Aircraft Noise Measurement Report

Claire Drive

Elkridge, MD 21075

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 October 13 to October 28, 2015 at Claire Drive Elkridge, MD 21075. This residence is located approximately 2.7 miles northwest of the northwestern end of Runway 15R/33L of Baltimore-Washington International Thurgood Marshall Airport (BWI Marshall). Figure 1 shows the location of the measurement site (marked as BW232) relative to BWI Marshall. Measurement data were collected and analyzed on behalf of the Maryland Aviation Administration (MAA) by Harris Miller Miller & Hanson (HMMH) and Straughan Environmental (SE).

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.

During analysis of the noise levels, it became clear that the noise monitoring equipment had malfunctioned during the measurements. Measured noise levels for individual aircraft flights were approximately ten decibels lower than expected. This discrepancy was verified through comparison to measured noise levels at two other noise monitors which were in the field simultaneously to BW232. One temporary noise monitor was at a home approximately 0.7 mi to the east-northeast. A permanent noise monitor, RMS01, is located approximately 0.3 mi to the northeast and shown on Figure 1. Noise levels on a flight-by-flight basis were nearly identical at these two nearby locations, while measured noise levels at BW232 were much lower. Due to the noise monitor malfunction at BW232 and the close proximity of RMS01, this report presents measured noise levels from RMS01.

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

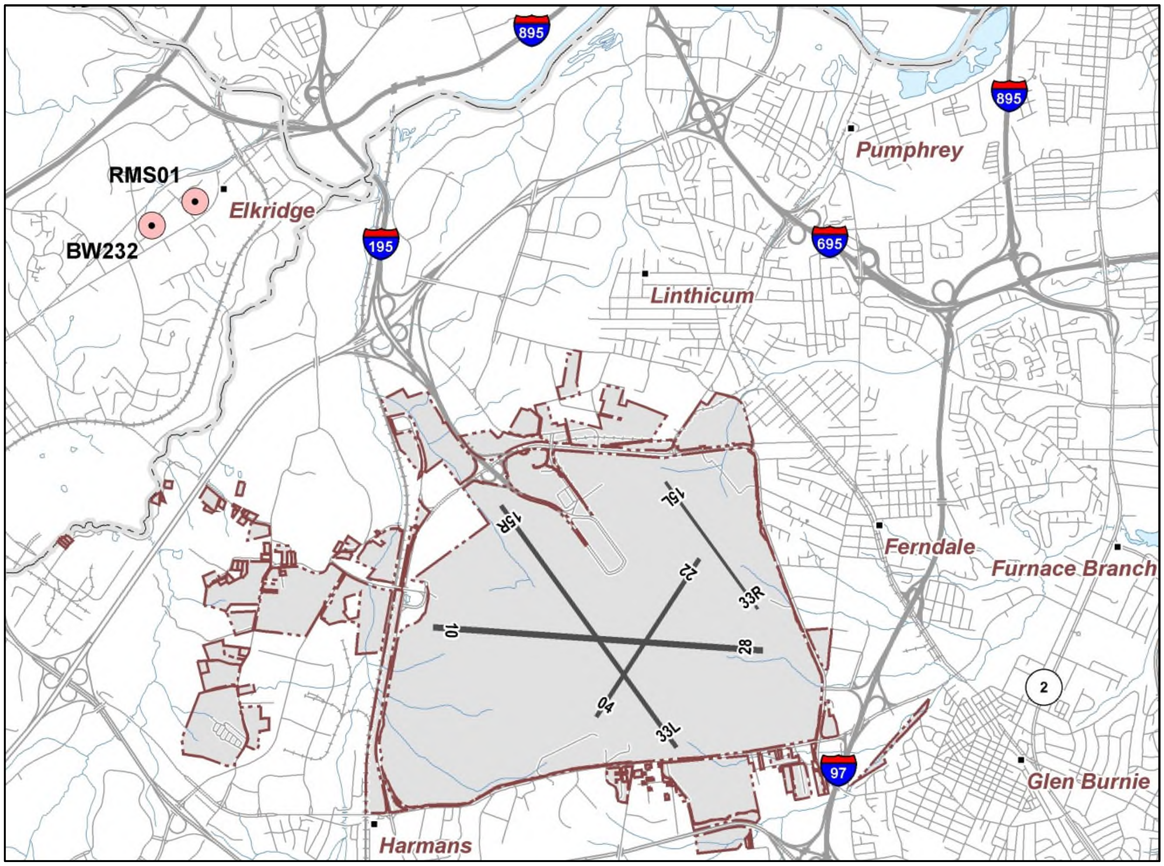

Figure 1. Noise Monitoring Location Map

2. MEASUREMENT SITE

Aircraft noise levels were measured from the late morning of October 13 to midday on October 28, 2015 at Claire Drive in Elkridge. As noted in the previous section, an equipment malfunction was not detected until the completion of the measurements. Data from the nearby permanent noise monitor, RMS01, were analyzed for use in this report.

Notable noise sources at this site include aircraft overflights, primarily departures on BWI Marshall Runway 33L and arrivals to Runway 15R, and typical suburban sounds such as local and distant road traffic, birds, and neighbors.

