Appendix B Noise

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B.1 Basics of Sound and A-Weighted Sound Level

The loudest sounds that can be detected comfortably by the human ear have intensities a trillion times greater than those of sounds barely detectable. This vast range renders a linear scale impractical to represent all sound intensities. The decibel (dB) is a logarithmic unit used to represent the intensity of a sound, also referred to as the sound level. Table B-1 provides a comparison of how the human ear perceives changes in loudness on the logarithmic scale. A difference of 3 dB is generally barely perceptible, while a difference of 20 dB is typically experienced as a fourfold change in loudness.

Table B-1 Subjective Responses to Changes in A-Weighted Decibels

Change	***Change in Perceived Loudness***
3 dB	Barely perceptible
5 dB	Quite noticeable
10 dB	Dramatic – twice or half as loud
20 dB	Striking – fourfold change

Note: dB = decibels

Figure B-1 provides a chart of A-weighted sound levels (dBA) from typical noise sources (Cowan, 1994). Some noise sources (e.g., air conditioner, vacuum cleaner) are continuous sounds that maintain a constant sound level for some period of time. Other sources (e.g., automobile, heavy truck) shown in the figure represent the maximum sound produced during an event like a vehicle pass-by. Other sounds (e.g., urban daytime, urban nighttime) are averages taken over extended periods of time. A variety of noise metrics have been developed to describe noise over different time periods, as discussed below.

The different levels of frequencies of a sound make up the spectral content, and the frequency is measured in cycles per second or Hertz. To correspond to the human ear’s non-linear sensitivity and perception of different frequencies of sound more closely, the spectral content is weighted. For example, environmental noise measurements are usually on an “A-weighted” scale that filters out very low and very high frequencies to approximate human sensitivity. It is common to add the “A” to the measurement unit to identify that the measurement has been made with this filtering process. In this document, the dB unit refers to dBA.

Noise levels from aircraft operations that exceed background noise levels at an airfield typically occur beneath main approach and departure corridors, in local air traffic patterns around the airfield, and in areas immediately adjacent to parking ramps and aircraft staging areas. As aircraft in flight gain altitude or distance from a noise-sensitive land use, their noise contributions at ground level generally decrease until becoming indistinguishable from the background ambient noise.

