Aircraft Noise Measurement Report

Carriage Dr.

Severn, MD 21144

Prepared by Harris Miller Miller & Hanson, Inc.

January 2018

1. INTRODUCTION

This memorandum presents the measured aircraft noise levels for the period of December 1 to December 15, 2017 at Carriage Dr. Severn, MD 21144. This residence is locatedapproximately 3.1 miles southwest of the western end of Runway 10/28 of Baltimore/WashingtonInternational Thurgood Marshall (BWI Marshall) Airport. Figure 1 shows the location of themeasurement site (marked as BW260) relative to BWI Marshall. Measurement data were collectedand 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.

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.

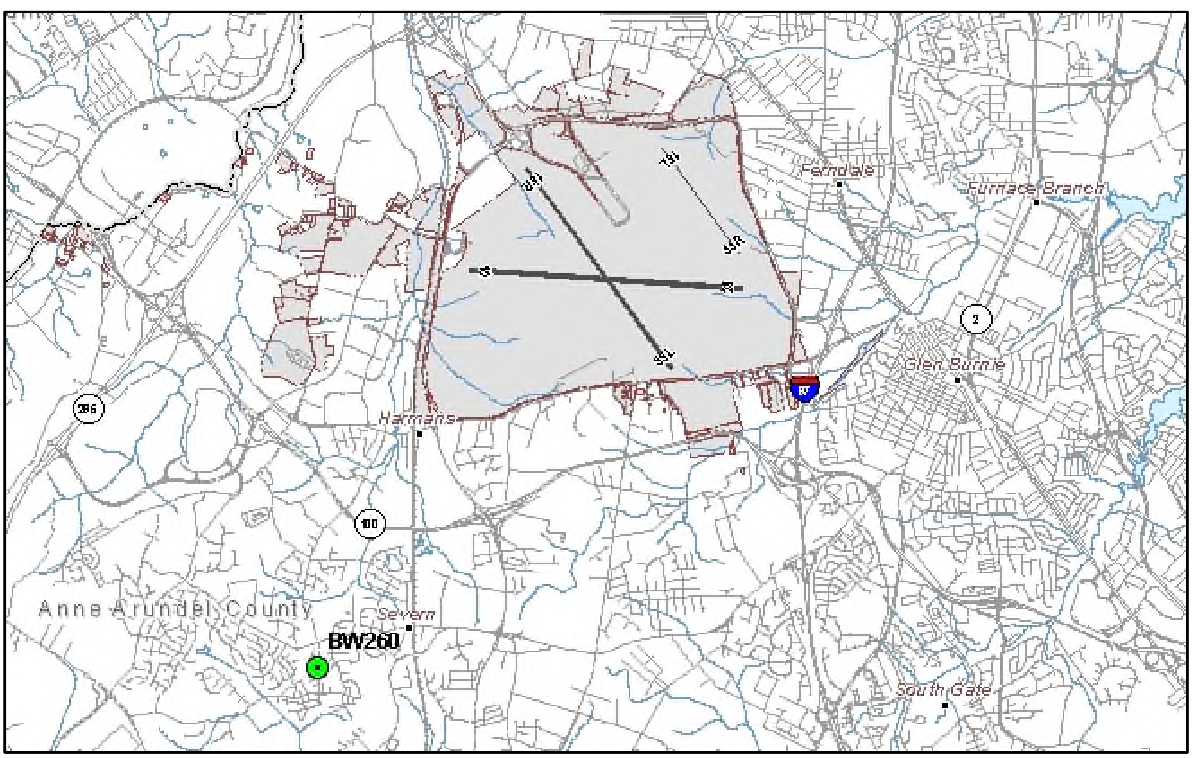

Figure 1. Noise Monitoring Location Map

2. MEASUREMENT SITE

Aircraft noise levels were measured from late morning on December 1 through late morning on December 15, 2017 at Carriage Dr. in Severn. The noise monitor was placed in the backyard ofthe 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, as well as typical suburban sounds including landscaping equipment and vehicle traffic.

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Figure 2. Noise Measurement Microphone

3. AIRCRAFT OPERATIONS

The measurement site is located to the southwest of BWI Marshall and the primary aircraft noise events for this site are due to departures on BWI Marshall Runways 15R and 28. Other less common aircraft noise events are due to overflights not associated with BWI Marshall.

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 ten days during the measurement period. On five days, BWI Marshall operated in combinations of the two configurations above during different portions of the day. BWI Marshall did not operate in the east flow configuration, departures on Runway 15R and arrivals on Runway 10, for a full day during the measurement period. 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, "BW260". Figure 4 displays the same west flow flight tracks at a closer scale. Again, the text "BW260" shows the location of the measurement site. In west flow, the primary BWI Marshall overflights were departures on Runway 28. Departures on Runway 28 were 2,400 to 6,400 ft. above ground level at their point of closest approach to the measurement site, with the most common altitude being 4,600 ft.

Figure 5 displays BWI Marshall flight tracks for the east flow portion of the day during the measurement period with the most east flow operations. East flow primarily utilizes Runway 15R for departures and Runway 10 for arrivals. Figure 6 displays the same flight tracks at a closer scale. In east flow, the primary BWI Marshall overflights were departures on Runway 15R. Departures on Runway 15R were 2,300 to 4,900 ft. above ground level at their point of closest approach to the measurement site, with the most common altitude being 3,200 ft.

