Noise Analysis.

THE PURPOSE OF THIS CHAPTER IS TO DEFINE THE NOISE ENVIRONMENT IN AND AROUND THE ENVIRONS OF PAINE FIELD WITH RESPECT TO GUIDELINES USED IN COMMUNITY NOISE ASSESSMENT. THIS WAS ACHIEVED THROUGH A COMPUTER MODELING EFFORT, AND THE UTILIZATION OF THE EXISTING, AND SUPPLEMENTARY, NOISE MONITORS AT THE AIRPORT. THESE NOISE LEVELS WILL THEN BE USED AS THE FOUNDATION TO DEVELOP SUBSEQUENT PROGRAMS IN ASSESSING AND MINIMIZING LAND USE COMPATIBILITY CONFLICTS IN THE VICINITY OF THE AIRPORT. THIS CHAPTER IS DIVIDED INTO TWO SECTIONS.

1. The first section discusses background information on noise and community noise assessment criteria. This includes Federal and State noise criteria. This is intended to give the reader a greater understanding on noise and on criteria used to assess potential impacts from aircraft noise. The methodology used in the analysis is also presented in this section.

2. The second section presents the results of the computer modeling effort at the airport. The existing and five-year future DNL noise contours for the airport are presented, taking into account both engine run-ups and operations.

Background

Noise Definitions and Assessment Criteria. Sound is technically described in terms of the loudness (amplitude) of the sound and frequency (pitch) of the sound. The standard unit of measurement of the loudness of sound is the Decibel (dB). Since the human ear is not equally sensitive to sound at all frequencies, a special frequency-dependent rating scale has been devised to relate noise to human sensitivity. The A-weighted decibel scale (dBA) performs this compensation by discriminating against frequencies in a manner approximating the sensitivity of the human ear.

Decibels are based on the logarithmic scale. The logarithmic scale compresses the wide range in sound pressure levels to a more usable range of numbers in a manner similar to the Richter scale used to measure earthquakes. In terms of human response to noise, a sound 10 dBA higher than another is judged to be twice as loud; and 20 dBA higher four times as loud; and so forth. Everyday sounds normally range from 30 dB (very quiet) to 100 dB (very loud). Examples of various sound levels in different environments are shown in Figure C1.

Sound levels decrease as a function of distance from the source as a result of wave divergence atmospheric absorption and ground attenuation. As the sound wave form travels away from the source, the sound energy is dispersed over a greater area which in turn is dispersing the sound power of the wave. Atmospheric absorption also influences the levels that are received by the observer. The greater the distance traveled, the greater the influence and the resultant fluctuations. The degree of absorption is a function of the frequency of the sound as well as the humidity and temperature of the air. Turbulence and gradients of wind, temperature and humidity also play a significant role in determining the degree of attenuation.

Noise has been defined as unwanted sound and it is known to have several adverse effects on people. From these known effects of noise, criteria have been established to help protect the public health and safety and prevent disruption of certain human activities. This criteria is based on such known effects of noise on people as hearing loss (not a factor with community noise), communication interference, sleep interference, physiological responses and annoyance. It must be noted that people respond to noise differently, with different thresholds of annoyance.

Noise Assessment Metrics. The description, analysis and reporting of community noise levels around airports is made difficult by the complexity of human response to noise and the myriad of noise metrics that have been developed for describing noise impacts. Each of these metrics attempt to quantify noise levels with respect to community response. These noise metrics can be divided into two categories: single event and cumulative. Single event metrics describe the noise levels from an individual aircraft flyover. Cumulative metrics average the total noise over a specific time period, which is typically 24 hours for airport noise.

Single Event Noise Metrics

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. Then as the aircraft passes, the noise level decreases until the sound level again settles to ambient levels. Such a history of a flyover is plotted in the top half of Figure C2. The highest noise level reached during the flyover is, not surprisingly, called the "Maximum Noise Level", or Lmax. It is this metric to which people instantaneously respond when an aircraft flyover occurs.

Another metric that is reported for aircraft flyovers is the Sound Exposure Level (SEL). Referring again to Figure C2, the shaded area, or the area within 10 dB of the maximum noise level, is the area from which the SEL is computed. This metric takes into account the maximum noise level of the event and the duration of the event. The SEL is essentially the same as SENEL, as recorded in the noise monitoring system for Paine Field. The SEL value is always higher than the Lmax value for aircraft events. Single event metrics are useful in describing and or controlling noise from individual aircraft types (Federal Aviation Regulation [FAR] Part 36 Standards are in terms of another single event metric Effective Perceived Noise Level [EPN dB]) and in noise measurement surveys. The SEL is important because when combined within the total number of events, it can also be used to calculate cumulative noise metrics (described in the next paragraph).

