DETROIT METROPOLITAN WAYNE COUNTY AIRPORT
FAR PART 150 NOISE COMPATIBILITY STUDY UPDATE

DETROIT METRO • WILLOW RUN
WAYNE COUNTY AIRPORT AUTHORITY

CHAPTER C

BACKGROUND INFORMATION ON NOISE & ITS MEASUREMENT

Background Information on Noise and its Measurement

Introduction to Background Information on Noise

Noise, by its definition, is unwanted sound. Noise is perceived by, and consequently affects people in a variety of ways. This section presents background information on the characteristics of sound and provides insight into the human perception of noise. This section also provides a means to relate the sound made by aircraft operating to and from Detroit Metropolitan Wayne County Airport (DTW) to the noise in the surrounding communities. The metrics (the way noise is measured or described) and methodologies used in the Part 150 Noise and Land Use Compatibility Study (Study) to describe noise from aircraft operating at DTW are also presented. These metrics enable the characterization of existing and future noise. This section is divided into the following sub-sections:

- Characteristics of Sound - Presents properties of sound that are important for describing noise in the airport setting.
- Factors Influencing Human Response to Sound - Discusses sound level conditions that produce subjective perceptions and elicit a response in humans.
- Health Effects of Noise - Summarizes the potential disturbances and health effects of noise to humans.
- Sound Rating Scales - Presents various sound rating scales and how these scales are applied to assessing noise from aircraft operations.
- Noise/Land Use Compatibility Guidelines - Summarizes the current guidelines and regulations used to control the use of land in areas affected by aircraft noise.
- Airport Noise Assessment Methodology - Describes computer modeling and on-site sound level measurements used to measure aircraft and other noise in the vicinity of airports.

Characteristics of Sound

> **Highlights of Sound**
>
> Noise by definition is unwanted sound. There are many ways to describe noise (metrics), however, the most commonly relied on metric is the decibel (dB), which uses a weighting system that most closely reflects the human ear (the A-weighted decibel – dBA).
>
> A number of factors affect sound, including weather, ground effects, as well as human reaction to the noise source. Health effects associated with aircraft noise are typically impacts to sleep and communication that cause stress.
>
> As required by Federal law, aircraft noise must be measured using the Day-Night Average Level (DNL), which is based on averaging dBA. The Airport Authority will be supplementing this metric with other tools such as the Sound Exposure Level (SEL) and the Time Above (TA) measures.
>
> FAA and other federal agencies have established land use compatibility guidelines based on the DNL, that identify the acceptability of various types of land use with aircraft noise exposure.

Sound Level and Frequency. Sound is described in terms of the sound pressure (amplitude) and frequency (similar to pitch).

Sound pressure is a direct measure of the magnitude of a sound without consideration for other factors that may influence its perception. The range of sound pressures that occur in the environment is so large that it is convenient to express them on a logarithmic scale. The standard unit of measurement for sound pressure is the Decibel (dB). One decibel is used to describe the reference point of 20 micro Pascals or about 0.000000003 pounds per square inch of energy. Thus, 65 decibels is that amount to the 65th power. A logarithmic scale is used because of the difficulty in expressing such large numbers.

On the logarithmic scale, a sound level of 70 dB has 10 times the energy as a level of 60 dB, while a sound level of 80 has 100 times as much acoustic energy as 60 dB. This differs from the human perception to noise, which typically judges a sound 10 dB higher than another to be twice as loud, 20 dB higher to be four times as loud, and so forth.

The frequency of a sound is expressed as Hertz (Hz) or cycles per second. The normal audible frequency range for young adults is 20 Hz to 20,000 Hz. The prominent frequency range for community noise, including aircraft and motor vehicles, is between 50 Hz and 5,000 Hz. The human ear is not equally sensitive to all frequencies, with some frequencies judged to be louder for a given signal than others. As a result, research studies have analyzed how individuals make relative judgments as to the "loudness" or "annoyance" of a sound. The most prominent of these scales includes Loudness Level, Frequency-Weighted Contours (such as the A-weighted scale), and Perceived Noise Level. Noise metrics used in aircraft noise assessments are based upon these frequency weighting scales. Below is a glossary of noise metric terminologies, which is discussed in the following paragraphs.

Loudness Level. This scale has been devised to approximate the human subjective assessment of the "loudness" of a sound. Loudness is the subjective judgment of an individual as to how loud or quiet a particular sound is perceived.

Frequency-Weighted Contours (dBA, dBB, and dBC). To simplify the measurement and computation of sound loudness levels, frequency-weighted metrics are used. These frequency-weighted contours demonstrate different aspects of noise, and are presented in **Figure C1**.

The most common frequency weighting is the A-weighted noise curve. The A-weighted decibel scale (dBA) focuses on frequencies approximating the sensitivity of the human ear. In the A-weighted decibel, everyday sounds normally range from 30 dBA (very quiet) to 100 dBA (very loud). Most community noise analyses are based upon the A-weighted decibel scale. Examples of various sound environments, expressed in dBA, are presented in **Figure C2**.

Some interest has developed in using a noise curve that measures lower frequency noise sources. For example, the C-weighted curve is used for the analysis of the noise impacts from artillery noise, which captures the low rumble that many associate with vibration.

Perceived Noise Level. Perceived noisiness was originally developed for the assessment of aircraft noise. Perceived noisiness is defined as "the subjective impression of the unwantedness of a not unexpected, non-pain or fear-provoking sound as part of one's environment," (Kryter, 1970) "Noisiness" curves differ from "loudness curves" in that they have been developed to rate the noisiness or annoyance of a sound as opposed to the loudness of a sound (i.e., perception of the noise).

As with loudness curves, noisiness curves have been developed from laboratory surveys of individuals. However, in noisiness surveys, individuals are asked to judge in a laboratory setting when two sounds are equally noisy or disturbing if heard regularly in their own environment. These surveys are more complex and are therefore subject to greater variability. Aircraft certification data are based upon these types of noisiness curves [see Federal Aviation Regulation (FAR) Part 36 Regulations presented in the Noise and Land Use section of this chapter].

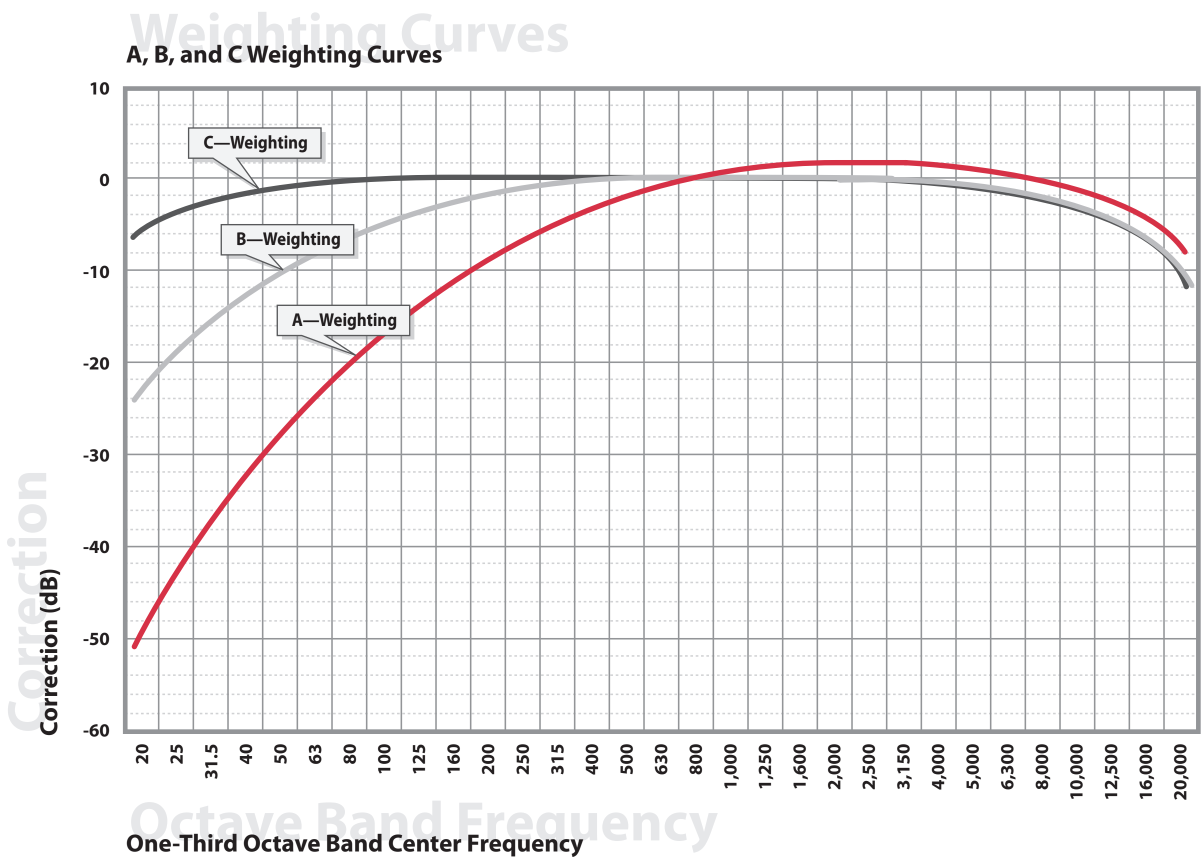


Figure C1 **Frequency Weighted Contours (dBA, dBB, dBC)**

EXAMPLES OF VARIOUS A-WEIGHTED DECIBEL SOUND ENVIRONMENTS

dB(A)	OVER-ALL LEVEL Sound Pressure Level Approx. 0.0002 Microbar	COMMUNITY (Outdoor)	HOME or INDUSTRY	LOUDNESS Human Judgement of Different Sound Levels
130		Military Jet Aircraft Takeoff with Afterburner from Aircraft Carrier @ 50 ft. (130)	Oxygen Torch (121)	120 dB(A) 32 Times as Loud
120 110	UNCOMFORTABLY LOUD	Concorde Takeoff (113)	Riveting Machine (110) Rock and Roll Band (108-114)	110 dB(A) 16 Times as Loud
100		Boeing 747-200 Takeoff (101)		100 dB(A) 8 Times as Loud
90	VERY LOUD	Power Mower (96) DC-10-30 Takeoff (96)	Newspaper Press (97)	90 dB(A) 4 Times as Loud
80		Car Wash @ 20 ft. (89) Boeing 727 Hushkit Takeoff (89)	Food Blender (88) Milling Machine (85) Garbage Disposal (80)	80 dB(A) 2 Times as Loud
70	MODERATELY LOUD	High Urban Ambient Sound (80) Passenger Car, 65 mph @ 25 ft. (77) Boeing 757 Takeoff (76)	Living Room Music (76) TV-Audio, Vacumn Cleaner	70 dB(A)
60		Propeller Airplane Takeoff (67) Air Conditioning Unit @ 100 ft. (60)	Cash Register @ 10 ft. (65-70) Electric Typewriter @ 10 ft. (64) Conversation (60)	60 dB(A) 1/2 Times as Loud
50	QUIET	Large Transformers @ 100 ft. (50)		50 dB(A) 1/4 Times as Loud
40		Bird Calls (44) Low Urban Ambient Sound (40)		40 dB(A) 1/8 Times as Loud

"Aircraft takeoff noise measured 6,500 meters from beginning of takeoff roll
(Source: Advisory Circular AC-36-3G)"

Figure C2 **Example of Various Sound Environments**

Propagation of Noise. Outdoor sound levels decrease as a result of several factors, including increasing the distance from the sound source, atmospheric absorption (characteristics in the atmosphere that actually absorb sound), and ground attenuation (characteristics on the ground that absorb sound). Sound typically travels in spherical waves, similar to waves created from dropping a stone into water. As the sound wave travels away from the source, the sound energy is spread over a greater area, dispersing the sound power of the wave.

Temperature and humidity of the atmosphere also influence the sound levels at a particular location. These influences increase with distance and become particularly important at distances greater than 1,000 feet. The degree of absorption depends on the frequency of the sound, as well as humidity and air temperature. For example, when the air is cold and humid, and therefore denser, atmospheric absorption is lowest. Higher frequencies are more readily absorbed than the lower frequencies. Over large distances, lower frequency sounds become dominant as the higher frequencies are attenuated. Examples of the effects of temperature and humidity on sound absorption are presented in **Figure C3**.

Noise propagation is particularly relevant in the Detroit area due to winter weather conditions. During the winter, high humidity and cold overcast conditions result in lowered noise attenuation, causing noise levels to remain higher farther from a noise source than would occur under standard summer conditions. Winter weather facilitates an atmospheric inversion (when the air nearest the earth is colder than the air above), which also results in higher aircraft noise than when inversions are not present.

Duration of Sound. Duration of a noise event is an important factor in describing sound in a community setting. The longer the noise event, the more likely that the sound will be perceived as annoying. The "effective duration" of a sound starts when a sound rises above the background sound level and ends when it drops back below the background level. Studies have confirmed a relationship between duration and annoyance and established the amount a sound must be reduced to be judged equally annoying over an increased duration time.