Figure 7 displays all overflights not associated with BWI Marshall for a typical day during the measurement period. Figure 8 displays the same flight tracks at a closer scale. Both low and high altitude overflights produce noise at the measurement site. The primary low altitude overflights in these figures are local helicopter operations. These overflights were 700 to 1,300 ft. above ground level at their point of closest approach to the measurement site, with the most common altitude being 700 ft. The primary high altitude overflights in these figures are commercial jet arrivals to Ronald Reagan Washington National Airport. These overflights were 9,000 to 9,800 ft. above ground level at their point of closest approach with the most common altitude being 9,400 ft.

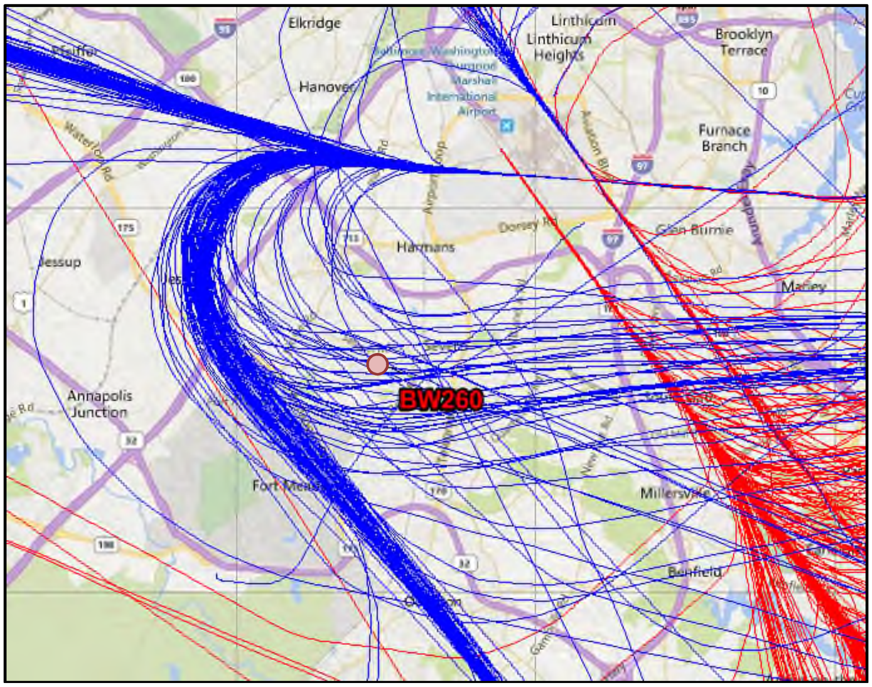

Figure 3. All Flight Tracks for a West Flow Day – December 2, 2017
(red = arrivals, blue = departures)