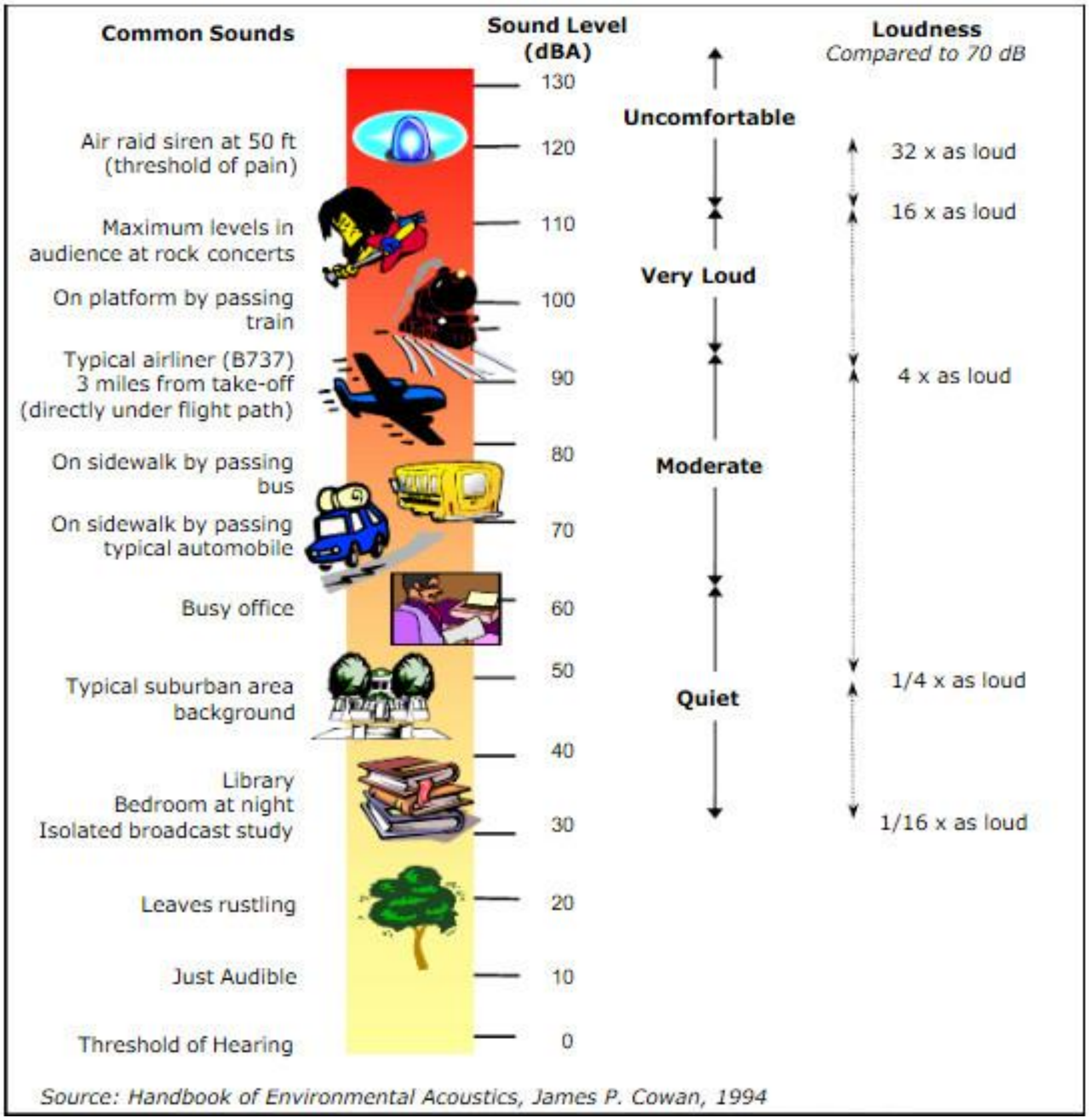

Figure B-1 A-Weighted Sound Levels from Typical Sources

B.2 Noise Metrics

A metric is a system for measuring or quantifying a particular characteristic of a subject. Since noise is a complex physical phenomenon, different noise metrics help to quantify the noise environment. While day-night average sound level (DNL) is the most commonly used tool for analyzing noise generated at an airfield, other metrics (and analysis techniques) for communicating noise levels have been developed. These supplemental metrics and analysis tools provide more detailed noise exposure information for the decision process and improve the discussion regarding noise exposure. The following sections summarize the noise metrics used to complete the analysis in the Environmental Assessment (EA).

B.2.1 Day-Night Average Sound Level

The DNL metric is the energy-averaged sound level measured over a 24-hour period equating to the continuous sound level that would be present if all the variations in sound level were averaged, with a 10 dB adjustment assigned to noise events occurring after 10 p.m. and before 7 a.m. The DNL metric quantifies the total sound energy received and is therefore a cumulative measure, but it does not provide specific information on the number of noise events or the individual sound levels that occur during the 24-hour day. The 10 dB adjustment accounts for the added intrusiveness of sounds occurring while people are most likely at home or sleeping. The “daytime” and “nighttime” periods defined by DNL, sometimes referred to as “acoustic day” and “acoustic night,” always correspond to the times given independent of the “day” and “night” used commonly in military aviation, which are directly related to the times of sunrise and sunset.

Scientific studies have found a correlation between the percentages of groups of people highly annoyed by noise and the level of their average noise exposure measured in DNL (USEPA, 1978; Schultz, 1979). DNL has been determined to be a reliable measure of long-term community annoyance with aircraft noise and has become the standard noise metric used by the U.S. Department of Housing and Urban Development, Federal Aviation Administration, U.S. Environmental Protection Agency, Department of Defense (DoD), Federal Interagency Committee on Noise, American National Standards Institute, and World Health Organization, among others, for measuring noise effects. In accordance with DoD Instruction 4165.57, DNL noise contours are used for recommending land uses that are compatible with aircraft noise levels. Studies of community annoyance in response to numerous types of environmental noise show that DNL correlates well with effect assessments (Schultz, 1979); there is a relationship between DNL and the level of annoyance experienced.

The DoD recommends land use controls beginning at the 65 dB DNL level. Research has indicated that about 87 percent of the population is not highly annoyed by outdoor sound levels below 65 dB DNL (Federal Interagency Committee on Urban Noise, 1980). Most people are exposed to sound levels of 50 to 55 DNL or higher daily. Therefore, the 65 dB DNL noise contour is used to help determine compatibility of military aircraft operations with local land use, particularly for land use associated with airfields.

B.2.2 Sound Exposure Level

The sound exposure level (SEL) metric combines both the intensity of a sound and its duration by providing the equivalent sound level that would contain the same sound energy of the noise event if occurring over one second. Individual time-varying noise events (e.g., aircraft overflights) have two main characteristics: a sound level that changes throughout the event and a period of time during which the event is heard. During an aircraft flyover, SEL captures the total sound energy from the beginning of the acoustic event to the point when the receiver no longer hears the sound. Because the SEL metric describes overflights by their one-second energy averages, it is useful for comparing overflights with differing durations and intensities. SEL does not directly represent the sound level heard at any given time, but instead provides a measure of total sound energy of the entire acoustic event. In this EA, SEL is used in aircraft comparison.

B.2.3 Maximum Sound Level

The highest dBA measured during a single event where the sound level changes value with time (e.g., an aircraft overflight) is called the maximum sound level or L_{max}. During an aircraft overflight, the noise level starts at the ambient or background noise level, rises to the maximum level as the aircraft flies closest to the observer, and returns to the background level as the aircraft recedes into the distance. L_{max} defines the maximum sound level occurring for a fraction of a second. For aircraft noise, the "fraction of a second" over which the maximum level is defined is generally 1/8 second (American National Standards Institute, 1988). For sound from aircraft overflights, the SEL is usually greater than the L_{max} because an individual overflight takes seconds and the L_{max} occurs instantaneously. In this EA, L_{max} is used in the analysis of construction activities.

