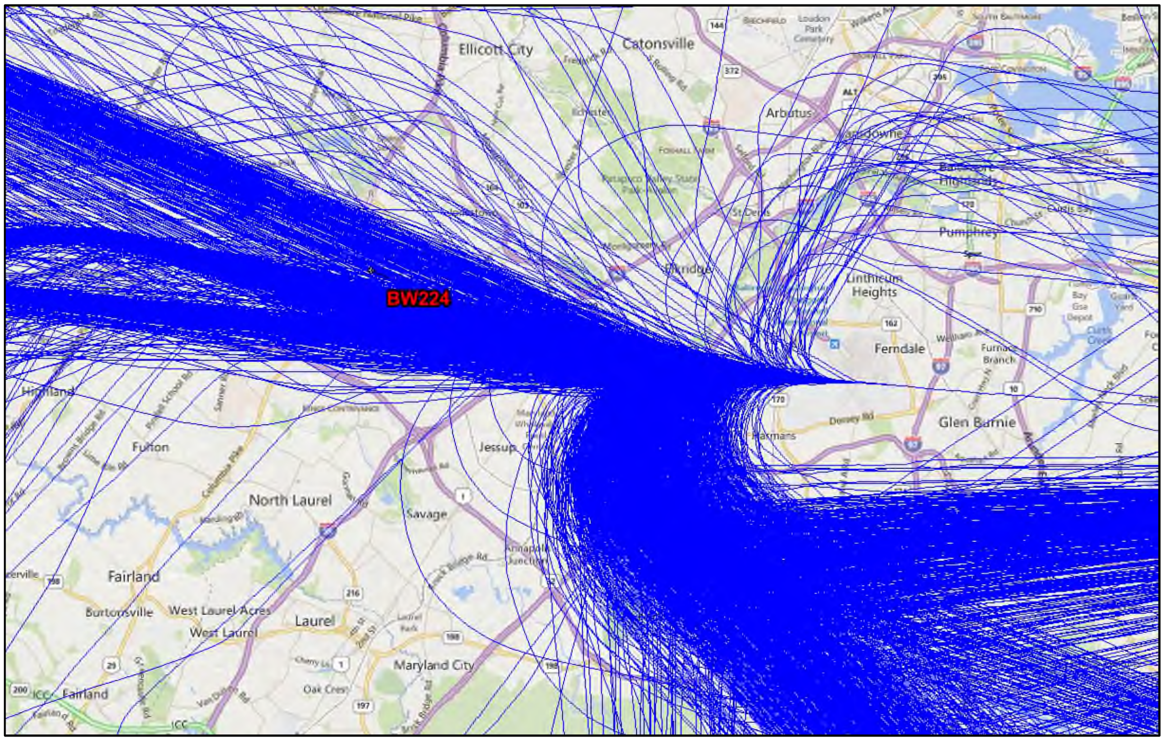

Figure 3. All Departure Flight Tracks from Measurement Period – Runway 28

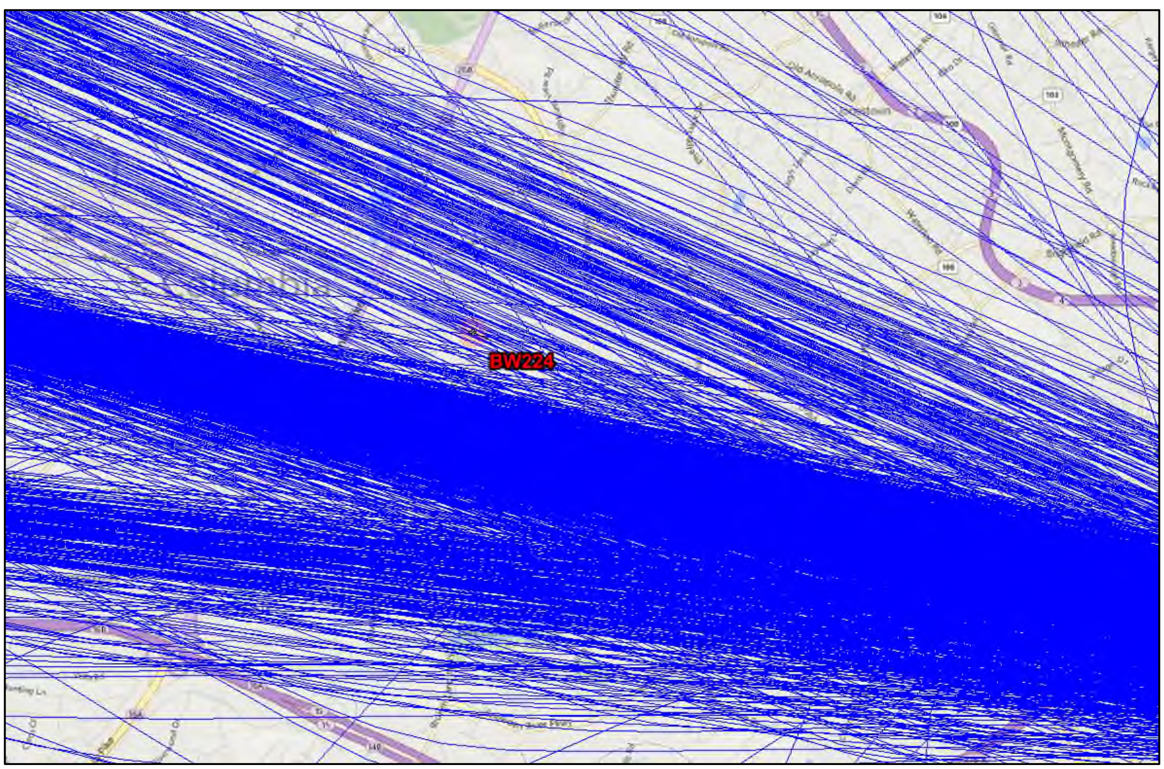

Figure 4. All Departure Flight Tracks from Measurement Period – Runway 28

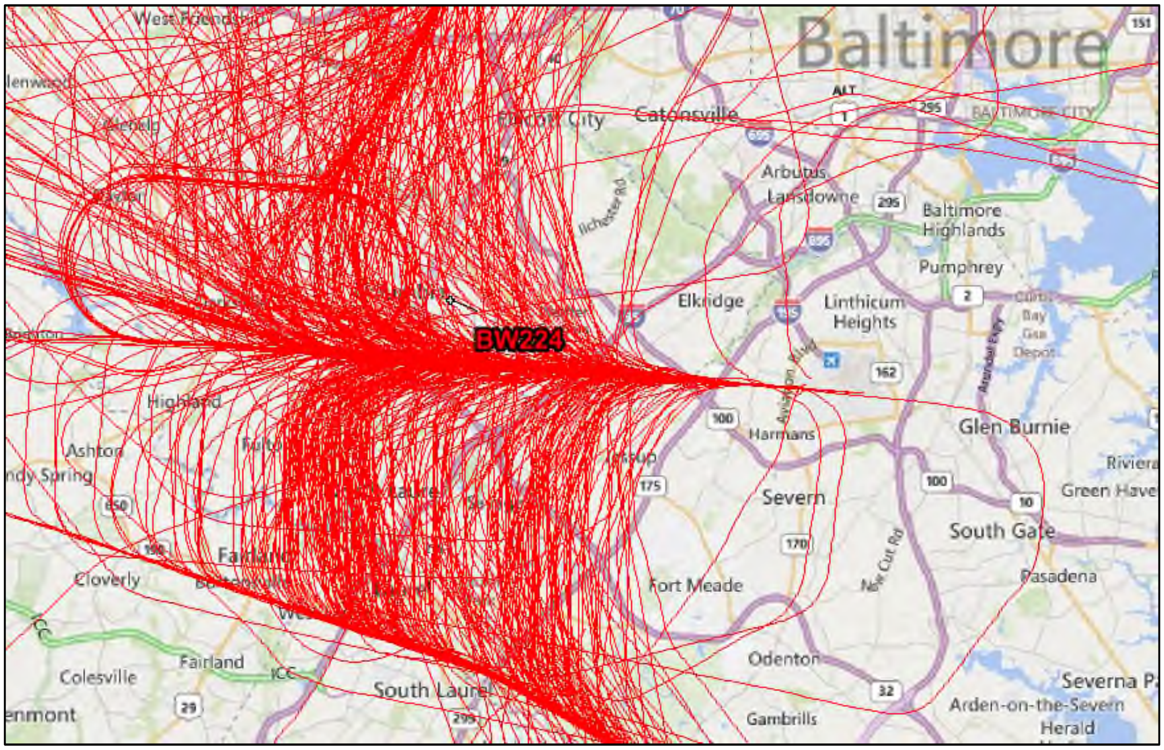

Figure 5. All Arrival Flight Tracks from Measurement Period – Runway 10

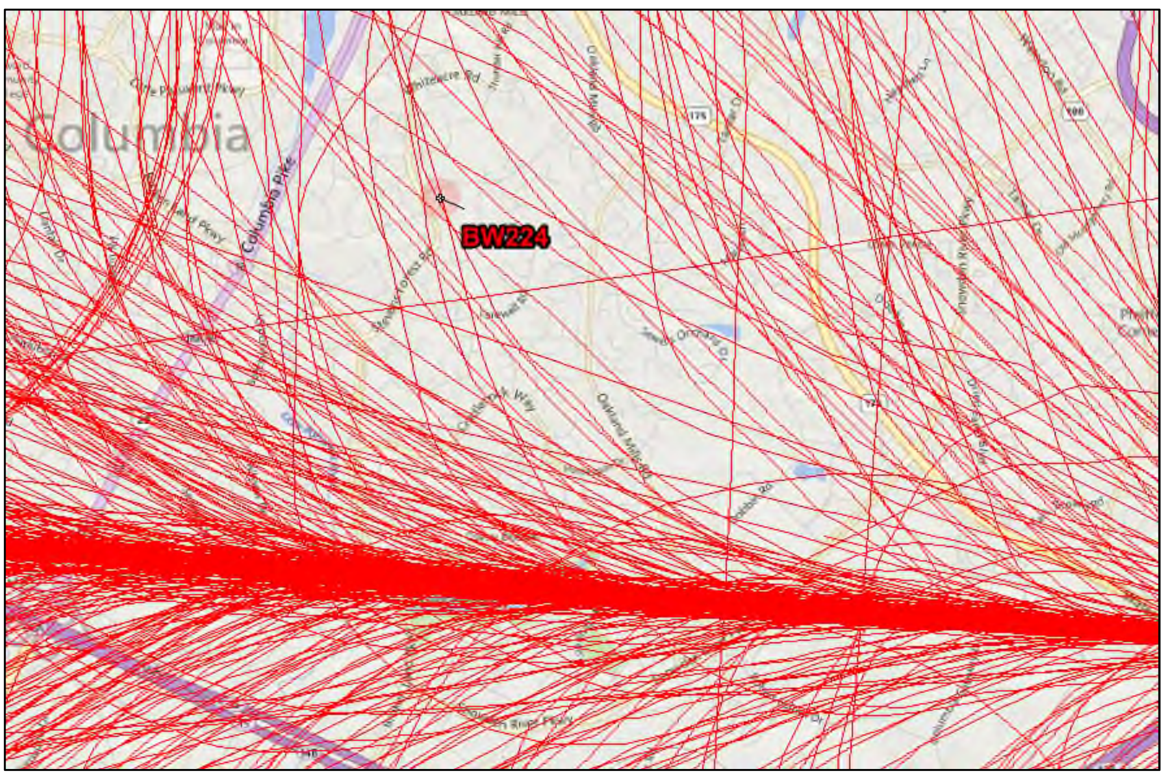

Figure 6. All Arrival Flight Tracks from Measurement Period – Runway 10

4. MEASURED NOISE LEVELS

This section provides an introduction to noise terminology, discusses the noise levels from individual aircraft noise events, and summarizes the cumulative noise exposure over the measurement period.

4.1 Aircraft Noise Terminology

There are several key metrics which are used to describe aircraft noise on a single-event and cumulative basis. The appendix titled "How Do We Describe Aircraft Noise" provides a more detailed overview of the metrics which are discussed in this section.

In brief, noise can be described by A-Weighted Sound Pressure Level[1] and is expressed in decibels (noted as dB or dBA). This noise level rises and falls from second to second as noise becomes louder or quieter. The average noise level over some time period, such as an hour, is called the Equivalent Sound Pressure