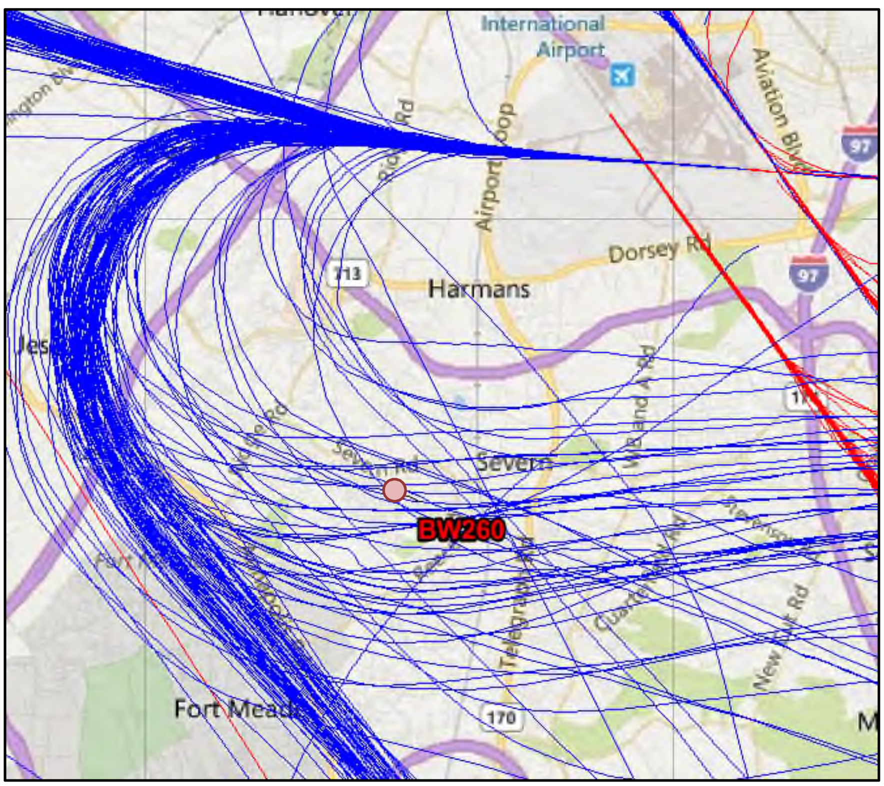

Figure 4. All Flight Tracks for a West Flow Day – December 2, 2017
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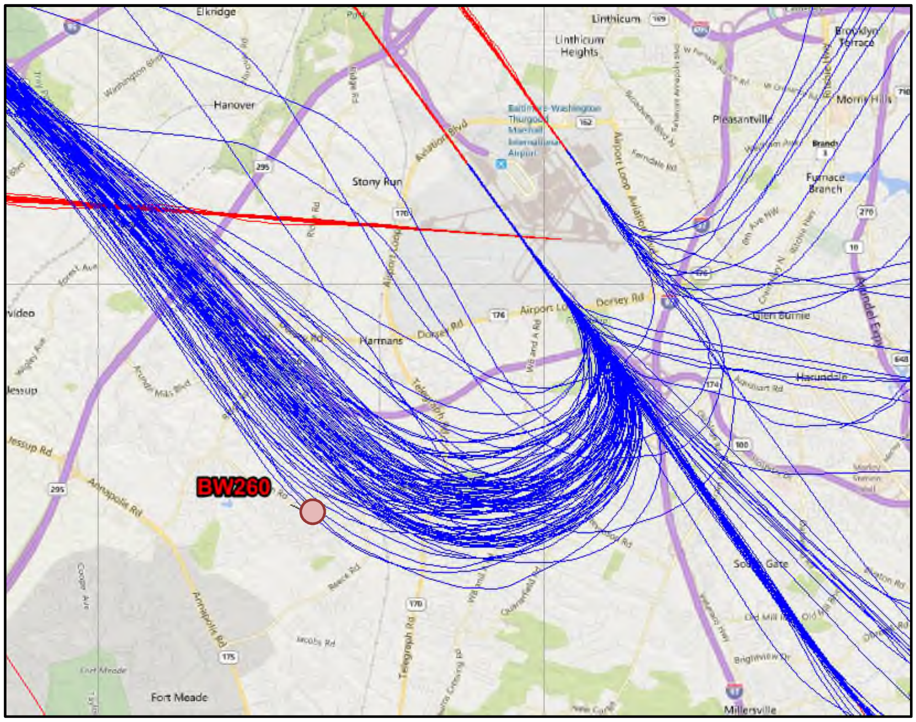

Figure 5. All Flight Tracks for an East Flow Period – Morning of December 5 2017 (red = arrivals, blue = departures)

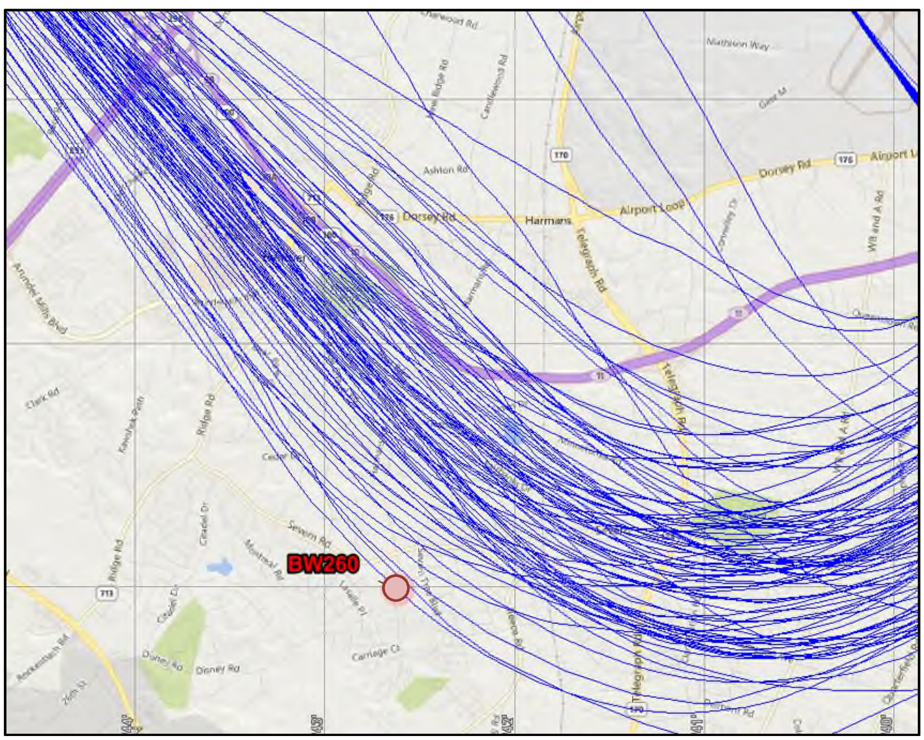

Figure 6. All Flight Tracks for an East Flow Period – Morning of December 5, 2017 (red = arrivals, blue = departures)