3. AIRCRAFT OPERATIONS

The measurement site (RMS01) is located to the northwest of BWI Marshall, west of the extended centerline of Runway 15R/33L. The primary aircraft noise events for this site are from departures on BWI Marshall Runway 33L and arrivals on Runway 15R. Other less common aircraft noise events are due to departures on BWI Marshall Runway 33R.

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

- Departures and arrivals on Runway 33L
- Departures and arrivals on Runway 15R

The most common configuration, departures and arrivals on Runway 33L, was active for thirteen full days during the measurement period. The configuration with departures and arrivals on Runway 15R was active for two days during the measurement period. On one day, both configurations were used for 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.

Starting on August 31, Runway 10/28 was closed for a runway rehabilitation project. During this closure, both west and east flow runway configurations were altered. In typical west flow conditions the primary arrival runway is Runway 33L and the primary departure runway is Runway 28. In typical east flow conditions the primary arrival runway is Runway 10 and the primary departure runway is Runway 15R.

Figure 2 displays all BWI Marshall flight tracks for a west flow day during the measurement period with Runway 10/28 closed. The primary runway for both arrivals and departures was Runway 33L. Figure 3 displays the same west flow flight tracks at a larger scale. The primary BWI Marshall overflights were departures on Runway 33L which were 1,700 ft. to 2,800 ft. above ground level at their point of closest approach to the measurement site. The most common altitude was 2,000 ft. A smaller number of departures on Runway 33R overflew the site at 1,700 ft. to 4,300 ft. above ground level at their point of closest approach. The most common altitude was 3,200 ft.

Figure 4 displays all BWI Marshall flight tracks for an east flow day during the measurement period with Runway 10/28 closed. The primary runway for both arrivals and departures was Runway 15R. Figure 5 displays the same flight tracks at a larger scale. The primary BWI Marshall overflights were arrivals on Runway 15R which were 700 ft. to 800 ft. above ground level at their point of closest approach to the measurement site. The most common altitude was 800 ft.

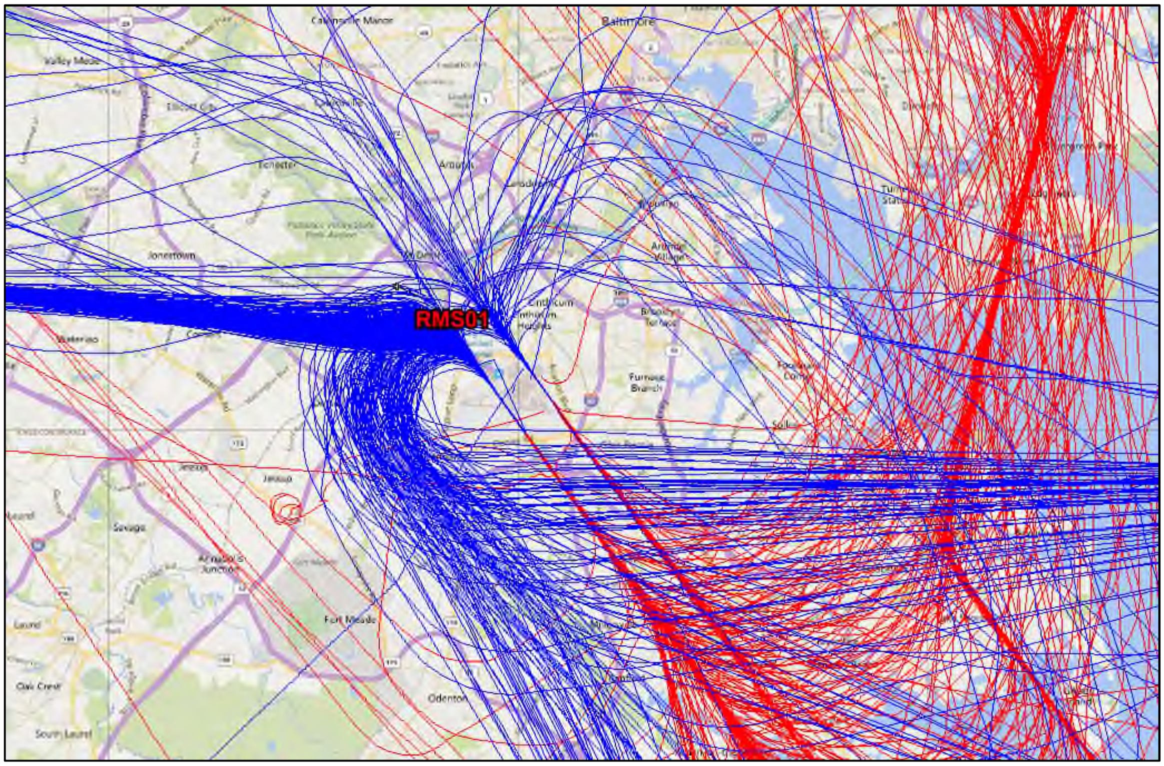

Figure 2. All Flight Tracks for a West Flow Day with a Runway 10/28 Closure – October 15, 2015 (red = arrivals, blue = departures)

