Aircraft Noise 101

LAX Community Noise Roundtable

May 9, 2012

ESA

ESA is where
solutions and
service meet.

Overview

- Aircraft Noise Roles and Responsibilities
- Regulatory Framework
- Aircraft Noise Metrics
- Quantifying Noise Exposure
- Propagation of Noise
- Noise “Rules of Thumb”

Roles and Responsibilities

- The primary players in aircraft noise issues are:
  - Federal Government
  - Airport Proprietors
  - State and Local Governments and Planning Agencies
  - Aircraft Operators
  - Residents and Prospective Residents

Roles and Responsibilities

- The Federal Aviation Administration's (FAA) 1976 Aviation Noise Abatement Policy described their roles as follows:

Roles and Responsibilities

- The Federal Government (the FAA)
  - Sets noise level requirements for aircraft
  - Provides funding for, and approval of, noise compatibility planning (when appropriate and/or when funds are available)
  - Manages the air traffic control and airspace system

Roles and Responsibilities

- Airport Proprietors
  - Plan and implement actions designed to reduce the adverse effects of noise on residents of the surrounding area including:
    - Improvements in airport design
    - Noise abatement ground procedures
    - Promote noise mitigation alternatives
    - Restrictions on airport use*

*Severely limited by the 1990 Aircraft Noise and Capacity Act (ANCA)

Roles and Responsibilities

- State and Local Governments and Planning Agencies
  - Plan the land uses around an airport in a manner that will be compatible with airport and aircraft operations

Roles and Responsibilities

- Aircraft Operators
  - Fly quieter aircraft
  - Fly responsibly
    - Safety first and foremost
    - Use industry recommended noise abatement procedures
    - Use preferred noise abatement runways
    - Follow airport's published noise abatement procedures
    - Follow noise abatement flight tracks

Roles and Responsibilities

- Pilot in command has sole responsibility for the safe operation of his or her aircraft

Roles and Responsibilities

- Aviation system users pay for the entire aviation system including the adverse impacts of noise
  - Passengers, air cargo operators, general aviation pilots, corporate aviation, and flight schools finance airport development, maintenance, and the cost of noise-reducing measures such as:
    - New quieter aircraft
    - Research and development into noise reducing technologies
    - Planning and land use compatibility studies
    - Land acquisition, sound insulation
    - Ground runup enclosures

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Roles and Responsibilities

- Current and Prospective Residents
  - Current Residents:
    - Seek to understand the noise problem and what can be done to minimize its effects
    - Recognize that everybody responds to noise differently; reducing the noise level may not eliminate your annoyance
  - Prospective Residents:
    - Be aware of the potential effects of aircraft noise on your future quality of life and act accordingly

Regulatory Framework

- Federal law sets aircraft noise standards, prescribes operating rules, establishes the federal compatibility planning process, and limits airport proprietor's ability to restrict aircraft operations

- State law sets forth state compatibility planning guidelines and noise standards, but exempts aircraft in flight

- Local noise ordinances set noise standards and provide for compatible land use planning, but exempt aircraft in flight

FEDERAL LAW PREEMPTS STATE AND LOCAL REGULATIONS

Regulatory Framework

- There are many Federal Aviation Regulations (FARs) related to aircraft noise, including but not limited to:
  - FAR Part 36 – Noise Standards: Aircraft Type and Airworthiness Certification
  - FAR Part 91 – General Operating and Flight Rules
  - FAR Part 150 – Airport Noise Compatibility Planning
  - FAR Part 161 – Notice and Approval of Airport Noise and Access Restrictions

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Regulatory Framework

- There are many FAA Orders that provide guidance on noise analyses and funding for noise-related projects, including but not limited to:
  - FAA Order 1050.1E – Environmental Impacts: Policies and Procedures
  - FAA Order 5050.4B – National Environmental Policy Act Implementing Instructions for Airport Actions
  - FAA Environmental Desk Reference for Airport Actions
  - FAA Order 5100.38C – Airport Improvement Handbook

Aircraft Noise Metrics

- What is noise?