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	UNCOMFORTABLY	Military Jet Aircraft take-Off with Afterburner from Aircraft Carrier @ 50 ft. (130)	Oxygen Torch (121)	120 dB(A) 32 Times as Loud
120 110	LOUD	Turbo-fan Aircraft @ take-off Power @ 200 ft. (90)	Riveting Machine (110) Rock and Roll Band (108-114)	110 dB(A) 16 Times as Loud
100	VERY	Boeing 707 @ 1000 ft. (103) DC-8 @ 6080 ft. (106) Bell J2A Helicopter @ 100 ft. (100)		100 dB(A) 8 Times as Loud
90	LOUD	Power Mower (96) Boeing 737, DC-9 @ 6080 ft. (97) Motorcycle @ 25 ft.(90)	Newspaper Press (97)	90 dB(A) 4 Times as Loud
80		Car Wash @ 20 ft. (89) Prop. Airplane Flyover @ 1000 ft. (88) Diesel Truck, 40 mph @ 50 ft. (84)	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) Freeway @ 50 ft., 10:00 a.m. (76)	Living Room Music (76) TV-Audio, Vacumn Cleaner	70 dB(A)
60		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
	JUST AUDIBLE	(dB(A) Scale Interrupted)		
10	THRESHOLD OF HEARING			

Figure C1 ***Examples of Typical Sound Levels***

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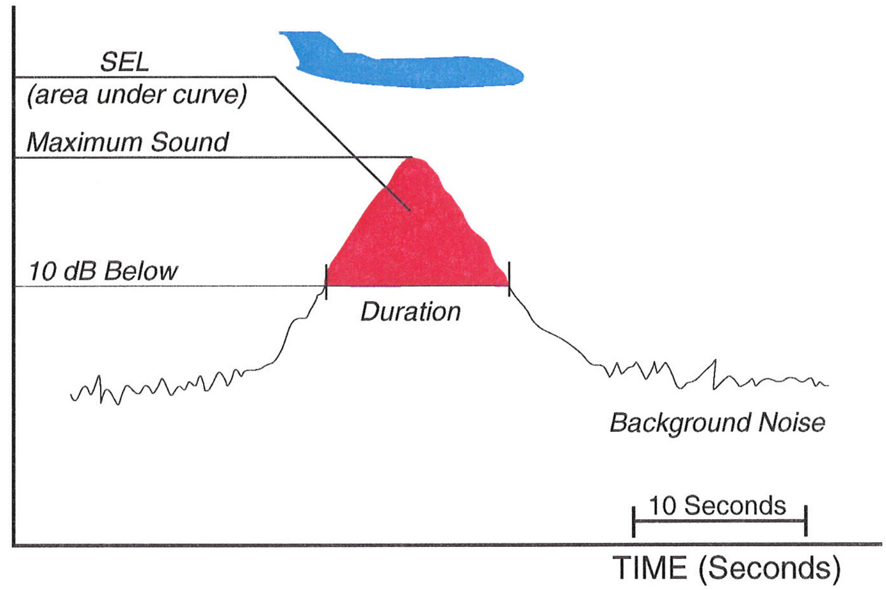
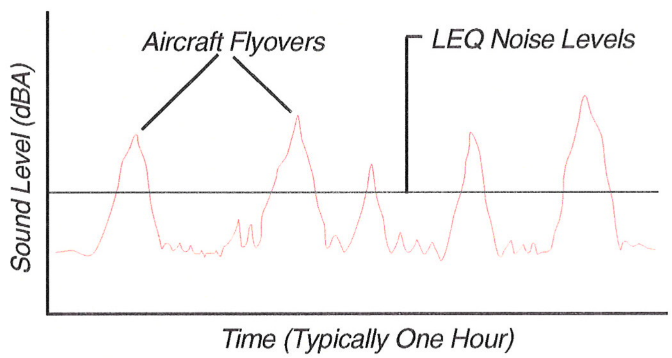
REID MIDDLETON, INC.
TRIANGLE ASSOCIATES, INC.
HAMMER SILER GEORGE ASSOCIATES, INC.

SOURCE: Reproduced from Melville C. Branch and R. Dale Beland, "Outdoor Noise in the Metropolitan Environment", Published by the City of Los Angeles. 1970, p.2.