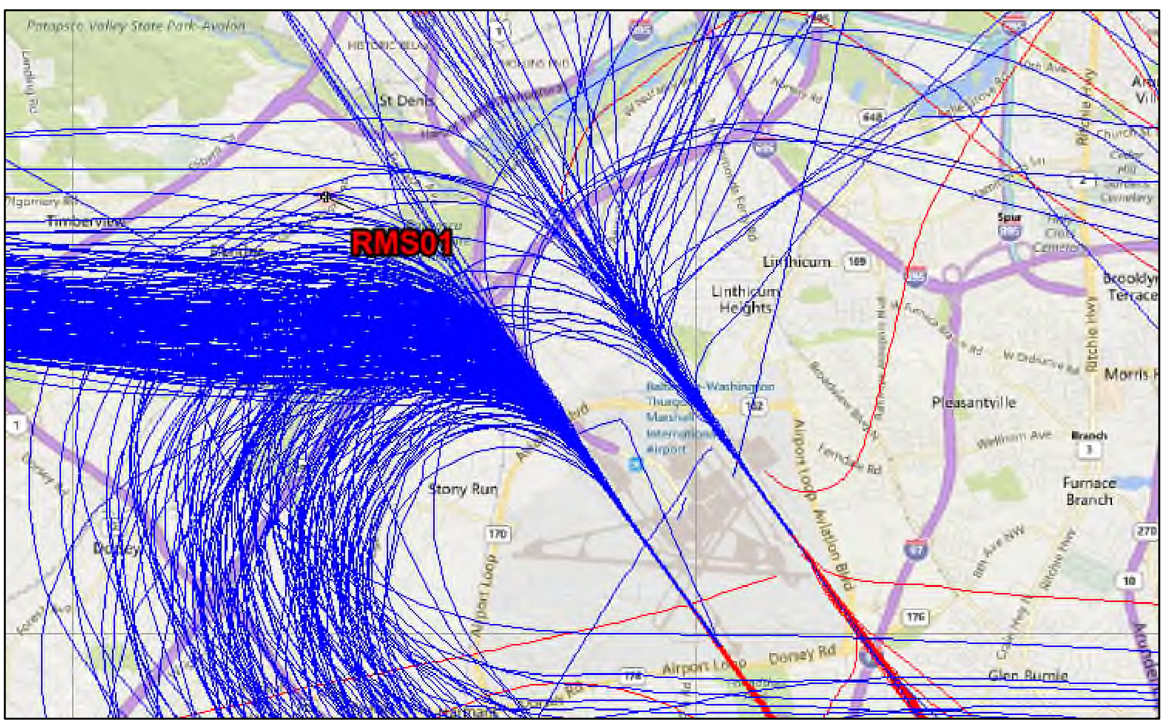

Figure 3. All Flight Tracks for a West Flow Day with a Runway 10/28 Closure – October 15, 2015 (red = arrivals, blue = departures)

