Aircraft Noise Measurement Report

Cedar Lane

Severn, MD 21144

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1. INTRODUCTION

This memorandum presents the measured aircraft noise levels for the period of December 23, 2016 to January 6, 2017 at Cedar Lane Severn, MD 21144. This residence is located approximately 1.2 miles south of the southern end of Runway 15R/33L of Baltimore/Washington International Thurgood Marshall (BWI Marshall) Airport. Figure 1 shows the location of the measurement site (marked as BW243) relative to BWI Marshall. Measurement data were collected and analyzed on behalf of the Maryland Department of Transportation 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.

Note that noise levels at this location were also monitored over the period of December 6 to December 23, 2016. Regular calibration checks on two occasions during this initial measurement period indicated an equipment malfunction leading to erroneous noise levels. The meter was removed from the field on December 23 and replaced with a new meter. Regular calibration checks on the replacement meter over the period of December 23, 2016 to January 6, 2017 indicated no malfunctions. <u>This report covers the data recorded by the replacement meter.</u>

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 flights 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 2 of this memorandum describes the measurement location. Section 3 presents information about the aircraft operations during the measurement period. Section 4 summarizes the measured noise levels. Section 5 provides conclusions. The appendix titled "How Do We Describe Aircraft Noise" provides background information on acoustical terms used in this memorandum.

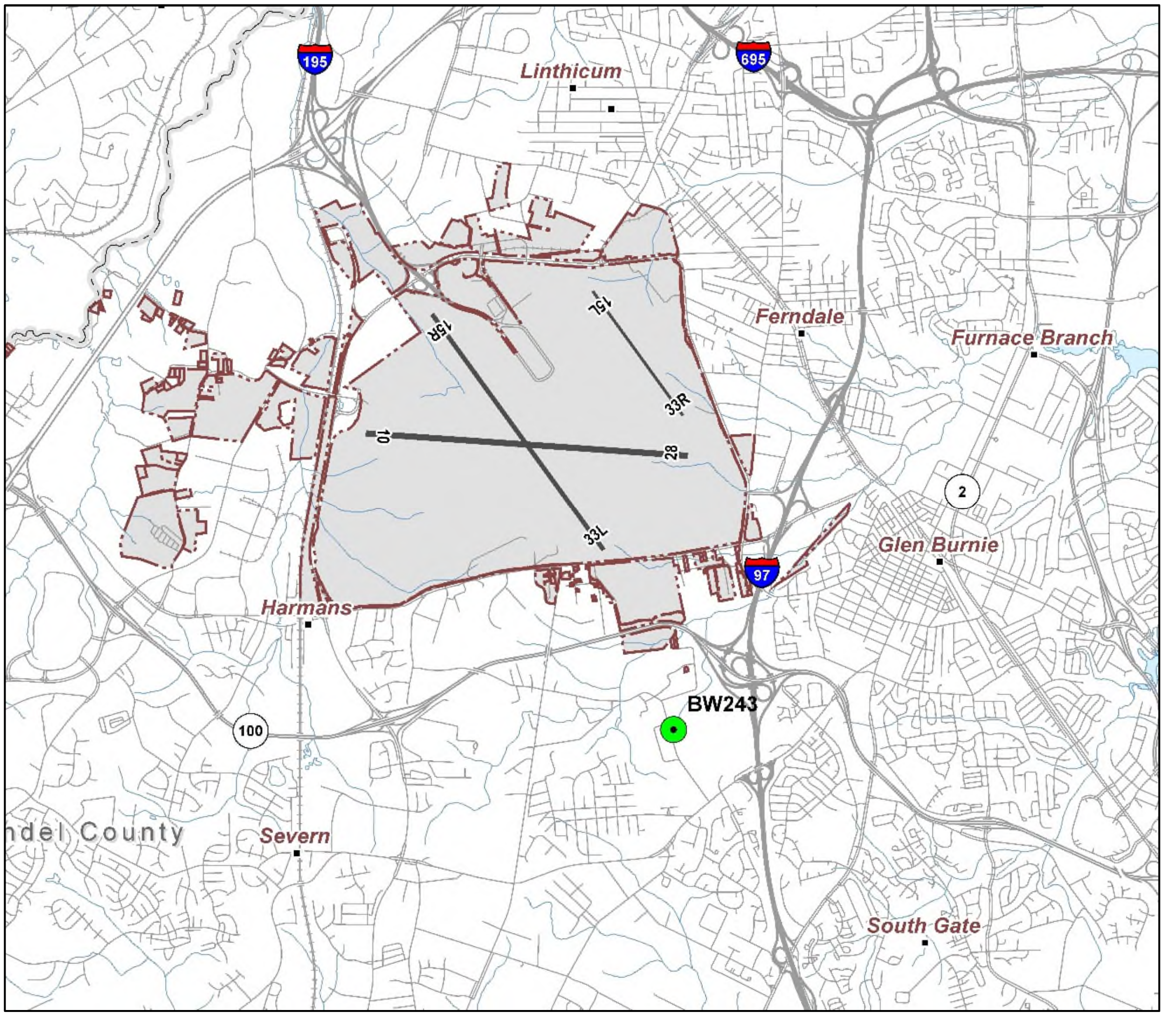

Figure 1. Noise Monitoring Location Map

2. MEASUREMENT SITE

Aircraft noise levels were measured from the early afternoon on December 23, 2016 through the early afternoon of January 6, 2017 at Cedar Lane in Severn. The noise monitor was placed in the front yard 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 three to four days during the measurements during equipment checks. The meter was only stopped briefly for the periodic calibration checks.