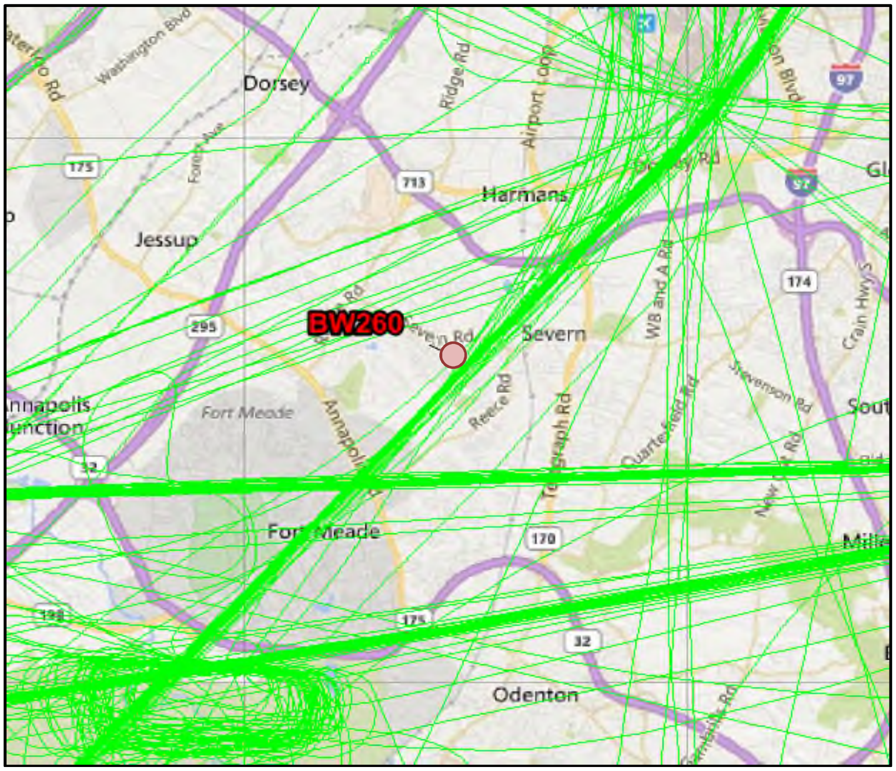

Figure 7. All Overflights not associated with BWI Marshall – December 7, 2017

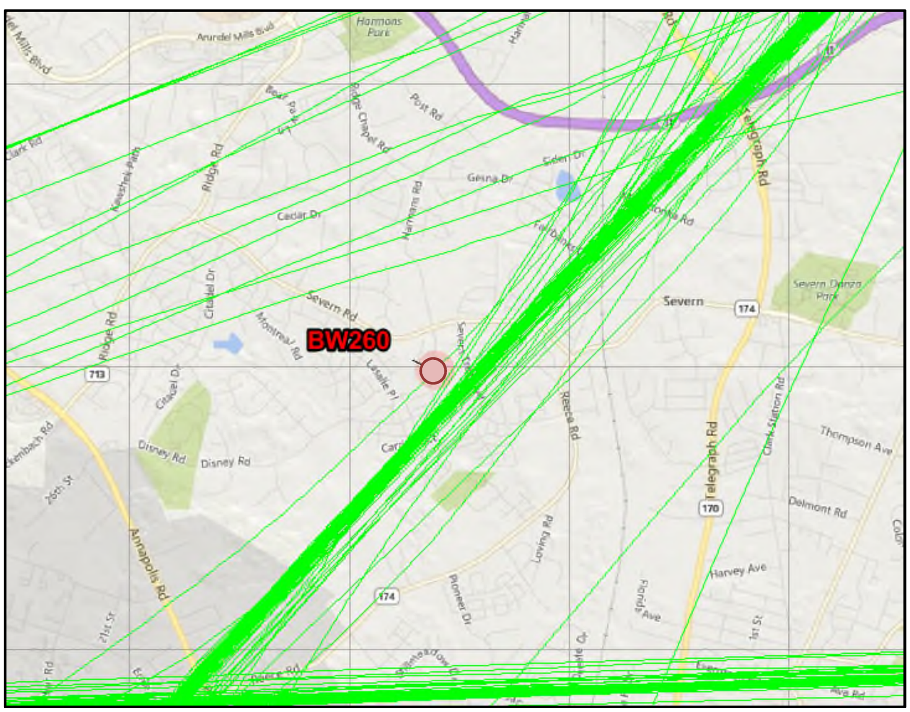

Figure 8. All Overflights not associated with BWI Marshall – December 7, 2017

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 9 presents a count of noise events due to departures on Runways 15R and 28 at various Lmax values for the complete measurement period. For example, the tallest light blue bar in the figure shows that 50 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 10 shows counts of noise events at various Lmax values due to other overflights not associated with BWI Marshall. Note that there were far fewer noise events due to these aircraft operations as compared to departures on Runways 15R and 28 and therefore the vertical scale of this figure is quite different from the scale in Figure 9.

Figure 11 and Figure 12 tell a similar story using the SEL metric which corresponds better to people's judgment of the noisiness of an event. Departures on Runways 15R and 28 produced the largest number of loud noise events. Noise events due to other overflights not associated with BWI Marshall were much less common than noise events due to departures on Runways 15R and 28.

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.