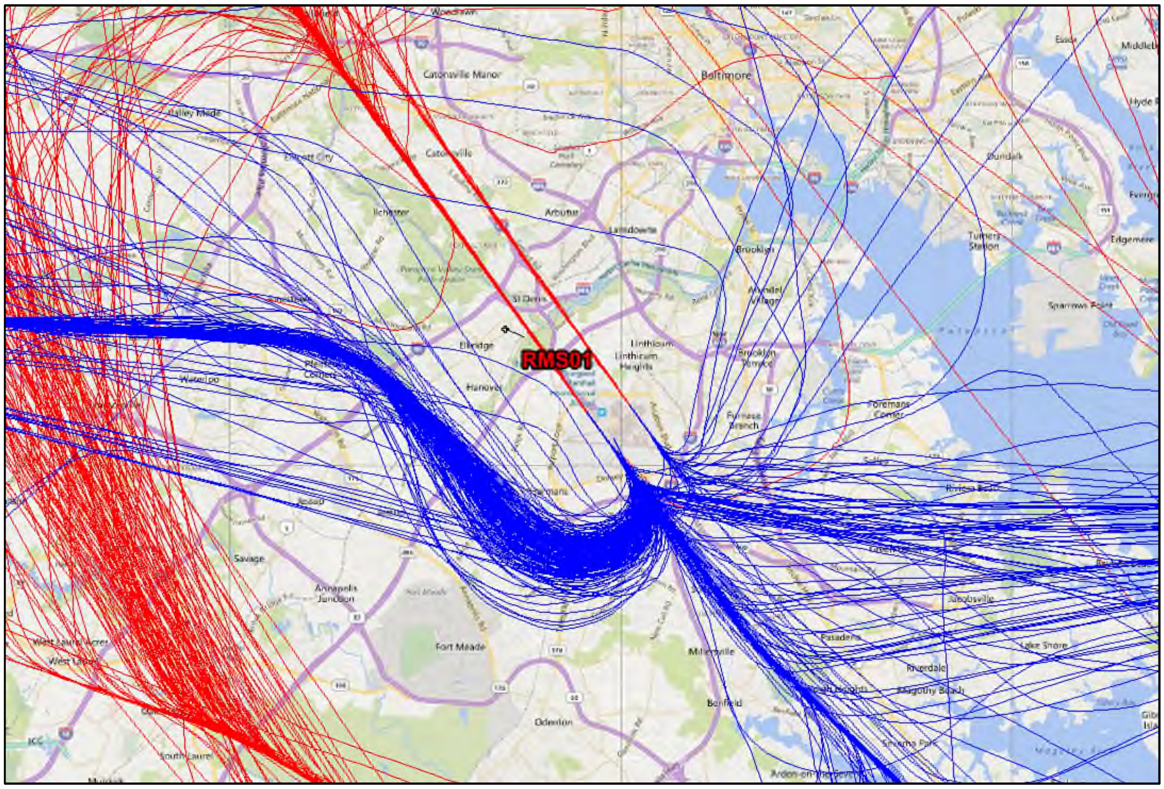

Figure 4. All Flight Tracks for an East Flow Day with a Runway 10/28 Closure – October 28, 2015 (red = arrivals, blue = departures)

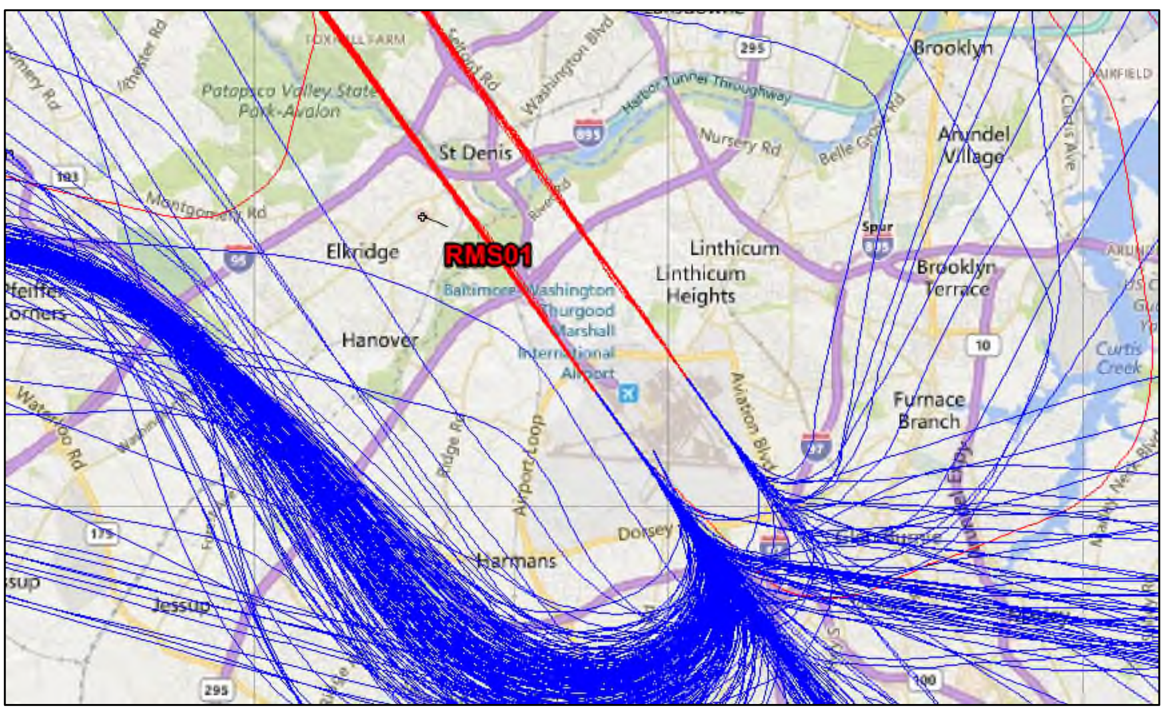

Figure 5. All Flight Tracks for an East Flow Day with a Runway 10/28 Closure – October 28, 2015 (red = arrivals, blue = departures)

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 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 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 6 presents a count of noise events due to departures on Runway 33L and arrivals on Runway 15R at various Lmax values for the complete measurement period. For example, the tallest bars in the figure show that 263 departures on Runway 33L had an Lmax of 69 dB and another 263 departures 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 7 presents the counts of noise events due to departures on Runway 33R. Note that there were many fewer of these events and that the vertical scale of the graphic is very different than that of Figure 6.

Figure 8 and Figure 9 tell a similar story using the SEL metric which corresponds better to people's judgment of the noisiness of an event. Departures on Runway 33L produced the largest number of loud noise events. Noise events from arrivals on Runway 15R were much less frequent during the measurement period and were generally quieter than departures on Runway 33L. Noise events due to departures on Runway 33R were the least common. Again note that the vertical scale of Figure 9 is very different than that of Figure 8.

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.

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[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.