Notable noise sources at this site include aircraft overflights, primarily arrivals to and departures from BWI Marshall, and typical suburban sounds including local street traffic and dogs.

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Figure 2. Noise Measurement Microphone

3. AIRCRAFT OPERATIONS

The measurement site is located to the south of BWI Marshall and the primary aircraft noise events for this site are due to departures on BWI Marshall Runway 15R and arrivals on Runway 10. Other less common aircraft noise events are due to departures on Runway 28 and arrivals on Runway 33R.

During the measurement period, BWI Marshall operated in two configurations:

- departures on Runway 28 and arrivals on Runway 33L (west flow) and
- departures on Runway 15R and arrivals on Runway 10 (east flow).

The most common configuration on an annual basis at BWI Marshall, departures on Runway 28 and arrivals on Runway 33L, was active for nine days during the measurement period. The configurations with departures on Runway 15R and arrivals on Runway 10 was active for two days during the period. On three days, BWI Marshall operated in combinations of the two configurations above 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 displays all BWI Marshall flight tracks for a typical day during the measurement period in west flow, which primarily utilizes Runway 28 for departures and Runway 33L for arrivals. The red flight tracks are arrivals and the blue flight tracks are departures. The location of the measurement site is marked with its unique identifier in the NOMS, “BW243”. Figure 4 displays the same west flow flight tracks at a larger scale. Again, the text “BW243” shows the location of the measurement site. In west flow, the primary BWI Marshall overflights were arrivals on Runway 33L which were 300 to 500 ft. above ground level at their point of closest approach to the measurement site. The most common altitude was 400 ft.

Figure 5 displays all BWI Marshall flight tracks for a typical day during the measurement period in east flow, which primarily utilizes Runway 15R for departures and Runway 10 for arrivals. Figure 6 displays the same flight tracks at a larger scale. In east flow, the primary BWI Marshall overflights were departures on Runway 15R. Departures on Runway 15R were 1,200 to 2,100 ft. above ground level at their point of closest approach to the measurement site, with the most common altitude being 1,500 ft.

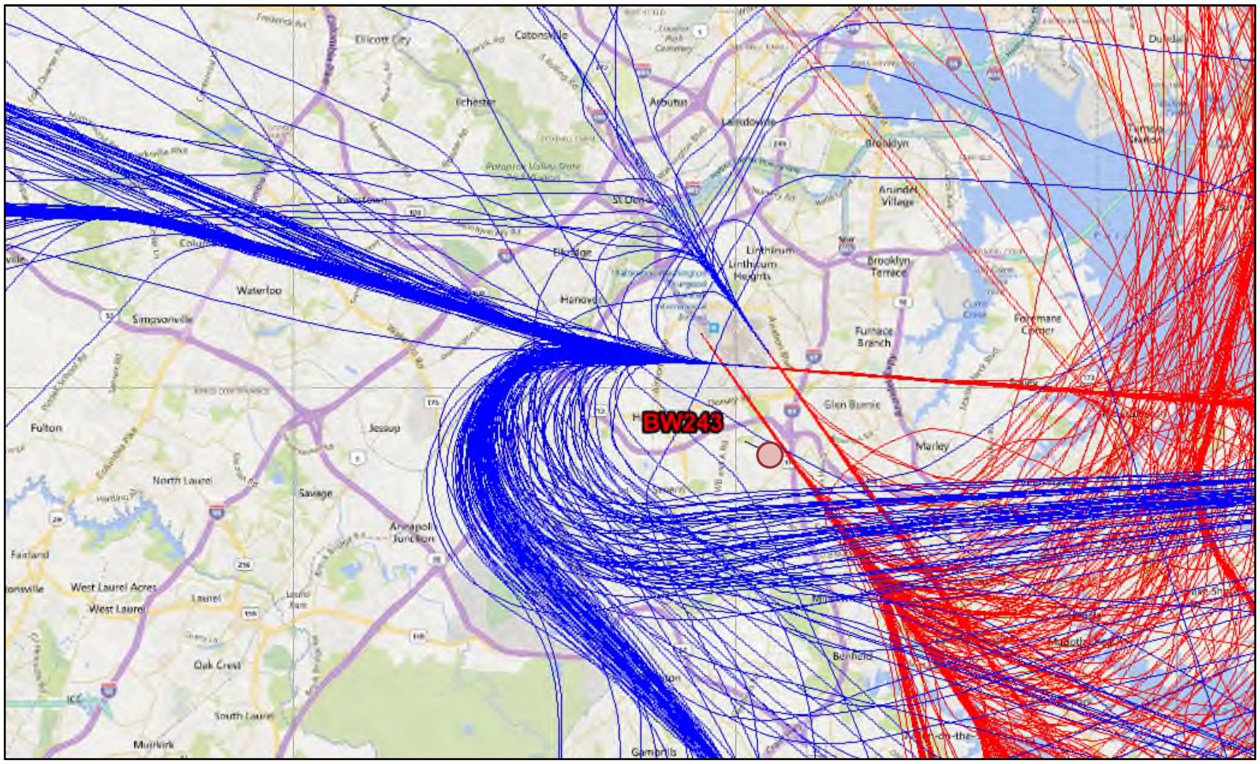
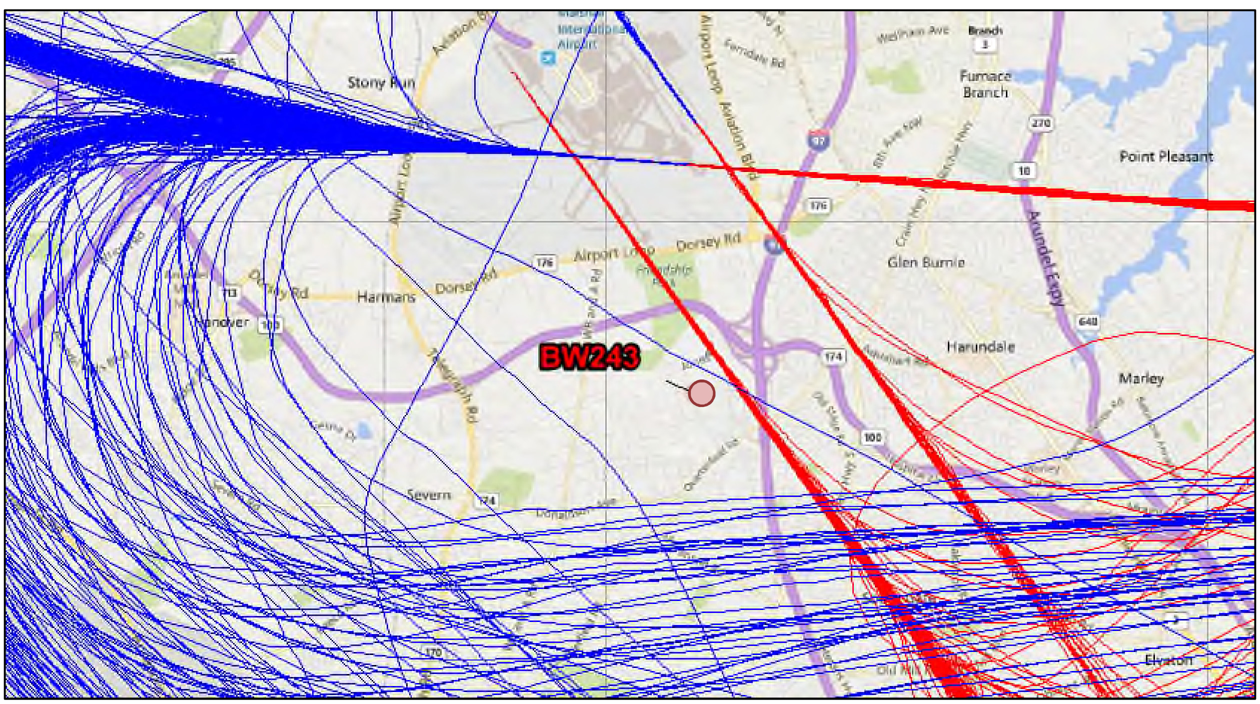