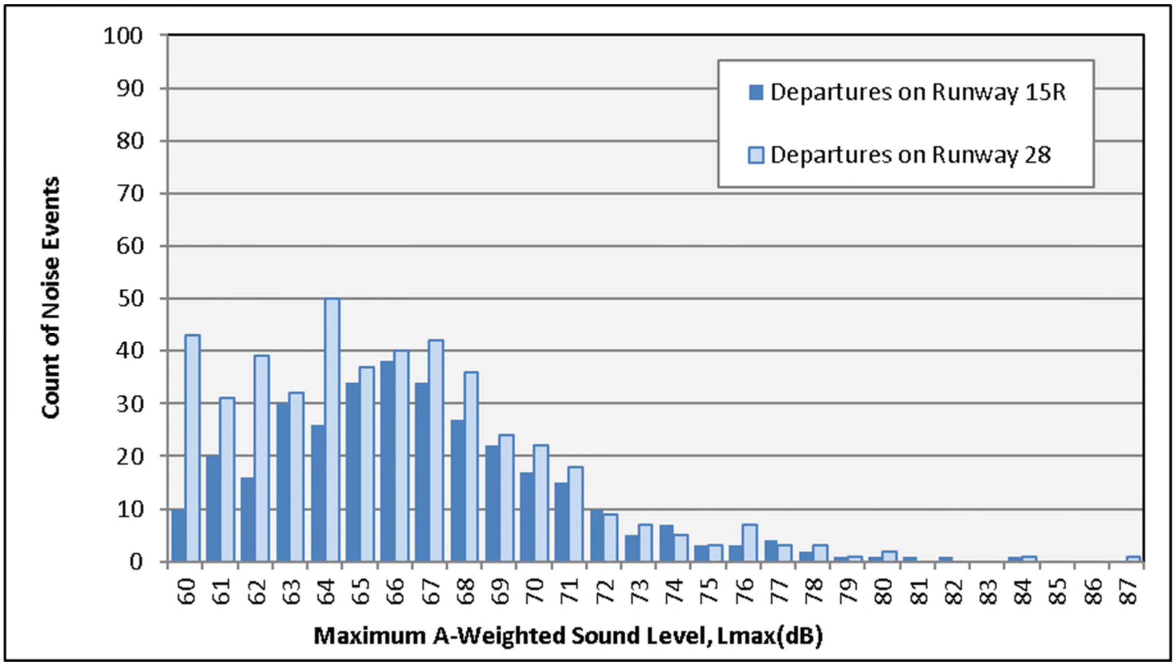

Figure 9. Counts of Maximum Noise Levels from Aircraft Overflights over the Full Measurement Period – Departures on Runways 15R and 28

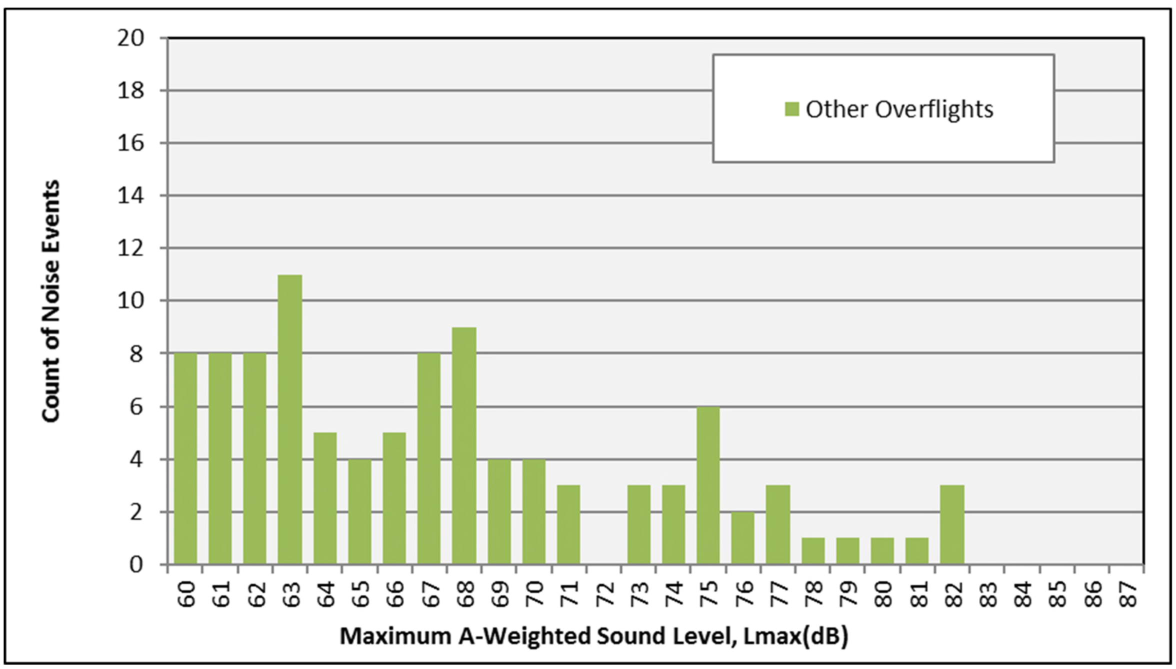

Figure 10. Counts of Maximum Noise Levels from Aircraft Overflights over the Full Measurement Period – Other Overflights not associated with BWI Marshall