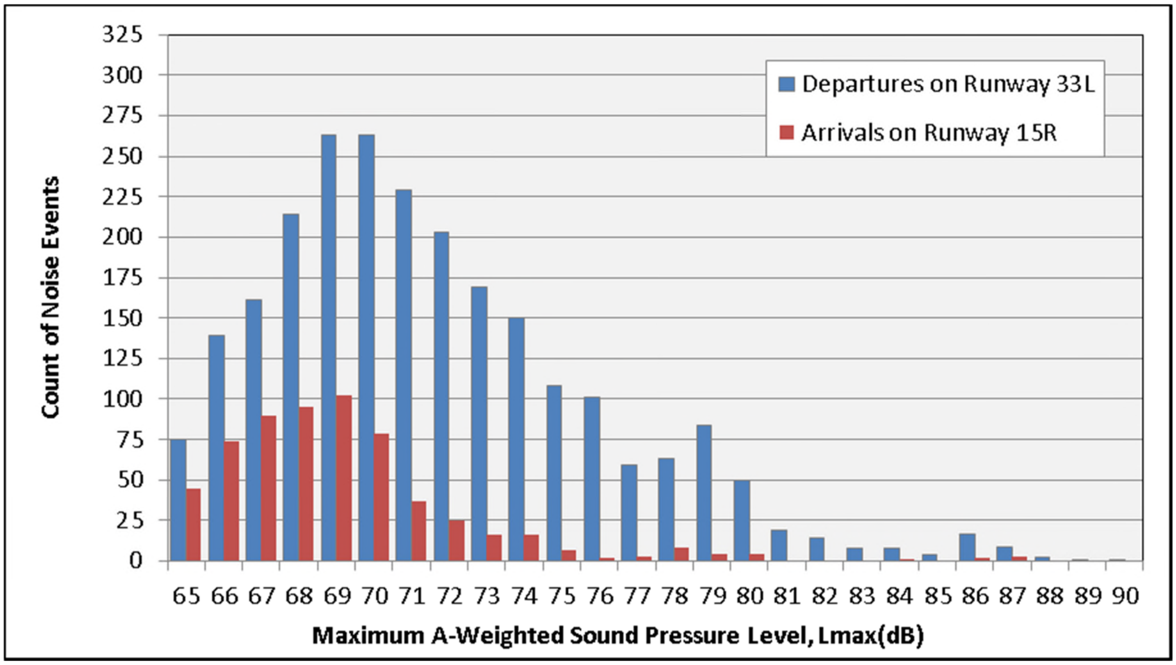

Figure 6. Counts of Maximum Noise Levels from Aircraft Overflights over the Full Measurement Period – Departures on Runway 33L and Arrivals on Runway 15R

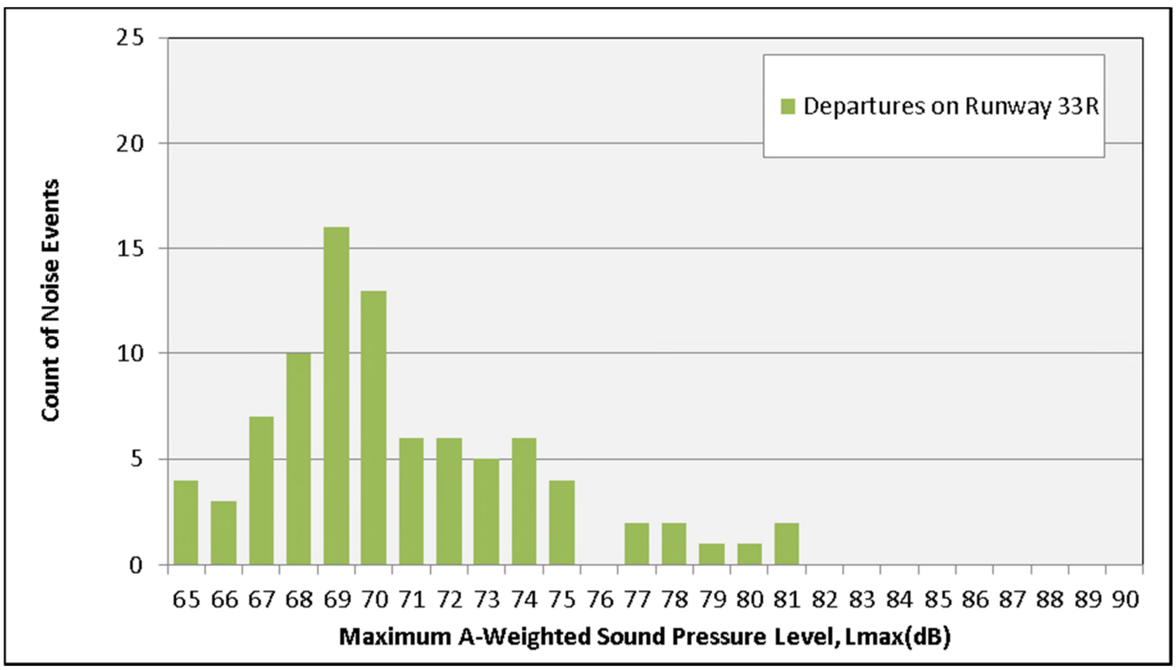

Figure 7. Counts of Maximum Noise Levels from Aircraft Overflights over the Full Measurement Period – Departures on Runway 33R

