Aircraft Noise Measurement Report

Mark Rd

Pumphrey, MD 21225

Prepared by Harris Miller Miller & Hanson, Inc.

April 2015

1. INTRODUCTION

This memorandum presents the measured aircraft noise levels for the period of March 10 to March 25, 2015 at Mark Rd Pumphrey, MD 21225. This residence is located approximately 2.2 miles northeast of Runway 15L/33R of Baltimore-Washington International Thurgood Marshall Airport (BWI Marshall). Figure 1 shows the location of the measurement site (marked as BW226) 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). 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.

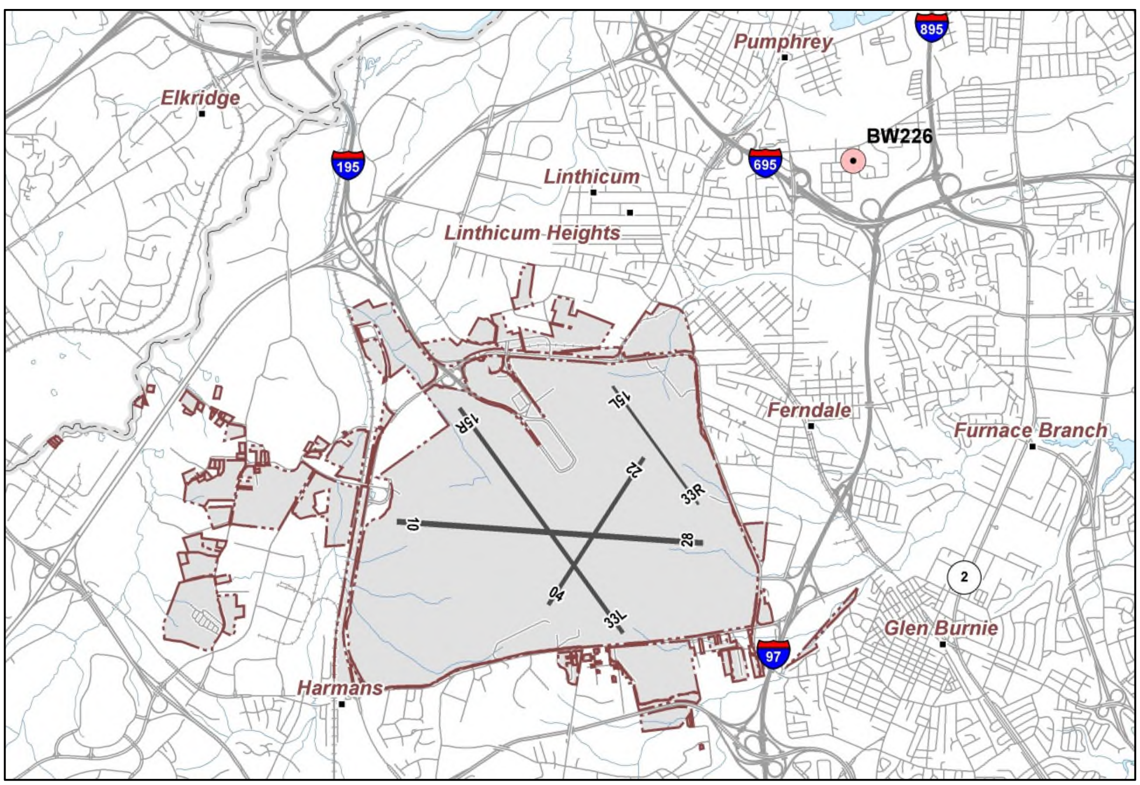


Figure 1. Noise Monitoring Location Map

2. MEASUREMENT SITE

Aircraft noise levels were measured from mid-day on March 10 to the morning of March 25, 2015 at Mark Rd in Pumphrey. 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, including both operations not associated with BWI Marshall and arrivals and departures at BWI Marshall, and typical suburban sounds such as local street traffic and the nearby highways.

Image removed for web publication

Figure 2. Noise Measurement Microphone

3. AIRCRAFT OPERATIONS

The measurement site is located to the northeast of BWI Marshall. The primary aircraft noise events for this site are from aircraft transiting the area from north to south or vice versa by flying over BWI Marshall. Other less common aircraft noise events are due to BWI Marshall arrivals and departures.

Figure 3 displays all BWI Marshall arrival and departure flight tracks for a typical west-flow day (March 23rd). In west-flow, aircraft arrive on Runways 33L and 33R and depart on Runways 28 and 33R. The location of the measurement site is marked with its unique identifier in the NOMS, "BW226". Figure 4 displays the same arrival and departure flight tracks at a larger scale. Again, the text "BW226" shows the location of the measurement site. The measurement location is not aligned with any active runway and is not located under the major aircraft flight corridors in this configuration.

Figure 5 displays all aircraft flight tracks for operations not associated with BWI Marshall for the same day (March 23rd). Figure 6 displays the same flight tracks at a larger scale. Aircraft transiting the area from north to south or south to north often fly directly over BWI Marshall. The flight path for these aircraft is located just southeast of the measurement site. These aircraft include propeller aircraft and helicopters at altitudes of 700 ft to 1,400 ft above ground level and jets at or above 9,600 ft.

Figure 7 displays all BWI Marshall arrival and departure flight tracks for a typical east-flow day (March 24th). In east-flow, aircraft arrive on Runways 10 and 15L and depart on Runways 15R and 15L. Note that BWI Marshall was in west-flow for a small portion of the day. Figure 8 displays the same arrival and departure flight tracks at a larger scale. The measurement location is not aligned with any active runway and is not located under the major aircraft flight corridors in this configuration.