Single Event (SEL)



One Hour of Events (LEQ)



Time Axis Not Drawn To Scale
Noise Events Are Much Shorter Duration Than Shown Here

One Day of Events (DNL)

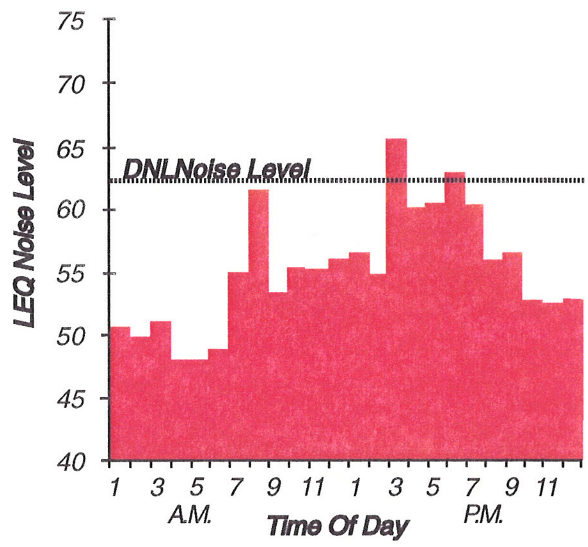


Figure C2 **Noise Metric Illustrations**

PAINE FIELD MASTER PLAN & NOISE STUDY UPDATE

Barnard Dunkelberg & Company
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SOURCE: MGA Analysis

Cumulative Noise Metrics

Cumulative noise metrics have been developed to assess community response to noise. They are useful because these scales attempt to include the loudness of each event, the duration of these events, the total number of events and the time of day these events occur into one single number rating scale. They are designed to account for the known health effects of noise on people described previously. Based on these effects, the observation has been made that the potential for a noise to impact people is dependent on the total acoustical energy content of the noise. A number of noise scales have been developed to account for this observation. The predominate scales are: the Equivalent Noise Level (LEQ) and the Day Night Noise Level (DNL). This designation is the new method for identifying the Ldn metric, which is exactly the same metric. These scales are described in the following paragraphs.

LEQ is the sound level corresponding to a steady-state sound level containing the same total energy as a time-varying signal over a given sample period. LEQ is the "energy" average noise level during the time period of the sample. LEQ can be measured for any time period, but is typically measured for one hour. This is also referred to as the Hourly Noise Level (HNL). It is the energy sum of all the events that occur during that time period. This is graphically illustrated in the lower left hand corner of Figure C2.

DNL is a 24-hour, time-weighted annual average noise level. It is a measure of the overall noise experienced during an entire day. The time-weighted refers to the fact that noises that occur during certain sensitive time periods are penalized for occurring at these times. In the DNL scale, those events that take place during the night (10 p.m. to 7 a.m.) are penalized by 10 dB. This penalty was selected to attempt to account for increased human sensitivity to noise during the quieter period of a day, where home and sleep is the most probable activity.

The DNL accounts for the number of events per day, the time of day and the loudness of the events. Since the hourly LEQ is the average of the SELs during an hour, DNL is often computed by energy adding the hourly LEQs for the day with the same weighing factors specified above. The result is mathematically identical to adding SEL values. The DNL scale is specified by the Federal Aviation Administration (FAA) and the Environmental Protection Agency (EPA) for airport noise assessment. Referring again to Figure C2, the lower right hand corner of the Figure depicts how hourly LEQs are summed and weighted to compute the daily DNL level.

The public reaction to different noise levels varies from community to community. Extensive research has been conducted on human responses to exposure of different levels of aircraft noise. Community noise standards are derived from tradeoffs between community response surveys, such as this, and economic considerations for achieving these levels.

Supplemental Noise Metric

The FAA has developed the Time Above metric as another metric for assessing impacts of aircraft noise around airports. The Time Above index 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 75 or 85 dBA sound levels. While this index is not widely used, it is usually used by the FAA in environmental assessments of airport projects that show a significant increase in noise levels. There are no noise and land use standards in terms of the Time Above index.

Noise/Land Use Compatibility Guidelines. The purpose of this section is to present information regarding the compatibility of various land uses with environmental noise. Noise/Land use guidelines have been produced by a number of agencies including the Federal Aviation Administration, the Environmental Protection Agency, and state and local governments. A number of these guidelines are summarized below.

Federal Aviation Administration

As part of the FAR Part 150 Noise Control program, the FAA published noise and land use compatibility charts to be used for land use planning with respect to aircraft noise. An expanded version of this chart appears in Aviation Circular 150/5020-1 (dated August 5, 1983). This chart is presented in Figure C3. These guidelines represent recommendations to local authorities for determining acceptability and permissibility of land uses. The guidelines specify maximum amount of noise exposure (in terms of the cumulative noise metric DNL) that will be considered acceptable or compatible to people in living and working areas. These noise levels are derived from case histories involving aircraft noise problems at civilian and military airports and the resultant community response. Note that residential land use is deemed acceptable for noise exposures up to 65 DNL. Several important notes appear for the FAA guidelines, including one which indicates that ultimately the local jurisdiction can determine land use compatibility based on noise contours.