Figure 3. All Flight Tracks for a West Flow Day – December 27, 2016
(red = arrivals, blue = departures)



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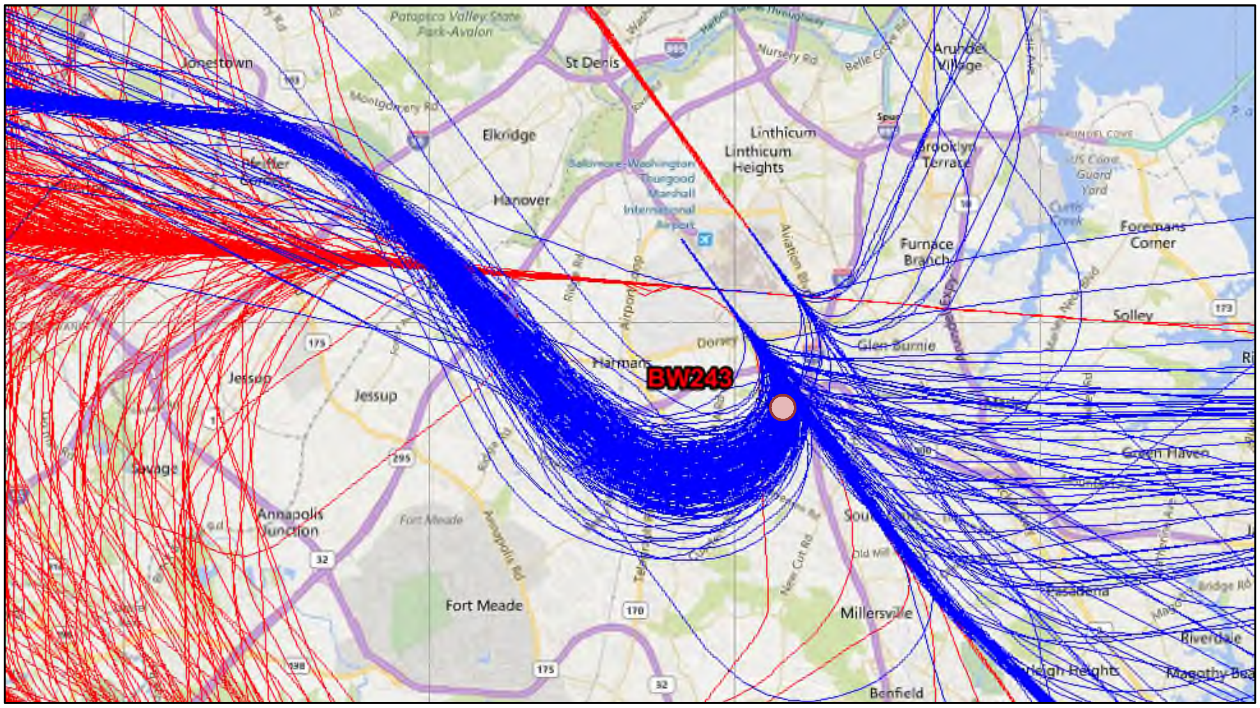