  - Noise is unwanted sound
  - Noise is very subjective
  - We measure sound, not noise

Aircraft Noise Metrics - Federal

- Federal Aviation Regulation (FAR) Part 150 prescribes aircraft noise metrics and methodology to be used in assessing aircraft noise exposure in federally-funded noise studies
  - The Decibel (dB)
  - A-weighting (dBA)
  - Maximum A-weighted sound level (Lmax)
  - Sound Exposure Level (SEL)
  - Day-Night Average Sound Level (DNL)
  - The Integrated Noise Model (INM)
  - The Military Noise Model (NOISEMAP)
  - Modeling only, no noise measurements

Aircraft Noise Metrics - California

- California Code of Regulations Title 21 prescribes aircraft noise metrics and methodology to be used in assessing aircraft noise exposure in California
  - The Decibel (dB)
  - A-weighting (dBA)
  - Noise Exposure Level (NEL)
  - Single Event Noise Exposure Level (SENEL)
  - Hourly Noise Level (HNL)
  - Community Noise Equivalent Level (CNEL)
  - “. . . an approved computer model and the data reported by the noise monitoring system.”

Aircraft Noise Metrics

The Decibel Scale

NORMAL NUMBERS	DECIBELS	COMMON SOUNDS
100,000,000,000,000	140	Near Jet Engine
10,000,000,000,000	130	Threshold of Pain
1,000,000,000,000	120	Night Club, Discotheque
100,000,000,000	110	
10,000,000,000	100	Pneumatic Hammer at 6 Feet
1,000,000,000	90	
100,000,000	80	Vacuum Cleaner
10,000,000	70	
1,000,000	60	Normal Speech
100,000	50	
10,000	40	Quiet Residential Neighborhood
1,000	30	
100	20	Whisper
10	10	
1	0	Threshold of Hearing
0.1	-10	
0.01	-20	

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Aircraft Noise Metrics

- Frequency-Weighted Metrics (dBA)
  - To simplify measurement and computation of sound loudness levels, frequency weighted networks have obtained wide acceptance
  - A-weighting (dBA) has become the most prominent of these scales
  - Replicates the way we hear sounds

Aircraft Noise Metrics

- Frequency-Weighted Metrics (dBA)
  - Shows good correlation with community response and is easily measured
  - Most aircraft noise studies use the dBA scale
  - FAR Part 150 and Title 21 require the use of A-weighting

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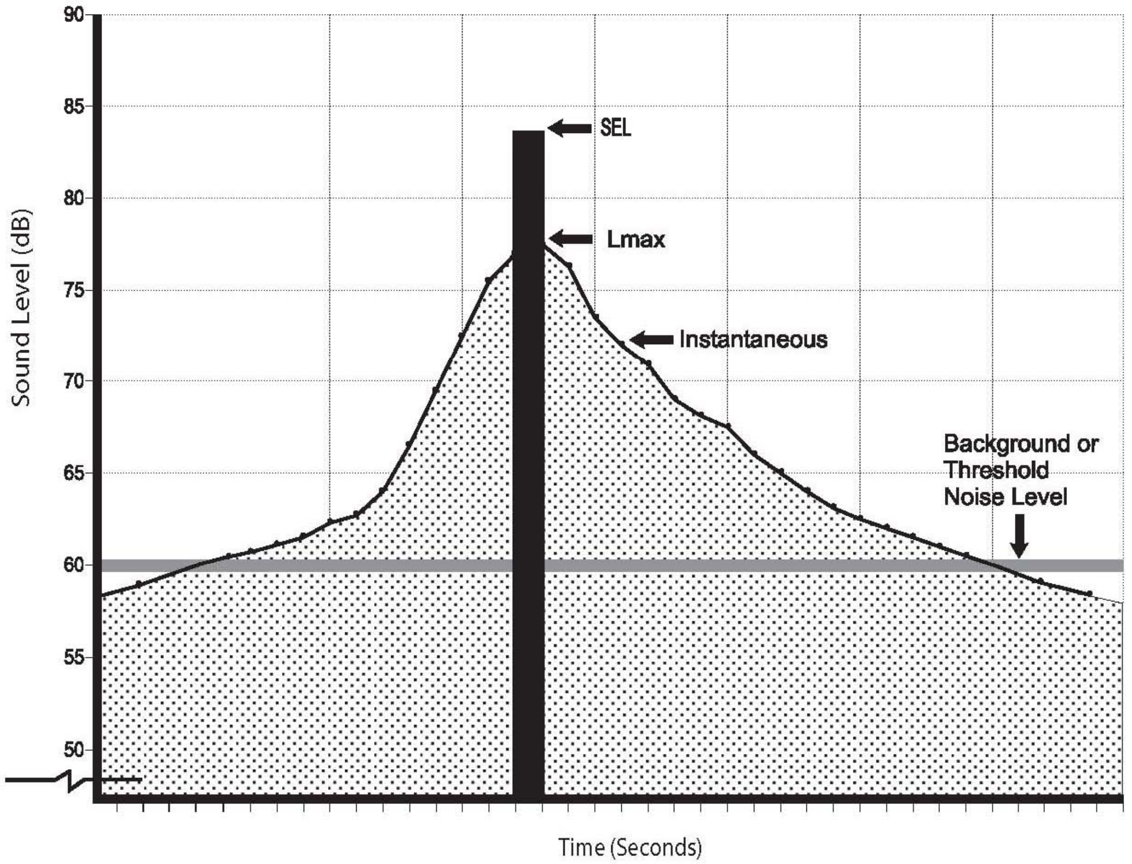
Aircraft Noise Metrics