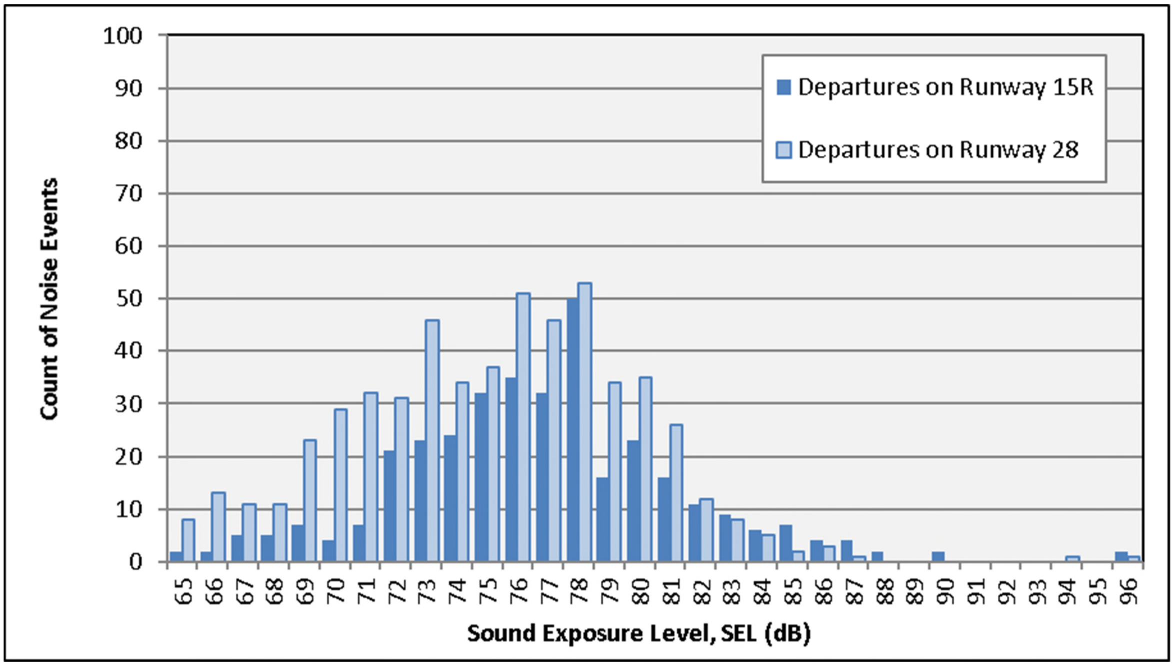

Figure 11. Counts of Sound Exposure Levels from Aircraft Overflights over the Full Measurement Period – Departures on Runways 15R and 28

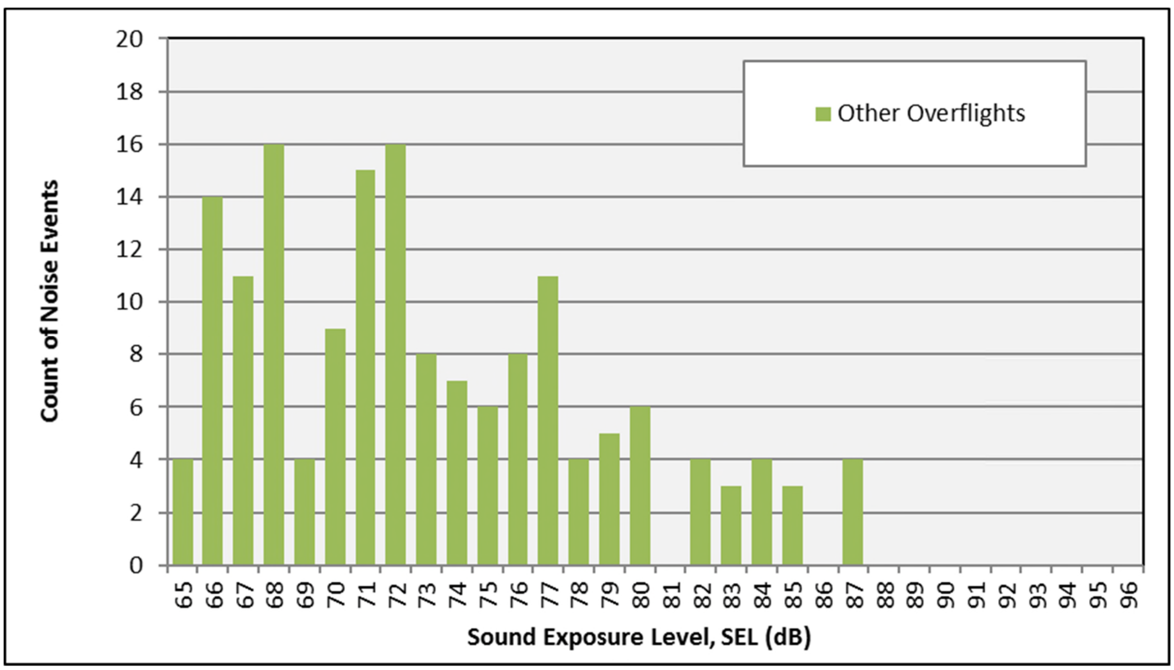

Figure 12. Counts of Sound Exposure Levels from Aircraft Overflights over the Full Measurement Period – Other Overflights not associated with BWI Marshall

4.3 Cumulative Noise Levels

Figure 13 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.