Figure 5. All Flight Tracks for an East Flow Day – December 26, 2016
(red = arrivals, blue = departures)

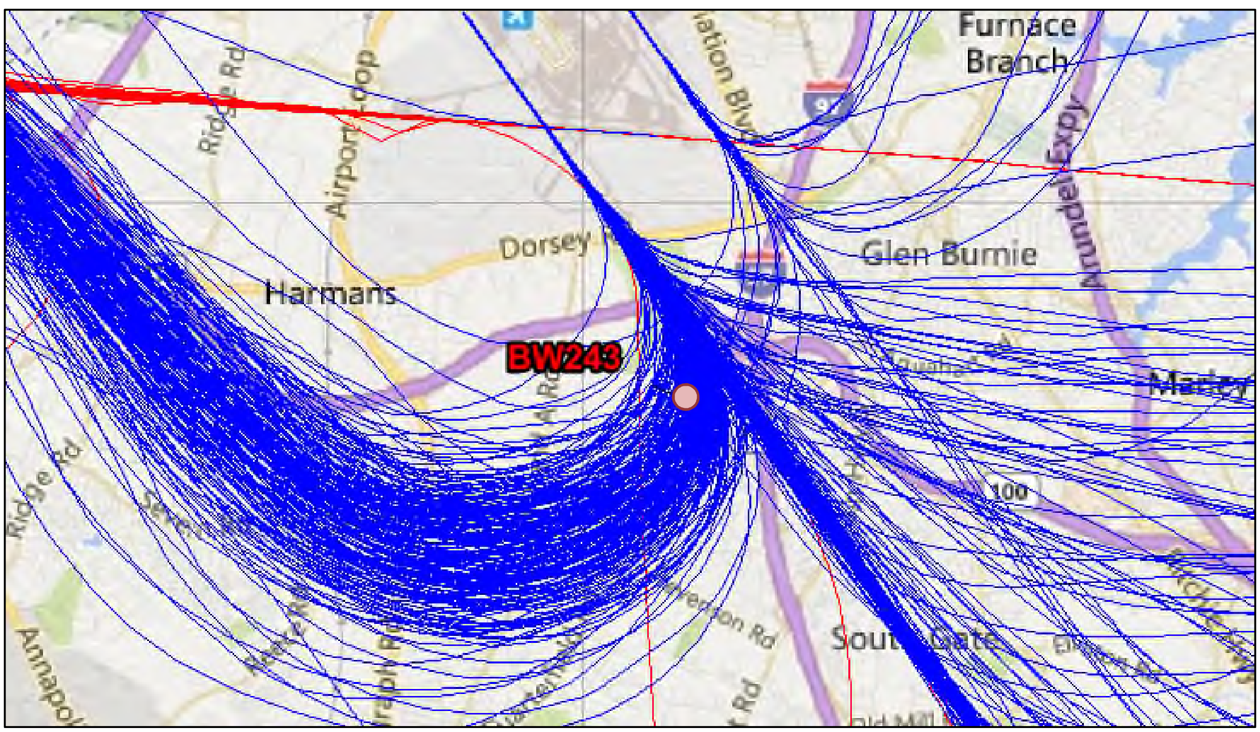

Figure 6. All Flight Tracks for an East Flow Day – December 26, 2016
(red = arrivals, blue = departures)

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 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 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 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 ten decibel weighting for any noise which occurs during the nighttime (10 pm to 7 am) to account for the intrusive nature of these noise events.

4.2 Single Event Noise Levels

Figure 7 presents a count of noise events due to departures on Runway 15R and arrivals on Runway 33L at various Lmax values for the complete measurement period. For example, the tallest red bar in the figure shows that 607 arrivals on Runway 33L had an Lmax of 70 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 shows counts of noise events at various Lmax values due to departures on Runway 28 and other arrivals on Runway 33R. Note that there were far fewer noise events due to these aircraft operations as compared to arrivals on Runway 10 and therefore the vertical scale of this figure is quite different from the scale in 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. Arrivals on Runway 33L produced the largest number of loud noise events. Departures on Runway 15R were less common, but generally louder. Noise events due to departures on Runway 28 and arrivals on Runway 33R were much less common.

Note that the noise events measured and presented in this report are those which can be clearly detected by the noise measurement equipment. 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.