B.2.4 Noise Effects

An extensive amount of research has been conducted regarding noise effects, including annoyance, effects on domestic animals and wildlife, property values, structures, terrain, and archaeological sites. Annoyance effects are summarized below.

B.2.4.1 Annoyance

As previously noted, the primary effect of aircraft noise on exposed communities is long-term annoyance, defined by the U.S. Environmental Protection Agency as any negative subjective reaction on the part of an individual or group. The scientific community has adopted the use of long-term annoyance as a primary indicator of community response because of the consistent relationship between DNL and the level of community annoyance (Federal Interagency Committee on Noise, 1992).

Examination of the relationship between annoyance and DNL shows a high correlation between groups of people, in the range of 85 to 90 percent. However, the correlation between individuals is much lower, at 50 percent or less. This finding is not surprising, given the personal differences between individuals, with some people more sensitive to noise than others. The surveys underlying this relationship show that annoyance from noise is also affected by non-acoustic factors. The influence of non-acoustic factors is a complex interaction influencing an individual's annoyance response to noise (Brisbane Airport Corporation, 2007). Newman and Beattie (1985) divided the non-acoustic factors into the emotional and physical variables shown in Table B-2.

Table B-2 Non-Acoustic Variables Influencing Aircraft Noise Annoyance

Emotional Variables	***Physical Variables***
Feeling about the necessity or preventability of the noise	Type of neighborhood
Judgment of the importance and value of the activity that is producing the noise	Length of time an individual is exposed to a noise
Activity at the time an individual hears the noise	Season
Attitude about the environment	Predictability of the noise
General sensitivity to noise	Control over the noise source
Belief about the effect of noise on one's health	Time of day
Feeling of fear associated with the noise	

B.2.4.1 Sleep Disturbance

Disturbance of sleep is a concern for communities exposed to nighttime aircraft noise. The DoD guidelines for evaluating sleep disturbance are based upon methodology and standards developed by the American National Standards Institute and the Acoustical Society of America in 2008 (American National Standards Institute, 1988; DoD Noise Working Group, 2009). It is based upon a probability curve and the relationship between the indoor SEL value and the probability of awakening. The SELs are based upon the particular type of aircraft, flight profile, power setting, speed, and altitude relative to the receptor. The results may then be presented as a percent probability of awakening if windows are open, assuming 15 dB outdoor-to-indoor noise level reduction, and if windows are closed, assuming a 25 dB reduction. For example, an outdoor SEL of 94 dB would be associated with a probability of awakening of 3 percent if windows are open and 2 percent if windows are closed. The American National Standards Institute standard and DoD Noise Working Group guidance note that the probabilities of awakening are lower when exposed households have been exposed to similar noise sources for long periods of time.

B.2.5 Noise Modeling and Methodology

Computer modeling provides a tool to assess potential noise effects. DNL noise contours are generated by a computer model that draws from a library of aircraft noise measurements under controlled conditions. Noise contours produced by the model allow a comparison of existing conditions and proposed changes or alternative actions, even when the aircraft studied are not currently operating from the base. For these reasons, on-site noise monitoring is seldom used at military air installations, especially when the aircraft mix and operational tempo are not uniform.

The noise environment for this EA was modeled using the NOISEMAP suite of computer programs that includes the core computational “NMAP” and Rotorcraft Noise Model software used for fixed-wing and rotorcraft operations in this study, respectively. The results of the two models are summed to yield overall aircraft noise levels. NOISEMAP and Rotorcraft Noise Model analyze all the operational data (types of aircraft, number of operations, flight tracks, altitude, speed of aircraft, engine power settings, and engine maintenance run-ups), environmental data (average humidity and temperature), and ground surface conditions in the study area (ground flow resistivity and terrain elevation). The result of the modeling is noise contours: lines connecting points of equal value (e.g., 65 dB DNL and 70 dB DNL). Noise zones cover an area between two noise contours and are usually shown in 5-dB increments (e.g., 65–69 dB DNL, 70–74 dB DNL, and 75–79 dB DNL). DNL airfield contours comprise all aircraft events occurring during an average annual day, which are a function of both the sound energy of each event as well as the frequency of occurrence and period of day at which each event occurs. As described in Section B.2.2, *Sound Exposure Level*, SEL provides the total sound energy of an acoustic event normalized to one second, allowing comparison of the energy across disparate events.

For proposed actions where new aircraft would generate SELs quieter than existing aircraft, calculating DNL as if all operations generate the same SEL yields a conservative estimate of potential DNL increase. Using this conservative approach, potential DNL changes can be calculated based solely on the number of operations conducted under baseline conditions and under the Proposed Action. As stated in Section B.1, *Basics of Sound and A-Weighted Sound Level*, changes in instantaneous noise levels of 3 dB are barely perceptible. In cases where the conservative DNL estimation method described above yields changes of less than 1 dB, changes would be unlikely to be noticed.

B.3 References

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