Level (Leq). For a particular noise event, such as an aircraft overflight, the loudest level at any instant during the event is the Maximum A-Weighted Sound Pressure Level (Lmax). The Lmax tends to correlate poorly to people's perception of the total "noisiness" of an event because it neglects the duration. The Sound Exposure Level (SEL) accounts for both the level and duration of the noise and is the best measure of the "noisiness" of a single event. Finally, the noise exposure over a complete day is represented by the Day-Night Average Sound Level (DNL). This metric sums all of the noise exposure over the day with a weighting for any noise which occurs during the nighttime (10 pm to 7 am).

4.2 Single Event Noise Levels

Figure 7 presents a count of noise events due to departures on Runway 28 at various Lmax values for the complete measurement period. For example, the tallest blue bar in the figure shows that 38 departures on Runway 28 had an Lmax of 64 dB. For typical conversational speech at a distance of approximately three feet, speech is interrupted by noise levels at or above 65 dB. Any noise events shown in this figure with a maximum level at or above 65 dB would, briefly for quieter events and longer for louder events, interrupt typical conversations outdoors. Figure 8 presents counts for some less common aircraft noise events: arrivals on Runway 10 and overflights not associated with BWI Marshall. Note that the scale of this chart is different due to the much smaller number of noise events as compared to Figure 7.

Figure 9 and Figure 10 tell a similar story using the SEL metric which corresponds better to people's judgment of the noisiness of an event. Departures on Runway 28 produced the largest number of noise events. Noise events from other aircraft operations, such as arrivals on Runway 10 or overflights not associated with BWI Marshall were less common.

Note that the focus of this study was louder aircraft noise events. Aircraft noise events with maximum levels at, near, or below the ambient noise levels from community noise sources are difficult, and sometimes impossible, to quantify and in most cases contribute little to the total noise exposure.

[1] A-Weighting simply refers to a method of computing the noise level which accounts for the particular response of the human ear. It is the standard for the vast majority of environmental noise analyses.

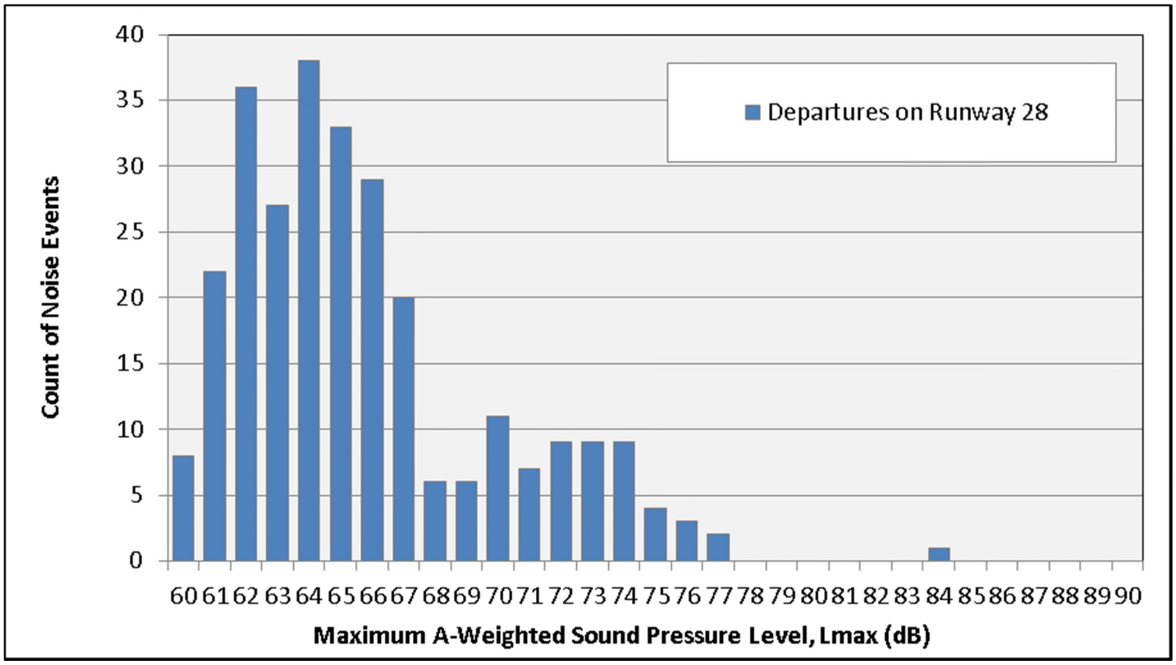

Figure 7. Counts of Maximum Noise Levels from Aircraft Overflights over the Full Measurement Period – Departures on Runway 28