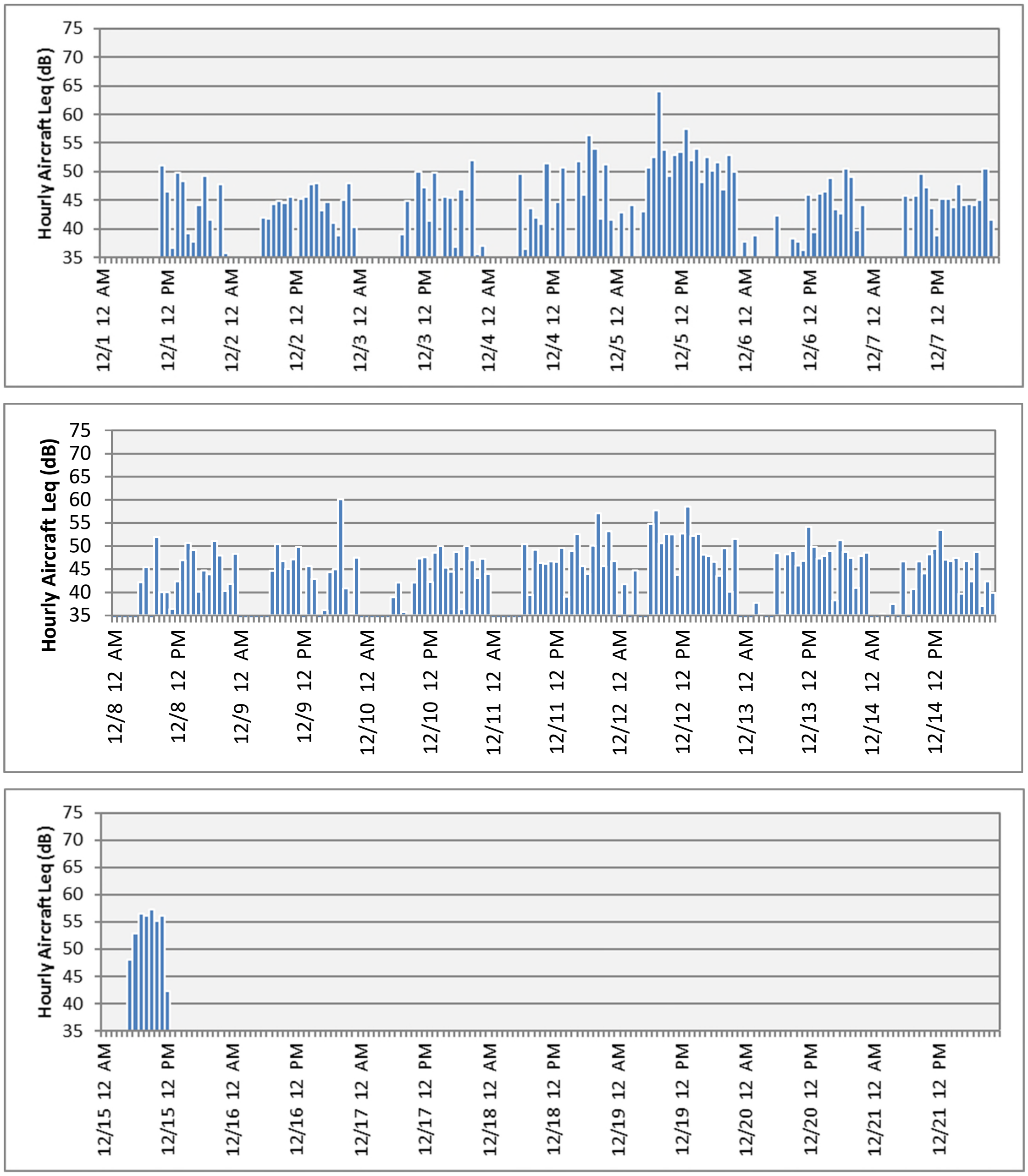

Figure 13. Average Hourly Aircraft Noise Levels

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 44 dB to 55 dB.

Table 1. Measured Daily Aircraft Noise Levels

Date	Day-Night Average Sound Level, DNL (dB)	Hours Measured	Primary Aircraft Operations
12/1/2017	49*	13	28 Dep/33L Arr
12/2/2017	47	24	28 Dep/33L Arr
12/3/2017	44	24	28 Dep/33L Arr
12/4/2017	52	24	28 Dep/33L Arr until midday then 15R Dep/10 Arr
12/5/2017	55	24	15R Dep/10 Arr until mid-afternoon then 28 Dep/33L Arr
12/6/2017	46	24	28 Dep/33L Arr
12/7/2017	47	24	28 Dep/33L Arr
12/8/2017	49	23	28 Dep/33L Arr
12/9/2017	50	24	28 Dep/33L Arr
12/10/2017	48	24	28 Dep/33L Arr
12/11/2017	53	24	28 Dep/33L Arr until midday then 15R Dep/10 Arr until about 10 pm then 28 Dep/33L Arr
12/12/2017	55	24	28 Dep/33L Arr
12/13/2017	51	24	28 Dep/33L Arr
12/14/2017	48	24	28 Dep/33L Arr until midday then 15R Dep/10 Arr
12/15/2017	56*	12	15R Dep/10 Arr until about 9 am then 28 Dep/33L Arr
Total	**51**	**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 9 through Figure 12, most of the loudest noise events at this site are from departures from Runways 15R and 28. Departures on Runway 15R accounted for about forty-five percent of the DNL. Departures on Runway 28 accounted for about forty-four percent of the DNL. Other overflights not associated with BWI Marshall accounted for about nine percent of the DNL. The small remainder of the DNL over the measurement period was due to arrivals and departures on other BWI Marshall runways.