Figure 9 displays all aircraft flight tracks for operations not associated with BWI Marshall for the same day (March 24th). Figure 10 displays the same flight tracks at a larger scale. A comparison to Figure 5 and Figure 6 shows that aircraft transiting the area take similar paths regardless of whether BWI Marshall is in east-flow or west-flow.

During the measurement period, BWI Marshall operated in two configurations: departures on Runway 28 and arrivals on Runway 33L or departures on Runway 15R and arrivals on Runway 10. The most common configuration, departures on Runway 28 and arrivals on Runway 33L, was active for nine days during the measurement period. The configuration with departures on Runway 15R and arrivals on Runway 10 was active for two days during the measurement period. On five 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.

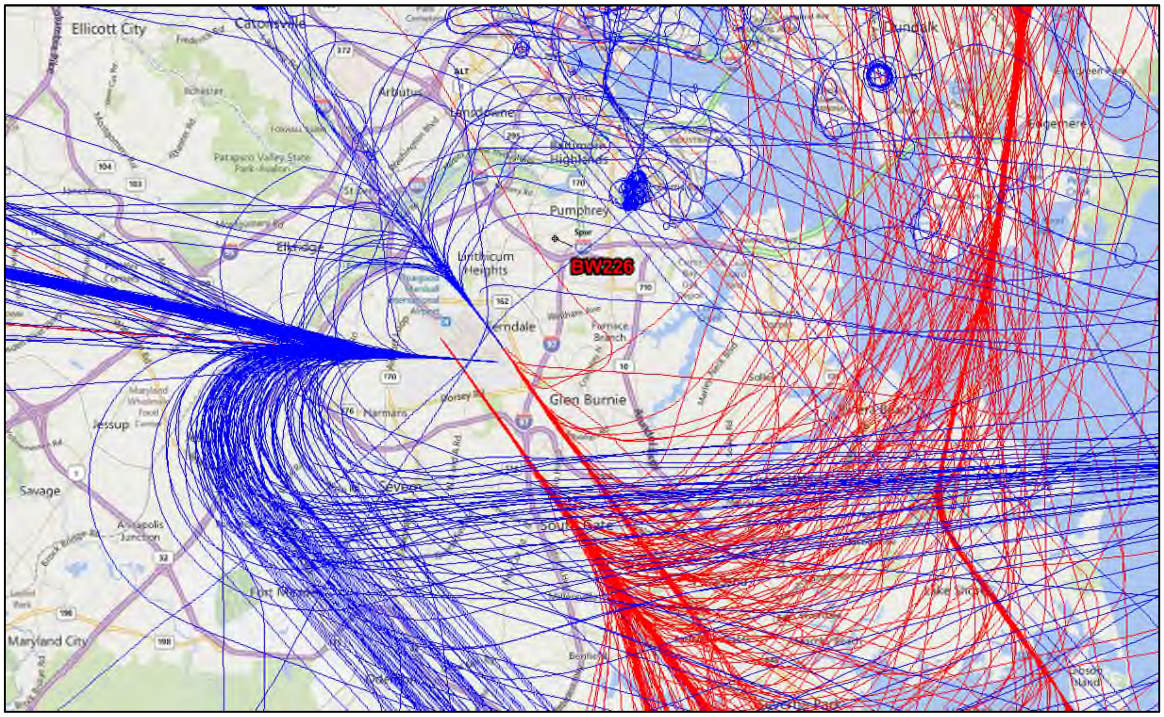


Figure 3. All BWI Marshall Flight Tracks from March 23, 2015 (West Flow)

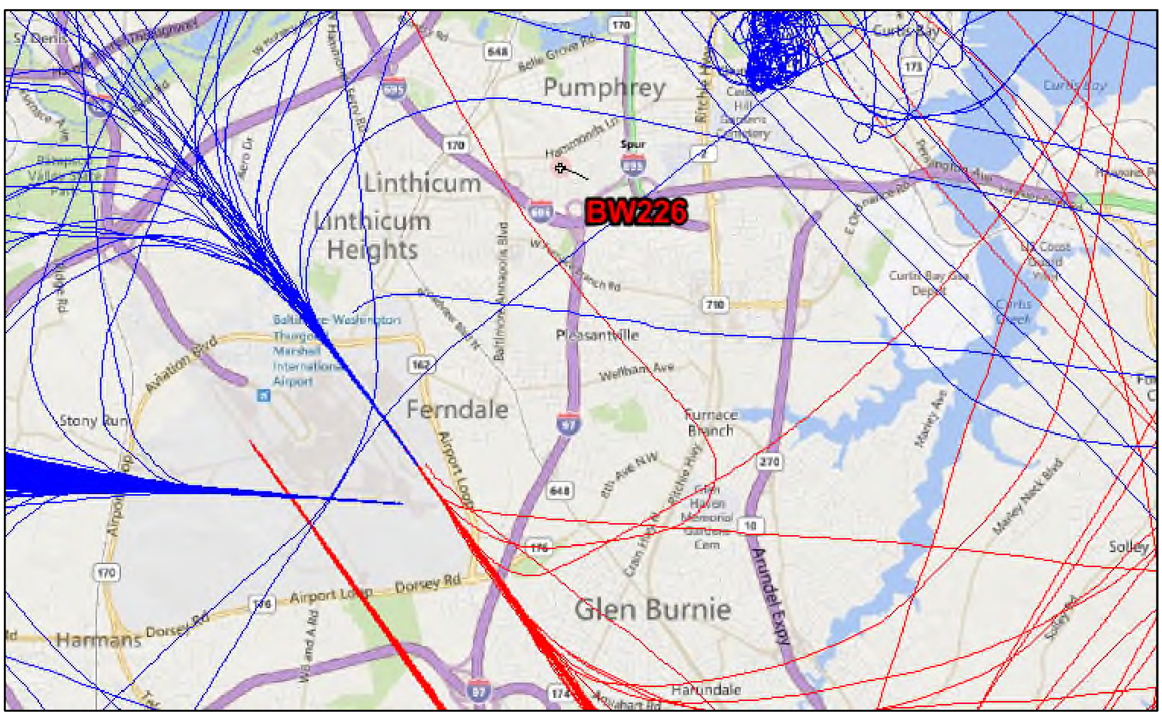


Figure 4. All BWI Marshall Flight Tracks from March 23, 2015 (West Flow)