This relationship between duration and noise level forms the basis of how the equivalent energy principal of sound exposure is measured. Reducing the acoustic energy of a sound by one-half results in a 3 dB reduction. Conversely, doubling the duration of the sound event increases the total energy of the event by 3 dB. This equivalent energy principle is based upon the premise that the potential for a noise to impact a person is dependent on the total acoustical energy content of the noise. Noise descriptors explained below (DNL, LEQ and SEL) are all based upon this equivalent energy principle.

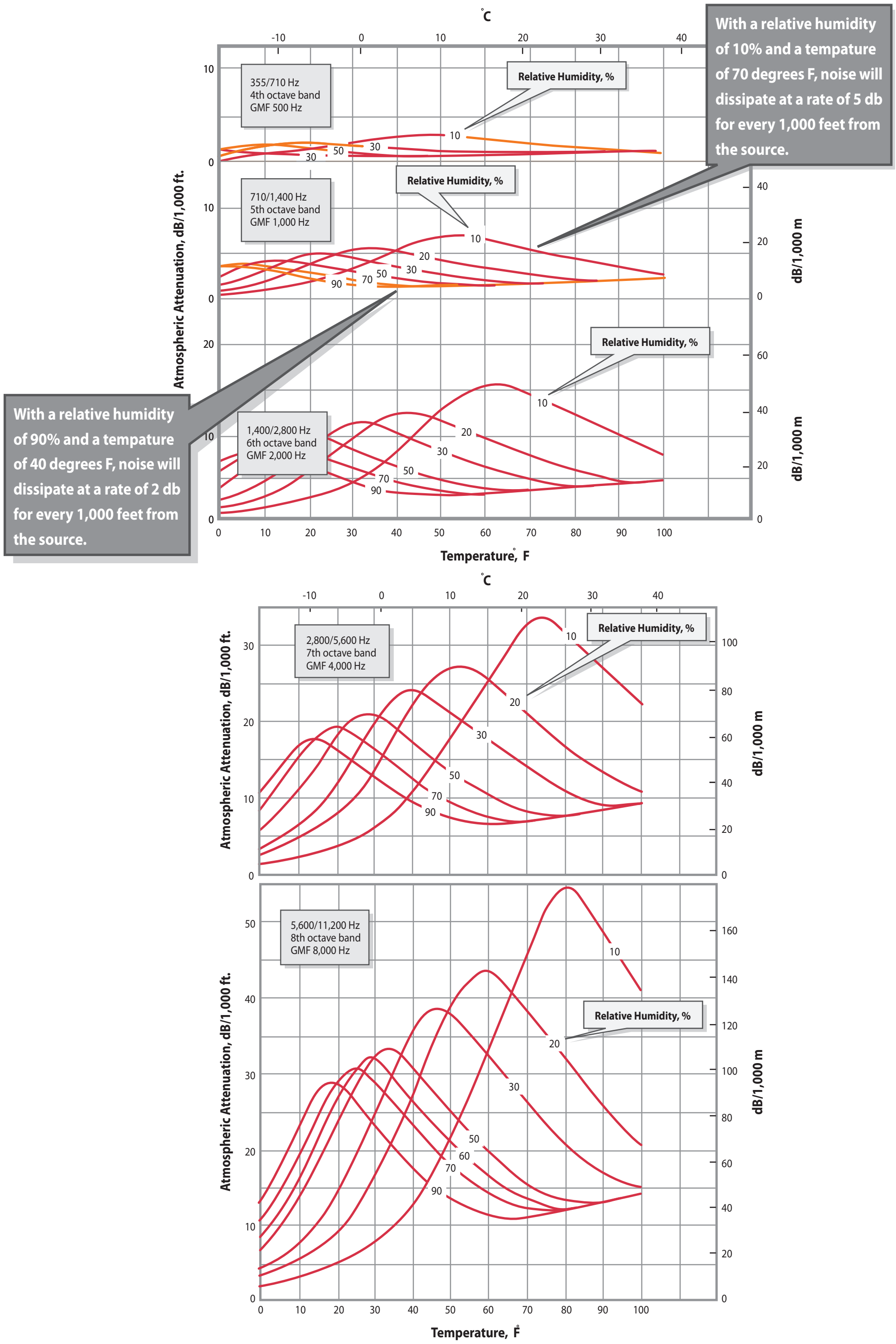


Figure C3 **Atmospheric Attenuation-How Noise Changes Over Distance Based On Humidity and Temperature**

Change in Noise Levels. The concept of change in sound levels is related to the reaction of the human ear to sound. The human ear detects relative differences between sound levels better than absolute values of levels. Under controlled laboratory conditions, a human listening to a steady unwavering pure tone sound can barely detect a change of approximately one decibel for sound levels in the mid-frequency region. However, when ordinary noises are heard, a young healthy ear can only detect changes of two to three decibels. A five-decibel change is noticeable while a 10-decibel change is judged by the majority of people as a doubling effect of the sound.

Masking Effect. One characteristic of sound is its ability to interfere with the listener's ability to hear another sound. This is defined as the masking effect. The presence of one sound effectively raises the threshold of audibility for the hearing of a second sound. For a sound to be heard, it must exceed the threshold of hearing for that particular individual and exceed the masking threshold for the background noise.

The masking characteristic is dependent upon many factors, including the spectral (frequency) characteristics of the two sounds, the sound pressure levels, and the relative start time of sound events. The masking effect is greatest when it is closest to the frequency of the signal. Low frequency sounds can mask higher frequency sounds; however, high frequency sounds do not easily mask low frequency sounds.

Ground Effects. This term describes the effects of vegetation on noise. As sound travels away from the source, some of it is absorbed by grass, plants, and trees. The amount of such ground attenuation (rate that noise level reduces at distances farther from the noise source) depends on the structure and density of trees and foliage, as well as the height of both the source and receiver and the frequency of the sound being absorbed. If the source and the receiver of the sound are both located below the average height of the intervening foliage, the ground covering will be most effective. If either the source or the receiver rises above the height of the ground covering, the excess attenuation will become less effective. Reflected sound, however, will still be reduced.

Factors Influencing Human Response to Sound

Many factors influence how a sound is perceived and whether or not it is considered annoying to the listener. This includes not only physical characteristics of the sound, but also secondary influences such as sociological and external factors. The "Handbook of Noise Control" describes human response to sound in terms of both acoustic and non-acoustic factors. These factors are summarized in **Table C1.**

Sound rating scales are developed to account for how humans respond to sound and how sounds are perceived in the community. Many non-acoustic parameters affect individual response to noise. Background sound, which is an additional acoustic factor, is important in describing sound in rural settings. Research has identified a clear association of reported noise annoyance and fear of an accident. In particular, there is firm evidence that noise annoyance is associated with: (1) the fear of an aircraft crashing or of danger from nearby surface transportation; (2) the belief that aircraft noise could be prevented or reduced by pilots or authorities related to airlines; and, (3) an expressed sensitivity to noise generally. Thus, it is important to recognize that such non-acoustic factors, as well as acoustic factors, contribute to human response to noise.

Table C1
FACTORS THAT AFFECT INDIVIDUAL ANNOYANCE TO NOISE
Detroit Metropolitan Wayne County Airport FAR Part 150 Noise Compatibility Study Update

Primary Acoustic Factors
Sound Level
Frequency
Duration
Secondary Acoustic Factors
Spectral (Frequency) Complexity
Fluctuations in Sound Level
Fluctuations in Frequency
Rise-time of the Noise
Localization of Noise Source
Non-acoustic Factors
Physiology
Adaptation and Past Experience
How the Listener's Activity Affects Annoyance
Predictability of When a Noise will Occur
Whether the Noise is Necessary
Individual Differences and Personality

Source: C. Harris, 1979

Health Effects of Noise

Noise is known to have adverse effects on people. From these effects, criteria have been established to help protect the public health and safety and prevent disruption of certain human activities. These criteria are based on effects of noise on people, such as hearing loss (not a factor with typical community noise), communication interference, sleep interference, physiological responses, and annoyance. Each of these potential noise impacts is briefly discussed in the following points:

- **Hearing Loss** is generally not a concern in community/aircraft noise situations, even when close to a major airport or a freeway. The potential for noise induced hearing loss is more commonly associated with occupational noise exposure in heavy industry; very noisy work environments with long-term, sometimes close-proximity exposure; or, certain very loud recreational activities such as target shooting, motorcycle or car racing, etc. The Occupational Safety and Health Administration (OSHA) identifies a noise exposure limit of 90 dBA for 8 hours per day to protect from hearing loss (higher limits are allowed for shorter duration exposures). Noise levels in neighborhoods near airports, even in very noisy neighborhoods, do not exceed the OSHA standards and are not sufficiently loud to cause hearing loss.

- **Communication Interference** is one of the primary concerns with aircraft noise. Communication interference includes interference with hearing, speech, or other forms of communication such as watching television and talking on the telephone. Normal conversational speech produces sound levels in the range of 60 to 65 dBA, and any noise in this range or louder may interfere with the ability of another individual to hear or understand what is spoken. There are specific methods for describing speech interference as a function of the distance between speaker, listener, and voice level. **Figure C4** shows the relationship between the quality of speech communication and various noise levels.

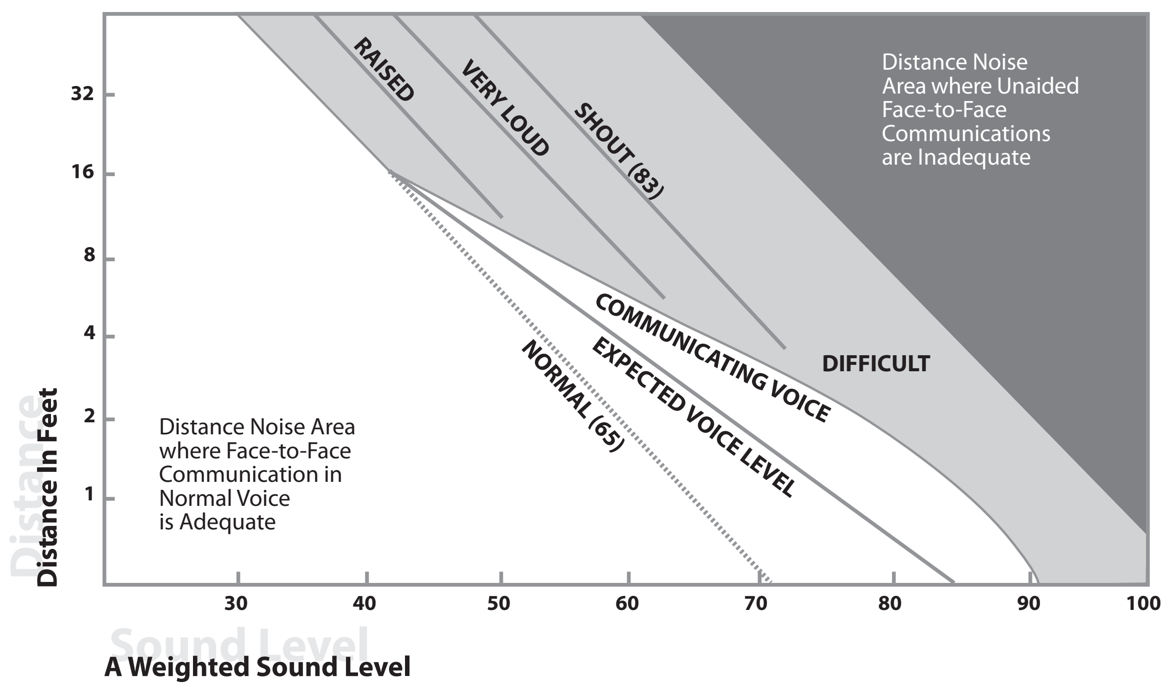


Figure C4 **Quality of Speech Communication in Relation to the Distance Between the Talked and the Listener**

- **Sleep Interference**, particularly during nighttime hours, is one of the major causes of annoyance due to noise. Noise may make it difficult to fall asleep, create momentary disturbances of natural sleep patterns by causing shifts from deep to lighter stages, and may cause awakenings that a person may not be able to recall.

  Research has shown that once a person is asleep in his own home, it is much more unlikely that he will be awakened by a noise. Some of this research has been criticized because it has been conducted in areas where subjects had become accustomed to aircraft noise. On the other hand, some of the earlier laboratory sleep studies have been criticized because of the extremely small sample sizes of most laboratory studies and because the laboratory was not necessarily a representative sleep environment.

  An English study assessed the effects of nighttime aircraft noise on sleep in 400 people (211 women and 189 men; 20-70 years of age; one per household) living at eight sites adjacent to four U.K. airports, with different levels of night flying. The main finding was that only a minority of aircraft noise events affected sleep, and, for most subjects, that domestic and other non-aircraft factors had much greater effects. As shown in **Figure C5**, aircraft noise is a minor contributor among a host of other factors that lead to awakening response.