5. CONCLUSION

The composite aircraft DNL over the full measurement period was 51 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 eighty-five percent of operations during the measurement period were in west flow and fifteen percent were in east flow, which is more than the typical annual average of seventy percent west flow operations. Noise levels at this site are higher in east flow. Based only on the measurements and a seventy percent annual west flow assumption, the annual DNL at the measurement site is likely somewhat higher than the 51 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.

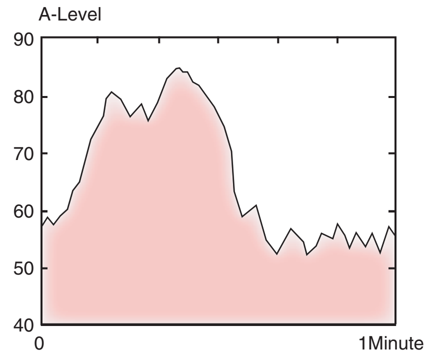

Figure 1. A-weighted Sound Levels Over Time

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.

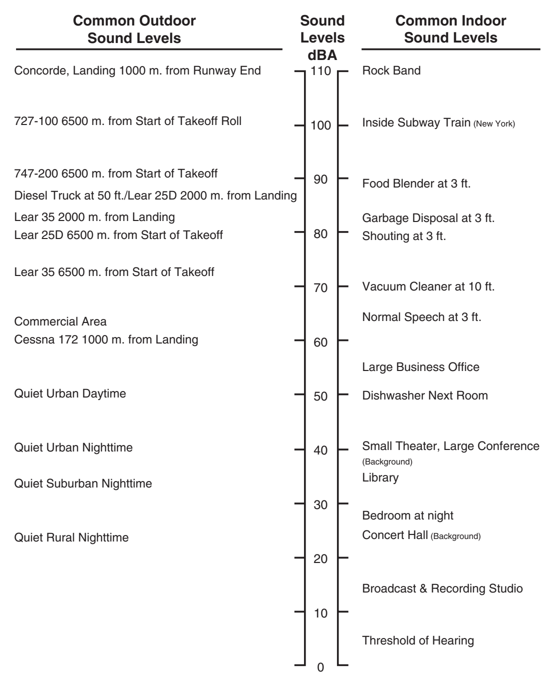

Figure 2. Common Environmental Sound Levels

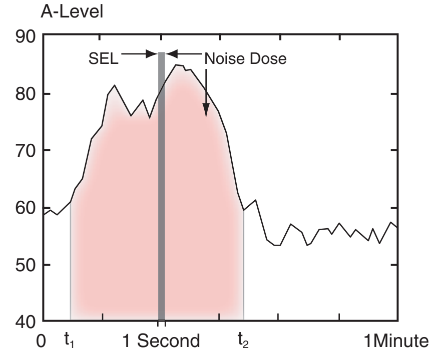

Figure 3. Sound Exposure Level

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.

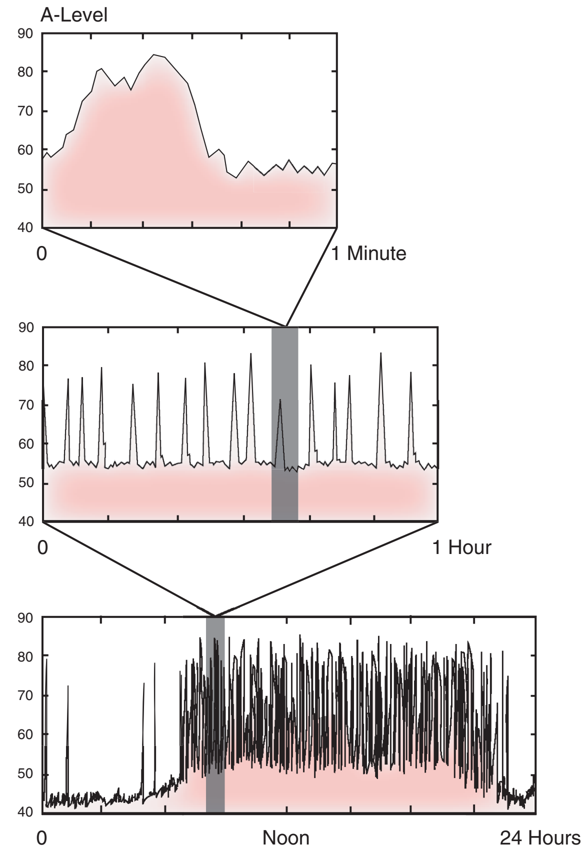

Figure 4. Daily Noise Dose

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.