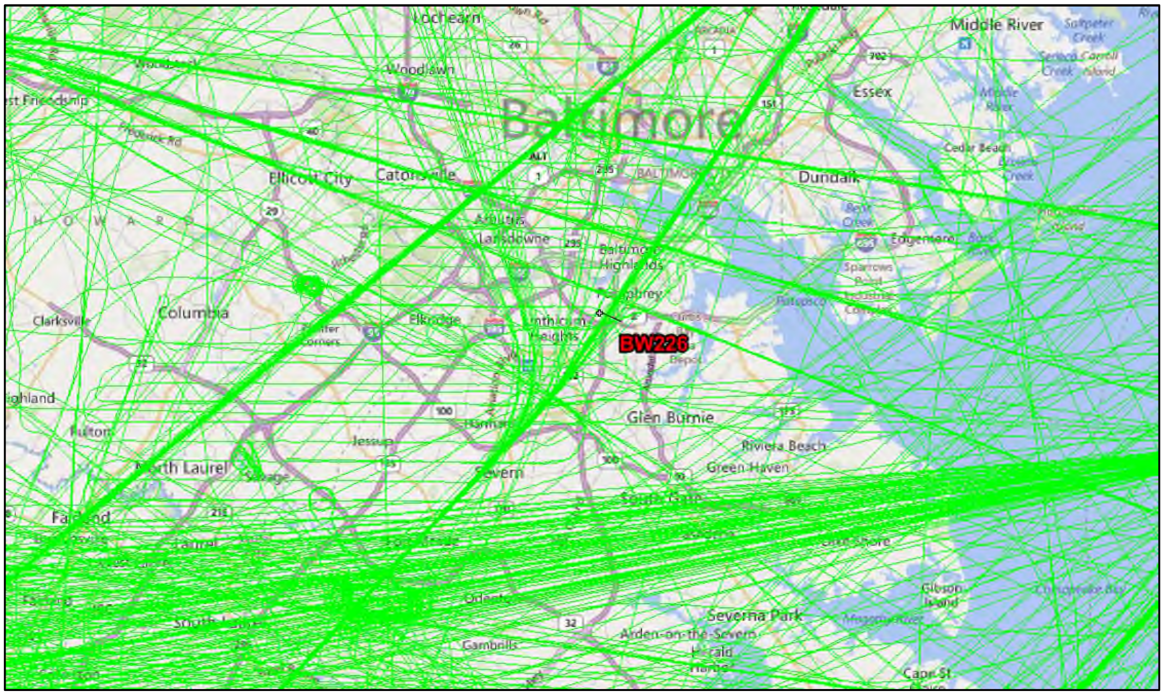


Figure 5. All Flight Tracks not associated with BWI Marshall from March 23, 2015

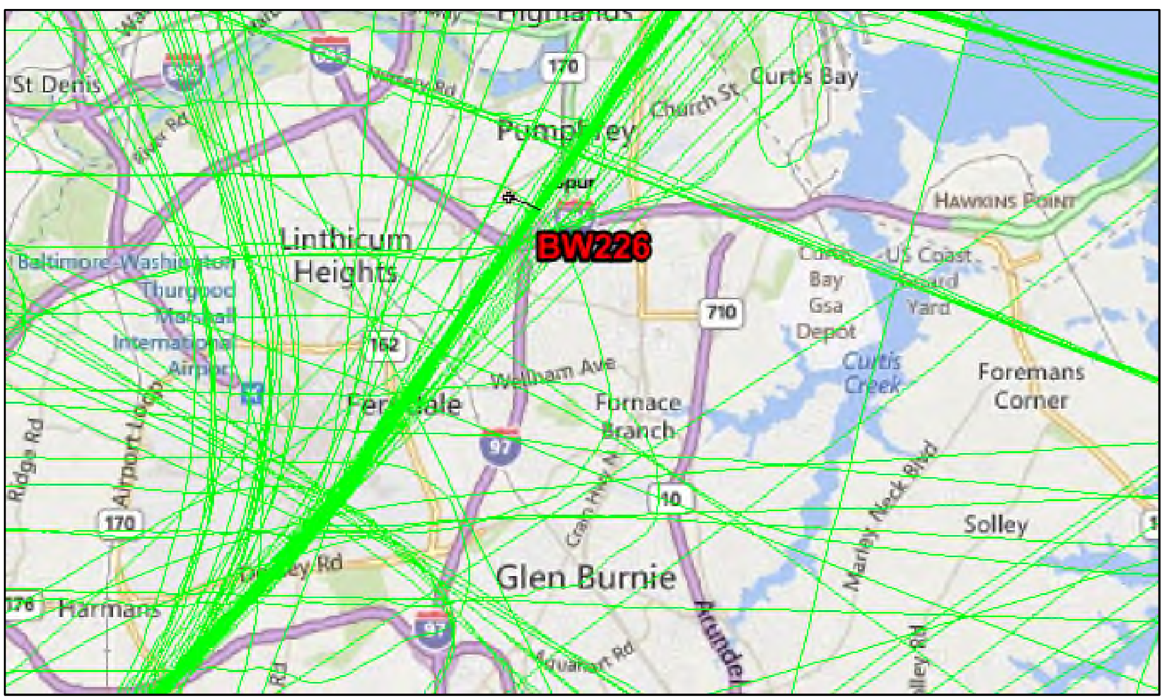


Figure 6. All Flight Tracks not associated with BWI Marshall from March 23, 2015