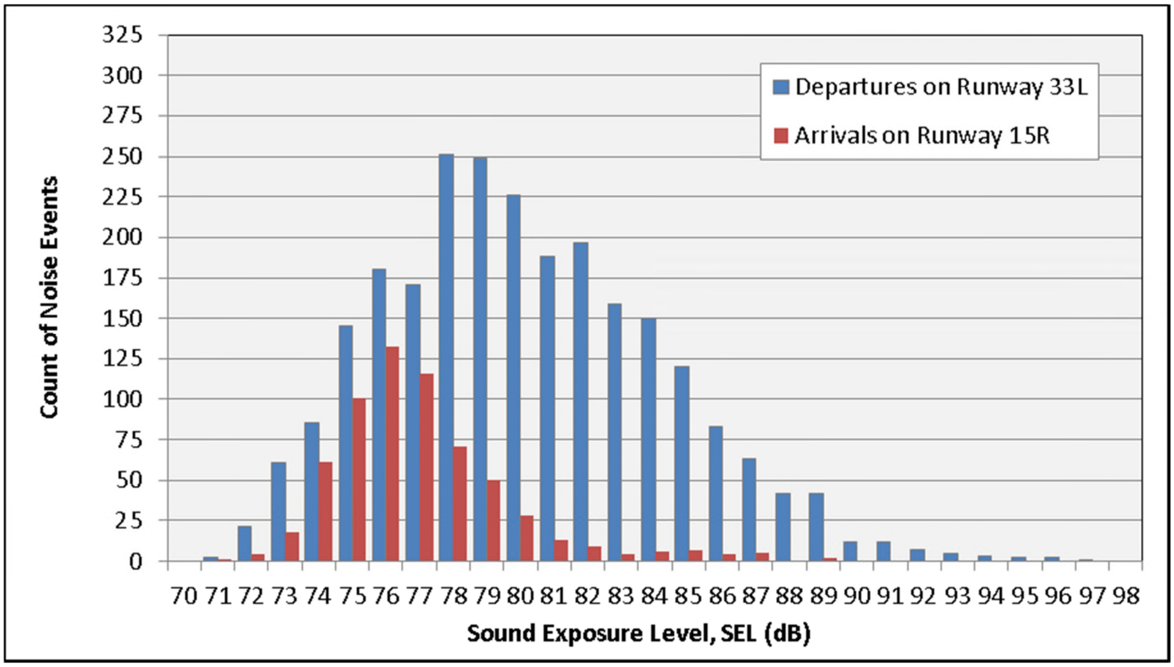

Figure 8. Counts of Sound Exposure Levels from Aircraft Overflights over the Full Measurement Period – Departures on Runway 33L and Arrivals on Runway 15R

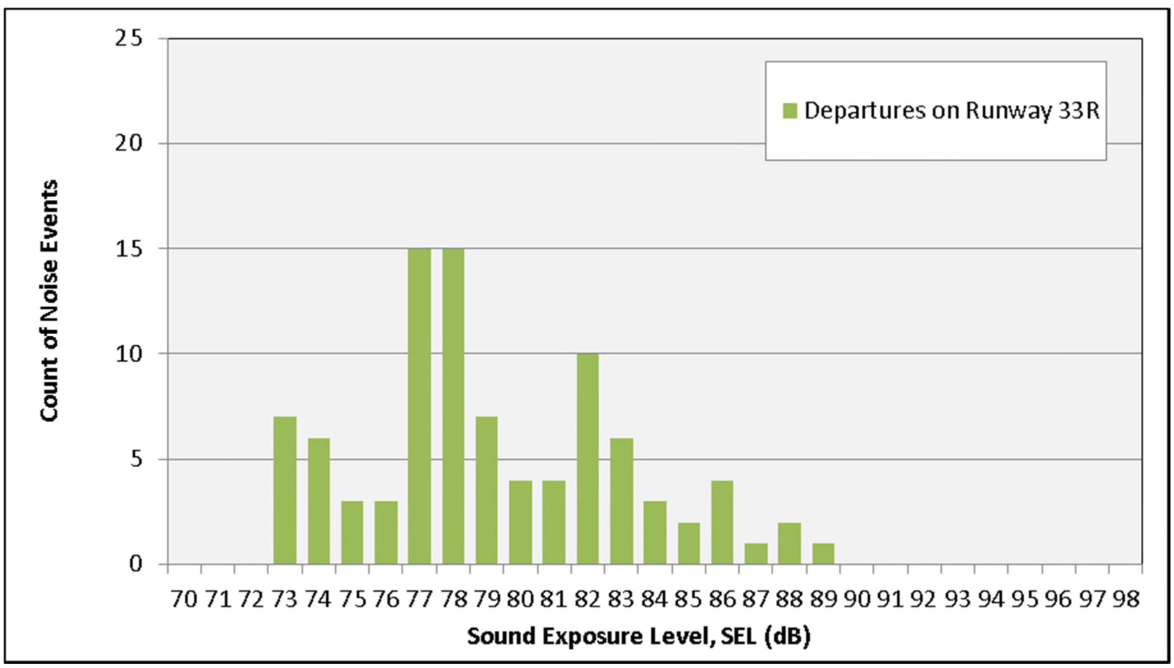

Figure 9. Counts of Sound Exposure Levels from Aircraft Overflights over the Full Measurement Period – Departures on Runways 33R

4.3 Cumulative Noise Levels

Figure 10 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.