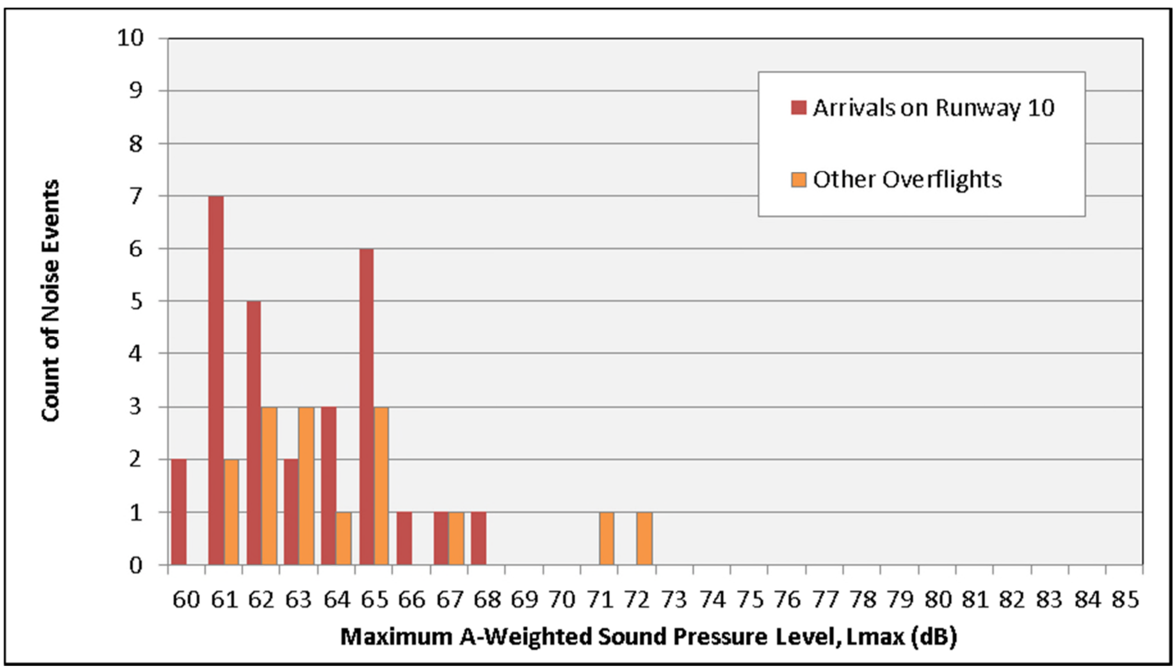

Figure 8. Counts of Maximum Noise Levels from Aircraft Overflights over the Full Measurement Period – Arrivals on Runway 10 and Overflights Not Associated with BWI Marshall

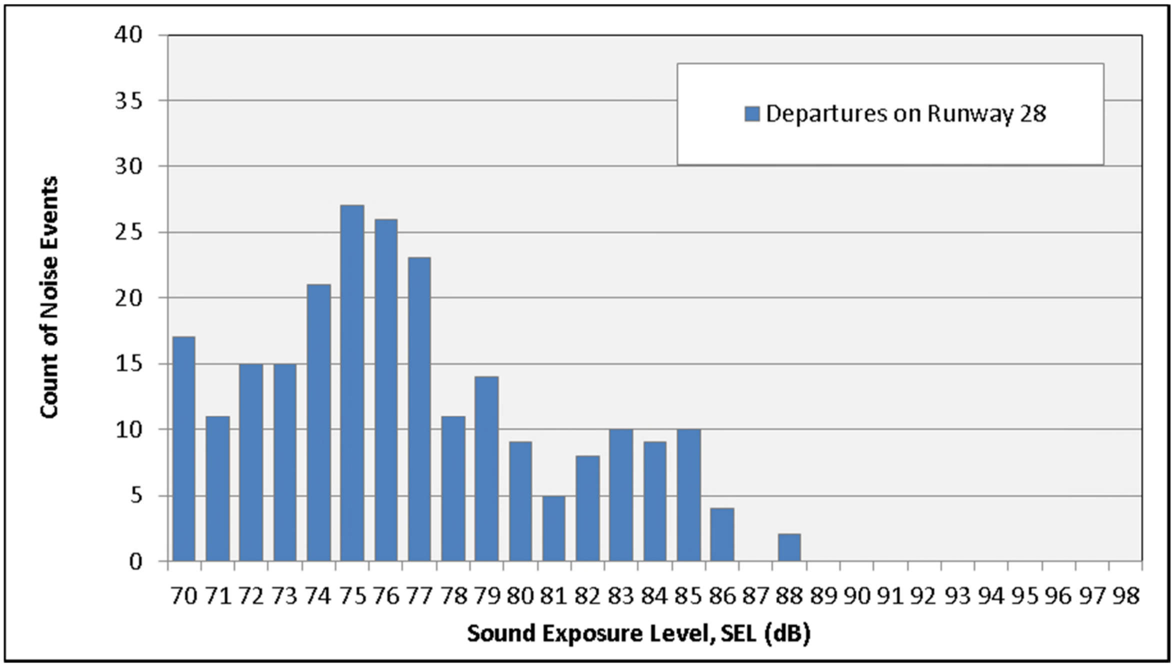

Figure 9. Counts of Sound Exposure Levels from Aircraft Overflights over the Full Measurement Period – Departures on Runway 28