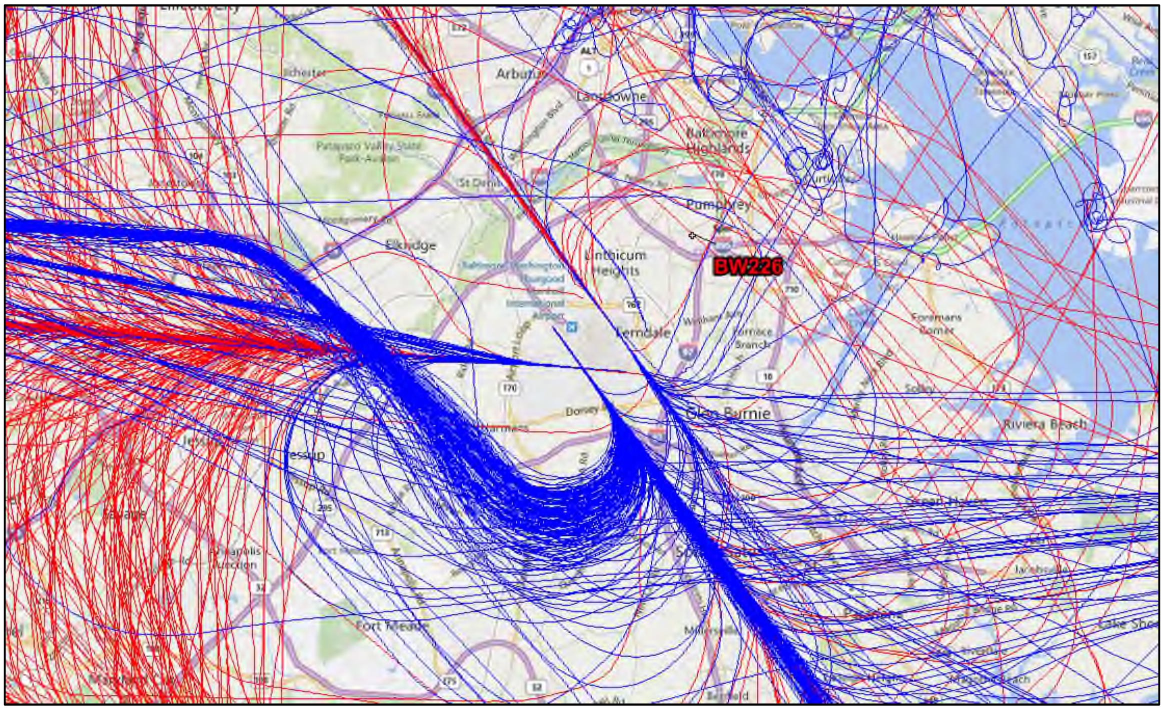


Figure 7. All BWI Marshall Flight Tracks from March 24, 2015 (East Flow)

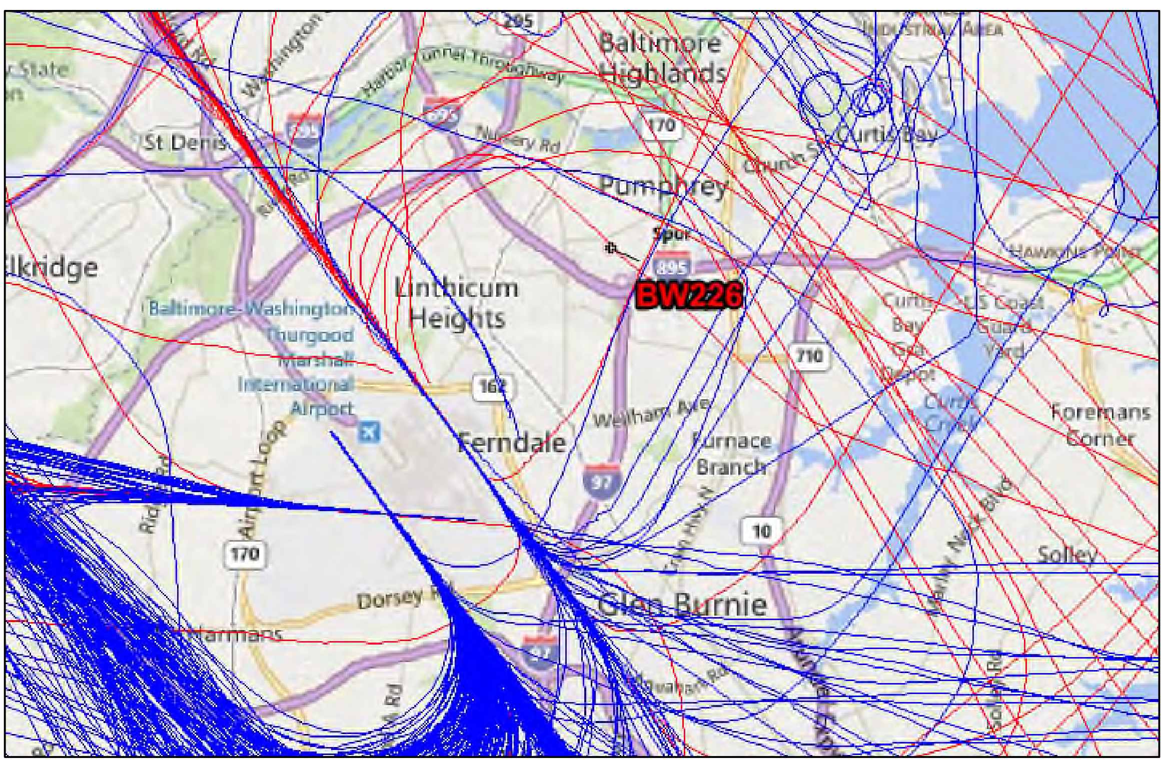


Figure 8. All BWI Marshall Flight Tracks from March 24, 2015 (East Flow)