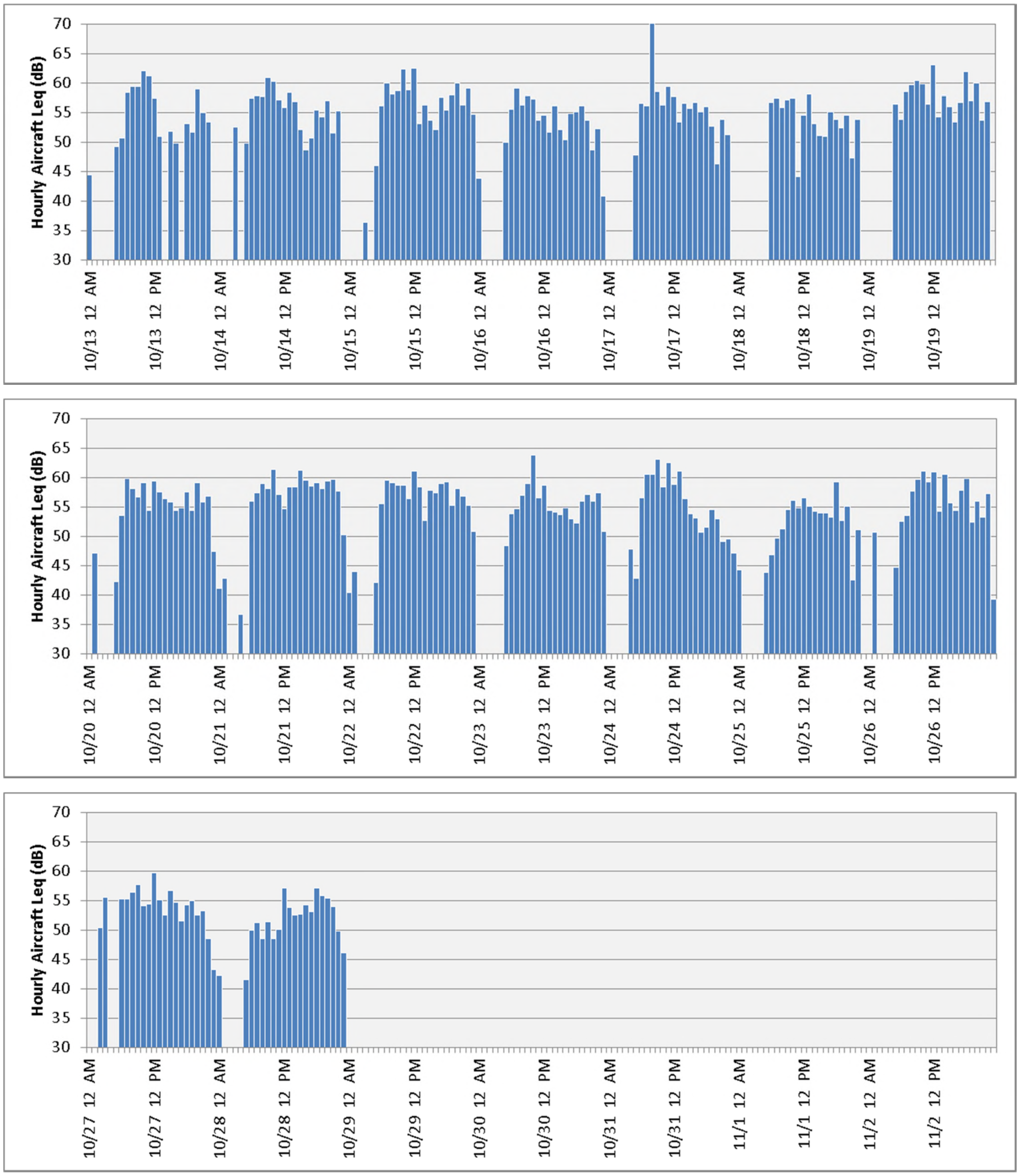

Figure 10. Average Hourly Aircraft Noise Levels

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, as shown in Table 1, ranged from 54 dB to 60 dB, with fourteen of the fifteen days between 57 dB and 60 dB. Table 1 also shows the primary runways in use each day of the measurement period.

Table 1. Measured Daily Aircraft Noise Levels

Date	Day-Night Average Sound Level, DNL (dB)	Hours Measured	Primary Aircraft Operations
10/13/2015	57	24	33L Arr / 33R Dep
10/14/2015	59	24	33L Arr / 33R Dep
10/15/2015	60	24	33L Arr / 33R Dep
10/16/2015	57	24	33L Arr / 33R Dep
10/17/2015	60	24	33L Arr / 33R Dep
10/18/2015	57	24	33L Arr / 33R Dep
10/19/2015	60	24	33L Arr / 33R Dep
10/20/2015	58	24	33L Arr / 33R Dep
10/21/2015	60	24	33L Arr / 33R Dep
10/22/2015	59	24	33L Arr / 33R Dep
10/23/2015	59	24	33L Arr / 33R Dep 15R Arr / 15R Dep
10/24/2015	59	24	33L Arr / 33R Dep
10/25/2015	54	24	33L Arr / 33R Dep
10/26/2015	59	24	15R Arr / 15R Dep
10/27/2015	58	24	15R Arr / 15R Dep
Total	**58**	**384**	-

As shown in the single event figures, Figure 6 through Figure 9, most of the loudest noise events at this site are from departures on Runway 33L. These departures accounted for about ninety-two percent of the DNL over the period. Arrivals on Runway 15R contributed approximately seven percent of the total DNL over the period. Departures on Runway 33R contributed approximately one percent of the total DNL over the period.