  Likewise, the Federal Interagency Committee On Noise (FICON) in an earlier 1992 document, entitled **Federal Interagency Review of Selected Airport Noise Analysis Issues,** recommended an interim dose-response curve for sleep disturbance based on laboratory studies of sleep disturbance. This review was updated in June 1997, when the Federal Interagency Committee on Aviation Noise (FICAN) replaced the FICON recommendation with an updated curve based on the more recent in-home sleep disturbance studies. The FICAN recommended a curve based on the upper limit of the data presented, and, therefore, considers the curve to represent the "maximum percent of the exposed population expected to be behaviorally awakened," or the "maximum awakened."

  The FICAN recommendation is shown on **Figure C6**. This is a very conservative approach. A more common statistical curve for the data points is also reflected in Figure C6. The differences indicate, for example, a 10% awakening rate at a level of approximately 100 dB SEL, while the "maximum awakened" curve prescribed by FICAN shows the 10% awakening rate being reached at 80 dB SEL. (The full FICAN report can be found on the internet at www.fican.org). Sleep interference continues to be a major concern to the public and an area of debate among researchers.

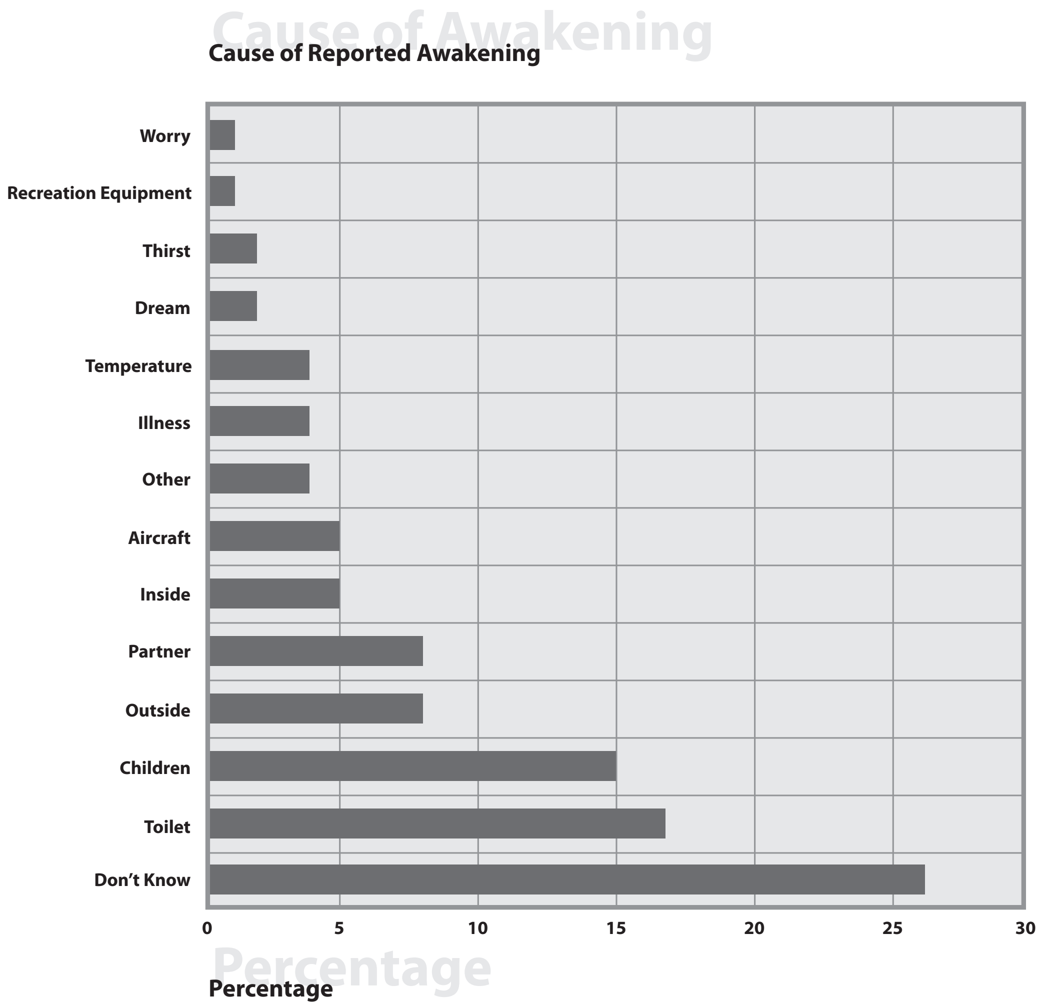


Figure C5 **Causes of Reported Awakenings**

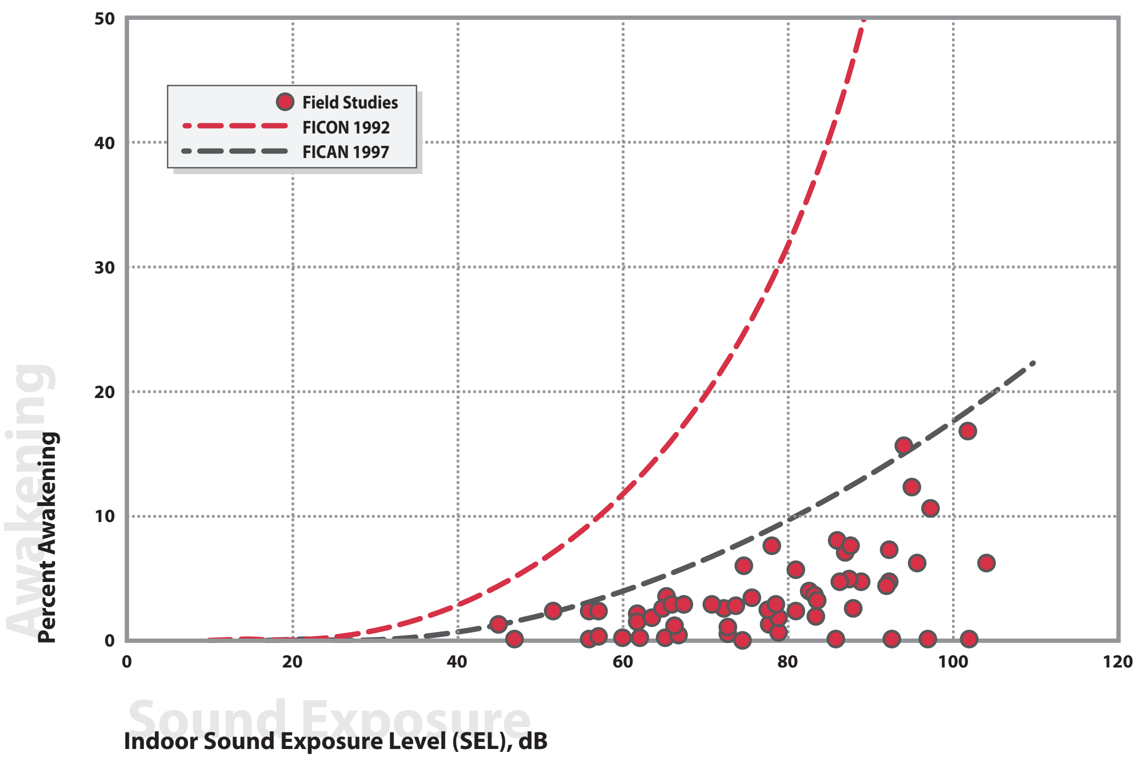


Figure C6 **Probability of Awakening for Different Indoor Sound Exposure Levels**

- **Physiological Responses** reflect measurable changes in pulse rate, blood pressure, etc. Generally, physiological responses reflect a reaction to a loud short-term noise, such as a rifle shot or a very loud jet over flight. While such effects can be induced and observed, the extent to which these physiological responses cause harm is not known.

- **Annoyance** is the most difficult of all noise responses to describe. Annoyance is an individual characteristic and can vary widely from person to person. What one person considers tolerable may be unbearable to another of equal hearing capability. The level of annoyance also depends on the characteristics of the noise (i.e., loudness, frequency, time, and duration), and how much activity interference (e.g., speech interference and sleep interference) results from the noise. However, the level of annoyance is also a function of the attitude of the receiver. Personal sensitivity to noise varies widely. It has been estimated that 2 to 10% of the population are highly susceptible to annoyance from noise not of their own making, while approximately 20 percent are unaffected by noise. Attitudes are affected by the relationship between the listener and the noise source (Is it your dog barking or the neighbor's dog?). Whether one believes that someone is trying to abate the noise will also affect their level of annoyance.

Sound Rating Scales

The description, analysis, and reporting of community sound levels are made difficult by the complexity of human response to sound, and the myriad of sound-rating scales and metrics that have been developed for describing acoustic effects. Various rating scales have been devised to approximate the human subjective assessment of "loudness" or "noisiness" of a sound.

Noise metrics can be categorized as single event metrics and cumulative metrics. Single event metrics describe the noise from individual events, such as an aircraft flyover. Cumulative metrics describe the noise in terms of the total noise exposure throughout the day. The noise metrics used in this study are summarized below:

Single Event Metrics

- **A-Weighted Metrics (dBA)**. To simplify the measurement and computation of sound loudness levels, frequency weighted metrics have obtained wide acceptance. The A-weighting (dBA) scale has become the most prominent of these scales and is widely used in community noise analysis. This metric has shown good correlation with community response and may be easily measured. The metrics used in this study are all based upon the dBA scale.

- **Maximum Noise Level.** The highest noise level reached during a noise event is called the "Maximum Noise Level," or Lmax. For example, as an aircraft approaches, the sound of the aircraft begins to rise above ambient noise levels. The closer the aircraft gets, the louder it is until the aircraft is at its closest point directly overhead. As the aircraft passes, the noise level decreases until the sound level settles to ambient levels. This is plotted at the top of **Figure C7**. It is this metric to which people generally respond when an aircraft flyover occurs.

- **Sound Exposure Level (SEL).** The duration of a noise event, or an aircraft flyover, is an important factor in assessing annoyance and is measured most typically as SEL. The effective duration of a sound starts when a sound rises above the background sound level and ends when it drops back below the background level. An SEL is calculated by summing the dB level at each second during a noise event (referring again to the shaded area at the top of **Figure C7**) and compressing that noise into one second. It is the level the noise would be if it all occurred in one second. The SEL value is the integration of all the acoustic energy contained within the event. This metric takes into account the maximum noise level of the event and the duration of the event. For aircraft flyovers, the SEL value is numerically about 10 dBA higher than the maximum noise level. Single event metrics are a convenient method for describing noise from individual aircraft events. Airport noise models contain aircraft noise curve data based upon the SEL metric. In addition, cumulative noise metrics such as Equivalent Noise Level (LEQ) and Day Night Noise Level (DNL) can be computed from SEL data (these metrics are described in the next paragraphs). The SEL metric will be used as a supplemental metric in the Detroit Metropolitan Wayne County Airport Part 150 Noise Compatibility Study.

Cumulative Metrics

Cumulative noise metrics have been developed to assess community response to noise. They are useful because these scales attempt to include the loudness and duration of the noise, the total number of noise events, and the time of day these events occur into one rating scale.

- **Equivalent Noise Level (LEQ).** LEQ is the sound level corresponding to a steady-state A-weighted sound level containing the same total energy as a time-varying signal (noise that constantly changes over time) over a given sample period. LEQ is the "energy" average taken from the sum of all the sound that occurs during a certain time period; however, it is based on the observation that the potential for a noise to impact people is dependent on the total acoustical energy content. This is graphically illustrated in the middle graph of **Figure C7**. LEQ can be measured for any time period, but is typically measured for 15 minutes, 1 hour, or 24 hours. LEQ for one hour is used to develop the DNL values for aircraft operations.

- **Day Night Noise Level (DNL).** The DNL describes noise experienced during an entire (24-hour) day. DNL calculations account for the SEL of aircraft, the number of aircraft operations, and include a penalty for nighttime operations. In the DNL scale, noise occurring between the hours of 10 p.m. to 7 a.m. is penalized by 10 dB. This penalty was selected to account for the higher sensitivity to noise in the nighttime and the expected further decrease in background noise levels that typically occur at night. DNL is required by the FAA for the measurement of aircraft noise and in evaluating noise during a Part 150 Study. In addition, it is used by other federal agencies including the Environmental Protection Agency (EPA), the Department of Defense (DOD), and the Department of Housing and Urban Development (HUD). DNL is graphically illustrated in the bottom of **Figure C7**. Examples of various noise environments in terms of DNL are presented in **Figure C8**. The FAA, with the support of these agencies, has developed land use compatibility guidelines that identify the acceptability of various land uses with aircraft noise.

Supplemental Metrics

While FAA's Part 150 guidance requires the use of the DNL to measure noise, other noise metrics (referred to as supplemental metrics) will be used during this study for DTW to supplement the DNL:

- **Time Above (TA).** The FAA developed the Time Above metric as a second metric for assessing impacts of aircraft noise around airports. The Time Above metric refers to the total time in seconds or minutes that aircraft noise exceeds certain dBA noise levels in a 24-hour period. It is typically expressed as Time Above 65, 75, and 85 dBA sound levels, which can be used to illustrate various degrees of noise interference. There are no noise/land use standards related to the Time Above index.