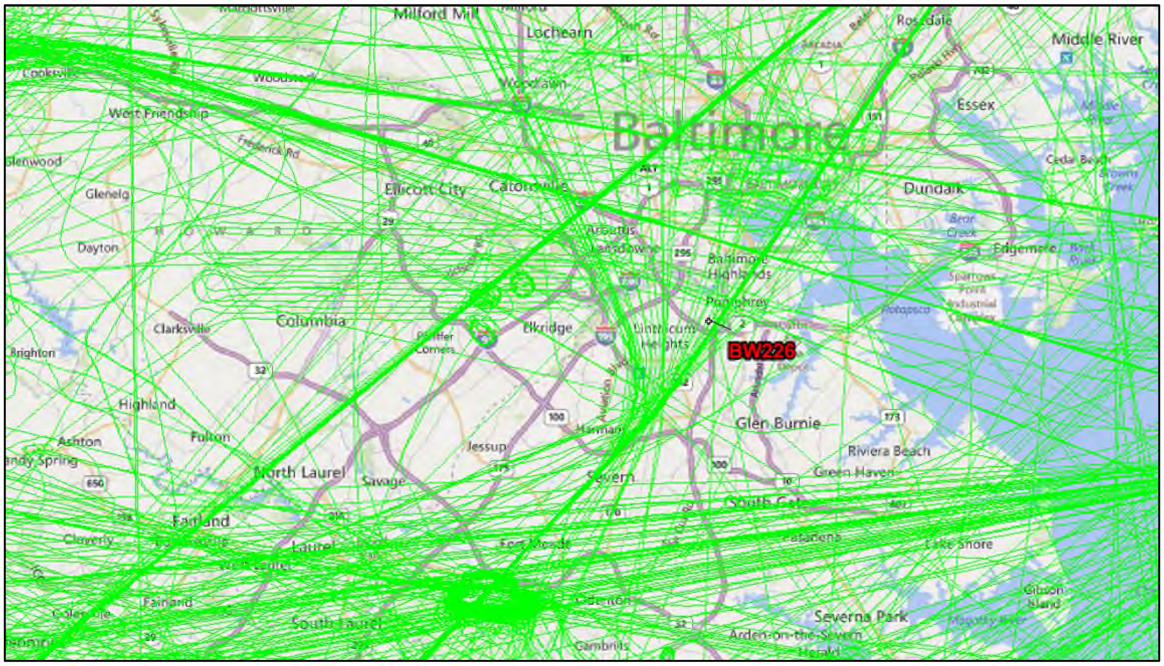


Figure 9. All Flight Tracks not associated with BWI Marshall from March 24, 2015

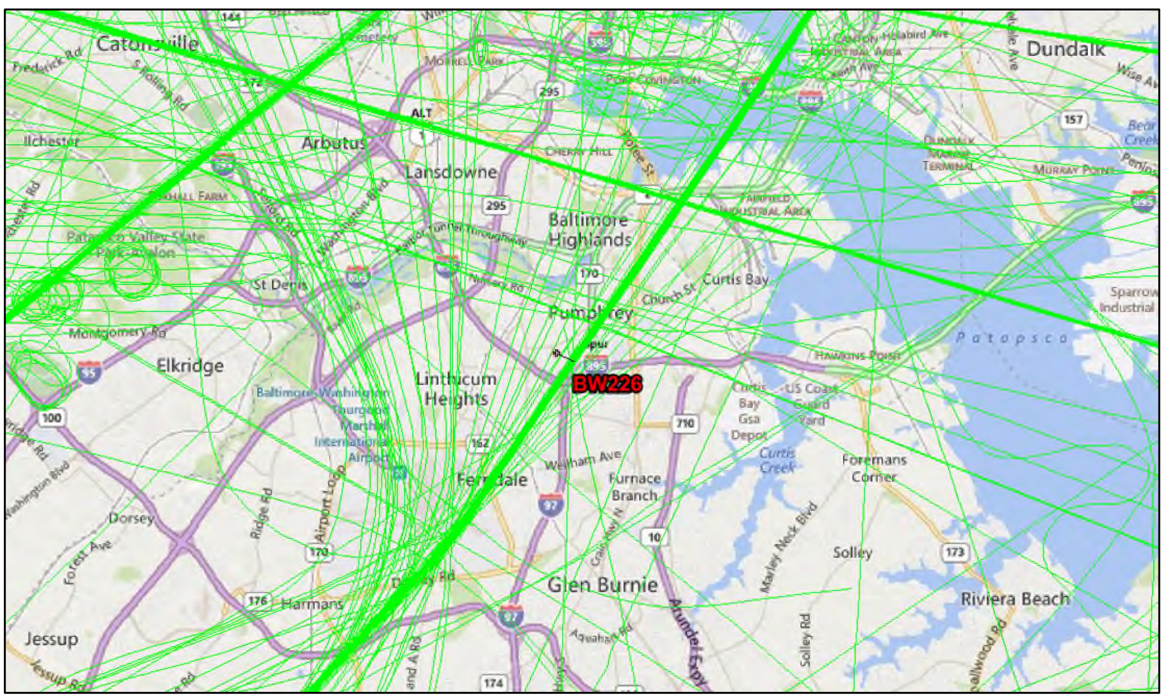


Figure 10. All Flight Tracks not associated with BWI Marshall from March 24, 2015

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 11 presents a count of noise events due to aircraft at various Lmax values for the complete measurement period. For example, the tallest orange bar in the figure shows that six departures from BWI Marshall had an Lmax of 65 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 12 tells a similar story using the SEL metric which corresponds better to people's judgment of the noisiness of an event. Aircraft overflights not associated with BWI Marshall produced the largest number of noise events. These aircraft include high altitude jets and lower altitude propeller aircraft and helicopters flying over BWI Marshall. Noise events from other aircraft operations, such as BWI Marshall arrivals or departures 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.