5. CONCLUSION

The composite aircraft DNL over the full measurement period was 58 dB. The DNL over a full year will depend on the type and number of aircraft transiting the areas and utilizing BWI Marshall and the percentage of time that the airport spends in various operational configurations. The conditions during the measurement period were atypical of operations at BWI Marshall due to the closure of Runway 10/28. The annual average DNL at this location is likely to be lower than measured during this 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.

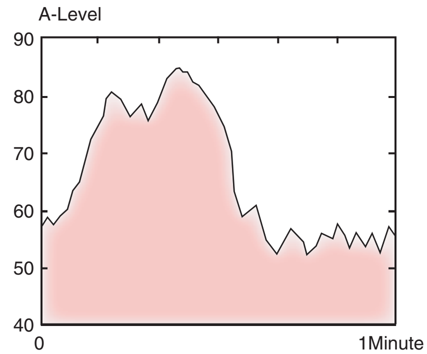

Figure 1. A-weighted Sound Levels Over Time

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.

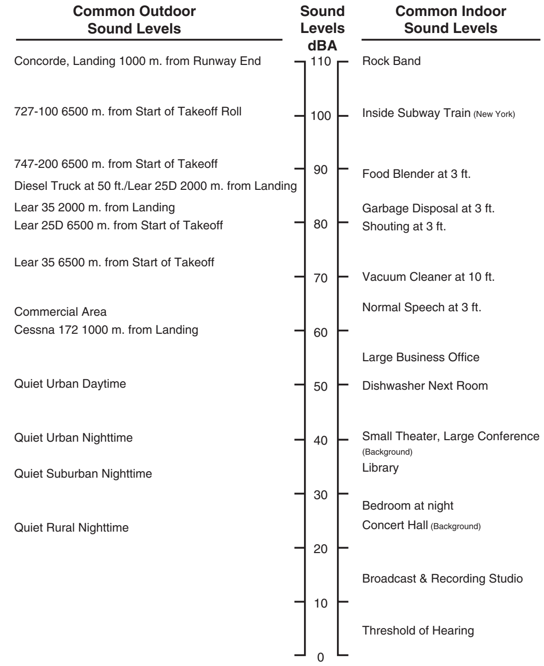

Figure 2. Common Environmental Sound Levels

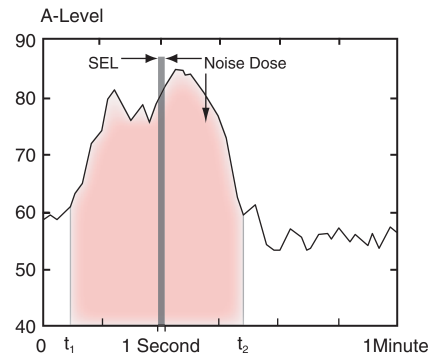

Figure 3. Sound Exposure Level

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.

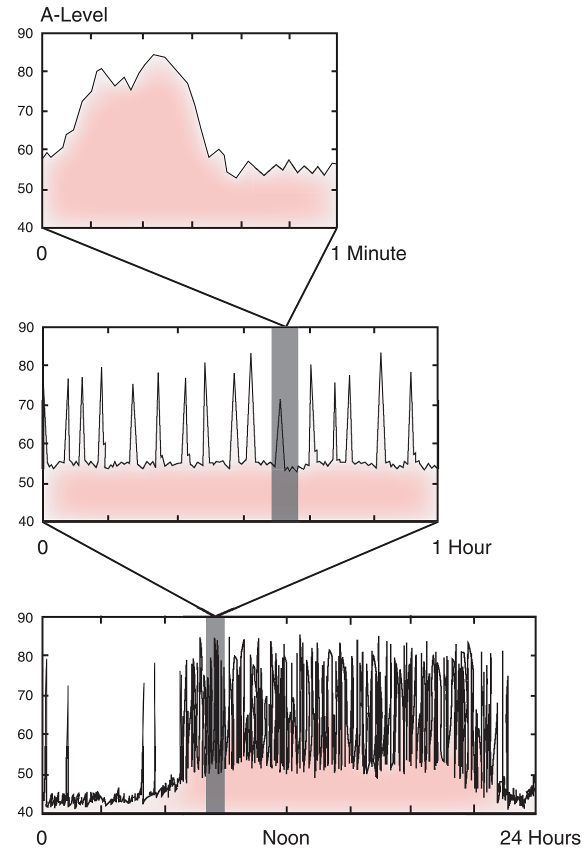

Figure 4. Daily Noise Dose

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.

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