  The Time Above levels can be used to illustrate the time that noise may disrupt various activities. One such threshold is the Time Above 65 dBA, which generally represents the time when noise is above 65 dBA, and is the level for where outdoor speech interference starts to occur. This metric will be used as a supplemental metric in the Detroit Metropolitan Wayne County Airport Part 150 Noise Compatibility Study.

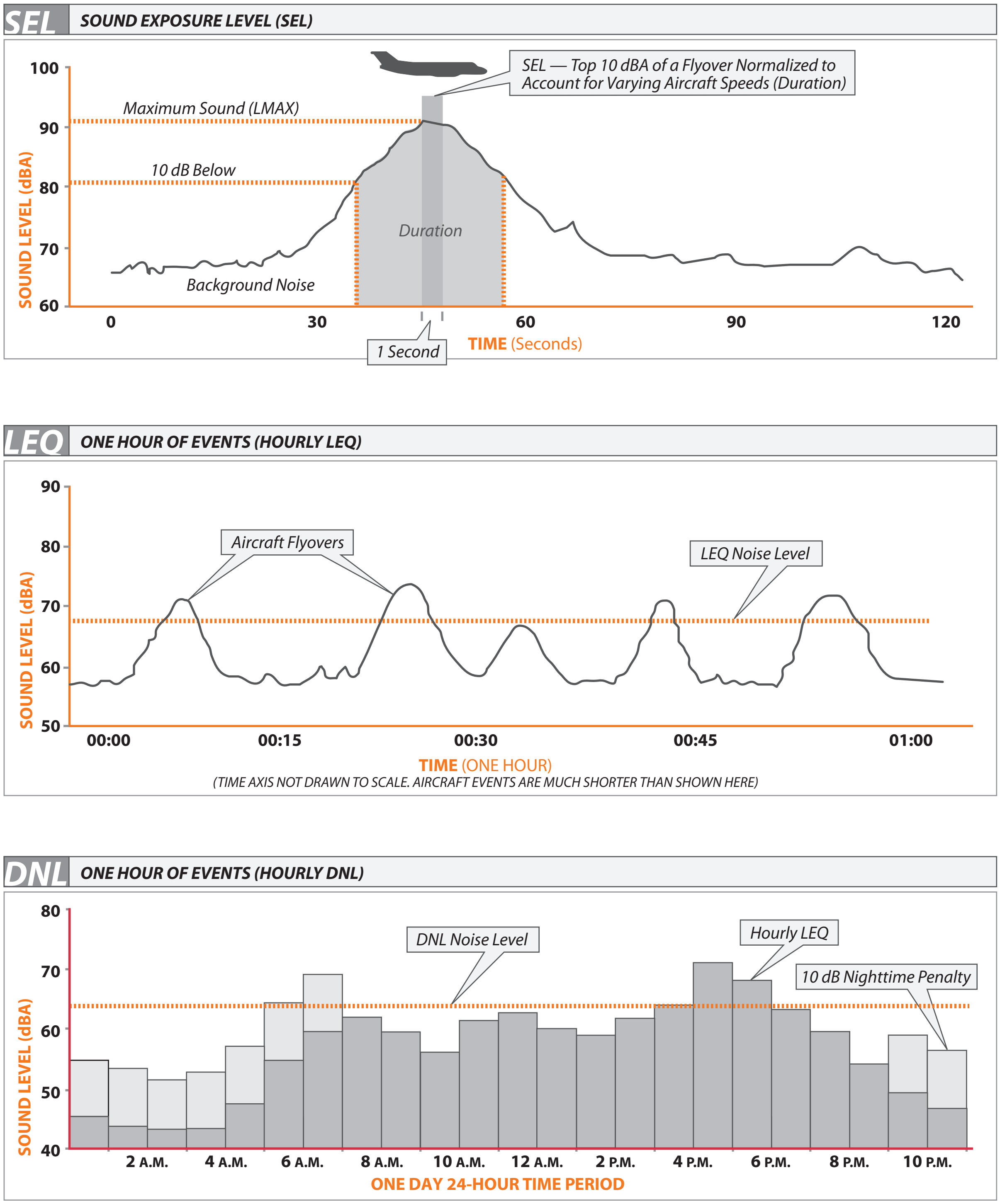


Figure C7 **Examples of Lmax, SEL, LEQ, and DNL Noise Levels**

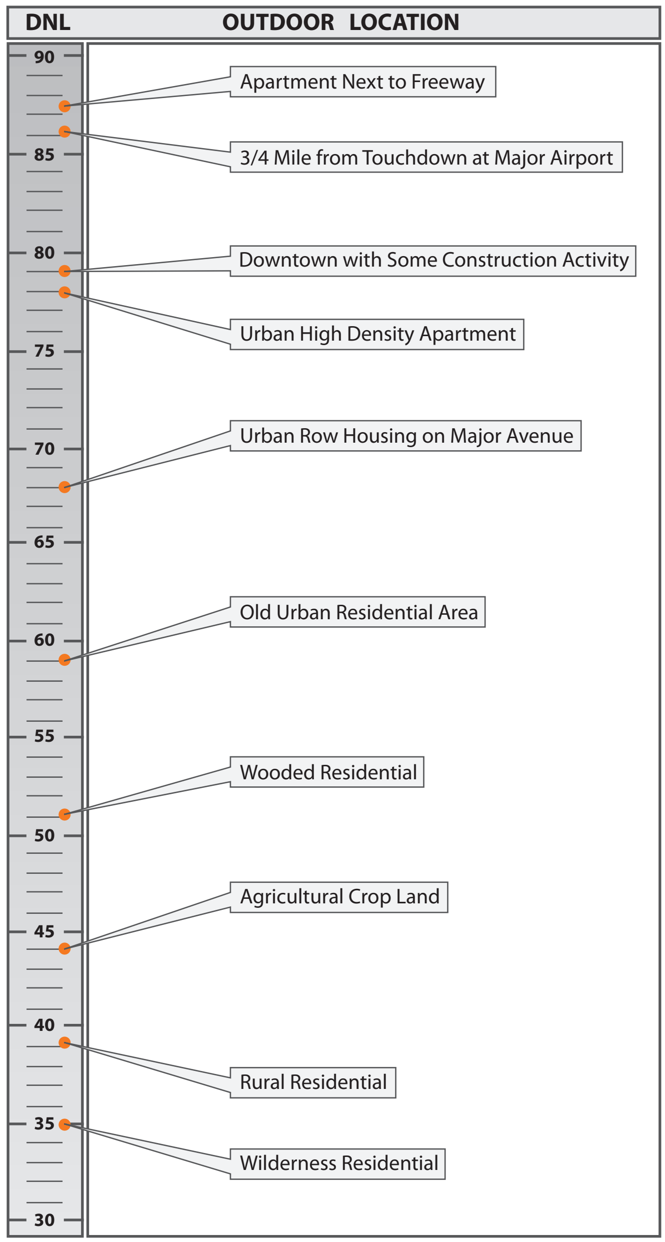


Figure C8 **Typical Outdoor Noise Levels in Terms of DNL**

Percent Noise Level (L_n). The Ln characterizes intermittent or fluctuating noise by showing the noise level that is exceeded n% of the time during the measurement period. It is usually measured in the A-weighted decibel, but can be an expression of any noise rating scale. Percent Noise Levels often are used to characterize ambient noise where, for example, L_{90} is the noise level exceeded 90% of the time, L_{50} is the level exceeded 50 percent of the time, and L_{10} is the level exceeded 10% of the time. L_{90} represents the background or minimum noise level; L_{50} represents the median noise level; and, L_{10} the peak or intrusive noise levels. Percent noise level is commonly used in community noise ordinances that regulate noise from stationary noise sources, such as mechanical equipment, entertainment noise sources, and the like.

For the Detroit Metropolitan Wayne County Airport Part 150 Noise Compatibility Study, the L_{90} is used to represent the background or ambient noise environment and will serve as a supplemental metric.

Noise/Land Use Compatibility Standards and Guidelines

Noise metrics describe noise exposure and help predict community response to various noise exposure levels. The public reaction to different noise levels has been estimated based upon extensive research on human responses to exposure of different levels of aircraft noise. **Figure C8** relates DNL noise levels to community response. Based on human response, land use compatibility guidelines have been developed that are defined in terms of the DNL described earlier (a 24-hour average that includes a sound level weighting for noise at night). Using these metrics and surveys, agencies have developed guidelines for assessing the compatibility of various land uses with the noise environment.

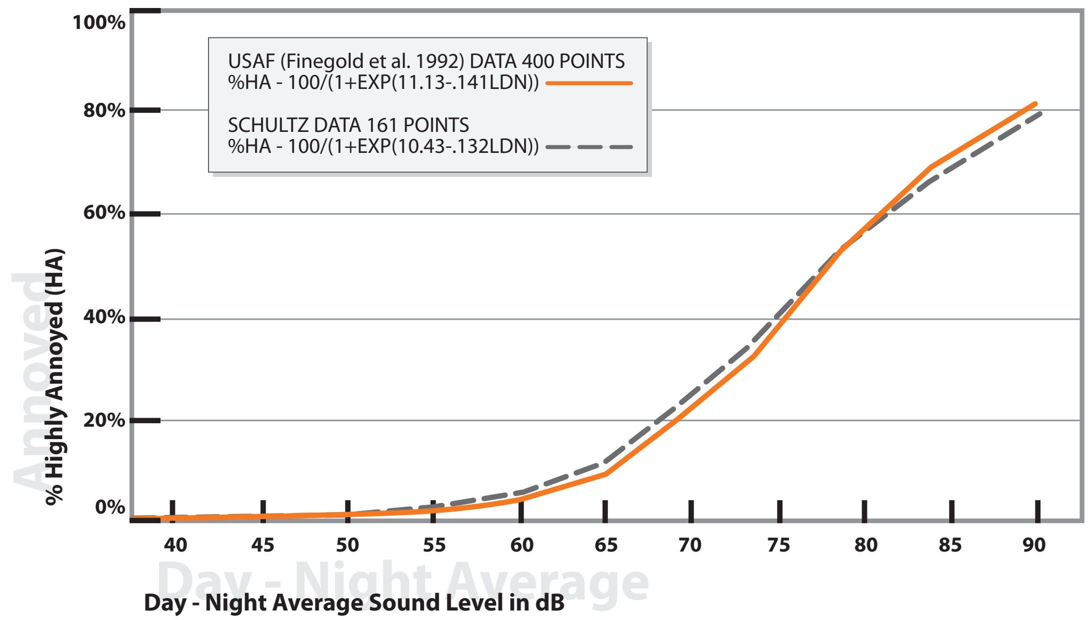
Highlights of Land Use Compatibility Guidelines

FAA and other federal agencies have established land use compatibility guidelines based on the DNL that identify the acceptability of various types of land use with aircraft noise exposure.

- Residential uses are compatible with noise up to 65 DNL and up to 70 DNL with sound insulation;
- Schools are compatible with noise up to 65 DNL and up to 70 DNL with sound insulation;
- Commercial development is compatible with noise up to 75 DNL

Numerous laws have been passed concerning aircraft noise.

- ASNA: FAA required to use DNL
- Phase-out of noisiest aircraft (Stage 2) >175,000 lbs in the year 2000;
- ANCA prevents adoption of airport access restrictions (i.e., curfews, and caps)



USAF	0.40	0.831	1.66	3.31	6.48	12.29	22.1	36.47	53.74	70.16	82.64
SCHULTZ	0.576	1.11	2.12	4.03	7.52	13.59	23.32	37.05	53.25	68.78	81.00

CALCULATED % HIGHLY ANNOYED (HA) POINTS

Figure C9 **Example of Community Reaction to Aircraft Noise**

The most common noise/land use compatibility guidelines or criteria used are 65 dBA DNL. The Schultz [9] curve, as shown in **Figure C9**, predicts approximately 14% of the exposed population would be highly annoyed with exposure to the 65 dBA DNL. At 60 dB DNL, it decreases to approximately 8% of the population highly annoyed. However, recent updates to the Schultz curve, done by the U.S. Air Force, indicate that even a higher percentage of residents may experience annoyance with 65 DNL.

A summary of pertinent regulations and guidelines is presented below:

- **Federal Aviation Regulation, Part 36, "Noise Standards: Aircraft Type and Airworthiness Certification"**

  Originally adopted in 1960, FAR Part 36 prescribes noise standards for issuance of new aircraft type certificates; it also limited noise levels for certification of new types of propeller-driven, small airplanes as well as for transport category, large airplanes. Subsequent amendments extended the standards to certain newly produced aircraft of older type designs. Other amendments extended the required compliance dates. Aircraft may be certificated as Stage 1, Stage 2, or Stage 3 (also called Chapter number outside the U.S.) aircraft based on their noise level, weight, number of engines, and, in some cases, number of passengers. Stage 1 aircraft over 75,000 pounds are no longer permitted to operate in the U.S. Stage 2 aircraft over 75,000 pounds were phased-out of the U.S. fleet effective at the start of 2000, as discussed below by the Airport Noise and Capacity Act of 1990.