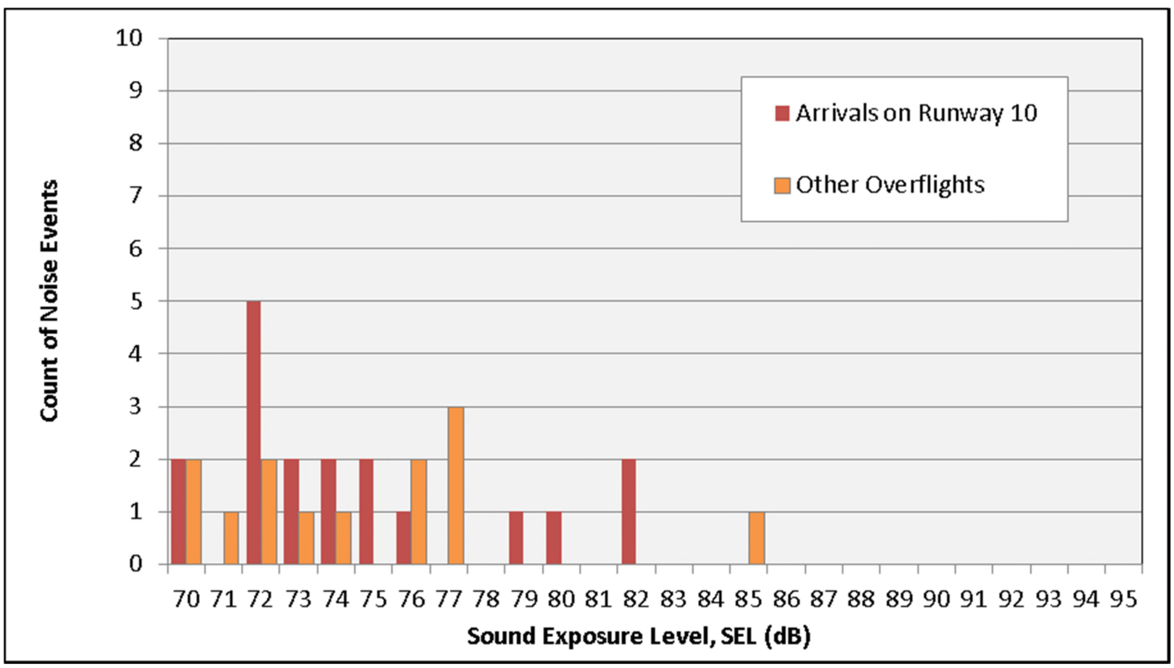

Figure 10. Counts of Sound Exposure Levels from Aircraft Overflights over the Full Measurement Period – Arrivals on Runway 10 and Overflights Not Associated with BWI Marshall

4.3 Cumulative Noise Levels

Figure 11 provides a way to visualize the changes in aircraft noise levels over the measurement period. The average aircraft noise level (Leq) is presented on an hourly basis. Hours with louder or more aircraft events will show higher Leq values. As one would expect, noise levels in early morning hours and late night tend to be the lowest. Regions where the bars are absent simply indicate periods where no loud aircraft noise events occurred.