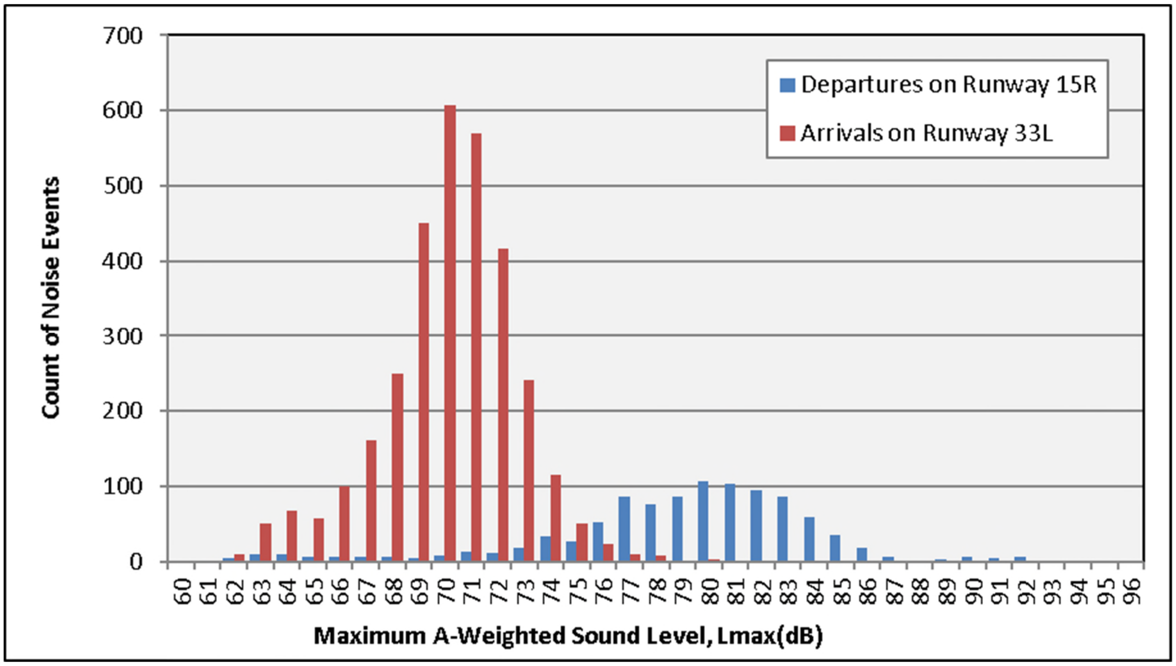

Figure 7. Counts of Maximum Noise Levels from Aircraft Overflights over the Full Measurement Period – Departures on Runway 15R and Arrivals on Runway 33L

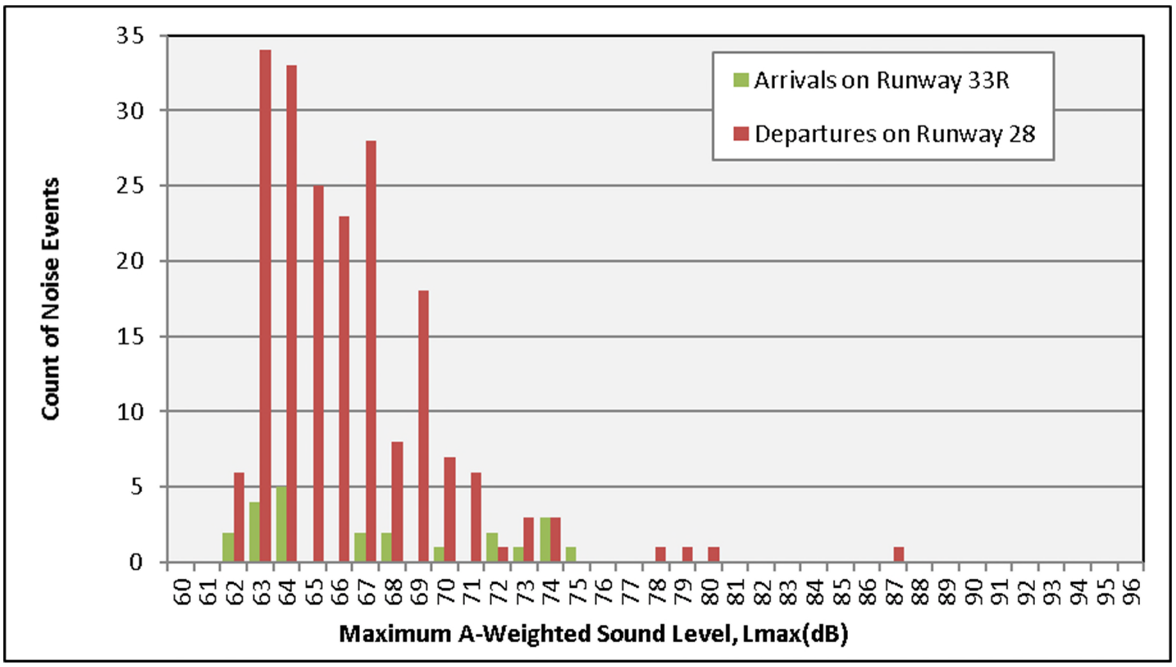

Figure 8. Counts of Maximum Noise Levels from Aircraft Overflights over the Full Measurement Period – Departures on Runway 28 and Arrivals on Runway 33R