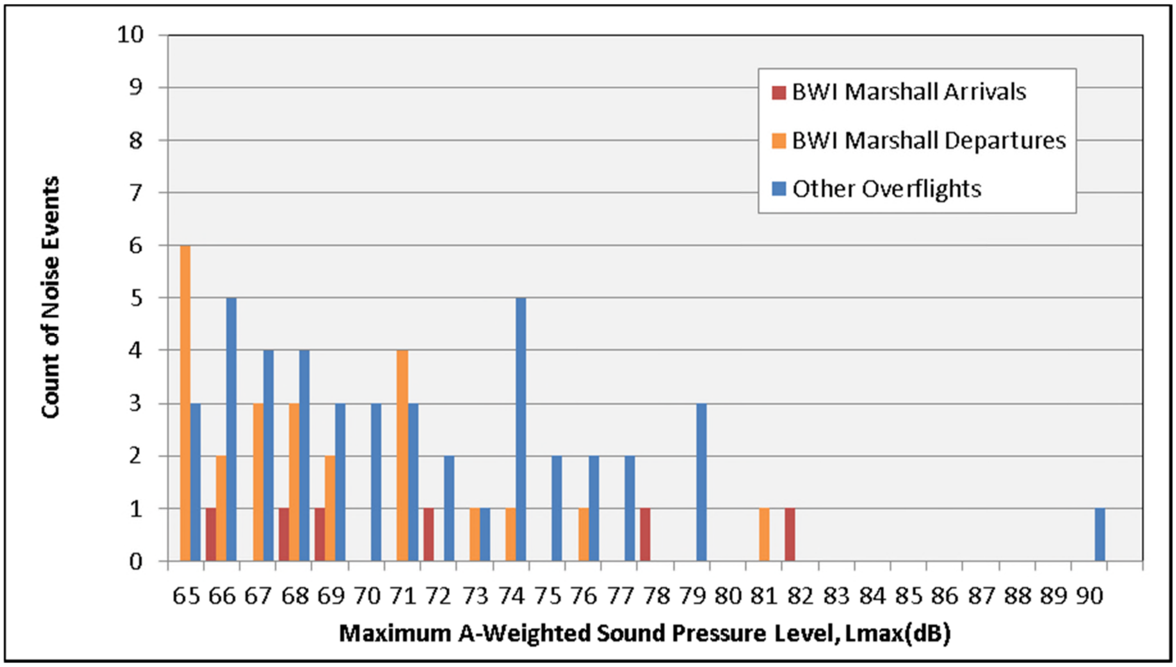


Figure 11. Counts of Maximum Noise Levels from Aircraft Overflights over the Full Measurement Period