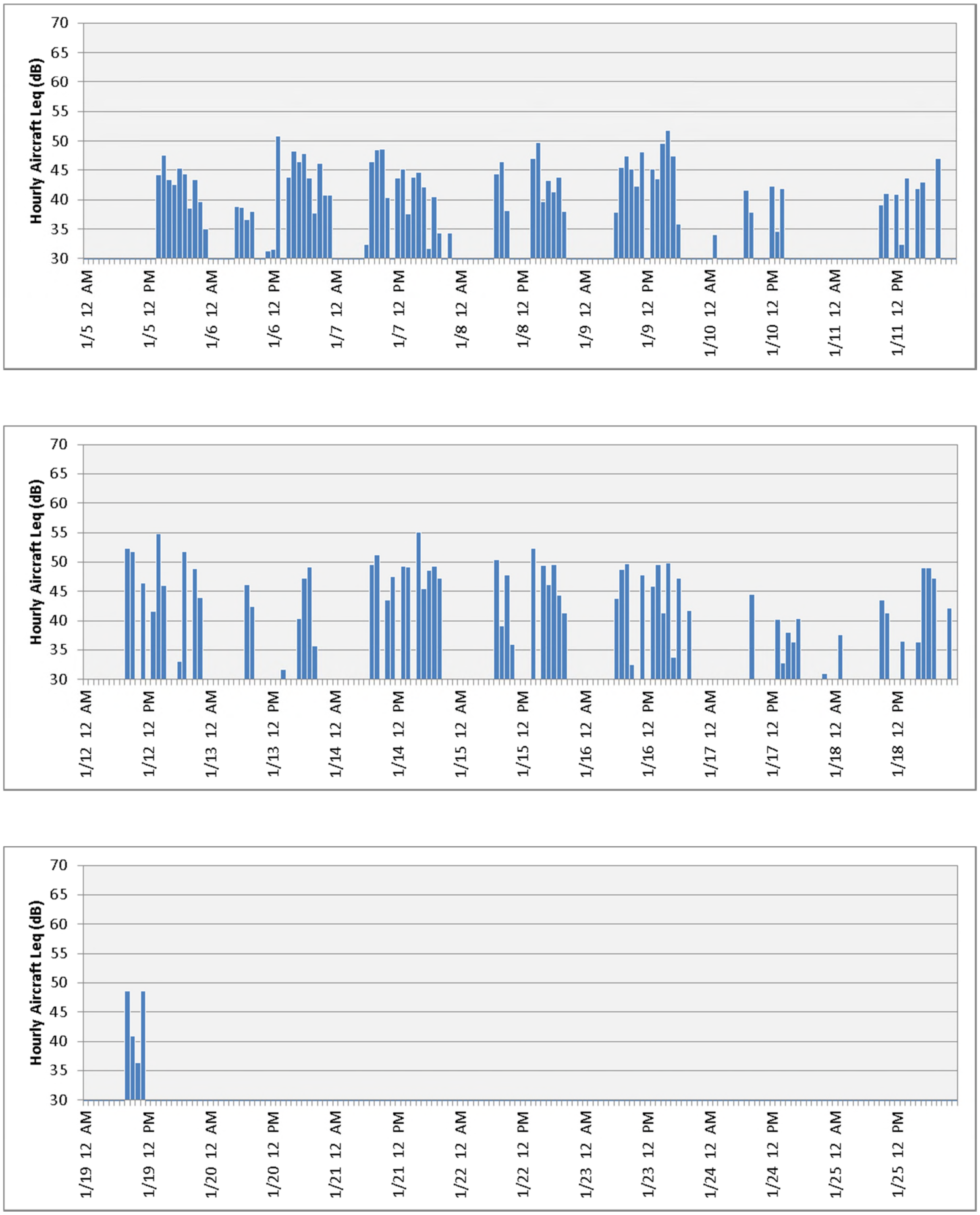

Figure 11. Average Hourly Aircraft Noise Levels

Table 1 summarizes the cumulative noise exposure over each of the fifteen days of recorded data within the measurement period using the DNL metric. DNL sums the noise from every aircraft noise event over the day. The formula for DNL gives an extra ten decibel weighting to nighttime noise events to account for the intrusive nature of these events. The DNL for the thirteen complete days, as shown in Table 1, ranged from 35 dB to 47 dB.

The composite aircraft DNL over the full measurement period was 43 dB. The DNL over a full year will depend on the type and number of aircraft utilizing BWI Marshall and percentage of time the airport spends in various operational configurations.

As shown in the single event figures, Figure 7 through Figure 10, most of the loudest noise events at this site are from Departures on Runway 28. Departures on Runway 28 accounted for about ninety-one percent of the DNL over the period. Arrivals on Runway 10 contributed approximately three percent of the total DNL over the period. The remainder was contributed by arrivals and departures on other BWI Marshall runways, and other aircraft overflights not associated with BWI Marshall.

Table 1. Measured Daily Aircraft Noise Levels

Date	Day-Night Average Sound Level, DNL (dB)	Hours Measured	Primary Aircraft Operations
1/5/2015	45*	9	33L Arr / 28 Dep
1/6/2015	45	24	10 Arr / 15R Dep 33L Arr / 28 Dep
1/7/2015	42	24	33L Arr / 28 Dep
1/8/2015	41	24	33L Arr / 28 Dep
1/9/2015	44	24	33L Arr / 28 Dep
1/10/2015	35	24	33L Arr / 28 Dep
1/11/2015	38	24	33L Arr / 28 Dep
1/12/2015	47	24	28 Arr / 28 Dep
1/13/2015	39	24	33L Arr / 28 Dep
1/14/2015	46	24	33L Arr / 28 Dep
1/15/2015	44	24	33L Arr / 28 Dep 10 Arr / 15R Dep 33L Arr / 28 Dep
1/16/2015	45	24	33L Arr / 28 Dep
1/17/2015	35	24	10 Arr / 15R Dep
1/18/2015	43	24	10 Arr / 15R Dep 33L Arr / 28 Dep
1/19/2015	40*	15	33L Arr / 28 Dep
Total	**43**	**336**	-

Notes:
* Measurements for a partial day may not represent the average noise level for the complete day.

4.4 Comparison of Noise Levels

The previous sections discuss the most recent measurements at this location, conducted in January of 2015. Aircraft noise measurements were also conducted at this site in June of 2014. Comparison of the results of these two sets of measurements show that the measured aircraft noise levels in January of 2015 were lower than those measured in June of 2014. Fewer loud noise events were recorded by the noise monitor and the individual noise events were quieter as well.

An analysis of the aircraft operations, flight profiles, and noise data for these two periods reveals three factors which may have contributed to the lower measured aircraft noise levels:

1. Aircraft operations decreased – In June, BWI Marshall had an average of 721 daily arrivals and departures. In January, that number decreased to 577 daily arrivals and departures. This twenty percent decrease in overall operations included a sixteen percent decrease in departures on Runway 28 and a forty-three percent decrease in arrivals on Runway 10, the two most important contributors to aircraft noise levels at this site.

2. Runway 28 departures were higher – Figure 12 displays the percentage distribution of altitudes for Runway 28 departures at their point of closest approach to the measurement site. On average, these departures were 1,150 ft higher in January of 2015 compared to June of 2014. Aircraft climb performance is partially dependent on atmospheric conditions such as wind, humidity, and temperature. In particular, aircraft climb more slowly at warmer temperatures compared to cooler temperatures.