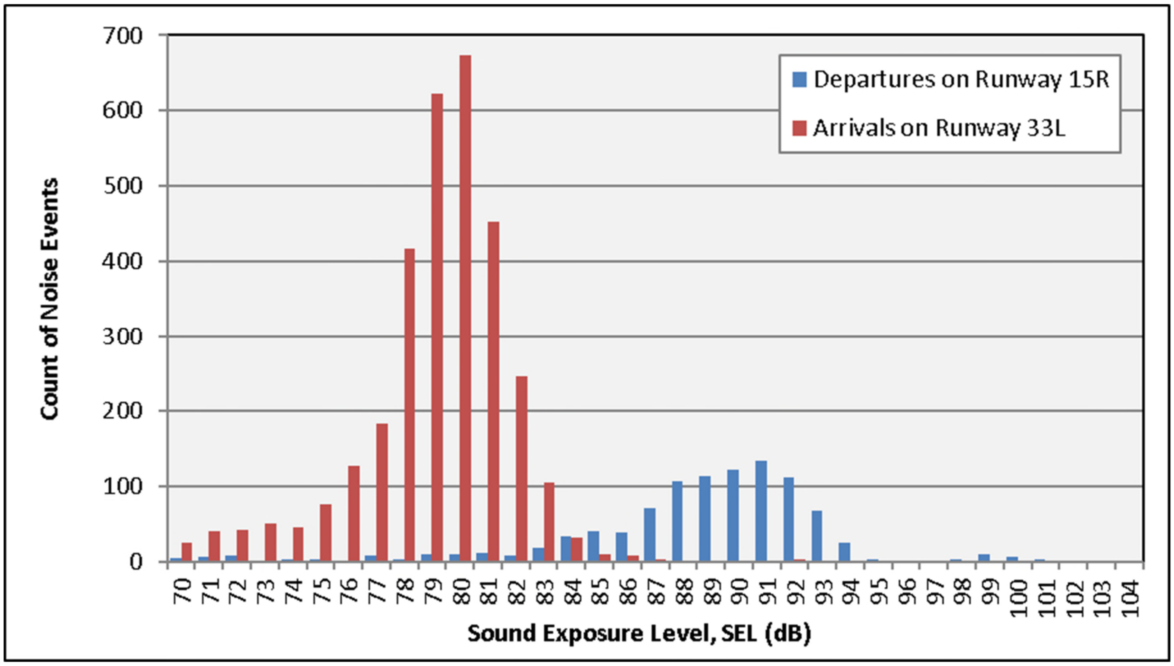

Figure 9. Counts of Sound Exposure Levels from Aircraft Overflights over the Full Measurement Period – Departures on Runway 15R and Arrivals on Runway 33L

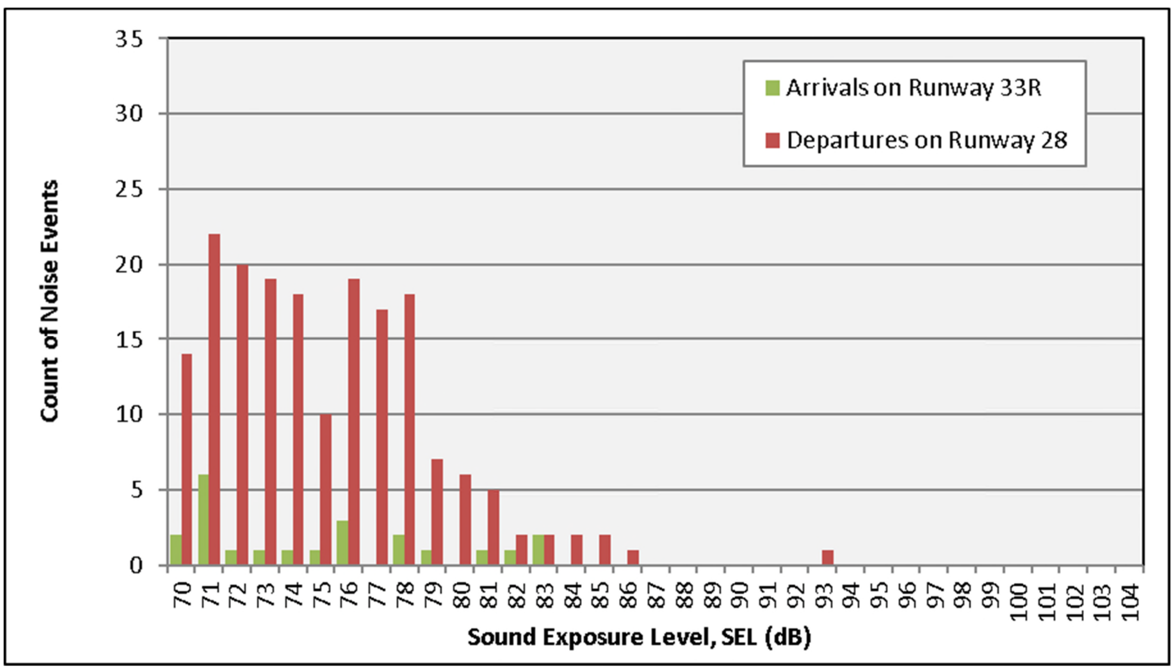

Figure 10. Counts of Sound Exposure Levels from Aircraft Overflights over the Full Measurement Period – Departures on Runway 28 and Arrivals on Runway 33R

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. Regions where the bars are absent simply indicate periods where no loud aircraft noise events occurred. Note that the cumulative noise level for each day incorporates these hourly noise levels with an additional ten decibel weighting for nighttime noise levels. This cumulative daily noise level, called DNL, is discussed next.