The FAA has developed guidelines (Order 5050.4A) for the environmental analysis of airports. Federal requirements now dictate that increases in noise levels in noise sensitive land uses of over 1.5 DNL are considered significant (1050.1D, 12/21/83).

Environmental Protection Agency

In March 1974, the EPA published a very important document entitled *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety* (EPA 550/9-74-004, Levels Document). In this report, 55 DNL is described as the requisite level with an adequate margin of safety for areas with outdoor uses; this includes residences and recreational areas. The EPA "levels document" does not constitute a standard, specification or regulation, but identifies safe levels, or guidelines, of environmental noise exposure without consideration for economic cost for achieving these levels.

State and Local Agencies

As with most states, the State of Washington does not have a specific noise standard to assess the compatibility of various land uses with noise from aircraft in flight. Ground engine noise is addressed in state and local statutes. Most airport/land use compatibility guidelines used in the State are based on the Federal Aviation Administration's guidelines for the assessment of noise and land use compatibility conflicts around airports found in FAR Part 150.

Methodology in Determining the Noise Environment. The noise environment at Paine Field was determined through the employment of the existing noise monitoring equipment to measure aircraft noise sources and incorporating these results into a computer noise model. In addition, supplementary noise monitors were used to help determine the noise associated with run-up operations and aircraft noise levels using the east runway (Runway 16L/34R). The results of the measurements, in

Land Use	*Yearly Day-Night Sound Level(L_{dn}) in decibels*					
	Below 65	*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)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.

KEY TO TABLE 1

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.

Source: FAR Part 150

Figure C3 ***FAR Part 150 Land Use Compatibility Matrix*** conjunction with annual airport operational data, were incorporated into a computer model through which an annual average of the noise levels at any location around the airport can be predicted. Noise monitoring locations are depicted on the Flight Track Map, Figure C4, and were done in accordance with Part 150 guidelines.

The noise environment is commonly depicted in terms of lines of equal noise levels, or noise contours. The following paragraphs detail the methodology used in the computer modeling of these results into noise contours.

Computer Modeling

The airport noise contours were generated using the Integrated Noise Model (INM) Version 3.10, developed by the Federal Aviation Administration (FAA). The original version was released in 1977, and the present Version 3.10 was released in 1992 with a new revised aircraft data base. The INM is a large computer program developed to plot noise contours for airports. The program is provided with standard aircraft noise and performance data for over one hundred aircraft types that can be tailored to the characteristics of the airport in question. The INM program requires the input of the physical and operational characteristics of the airport. Physical characteristics include runway coordinates, airport altitude, and temperature. Operational characteristics include aircraft mix, flight tracks, and approach profiles. Additional data that is contained within the model, or can be inputted specific to the airport, include departure profiles, approach parameters, and aircraft noise curves.

Operational Assumptions. In order to predict and model the noise environment, precise aircraft operational data is required. The 1992 aircraft operational levels were derived directly from airport summary of daily logs. The analysis is based upon 3,096 annual manufacturing/maintenance large transport air carrier operations, 5,893 military operations and 169,021 general aviation operations (an operation is one departure or one arrival) or approximately 488 daily operations. These operations are composed of manufacturing/maintenance large transport air carrier, general aviation and military aircraft.

The existing average annual aircraft operations are shown in Table C1. The five-year future noise contours were generated utilizing the Scenario 3 (Regional Low) forecast presented in the Forecast chapter, and these are also presented in Table C1.

The percent of operations that occur during the nighttime is also presented in Table C1. In the DNL metric, any operations that occur after 10 p.m. and before 7 a.m. are considered more intrusive and are weighted by 10 dBA. As there is not a twenty-four hour tower at Paine Field, the nighttime operations are a best estimate and may reflect a "worst case" estimate of such operations. Aircraft flight tracks, runway utilizations and profiles were obtained by observations during on-site visits; review of Air Route traffic radar plots, discussions with Air Traffic Control (ATC) personnel, discussion with military personnel, discussion with airport management staff and review of daily logs. There were fifty-two flight tracks identified for operations at the airport. These reflect all aircraft operations, including helicopters and touch-and-go operations. The flight tracks are shown on Figure C4, which is a computer plot of the actual flight tracks used in the INM. It must be remembered that these are generalized average flight tracks and are not intended to illustrate the exact location that aircraft fly on each track. Flight tracks are the same for both the existing and future conditions.