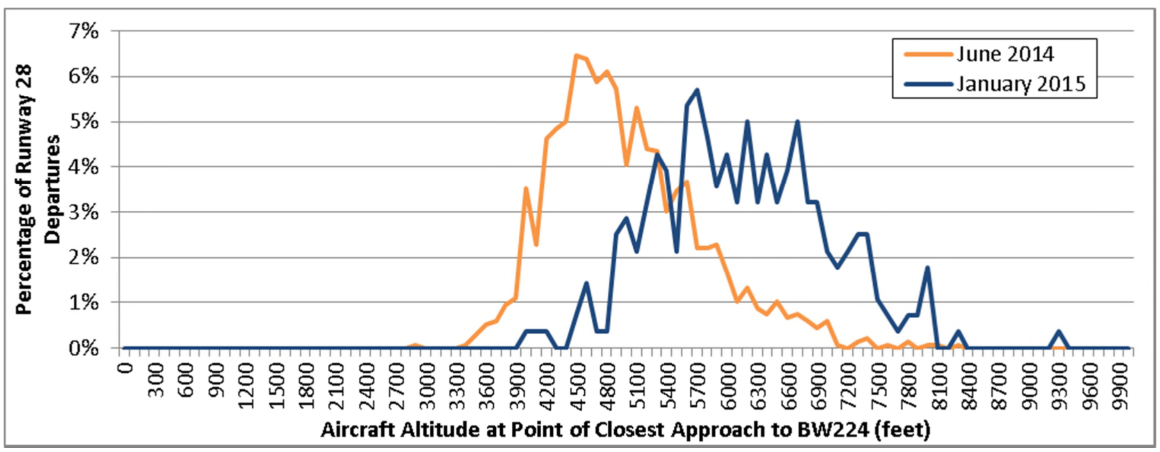

Figure 12. Distribution of Altitudes for Runway 28 Departures

3. Possible contamination by non-aircraft sources was reduced – Measured aircraft noise levels may include the contributions of local noise sources for two reasons. The noise-to-track matching in the NOMS errors on the side of attributing noise events to aircraft rather than a community noise source. If any aircraft is in the vicinity of the measurement site when a noise event occurs, the NOMS matches the noise event to this aircraft. Thus, the reported aircraft noise levels can be inflated due to loud local noises which occur when a relatively quiet aircraft is nearby.

   Additionally, the measured aircraft noise level always includes the contribution of background noises which occur as the aircraft passes. When the aircraft noise level is greater than ten decibels above the background, this contribution is negligible. When background noise levels are higher, this contribution may cause reported aircraft noise levels to be inflated.

In addition to logging loud noise events, the noise monitor tallies the distribution of all noise levels that occur over the measurement period. One metric which can be computed from this distribution is the background noise level[2]. Background noise levels at the measurement site were approximately 7 dB to 10 dB lower in January of 2015 than in June of 2014. In January, the quietest hours of the day, typically in the middle of the night, had background noise levels of 28 dB to 38 dB. The loudest hours of the day had background noise levels which ranged from 43 dB to 52 dB. In contrast, the quietest hours of the day in June had background noise levels of 37 dB to 49 dB. The loudest hours of the day had background noise levels which ranged from 50 dB to 59 dB.

The higher background noise levels in June may have contributed to the higher measured aircraft noise levels during this period.

[2] In technical terms, the background noise level for any hour is determined by computing the noise level which is exceeded ninety percent of the time.

How do we Describe Aircraft Noise?

We use a number of terms to describe aircraft noise. These metrics form the basis for the majority of noise analyses conducted at most airports in the U.S.

The Decibel, dB

All sounds come from a source – a musical instrument, a voice speaking, an airplane. The energy that produces these sounds is transmitted through the air in waves, or sound pressures, which impinge on the ear, creating the sound we hear.

The decibel is a ratio that compares the sound pressure of the sound source of interest (e.g., the aircraft over flight) to a reference pressure (the quietest sound we can hear). Because the range of sound pressures is very large, we use logarithms to simplify the expression to a smaller range, and express the resulting value in decibels (dB). Two useful rules of thumb to remember when comparing individual noise sources are: (1) most of us perceive a six to ten dB increase to be about a doubling of loudness, and (2) changes of less than about three dB are not easily detected outside of a laboratory.

The A-Weighted Decibel, dB(A)

Frequency, or "pitch", is an important characteristic of sound. When analyzing noise, we are interested in how much is low-, middle-, and high-frequency noise. This breakdown is important for two reasons. First, our ears are better equipped to hear mid- and high-frequencies; thus, we find mid- and high-frequency noise more annoying. Second, engineering solutions to noise problems are different for different frequency ranges. The "A" filter approximates the sensitivity of our ear and helps us to assess the relative loudness of various sounds.

Maximum A-weighted Sound Level, Lmax

A-weighted sound levels vary with time. For example, the sound increases as an aircraft approaches, then falls and blends into the background as the aircraft recedes into the distance. Figure 1 illustrates this phenomenon. We often describe a particular noise "event" by its maximum sound level (Lmax). Figure 2 shows typical Lmax values for some common noise sources. In fact, two events with identical Lmax may produce very different total exposures. One may be of very short duration, while the other may be much longer.