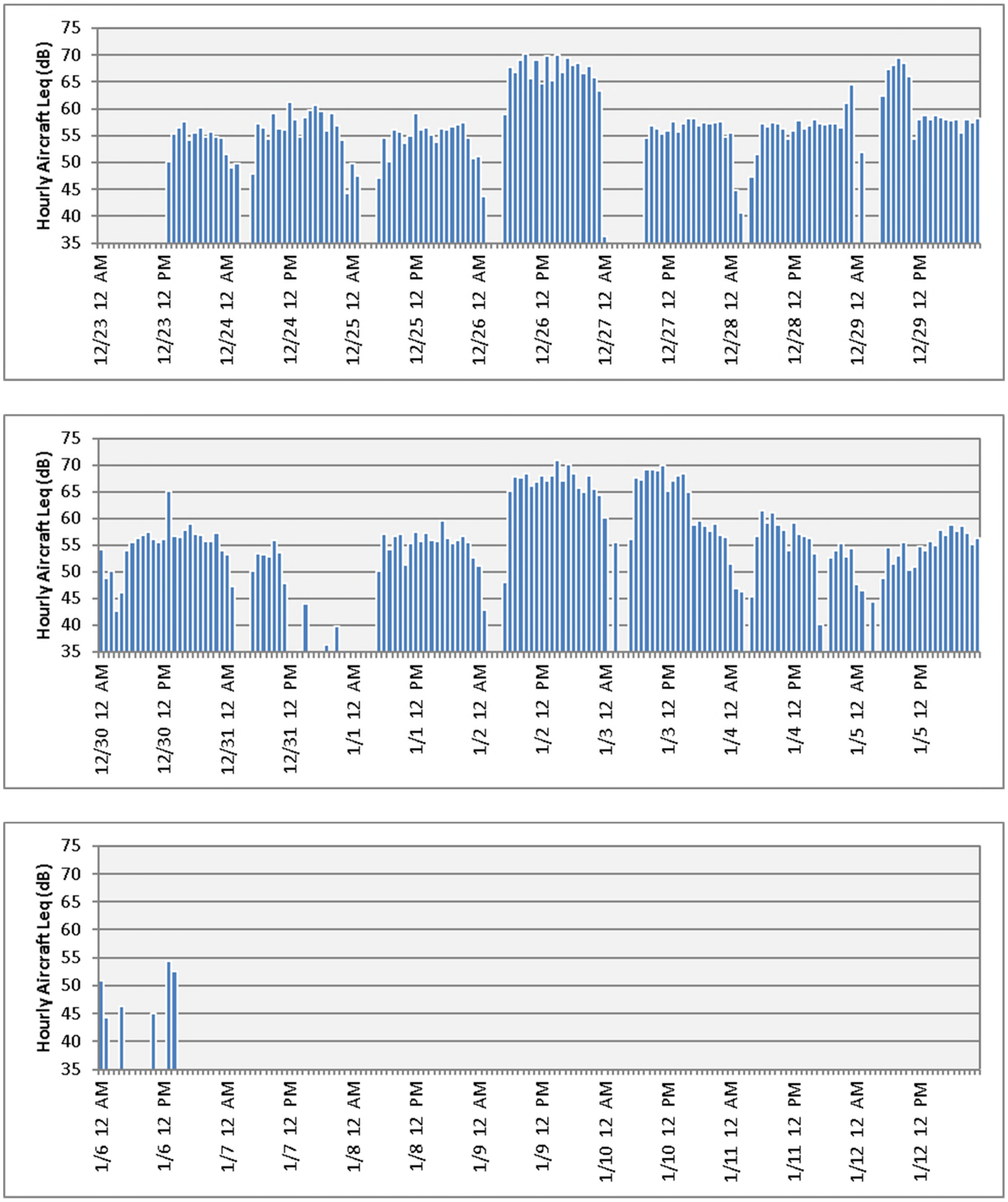

Figure 11 Average Hourly Aircraft Noise Levels

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 55 dB to 70 dB.

Table 1. Measured Daily Aircraft Noise Levels

Date	Day-Night Average Sound Level, DNL (dB)	Hours Measured	Primary Aircraft Operations
12/23/2016	60*	10	33L Arr / 28 Dep
12/24/2016	60	24	33L Arr / 28 Dep
12/25/2016	58	24	33L Arr / 28 Dep
12/26/2016	70	24	10 Arr / 15R Dep
12/27/2016	58	24	33L Arr / 28 Dep
12/28/2016	64	24	33L Arr / 28 Dep 10 Arr / 15R Dep (after 10 p.m.)
12/29/2016	67	24	10 Arr / 15R Dep (before 11 a.m.) 33L Arr / 28 Dep
12/30/2016	61	24	33L Arr / 28 Dep
12/31/2016	55	24	33L Arr / 28 Dep
1/1/2017	59	24	33L Arr / 28 Dep
1/2/2017	69	24	10 Arr / 15R Dep
1/3/2017	68	24	10 Arr / 15R Dep 33L Arr / 28 Dep (after 5 p.m.)
1/4/2017	61	24	33L Arr / 28 Dep
1/5/2017	59	24	33L Arr / 28 Dep
1/6/2017	52*	14	33L Arr / 28 Dep
Total	**64**	**336**	-

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

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 15R. These departures accounted for about seventy-five percent of the DNL over the period. Arrivals on Runway 33L contributed approximately twenty-four percent of the DNL over the period. Departures on Runway 28 contributed approximately one percent of the DNL over the period and arrivals on Runway 33R contributed less than one percent. The remainder of the DNL was due to other arrivals and departures at BWI Marshall and other aircraft overflights not associated with BWI Marshall.