- **Federal Aviation Regulation, Part 150, "Airport Noise Compatibility Planning"**

  As a means of implementing the Aviation Safety and Noise Abatement Act (ASNA), the FAA adopted Federal Aviation Regulation Part 150, Airport Noise Compatibility Planning Programs. FAR Part 150 established a uniform program for developing balanced and cost effective programs for reducing existing and future aircraft noise at individual airports. Included in FAR Part 150 was the FAA's adoption of noise and land use compatibility guidelines discussed earlier. An expanded version of these guidelines/chart appears in Aviation Circular 150/5020-1 (dated August 5, 1983) and is reproduced in **Figure C10**. These guidelines offer recommendations for determining acceptability and compatibility of land uses. The guidelines specify the maximum amount of noise exposure (in terms of the cumulative noise metric DNL) that would be considered acceptable or compatible to people in living and working areas.

LAND USE	BELOW 65	YEARLY DAY-NIGHT NOISE LEVEL (DNL) IN DECIBELS 65-70	70-75	75-80	80-85	OVER 85
RESIDENTIAL						
Residential, other than mobile homes and transient lodgings	Y	N(1)	N(1)	N	N	N
Mobile home parks	Y	N	N	N	N	N
Transient lodgings	Y	N(1)	N(1)	N(1)	N	N
PUBLIC USE						
Schools	Y	N(1)	N(1)	N	N	N
Hospitals and nursing homes	Y	25	30	N	N	N
Churches, auditoriums and concert halls	Y	25	30	N	N	N
Governmental services	Y	Y	25	30	N	N
Transportation	Y	Y	Y(2)	Y(3)	Y(4)	Y(4)
Parking	Y	Y	Y(2)	Y(3)	Y(4)	N
COMMERCIAL USE						
Offices, business and professional	Y	Y	25	30	N	N
Wholesale and retail-building materials, hardware and farm equipment	Y	Y	Y(2)	Y(3)	Y(4)	N
Retail trade-general	Y	Y	25	30	N	N
Utilities	Y	Y	Y(2)	Y(3)	Y(4)	N
Communication	Y	Y	25	30	N	N
MANUFACTURING AND PRODUCTION						
Manufacturing, general	Y	Y	Y(2)	Y(3)	Y(4)	N
Photographic and optical	Y	Y	25	30	N	N
Agriculture (except livestock) and forestry	Y	Y(6)	Y(7)	Y(8)	Y(8)	Y(8)
Livestock farming and breeding	Y	Y(6)	Y(7)	N	N	N
Mining and fishing resource production and extraction	Y	Y	Y	Y	Y	Y
RECREATIONAL						
Outdoor sports arenas and spectator sports	Y	Y(5)	Y(5)	N	N	N
Outdoor music shells, amphitheaters	Y	N	N	N	N	N
Nature exhibits and zoos	Y	Y	N	N	N	N
Amusements, parks, resorts and camps	Y	Y	Y	N	N	N
Golf courses, riding stables and water recreation	Y	Y	25	30	N	N

Numbers in parentheses refer to NOTES.

The designations contained in this table do not constitute a Federal determination that any use of land covered by the program is acceptable or unacceptable under Federal, State or local law. The responsibility for determining the acceptable and permissible land uses and the relationship between specific properties and specific noise contours rests with the local authorities. FAA determinations under Part 150 are not intended to substitute federally determined land uses for those determined to be appropriate by local authorities in response to locally determined needs and values in achieving noise compatible land uses.

TABLE KEY

SLUCM	Standard Land Use Coding Manual.
Y(Yes)	Land Use and related structures compatible without restrictions.
N(No)	Land Use and related structures are not compatible and should be prohibited.
NLR	Noise Level Reduction (outdoor to indoor) to be achieved through incorporation of noise attenuation into the design and construction of the structure.
25, 30 or 35	Land Use and related structures generally compatible; measures to achieve NLR of 25, 30 or 35 dB must be incorporated into design and construction of structure.

NOTES

(1) Where the community determines that residential or school uses must be allowed, measures to achieve outdoor to indoor Noise Level Reduction (NLR) of at least 25 dB to 30 dB should be incorporated into building codes and be considered in individual approvals. Normal residential construction can be expected to provide a NLR of 20 dB, thus, the reduction requirements are often stated as 5, 10 or 15 dB over standard construction and normally assume mechanical ventilation and closed windows year round. However, the use of NLR criteria will not eliminate outdoor noise problems.

(2) Measures to achieve NLR of 25 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.

(3) Measures to achieve NLR of 30 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.

(4) Measures to achieve NLR of 35 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.

(5) Land use compatible provided that special sound reinforcement systems are installed.

(6) Residential buildings require an NLR of 25.

(7) Residential buildings require an NLR of 30.

(8) Residential buildings not permitted.

Figure C10 **FAA FAR Part 150 Land Use Compatibility Matrix**

- **Federal Aviation Administration Order 5050.4A and Order 1050.1E for Environmental Analysis of Aircraft Noise Around Airports**

  FAA , like many other federal agencies, issues guidance for compliance with the National Environmental Policy Act (NEPA). FAA Order 1050.1E **Considering Impacts: Policies and Procedures,** identified the procedures for complying with NEPA for all divisions of the FAA. FAA Order 5050.4A (with 5050.4B in draft form) supplements 1050.1E and identified issues specific to the Airports Division of the FAA. These orders specify the processes for considering environmental factors when evaluating federal actions under NEPA, and include methodologies for assessing noise, as well as thresholds of significant project-related noise changes. This guidance requires the use of the FAA's Integrated Noise Model (INM), the preparation of noise contours showing 65, 70 and 75 DNL, and note that "A significant noise impact would occur if analysis shows that the proposed action will cause noise sensitive areas to experience an increase in noise of DNL 1.5 dB or more at or above DNL 65 dB noise exposure when compared to the no action alternative for the same time frame." Noise abatement alternatives that result in shifting of noise may trigger an environmental documentation process, subject to one of these orders, before they can be implemented.

- **Airport Noise and Capacity Act of 1990 (ANCA)**

  The Airport Noise and Capacity Act of 1990 (PL 101-508, 104 Stat. 1388), also known as ANCA or the Noise Act, established two broad directives for the FAA: (1) establish a method to review aircraft noise, and airport use or access restriction, imposed by airport proprietors, and (2) institute a program to phase-out Stage 2 aircraft over 75,000 pounds by December 31, 1999 [Stage 2 aircraft are older, noisier aircraft (B-737-200, B-727 and DC-9); Stage 3 aircraft are newer, quieter aircraft (B-737-300, B-757, MD-80/90)]. To implement ANCA, FAA amended Part 91 to address the phase-out of large Stage 2 aircraft and the phase-in of Stage 3 aircraft. In addition, Part 91 states that all Stage 2 aircraft over 75,000 pounds were to be removed from the domestic fleet or modified to meet Stage 3 by December 31, 1999. There are a few exceptions, but only Stage 3 aircraft greater than 75,000 pounds are now in the domestic fleet. The airlines have phased out Stage 2 aircraft, and the mainland domestic fleet is now all Stage 3 aircraft. Stage 2 aircraft less than 75,000 pounds include various older corporate jet aircraft such as Lear 25s and Gulfstream IIs, which are not common to Detroit Metro.

  Furthermore, FAR Part 161 was adopted to institute a highly stringent review and approval process for implementing use or access restrictions by airport proprietors. Part 161 sets out the requirements and procedures for implementing new airport use and access restrictions by airport proprietors. They must use the DNL metric to measure noise effects, and the Part 150 land use guideline table, including 65 DNL as the threshold contour to determine compatibility.

ANCA applies to all local noise restrictions that are proposed after October 1990, and to amendments to existing restrictions proposed after October 1990. The FAA has approved only one completed Part 161 Study to date (for restricting Stage 2 corporate jets). Recent litigation has upheld the validity and reasonableness of that Part 161 restriction.

- **Federal Interagency Committee on Noise (FICON) Report of 1992**

  The use of the DNL metric criteria has been criticized by various interest groups concerning its usefulness in assessing aircraft noise impacts. As a result, at the direction of the EPA and the FAA, the Federal Interagency Committee on Noise (FICON) was formed to review specific elements of the assessment on airport noise impacts and to recommend procedures for potential improvements. FICON included representatives from the Departments of Transportation, Defense, Justice, Veterans Affairs, Housing and Urban Development, the Environmental Protection Agency, and the Council on Environmental Quality.

  The FICON review focused primarily on the manner in which noise impacts are determined, including whether aircraft noise impacts are fundamentally different from other transportation noise impacts; how noise impacts are described; and, whether impacts outside of Day-Night Average A-Weighted Sound Level (DNL) 65 decibels (dB) should be reviewed in a National Environmental Policy Act (NEPA) document.

  The committee determined that there are no new descriptors or metrics of sufficient scientific standing to substitute for the present DNL cumulative noise exposure metric. FICON determined that the DNL method contains appropriate dose-response relationships (expected community reaction for a given noise level) to determine the noise impact is properly used to assess noise impacts at both civil and military airports. The report does support agency discretion in the use of supplemental noise analysis, recommends public understanding of the DNL and supplemental methodologies, as well as aircraft noise impacts. FICON did, however, recommend that if screening analysis shows a 1.5 dB increase within a 65 DNL or a 3.0 dB increase within a 60-65 DNL, then additional analysis should be conducted.

Introduction to Noise Assessment Methodology

Existing and future aircraft noise environments for airports are typically determined through a combination of computer modeling and on-site sound level measurements. Computer generated noise contours of existing aircraft noise are developed and then verified using the on-site measurements. The on-site measurements also help establish the ambient, (non-aircraft) noise environment and identify noise levels at specific areas of interest. Once reliable, computer generated contours are developed for existing conditions, the computer input files are altered to reflect future conditions based on forecasts of future operations and/or proposed noise abatement aircraft operational measures. New computer generated data and contours are then developed to assess those future conditions. The following sections provide the details on this process. This section is divided into the following sub-sections:

Highlights of Noise Assessment

Two tools are used to evaluate aircraft noise:

- Noise Monitoring of aircraft and ambient noise
- Integrated Noise Model (INM) computer model

FAA Part 150 Studies are required to model aircraft noise with the FAA Integrated Noise Model (INM) computer model.

Actual noise monitoring is not required for FAA Part 150 studies. It is used to supplement the computer model and as a tool to show citizens actual noise measurements.

Actual measurements were conducted during December 2004. Tests were collected at 42 sites: 20 sites for short periods and 22 sites for longer periods.

Aircraft radar data for a six month period was collected to identify the flight paths and use of the runways. This data was also compared with the actual noise measurements to identify aircraft and altitude.

- Noise Measurement Survey – Describes the noise monitoring sites and the methodology used in the noise measurement survey.
- Computer Modeling – Describes the computer noise model and modeling techniques used in the study.
- Measurement and Analysis Procedures – Describes the measurement and analysis procedures used to develop the various noise metrics of use in this study.

Noise Measurement Survey

Purpose of Measurement Survey

Measuring noise directly using calibrated and reliable monitoring devices augments computer modeling and offers several advantages over relying solely on computer modeling. While not specifically required by FAR Part 150, such programs are often very helpful in showing actual noise levels and ensuring the accuracy of the computer based modeling. The noise measurement survey is an integral part of this Study; it serves to:

- Identify noise levels for individual aircraft operations specific to the local Detroit Metropolitan Wayne County Airport environment and its unique conditions.
- Validate the computer model using actual noise measurement data from aircraft operating at the Airport. Specific issues unique to the Airport include:
    - The number of hush-kited DC9 aircraft that operate at the Airport.
    - The number of MD80 aircraft that operate at the Airport.
- Identify the aircraft and ambient noise level at multiple locations around the Airport using a variety of noise metrics.
- Give confidence in the accuracy of the noise exposure contours.

The primary goal of the measurement program for the Detroit Metropolitan Wayne County Airport Part 150 Noise Compatibility Study is the identification of the single event noise levels that can then be correlated to a variety of different aircraft types flying the different paths and procedures that are present in the Detroit metro area. Based upon this single event data and the annual operational flight data, it is then possible to calculate various different noise metrics of interest. These data can also be compared to the predicted single event noise levels incorporated within the FAA Integrated Noise Model (INM). The modeling assumptions can then be adjusted to more accurately reflect real-world conditions. With the verified noise model, it is then possible to ensure that the contours reflect real measurements and to prepare supplemental noise metrics. When it is not possible for the contour to exactly match the measurements, that difference is known.

Types of Field Noise Measurements

The field noise measurement program conducted for the Part 150 Noise Compatibility Study included the use of long-term and short-term portable measurement sites. Short-term site are sites where the equipment was placed for one to two days, whereas the monitors were placed at the long-term sites for two to three weeks of continuous measurements. The noise monitors recorded the one-second average noise levels on a continuous basis and were later analyzed to compute other noise metrics. These noise metrics included DNL, hourly LEQ, Time Above noise levels (TA85, TA75, and TA65), single event (SEL, Lmax, and duration), and ambient descriptors (L1, L10, L50, L90, L99).