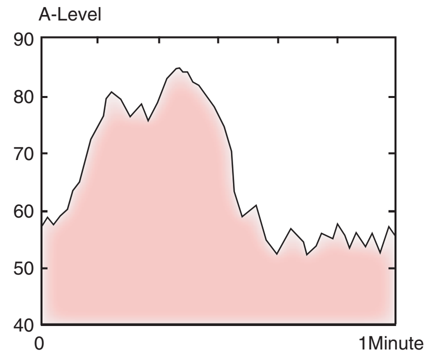

Figure 1. A-weighted Sound Levels Over Time

Sound Exposure Level, SEL

The most common measure of cumulative noise exposure for a single aircraft flyover is the Sound Exposure Level (SEL). Mathematically, it is the sum of the sound energy over the duration of a noise event – one can think of it as an equivalent noise event with a one-second duration. Figure 3 shows that portion of the sound energy included in this event. Because the SEL is normalized to one second, it will almost always be larger in magnitude than the Lmax for the event. In fact, for most aircraft events, the SEL is about 7 to 12 dB higher than the Lmax. Also, the fact that it is cumulative measure means that a higher SEL can result from either a louder or longer event, or some combination.

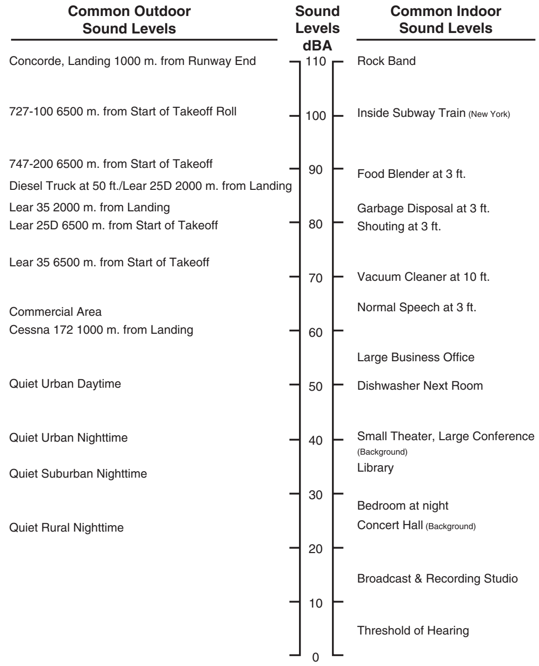

Figure 2. Common Environmental Sound Levels

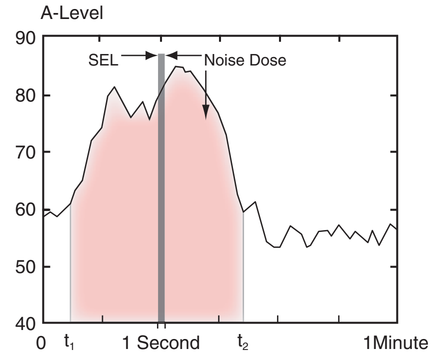

Figure 3. Sound Exposure Level

SEL provides a comprehensive way to describe noise events for use in modeling and comparing noise environments. Computer noise models base their computations on SEL values.

Day-Night Average Sound Level, DNL

The Day-Night Average Sound Level (DNL) represents noise as it occurs over a 24-hour period, with the assumption noise events occurring at night (10 p.m. to 7 a.m.) are 10 dB louder than they really are. This 10 dB penalty is applied to account for greater sensitivity to nighttime noise, and the fact that events at night are often perceived to be more intrusive because nighttime ambient noise is less than daytime ambient noise.

Figure 4 depicts a hypothetical daily noise dose. The top frame repeats the one-minute noise exposure that was shown in Figure 1. The center frame includes this one-minute interval within a full hour; now the shaded area represents the noise during that hour with 16 noise events, each producing an SEL. Finally, the bottom frame includes the one-hour interval within a full 24 hours. Here the shaded area represents the listener's noise dose over a full day.

DNL normally can be measured with standard monitoring equipment or predicted with computer models.

Most aircraft noise studies utilize computer-generated estimates of DNL, determined by accounting for all of the SELs from individual events which comprise the total noise dose at a given location on the ground.

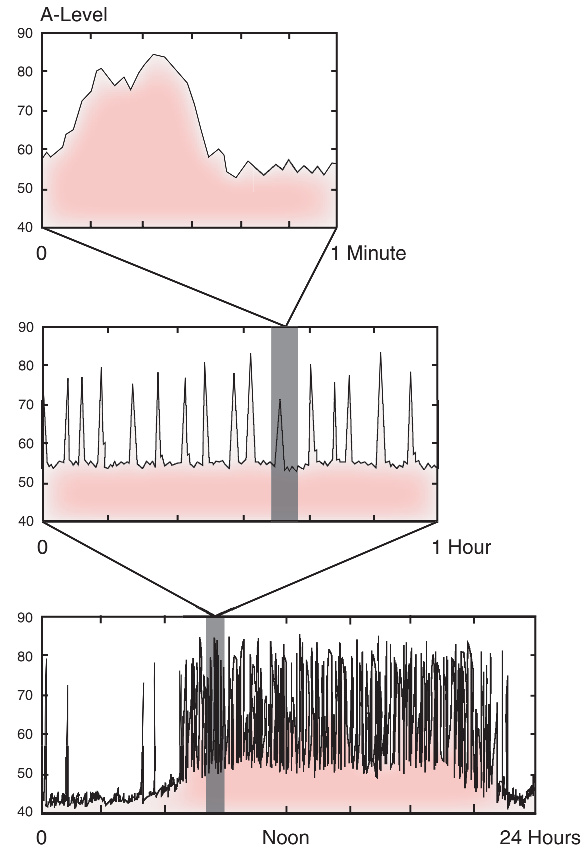

Figure 4. Daily Noise Dose

Computed values of DNL are often depicted as noise contours reflecting lines of equal exposure around an airport (much as topographic maps indicate contours of equal elevation). DNL contours usually reflect annual average operating conditions, taking into account the average number of flights each day, how often each runway is used throughout the year, and where over the surrounding communities the aircraft normally fly.