5. CONCLUSION

The composite aircraft DNL over the full measurement period was 64 dB. The precise DNL over a full year will depend on the type and number of aircraft utilizing BWI Marshall and the percentage of time the airport spends in various operational configurations. Approximately seventy-seven percent of operations during the measurement period were in west flow and twenty-three were in east flow, which is near the typical annual average of seventy percent west flow operations. Noise levels at this site are higher during east flow than during west flow. Based only on the measurements and a seventy percent annual west flow assumption, the annual DNL at the measurement site is likely similar to or slightly higher than the 64 dB that was measured for this period. Table 1 shows the primary runways in use each day of the measurement period.

In Appendix A of 14 CFR Part 150, the Federal Aviation Administration provides guidelines for the compatibility of land uses with various annual DNL values. These guidelines consider residential land use to be incompatible when the DNL is 75 dB or greater. For noise levels between 65 dB and 75 dB DNL, residential land use is considered incompatible, but where the community determines that this land use must be allowed, measures to achieve greater than typical outdoor to indoor noise level reduction should be incorporated into building codes. The guidelines designate all land uses, including residential, as compatible for DNL values below 65 dB.

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.

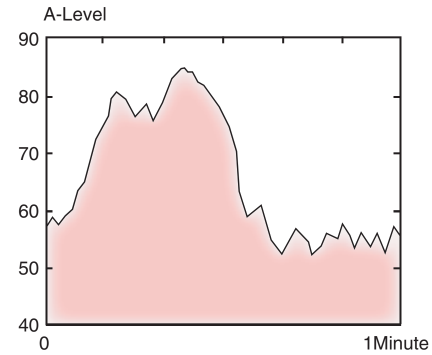

Figure 1. A-weighted Sound Levels Over Time

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.

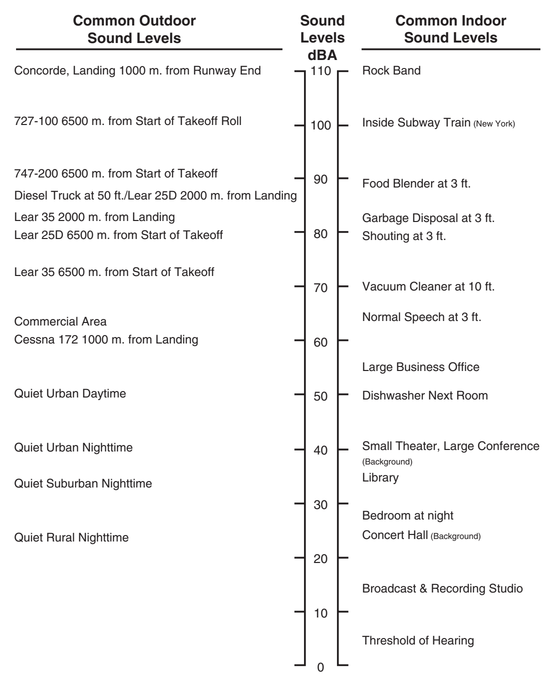

Figure 2. Common Environmental Sound Levels

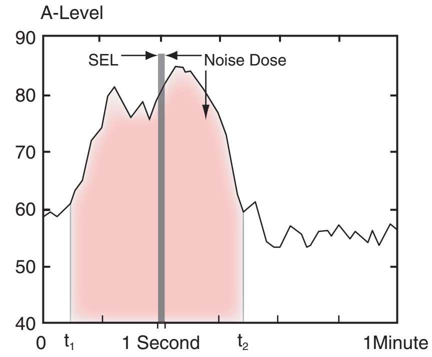

Figure 3. Sound Exposure Level

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.

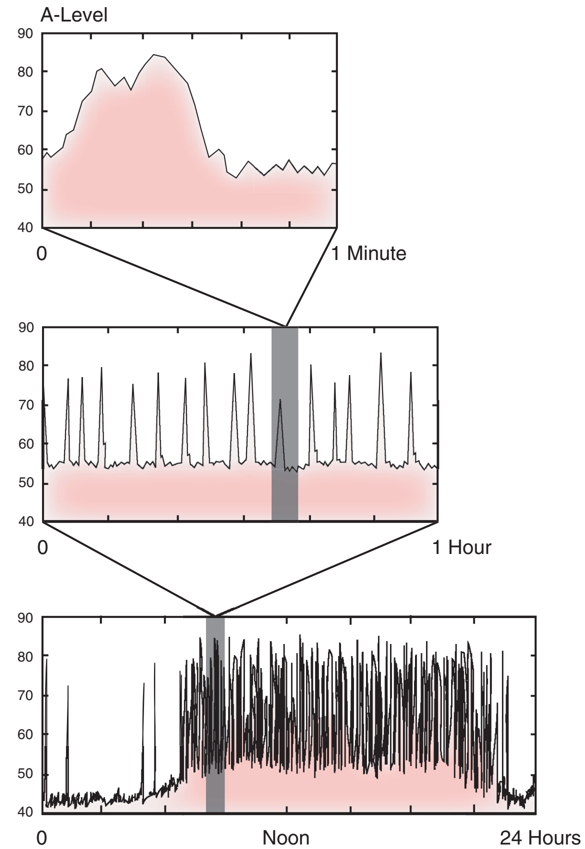

Figure 4. Daily Noise Dose

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.