Measurement locations were selected through coordination with the Study Advisory Committee and local community officials. The measurement program included the following numbers of measurement sites:

- Twenty-two (22) long-term aircraft and non-aircraft noise measurement sites
- Twenty (20) short-term aircraft and non-aircraft noise measurement sites

Site Selection Criteria

Noise monitoring sites included locations within the communities exposed to ground noise sources, and additional sites located along the primary flight paths (over-flight noise) within the study area. Noise monitoring sites were selected based upon technical suitability, as well as locations of public interest. Information used in the selection of the noise monitoring sites includes land use pattern/proximity to neighborhoods, flight tracks, distribution of the sites representatively around the Airport, and proximity to the previous and expected 65 DNL noise contour. Examples of the site selection criterion are listed below:

General Criteria

- Exposure to a variety of different aircraft activity sources:
  - Departures and arrivals
  - Commercial, commuter, and general aviation aircraft
  - Ground noise and/or over-flight noise
- Proximity of the site to the 65 DNL noise contour
- Representation of the potential exposure to surrounding residents
- Representation of the noise environment in the local area
- Locations that are not in close proximity to localized non-aircraft noise sources
- Locations that are not exposed to high wind speeds
- Locations that are not severely shielded from the aircraft activity
- Locations of public interest
- Security and ease of access to the noise monitoring equipment

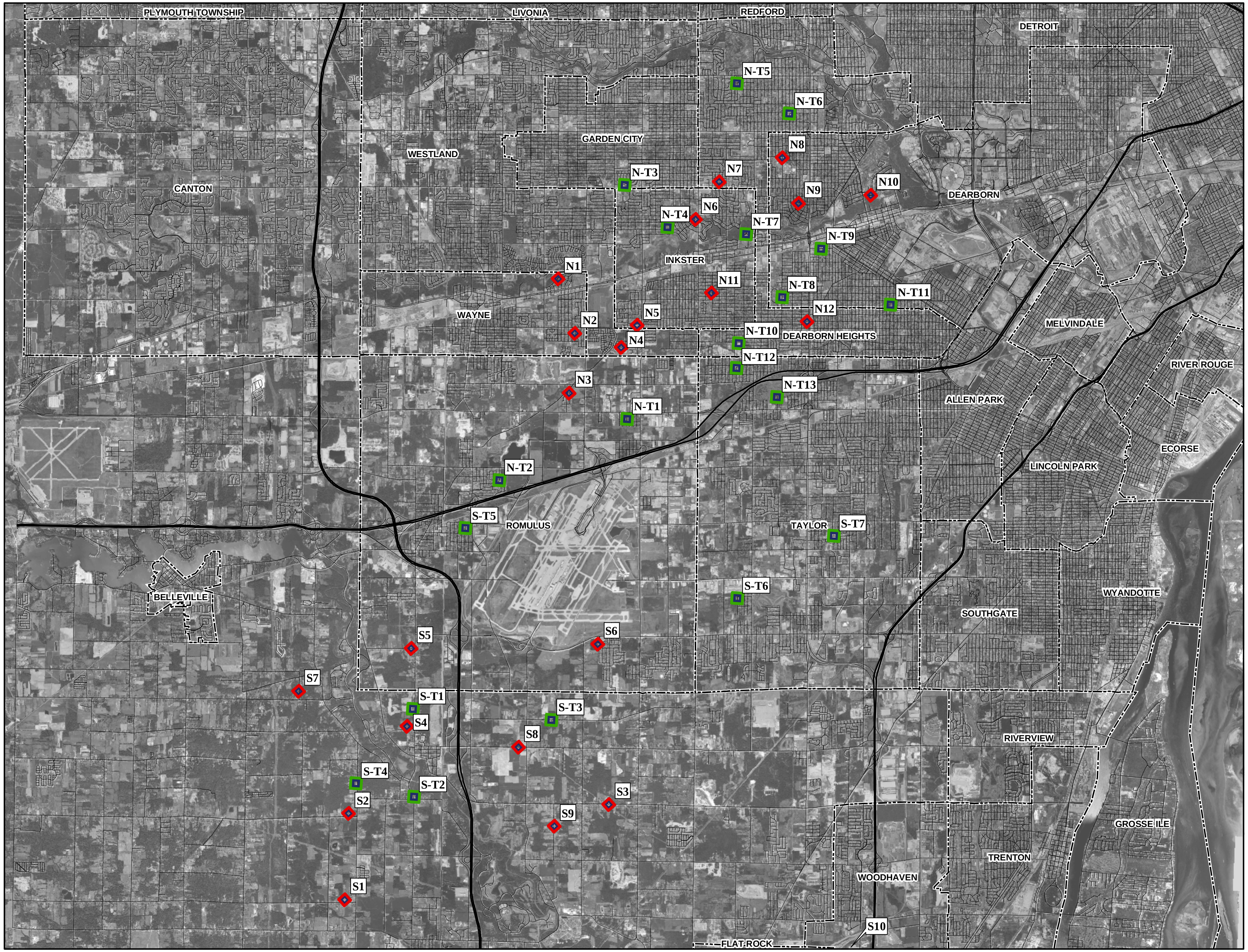
Specific Criteria

- Multiple locations at different distances sideline from the departure and arrival flight paths
- Locations exposed to both jet aircraft and commuter aircraft flight paths
- Locations at different distances along the flight path to measure departure noise at different stages of the climb profiles for notable aircraft types. This should include those sites both close to and more distant from the Airport.

Noise Measurement Locations

Noise measurements were conducted at selected locations within the Airport environs. The portable noise monitoring sites, both short-(1 to 2 days) and long-(1 to 3 weeks) term are presented in **Figure C11**. **Table C2** reflects the addresses of those locations where noise equipment was placed for monitoring purposes to the south of the Airport, and **Table C3** reflects the locations where the noise equipment was placed for monitoring purposes to the north of the Airport. The array of sites is designed to measure the difference in the sideline noise at different distances away from the flight path in conjunction with the data from the permanent noise monitoring system.

Figure C11 **Combined Noise Measurement Sites**



Legend

- Long-term
- Short-term

Long-Term Noise Monitoring Sites, South

Site	Address	City
S1	39933 Wear Road	New Boston
S2	39791 Judd Road	Belleville
S3	31740 King Road	New Boston
S4	37610 Harvest Lane	New Boston
S5	37541 Barth Street	Romulus
S6	15248 Colbert	Romulus
S7	17007 Renton Road	Belleville
S8	33675 Sibley Road	New Boston
S9	21950 Dickenson Road	New Boston
S10	32304 Stefano Court	Brownstown

Long-Term Noise Monitoring Sites, North

Site	Address	City
N1	2988 Hubbard Street	Wayne
N2	4851 Harrison Street	Wayne
N3	6547 Gloria Street	Romulus
N4	30131 Julius Blvd.	Westland
N5	29536 Thomas Circle	Inkster
N6	1072 Eastwood Street	Inkster
N7	337 Rosemary Street	Dearborn Heights
N8	1315 N. Silvery Lane	Dearborn
N9	24407 Rockford Street	Dearborn
N10	22262 Long Blvd.	Dearborn
N11	27019 Penn Street	Inkster
N12	24096 Lehigh Street	Dearborn Heights

Short-Term Noise Monitoring Sites, South

Site	Address	City
S-T1	17718 Huron River Dr.	New Boston
S-T2	37370 Judd Road	Huron
S-T3	32515 Prescott Road	Huron
S-T4	20530 Clark Road	Huron
S-T5	11087 Whitehorn Ave	Romulus
S-T6	13605 Harold	Taylor
S-T7	23230 Clinton	Taylor

Short-Term Noise Monitoring Sites, North

Site	Address	City
N-T1	7230 Burton Street	Romulus
N-T2	Malcom Dr and Lisa Dr.	Romulus
N-T3	29971 Leona Ave.	Garden City
N-T4	28503 Hazelwood Ave.	Inkster
N-T5	Figueroa & Rockland	Dearborn Hts
N-T6	George & Kingsbury	Dearborn Hts
N-T7	26111 S. River Park Drive	Inkster
N-T8	Westwood and Union	Dearborn
N-T9	23726 Harvard	Dearborn
N-T 10	26206 Powers Ave	Dearborn Hts
N-T11	3807-3821 Harding	Dearborn
N-T12	Ducan Ave, NE corner of Northwest Park	Taylor
N-T13	6708 Cherokee	Taylor

N

February 2005

DETROIT
METROPOLITAN WAYNE COUNTY AIRPORT

Source: Michigan Department of Natural Resources, SEMCOG, Detroit Metropolitan Wayne County Airport files.

Table C2
COMBINED NOISE MEASUREMENT SITES, SOUTH
Detroit Metropolitan Wayne County Airport FAR Part 150 Noise Compatibility Study Update

Sites	City	Address
Long-Term Sites (One – Three Weeks)		
S1	New Boston	39933 Wear Road
S2	Belleville	39791 Judd Road
S3	New Boston	31740 King Road
S4	New Boston	37610 Harvest Land
S5	Romulus	37541 Barth Street
S6	Romulus	15248 Colbert
S7	Belleville	17007 Renton Road
S8	New Boston	33675 Sibley Road
S9	New Boston	21950 Dickenson Road
S10	Brownstown	32304 Stefano Court
Short-Term Sites (One – Two Days)		
S-T1	New Boston	17718 Huron River Drive
S-T2	Huron	37370 Judd Road
S-T3	Huron	32515 Prescott Road
S-T4	Huron	20530 Clark Road
S-T5	Romulus	11087 Whitehorn Avenue
S-T6	Taylor	13605 Harold
S-T7	Taylor	23230 Clinton

Source: BridgeNet, December 2004

Table C3
COMBINED NOISE MEASUREMENT SITES, NORTH
Detroit Metropolitan Wayne County Airport FAR Part 150 Noise Compatibility Study Update

Sites	City	Address
Long-Term Sites (One – Three Weeks)		
N1	Wayne	2988 Hubbard Street
N2	Wayne	4851 Harrison Street
N3	Romulus	6547 Gloria Street
N4	Westland	30131 Julius Blvd
N5	Inkster	29536 Thomas Circle
N6	Inkster	1072 Eastwood Street
N7	Dearborn Heights	337 Rosemary Street
N8	Dearborn	1315 N. Silvery Lane
N9	Dearborn	24407 Rockford Street
N10	Dearborn	22262 Long Blvd
N11	Inkster	27019 Penn Street
N12	Dearborn Heights	24096 Lehigh Street
Short-Term Sites (One – Two Days)		
N-T1	Romulus	7230 Burton Street
N-T2	Romulus	Malcom Drive & Lisa Drive
N-T3	Garden City	29971 Leona Avenue
N-T4	Inkster	28503 Haezelwood Avenue
N-T5	Dearborn Heights	Figueroa & Rockland
N-T6	Dearborn Heights	George & Kingsbury
N-T7	Inkster	26111 S. River Park Drive
N-T8	Dearborn	Westwood & Union
N-T9	Dearborn	23726 Harvard
N-T10	Dearborn Heights	26206 Powers Avenue
N-T11	Dearborn	3807-3821 Harding Ave, NE Corner
N-T12	Taylor	Duncan Avenue, Northwest Park
N-T13	Taylor	6708 Cherokee

Source: BridgeNet, December 2004

Measurement Procedures

Noise measurements were conducted for this study starting from November 30, 2004 - December 14, 2004 and were conducted for a two to three week period at each of the long-term noise monitoring sites. Noise monitoring was conducted during this time period due to the timing of the Part 150 Study. While the noise measurements conducted in December 2004 were not used as INM model inputs, they were used to verify the shape and size of the noise contour to accurately depict aircraft operations at DTW. Short-term noise monitoring sites were set up to simultaneously collect continuous 1-second noise levels during the entire time the noise monitor is at a given location, generally one to two days. The equipment was checked and calibrated on a regular basis throughout the measurement survey. The time at each temporary site varied depending on the type of noise gathered. The noise measurements were conducted when the operations at the Airport were in a predominantly South direction. This direction, or traffic flow, occurs about 70 percent of the time, making it the most commonly used direction in which aircraft operate.

Acoustic Data

The noise measurement survey utilized specialized monitoring instrumentation that allowed for the measurement of aircraft single event data and ambient noise levels. The data determined at each portable noise measurement site is listed below:

- continuous one-second noise levels
- single event data (SEL, Lmax and Duration) for individual aircraft
- hourly noise data (LEQ, Level Percent, Time Above)
- daily noise level (DNL)
- correlation of noise data with aircraft identification
- non-aircraft ambient sound level (Level Percent)

The survey utilized software that provides continuous measurement and storage of the 1-second LEQ noise level. From this data, the above noise descriptors could be calculated. In addition, this data can be used to plot the time histories for noise events of interest.

Instrumentation

The monitoring program was consistent with state-of-the-art noise measurement procedures and equipment. The measurements consisted of monitoring A-weighted decibels in accordance with procedures and equipment that comply with specific International Standards (IEC), and measurement standards established by the American National Standards Institute (ANSI) for Type 1 instrumentation, as specified in FAA guidance concerning such measurement programs.