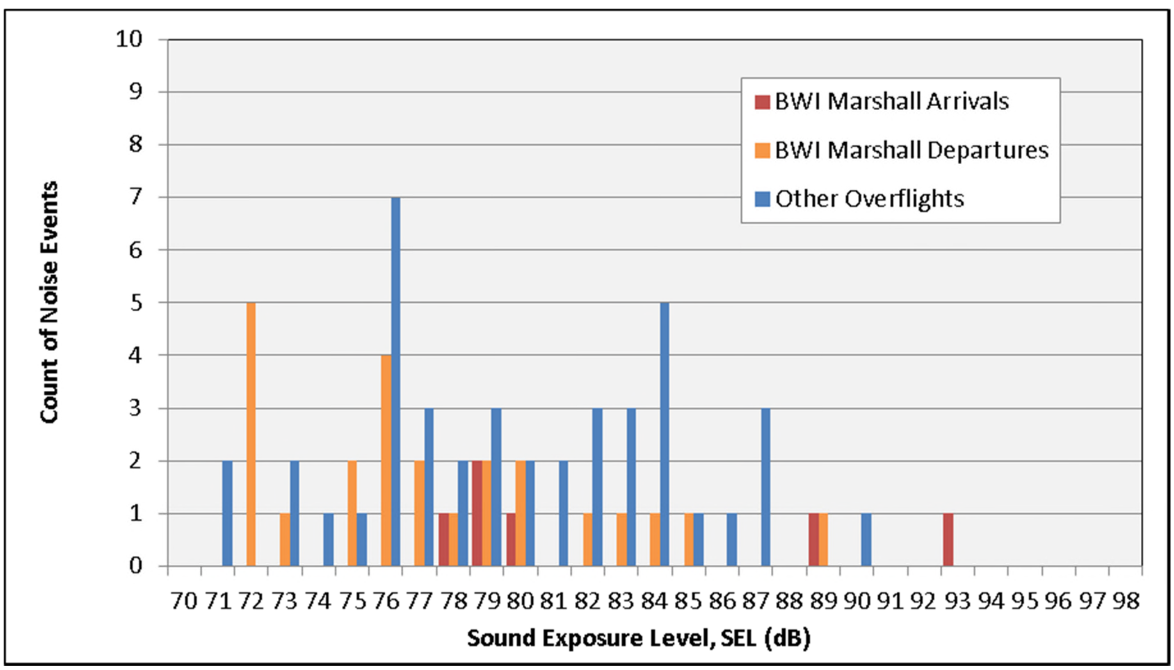
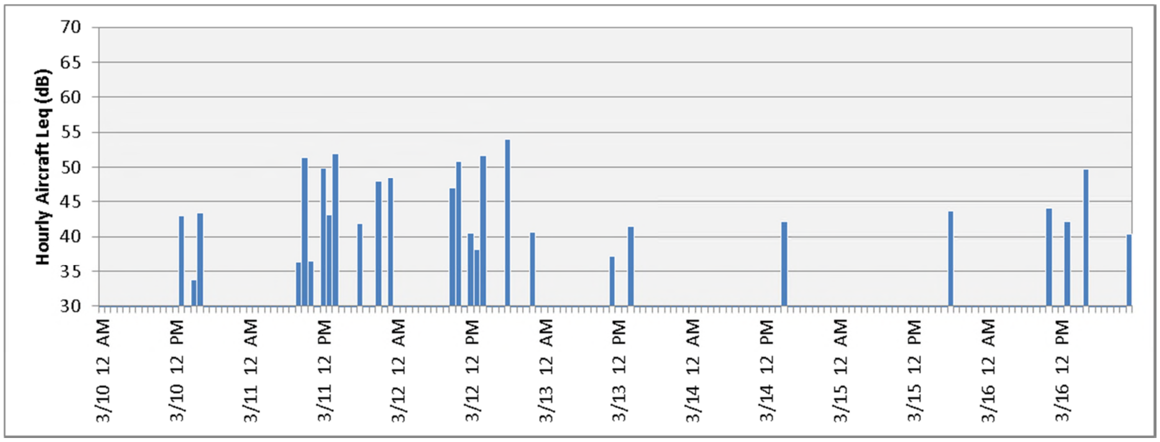
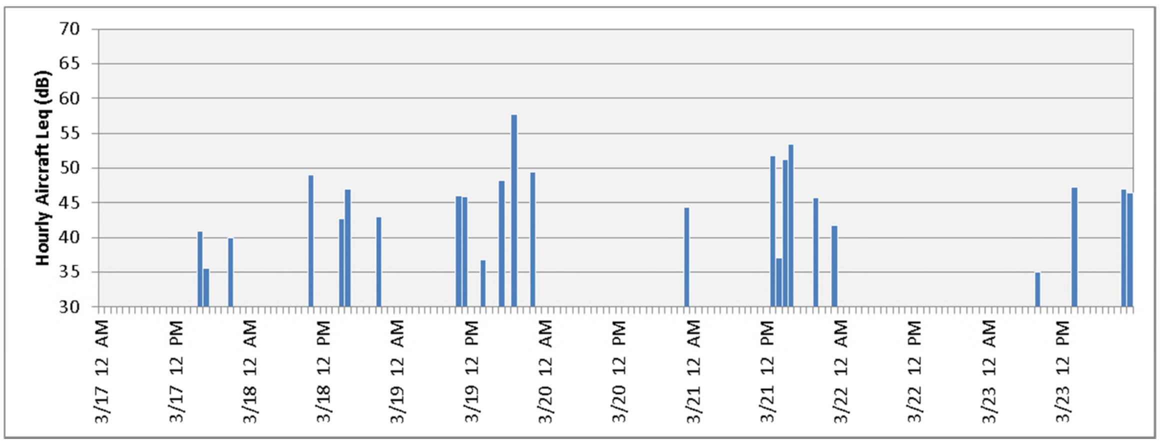


Figure 12. Counts of Sound Exposure Levels from Aircraft Overflights over the Full Measurement Period

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.