- Maximum Noise Level (Lmax)
  - Highest noise level reached during a noise event
  - Lmax achieved when aircraft is at its closest point
  - Generally, it is this metric that people instantaneously respond to when an aircraft flyover occurs

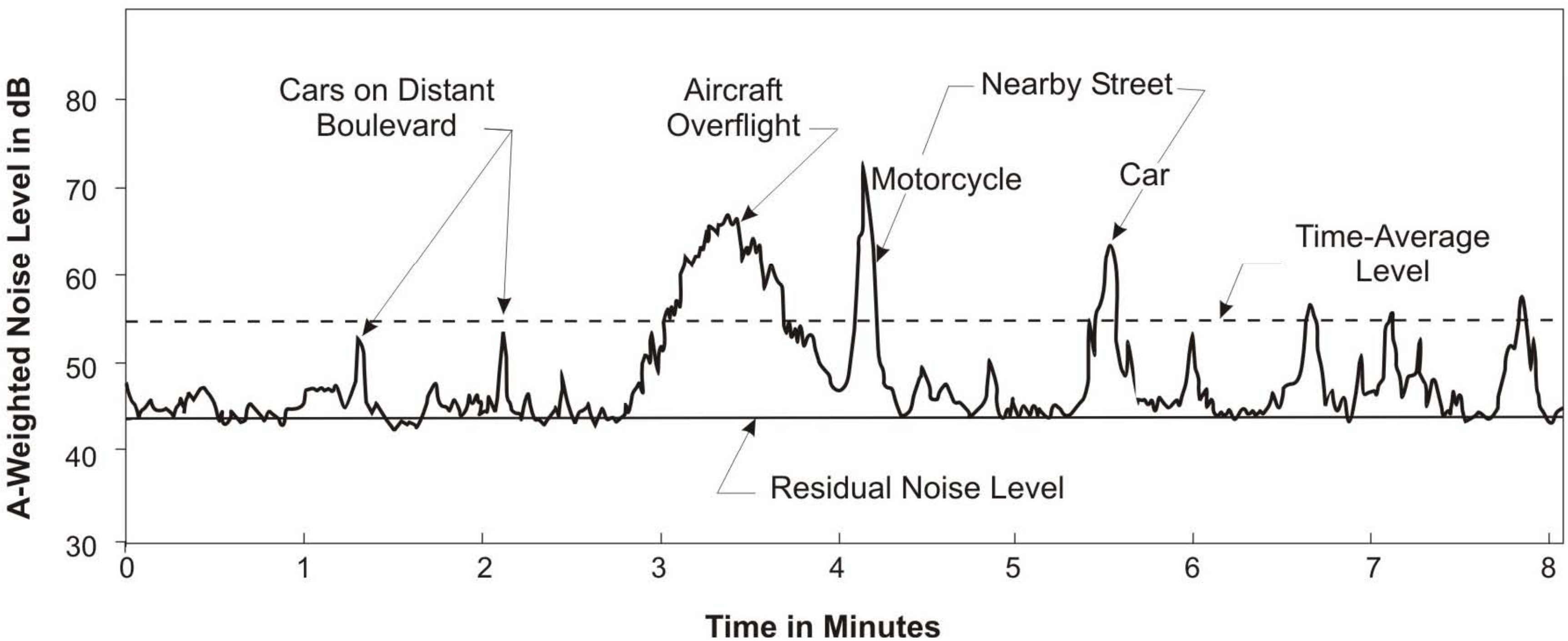
Aircraft Noise Metrics

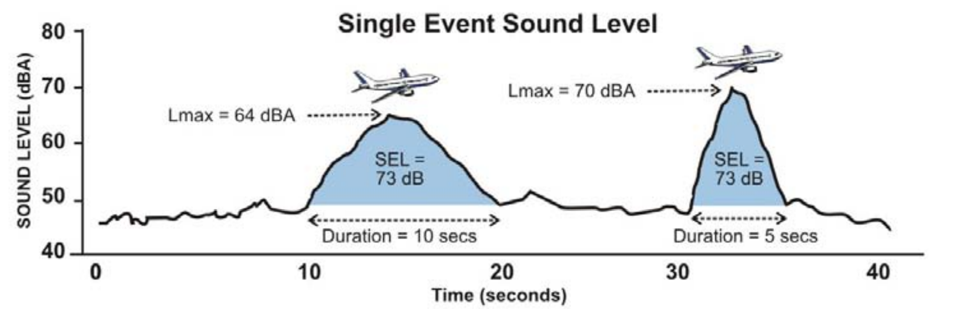
- Sound Exposure Level (SEL) or Single Event Noise Exposure Level (SENEL)
  - Computed from the A-weighted sound levels
  - Integration of all the acoustic energy contained within the event
  - Speech and sleep interference research can be assessed relative to SEL/SENEL data
  - Approximately 10 dB greater than Lmax

Instantaneous Level, Lmax, SEL, Background Level

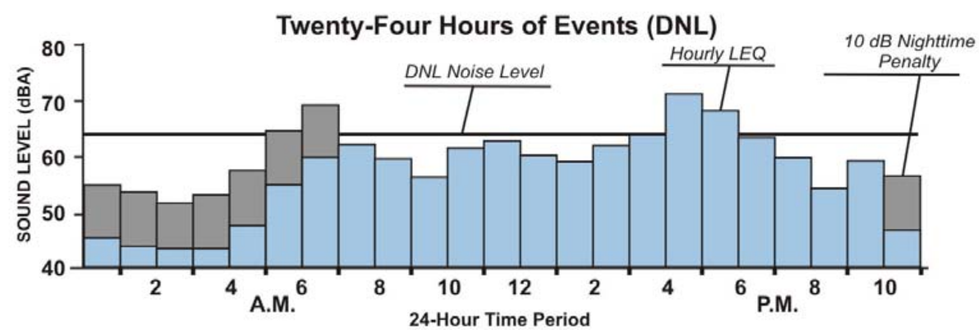


Sound Environs




Single Event Sound Level
SOUND LEVEL (dBA)
Lmax = 64 dBA
Lmax = 70 dBA
SEL = 73 dB
SEL = 73 dB
Duration = 10 secs
Duration = 5 secs
Time (seconds)


One Hour of Events (Hourly LEQ)
SOUND LEVEL (dBA)
Aircraft Flyovers
LEQ Noise Level
Time (one hour)
(Time axis not drawn to scale. Aircraft events are shorter than shown here)


Twenty-Four Hours of Events (DNL)
SOUND LEVEL (dBA)
DNL Noise Level
Hourly LEQ
10 dB Nighttime Penalty
A.M.
P.M.
24-Hour Time Period

Aircraft Noise Metrics

- Equivalent Noise Level (LEQ)
  - "Energy" average noise level during the time period of a sample
  - Based on the observation that potential for a noise to impact is dependent on the total acoustical energy content
  - Can be measured for any time period, but typically measured in 15 minutes, 1 hour, and 24 hours

Aircraft Noise Metrics

- Day-Night Average Sound Level (DNL)
  - 24-hour time weighted energy average noise level based on dBA
  - Noise occurring between 10 p.m. to 7 a.m. is penalized by 10 dB
  - Penalty was selected to account for the higher sensitivity to noise in the nighttime and accounts for the expected decrease in background noise levels that typically occur in the nighttime
  - FAA specifies DNL for airport noise assessment
  - Environmental Protection Agency (EPA) specifies DNL for community noise and airport noise assessment

Aircraft Noise Metrics

- Community Noise Equivalent Level (CNEL)
  - 24-hour time weighted energy average noise level based on dBA
  - Each noise event occurring between 7 p.m. to 10 p.m. is treated as three events and penalized by 4.77 dB
  - Each noise event occurring between 10 p.m. to 7 a.m. is treated as ten events and penalized by 10 dB
  - Penalties were selected to account for the higher sensitivity to noise during the evening and nighttime periods and account for the expected decrease in background noise levels that typically occur in the evening and nighttime
  - FAA permits the use of CNEL for airport noise assessment in California, Caltrans requires the use of CNEL for determining aircraft noise exposure