These sites utilized the Brüel & Kjaer 2236, Larson Davis 824 Sound Level Meters, and 01dB Solo sound level meters. The analyzers automatically calculate the various single event data. The Brüel & Kjaer, Larson Davis, and the 01dB systems include software that provides data storage for later retrieval and analysis.

During the survey, the noise monitoring instrumentation was calibrated at the start and end of each measurement cycle. This calibration was based on standards set by the National Institute of Standards and Technology, formerly the National Bureau of Standards. An accurate record of the meteorological conditions during measurement times was also maintained. All noise monitoring was consistent with FAR Part 150 guidelines.

Computer Modeling

Computer modeling generates maps or tabular data of an airport's noise environment expressed in the various metrics described above such as SEL, DNL, or TA. Computer models are most useful in developing contours that depict, like elevation contours on a topography map, areas of equal noise exposure. Accurate noise contours are largely dependent on the use of reliable, validated, and updated noise models, and collection of accurate aircraft operational data.

The FAA's Integrated Noise Model (INM) models civilian and military aviation operations. The original INM was released in 1977. The latest version, INM Version 6.1, was released for use in May 2003 and is the state-of-the-art in airport noise modeling. The program includes standard aircraft noise and performance data for over 100 aircraft types that can be tailored to the characteristics of specific individual airports. Version 6.1 includes an updated database that includes some newer aircraft, the ability to include run-ups (maintenance test when the aircraft is on the ground) and topography in the computations, and a provision to vary aircraft profiles in an automated fashion. It also includes more comprehensive and flexible contour plotting routines than earlier versions of the model.

Operational data for input to the INM are gathered in a meticulous manner to assure its accuracy, and the data are arranged for input to the model. The INM program requires the input of the physical and operational characteristics of an airport. Physical characteristics include runway coordinates, airport elevation, and temperature and, optionally, topographical data. Operational characteristics include aircraft types, flight tracks, departure procedures, arrival procedures, and stage lengths (flight distance) that are specific to the operations at the Airport. Aircraft data needed to generate noise contours include:

- Total operations
- Types of aircraft
- Number of aircraft operations by aircraft type
- Day/night time distribution by aircraft type
- Flight tracks
- Flight track utilization by aircraft type
- Flight profiles
- Typical operational procedures
- Average meteorological conditions

Measurement and Analysis Procedures

The following section outlines the methodology used to measure and quantify noise levels from aircraft operations and from ambient noise level conditions. Measurement methodology and analysis techniques used in the study are also described.

Continuous Measurement of the Noise

The methodology employed in this study used a data collection program that was designed to continuously measure and record the noise at each measurement location. An example of the time history of the continuous noise measured by each portable noise monitor is presented in **Figure C12**. This graph shows the continuous noise at one site for a 15-minute period. It is possible to see the duration of noise events and the time period of ambient noise in between the events. Since all of the noise data is collected during the measurements, it is possible to process the data and calculate different metrics of interest that may arise, including the aircraft single event noise event level, cumulative daily noise levels, time above levels, and the ambient levels. The process of calculating noise events from this data includes the use of floating threshold methodology, which allows for the measurement of lower noise level events. The parameters are adjustable and can be modified so that it is possible to recalculate noise events from raw data any time in the future.

Network of Multiple Noise Monitors

A network of portable noise monitors was set up to simultaneously and continuously measure noise at multiple monitoring sites. The network of continuously operating noise monitors is useful to compare noise levels at different locations for the same aircraft. For example, networks of noise monitors are established to illustrate the sideline noise levels at varying distances from the flight path centerline. An example of data from three sites is presented in **Figure C13**. This figure shows the continuous noise levels for the three sites north of the Airport. It is possible to see the different noise levels and different time sequences of the noise as the aircraft passes over the set of sites. In addition, the network of noise monitors is also used to help separate aircraft noise from other noise sources. Knowing the time sequence of noise events provides a pattern that is one of the components of the noise and flight data correlation process.

Operational Data and Field Observations

The Detroit Metropolitan Wayne County Airport Noise Management Office does not operate a permanent noise monitoring system. Radar flight track information was obtained from Passur, a third-party provider of radar data. Passur was used to obtain aircraft flight track data since it is more precise that the FAA's Aircraft Radar Tracking System (ARTS) or ASDi data. The radar data was collected independent from the FAA ARTS, but provides much of the same information. Once collected, the software program performs a number of processes, including determining if the track is associated with a departure or arrival operation, and assigning a runway to the track. Six months of data were collected during 2004. Flight data, radar tracks, and noise monitoring data were collected and integrated in a database for analysis and reporting of the radar data. To determine the direction of aircraft traffic, Aircraft Situational Display to Industry (ASDi) data as used; a full year of ASDi data was collected to determine the flow of aircraft traffic.

The radar data includes flight information about the aircraft that is operating on each track, as well as position information of the flight. The flight information includes data such as the aircraft type, airline code, flight number, type of operation, and runway. The position information includes the X and Y coordinates that position each aircraft for the flight track every four seconds of the flight, as well as the altitude of the aircraft at each point.

Example flight information data are listed below. An example of the data is also presented in **Table C4**. These input data were registered into a database that included all of the information associated with each flight.

- date and time of flight
- base or airport of operation
- operator
- aircraft type
- airline and flight number
- type of operation (departure or arrival)
- flight path
- runway
- comments

Figure C12
Example of Continuous Measurement of Noise
Period: Dec 2, 2004 00:30:00 AM to Dec 2, 2004 00:59:59 AM
Site: PS04 - 37610 Harvest Lane

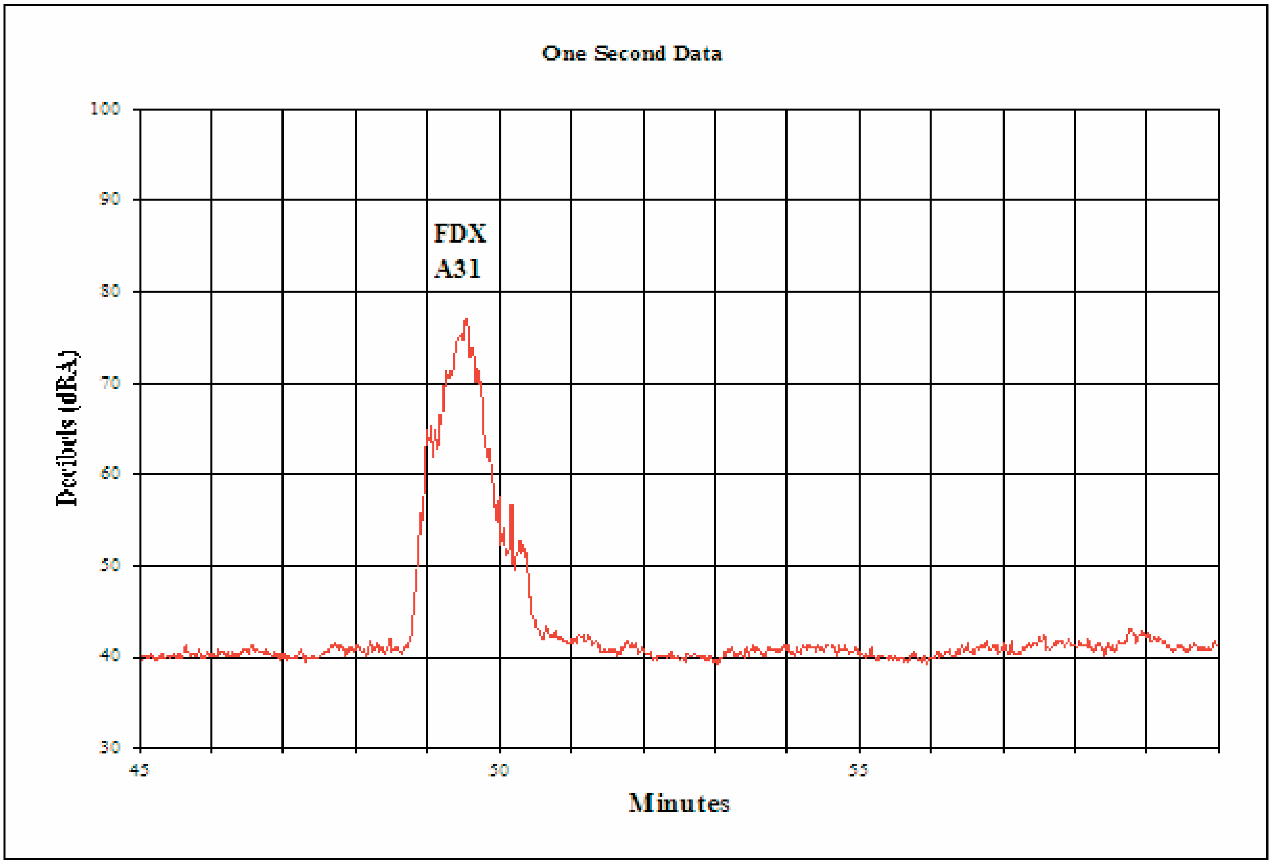


Figure C12 **Example of Continous Measurement of Noise**

Figure C13
Continous Noise Measurement at Multiple Sites
Period: Dec 17, 2004 09:15:00 to Dec 17, 2004 09:45:00
Sites: N03 - 6547 Gloria Street ; N04 - 30131 Julius Blvd; N05 - 29536 Thomas Circle

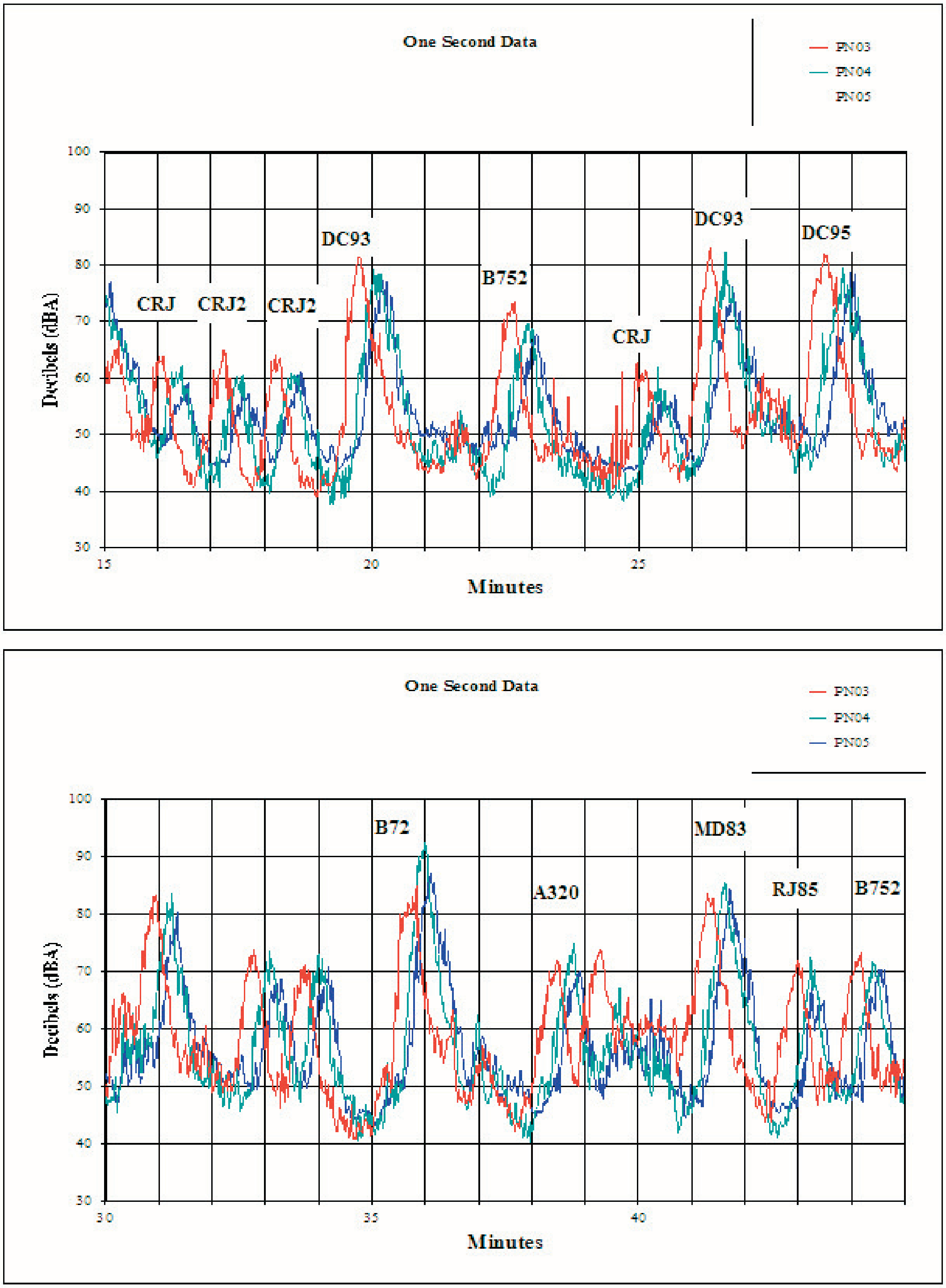


Figure C13 **Example of Continous Measurements at Multiple Sites**

In addition to the radar data, other sources of flight data used in the study included:

- field observations by engineers conducting the measurements
- aircraft situational display data (data from FAA national airspace system)
- airport tower counts

Correlation of Noise and Flight Data

From the radar data, it is possible to reconstruct the flight path for each operation. An example of flight paths for aircraft operations is presented in **Figure C14**. This figure illustrates the flight path of an aircraft at one point in time. The noise levels from each monitor at that same point in time are also shown. Computer software was used to correlate noise events with aircraft operating in the sky near the noise monitor at that same point in time. **Figure C15** represents a sample noise event time history taken from a site that is correlated with its source of operation.