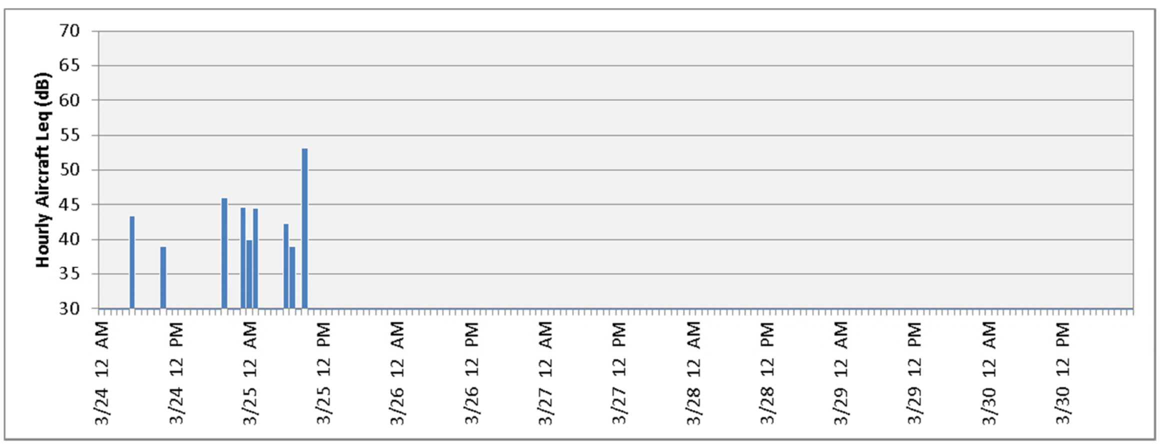


Figure 13. Average Hourly Aircraft Noise Levels

Table 1 summarizes the cumulative noise exposure over each of the sixteen 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 fourteen complete days, as shown in Table 1, ranged from very low 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 transiting the areas and utilizing BWI Marshall and percentage of time the airport spends in various operational configurations. Table 1 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
3/10/2015	34*	10	10 Arr / 15R Dep
3/11/2015	47	24	33L Arr / 28 Dep
3/12/2015	45	24	33L Arr / 28 Dep
3/13/2015	29	23	33L Arr / 28 Dep 10 Arr / 15R Dep
3/14/2015	28	24	10 Arr / 15R Dep 33L Arr / 28 Dep
3/15/2015	30	24	33L Arr / 28 Dep
3/16/2015	40	23	33L Arr / 28 Dep
3/17/2015	30	24	33L Arr / 28 Dep
3/18/2015	37	23	33L Arr / 28 Dep
3/19/2015	48	24	33L Arr / 28 Dep 10 Arr / 15R Dep
3/20/2015	41	23	10 Arr / 15R Dep
3/21/2015	45	24	33L Arr / 28 Dep
3/22/2015	-**	24	33L Arr / 28 Dep
3/23/2015	46	24	33L Arr / 28 Dep
3/24/2015	44	24	10 Arr / 15R Dep 33L Arr / 28 Dep
3/25/2015	49*	10	33L Arr / 28 Dep 10 Arr / 15R Dep
Total	**43**	**352**	33L Arr / 28 Dep

Notes:
* Measurements for a partial day may not represent the average noise level for the complete day.
** No loud aircraft noise events were recorded on 3/22/15

As shown in the single event figures, Figure 11 and Figure 12, most of the loudest noise events at this site are from overflights not associated with BWI Marshall. These overflights accounted for about sixty-two percent of the DNL over the period. BWI Marshall departures contributed approximately twenty-two percent of the total DNL over the period. BWI Marshall arrivals contributed approximately sixteen percent of the total DNL over the period.

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.

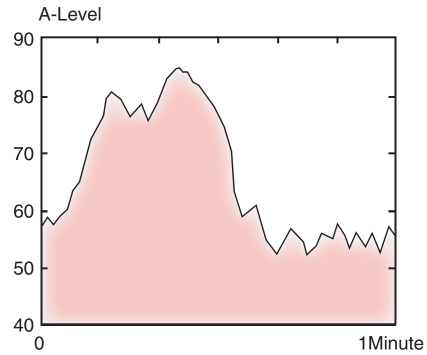


Figure 1. A-weighted Sound Levels Over Time

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.

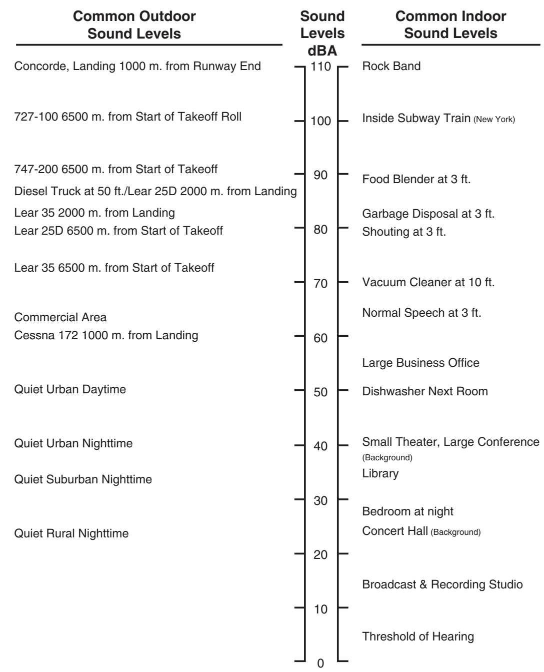


Figure 2. Common Environmental Sound Levels

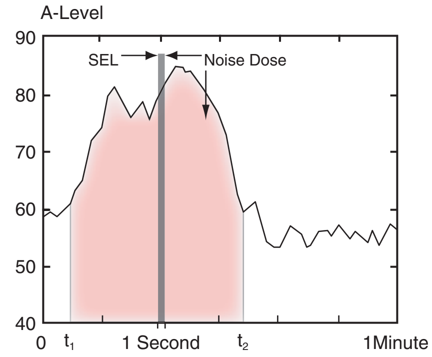


Figure 3. Sound Exposure Level

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.

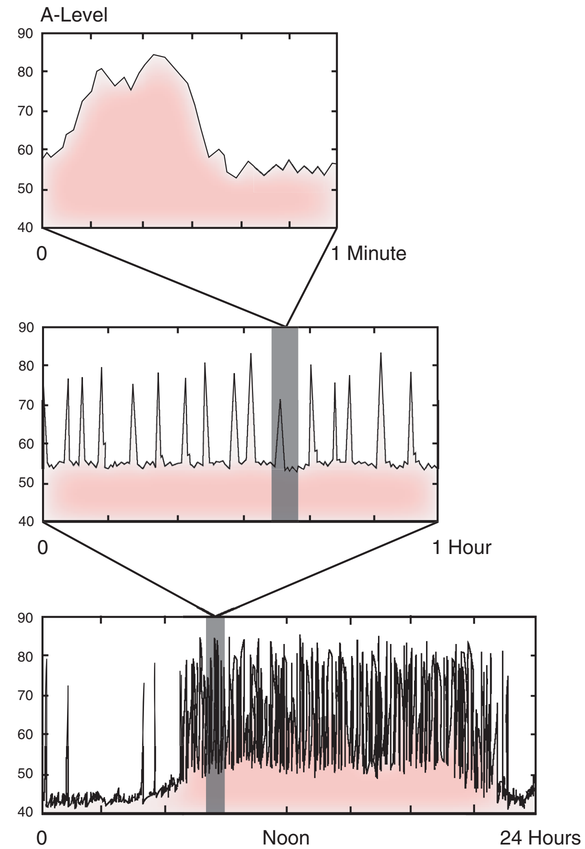


Figure 4. Daily Noise Dose

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.