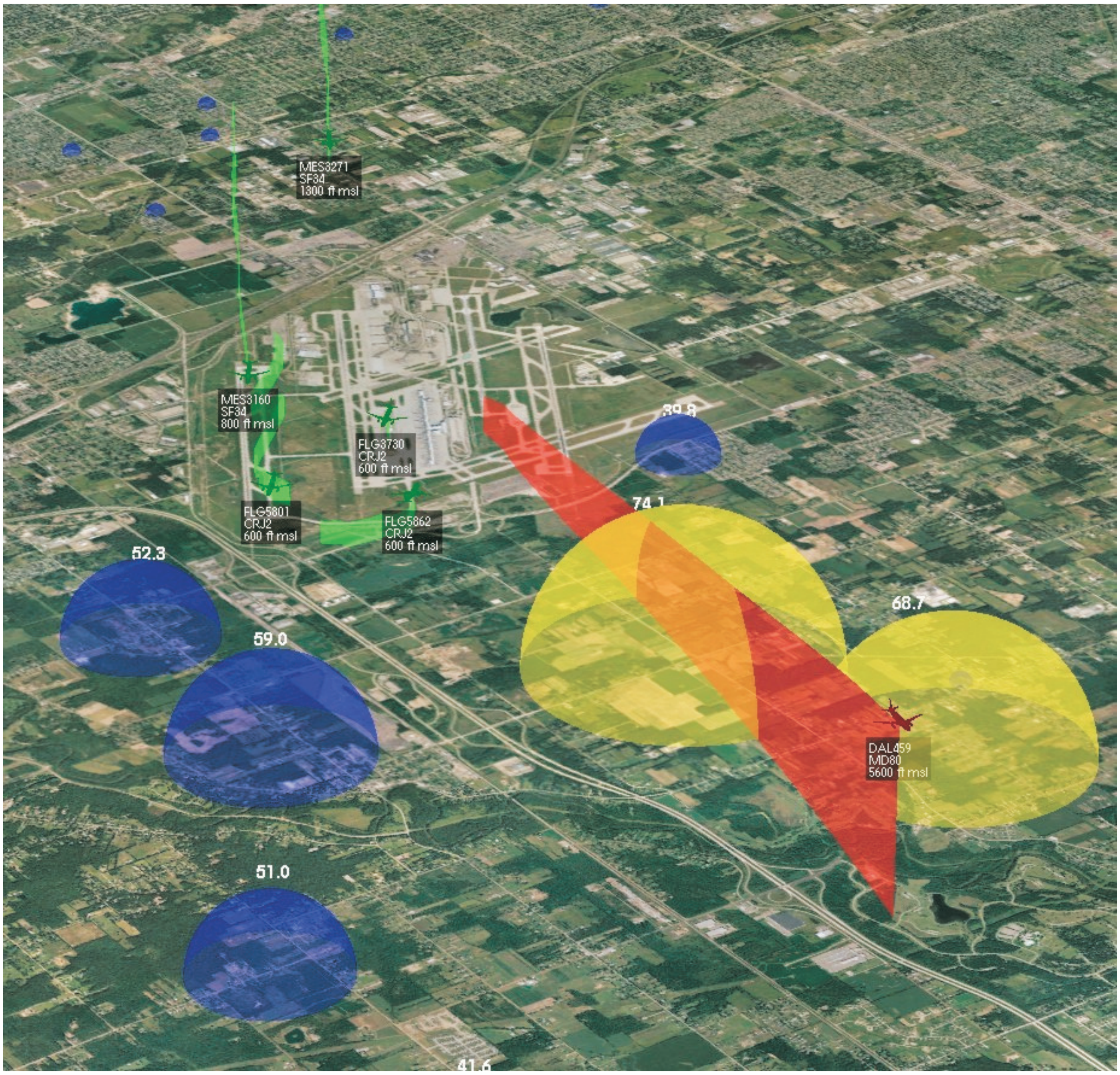
Calculation of Aircraft Noise Metrics

Once the collection and correlation of the noise and flight data are complete, the various noise metrics can then be calculated. A computer program is used to calculate the single event, time above, and cumulative noise metrics of interest. These results are presented in the next section.

Flight Data Listing Report
Detroit Metropolitan (Wayne County) Airport
Period: December 1, 2004

Date And Time	Airline Code	Aircraft ID	Aircraft Type	Runway	Operation	Destination
Dec-01 06:03:52	FDX	FDX1711	DC10	4L	A	IND
Dec-01 06:04:55	COM	COM198	CRJ1	3L	D	CVG
Dec-01 06:16:15	JIA	JIA2480	CRJ2	3L	D	PHL
Dec-01 06:26:39	LOF	LOF3592	E145	3L	D	PIT
Dec-01 06:26:59	DHL	DHL456	B72Q	4L	A	CVG
Dec-01 06:28:02	ASH	ASH7124	CRJ2	3L	D	IAD
Dec-01 06:31:54	UAL	UAL1205	A319	3L	D	ORD
Dec-01 06:39:23	EGF	EGF877	E135	3L	D	LGA
Dec-01 06:46:19	COM	COM288	CRJ2	3L	D	JFK
Dec-01 06:46:38	UPS	UPS482	A306	3R	A	SDF
Dec-01 06:51:06	SWA	SWA658	B73G	3L	D	MDW
Dec-01 06:55:57	AAL	AAL1793	MD82	3L	D	DFW
Dec-01 06:56:43	BTA	BTA2063	E135	3L	D	CLE
Dec-01 06:58:16	COA	COA1289	B73G	3L	D	IAH
Dec-01 07:04:17	USC	USC361	C208	3R	A	CMH
Dec-01 07:06:17	ABX	ABX138	DC9Q	3R	A	ILN
Dec-01 07:08:45	BTA	BTA2046	E145	3L	D	EWR
Dec-01 07:09:28	NWA	NWA1739	DC94	4R	A	CLE
Dec-01 07:10:13	SWA	SWA2316	B733	3L	D	BNA
Dec-01 07:11:32	KHA	KHA364	B72Q	4R	A	FWA
Dec-01 07:13:23	NWA	NWA1442	A319	4R	D	PVD
Dec-01 07:14:32	SWA	SWA2055	B73G	3L	D	PHX
Dec-01 07:14:55	MES	MES3218	SF34	3L	D	SDF
Dec-01 07:15:28	FLG	FLG5801	CRJ2	4L	A	MKG
Dec-01 07:17:32	NWA	NWA526	B752	4R	D	LGA
Dec-01 07:18:25	MES	MES3160	SF34	4L	A	DAY
Dec-01 07:20:30	NWA	NWA336	B752	4L	A	LAX
Dec-01 07:22:01	NWA	NWA1405	DC93	3R	A	IAD
Dec-01 07:23:01	MES	MES3096	SF34	3L	D	CLE
Dec-01 07:24:20	MES	MES3194	SF34	4L	A	SAW
Dec-01 07:24:24	NKS	NKS788	MD83	3L	D	PVD
Dec-01 07:24:24	HKA	HKA1632	C208	4R	D	MBS
Dec-01 07:27:07	FLG	FLG5862	CRJ2	4L	A	PLN
Dec-01 07:27:20	NWA	NWA289	A320	4R	D	MEM
Dec-01 07:28:38	NWA	NWA658	DC93	3L	D	EWR
Dec-01 07:29:53	NWA	NWA346	A320	3R	A	SFO
Dec-01 07:30:20	NKS	NKS709	MD83	3L	D	LGA
Dec-01 07:30:24	MRA	MRA852	C208	4R	D	LAN
Dec-01 07:33:16	NWA	NWA1918	DC93	3L	D	PIT
Dec-01 07:33:39	FLG	FLG5998	CRJ2	3R	A	GSP
Dec-01 07:34:30	NWA	NWA1778	A320	4R	D	PHL
Dec-01 07:34:35	NWA	NWA211	B752	3R	A	BWI
Dec-01 07:35:43	NWA	NWA739	B753	4R	D	MSP

Table C4 **Example of Flight Data Information**

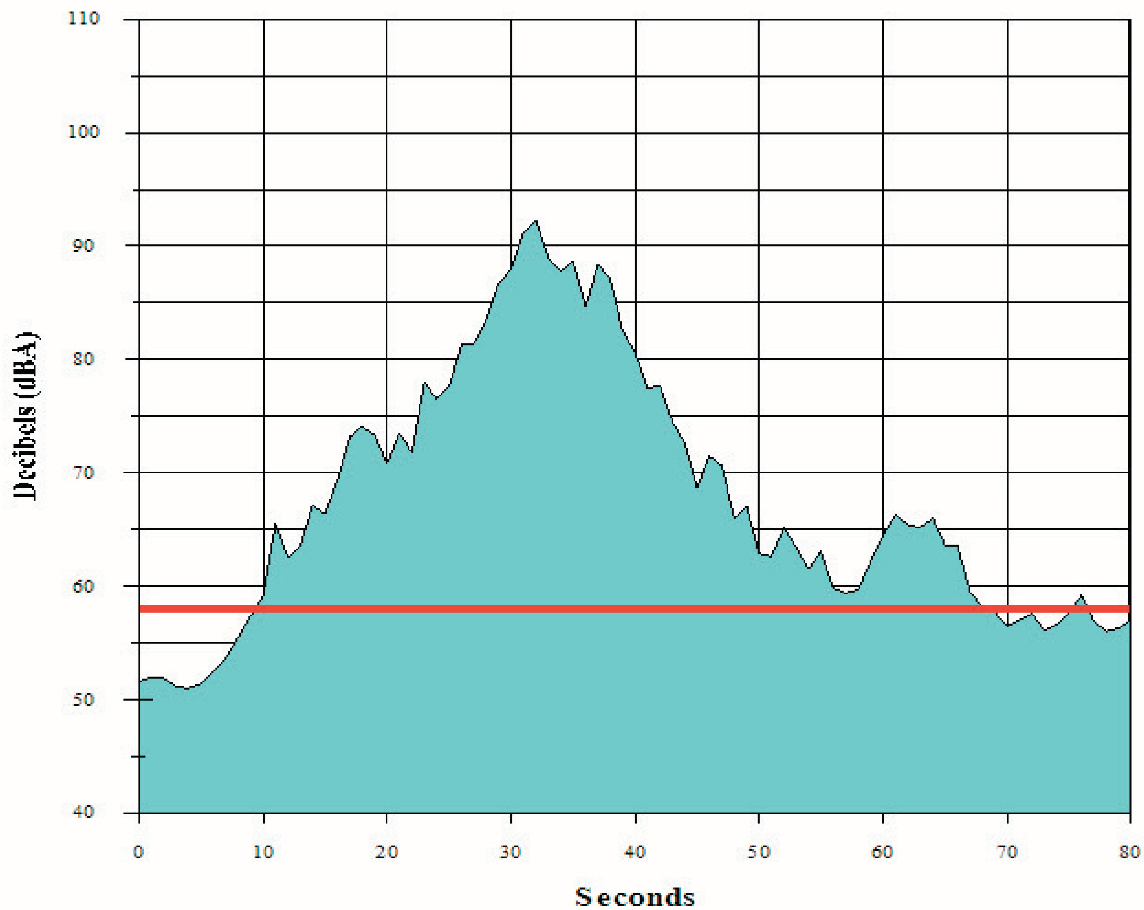


FigureC14 **Example of Playback on Noise and Flight Track Information**

Figure C15
Noise Event Plot Report
Period: 12/4/2004 1:40:21 PM
Site: S06 - 15248 Colbert

Start time:	1:29:59 PM	**Lmax time:**	1:40:21 PM
SEL (dBA):	99.6	**Max (dBA):**	92.3
Duration (seconds):	59	**Start to peak (seconds):**	22
SEL threshold (dBA):	58		
Filght No:	NWA1124		
Aircraft Type:	DC94	McDonnell-Douglas McDonnell-Douglas DC9-40	
Airline Code:	NWA	Northwest Airlines	
Operation:	Departure		
Runway:	21R		
Destination:	BUF	Greater Buffalo Intl - NY - USA	

Time History Plot of Noise Event



FigureC15 **Example of Correlated Noise and Flight Track Information**