Aircraft Noise Metrics - Federal

- The land use compatibility guidance in FAR Part 150:

  – Defines 65 DNL as the federal guideline for incompatibility

  – Considers all land uses outside the 65 DNL contour line to be compatible with aircraft noise

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Aircraft Noise Metrics - California

- Title 21 Noise Standards:
  - Defines 65 CNEL as the state guideline for incompatibility
  - Considers all land uses outside the 65 CNEL contour line to be compatible with aircraft noise
  - ". . .chosen for reasonable persons residing in urban residential areas where houses are of typical California construction and may have windows partially open. It has been selected with reference to speech, sleep and community reaction."

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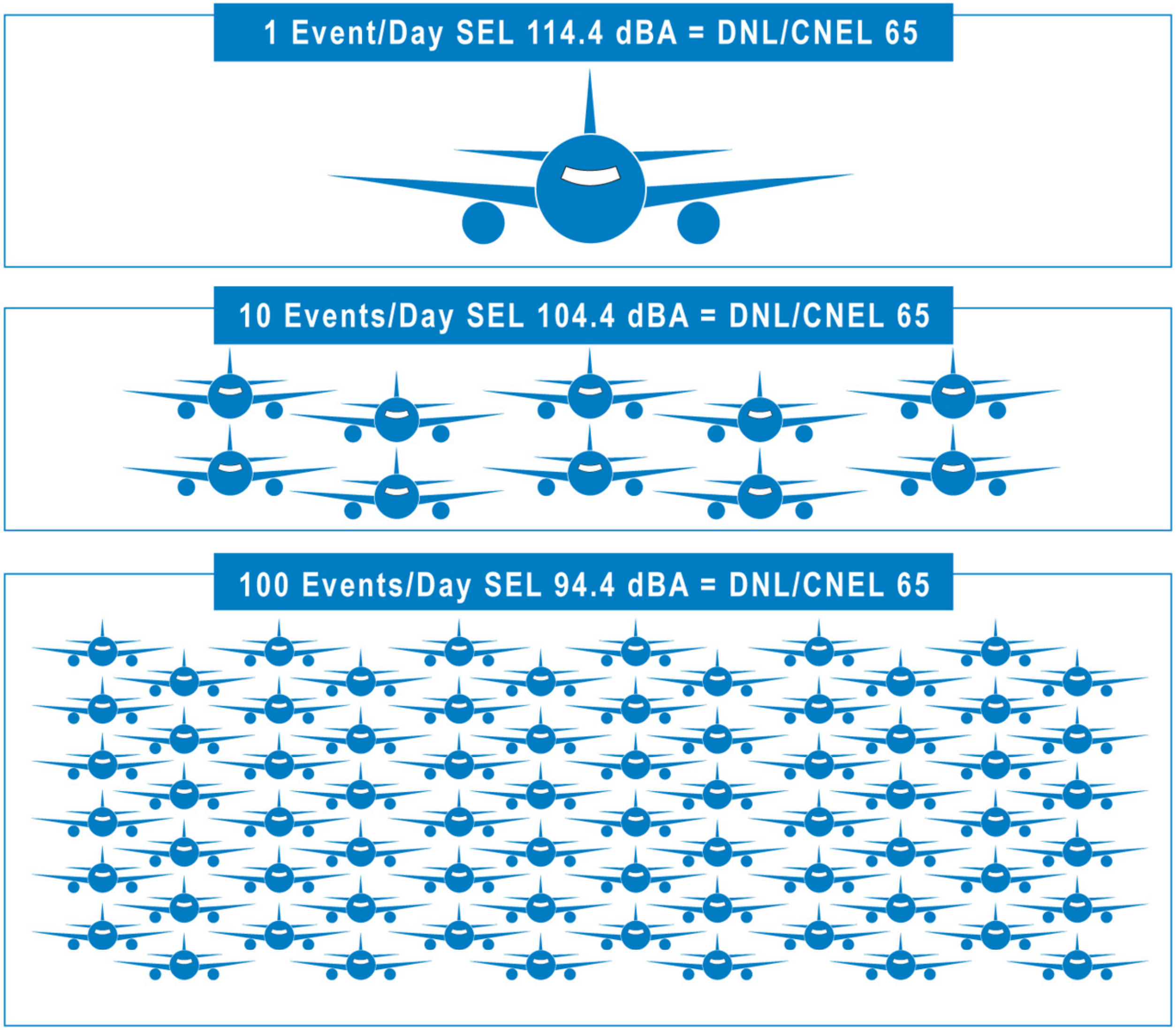
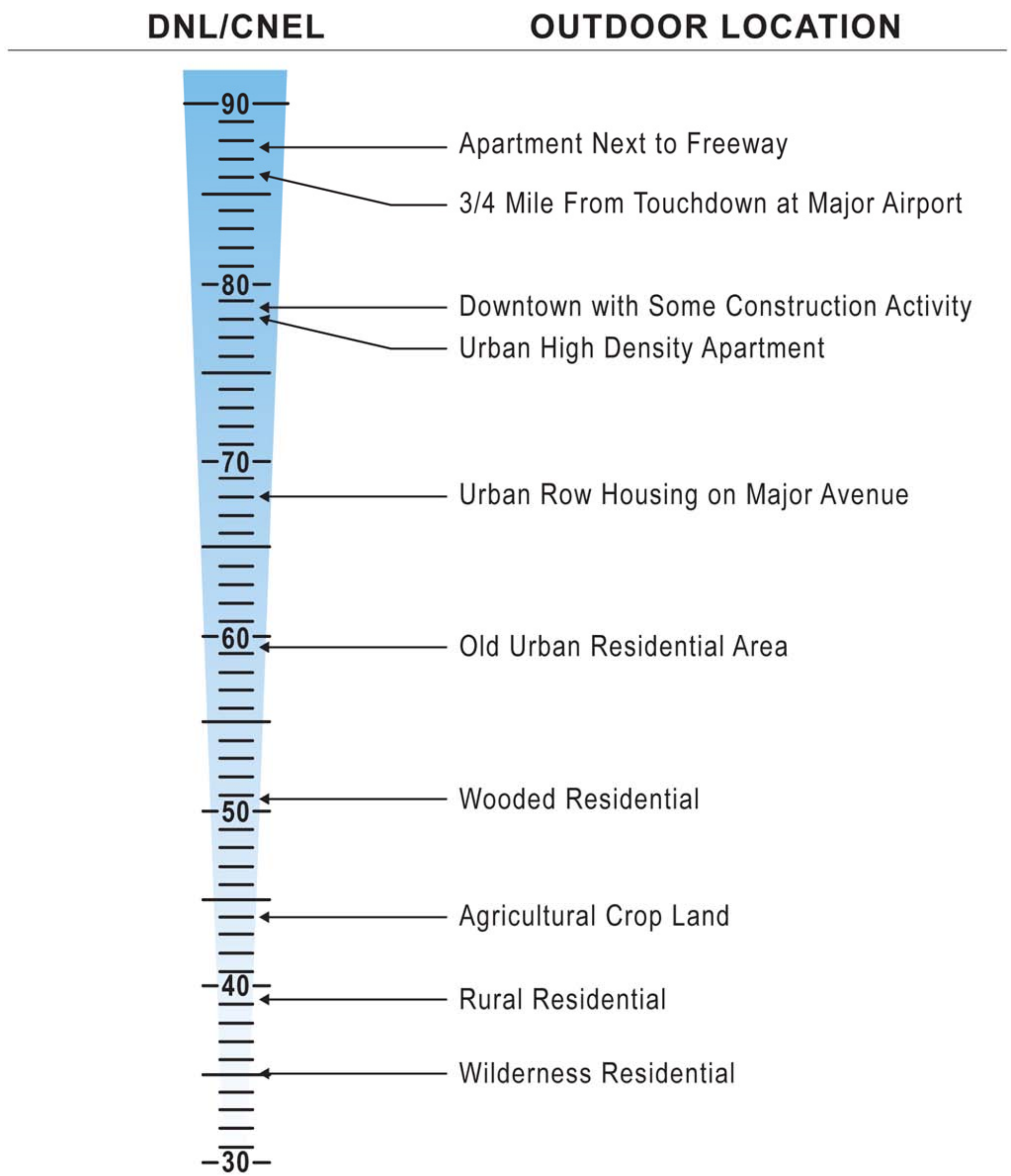
IDENTICAL DNL/CNEL LEVELS



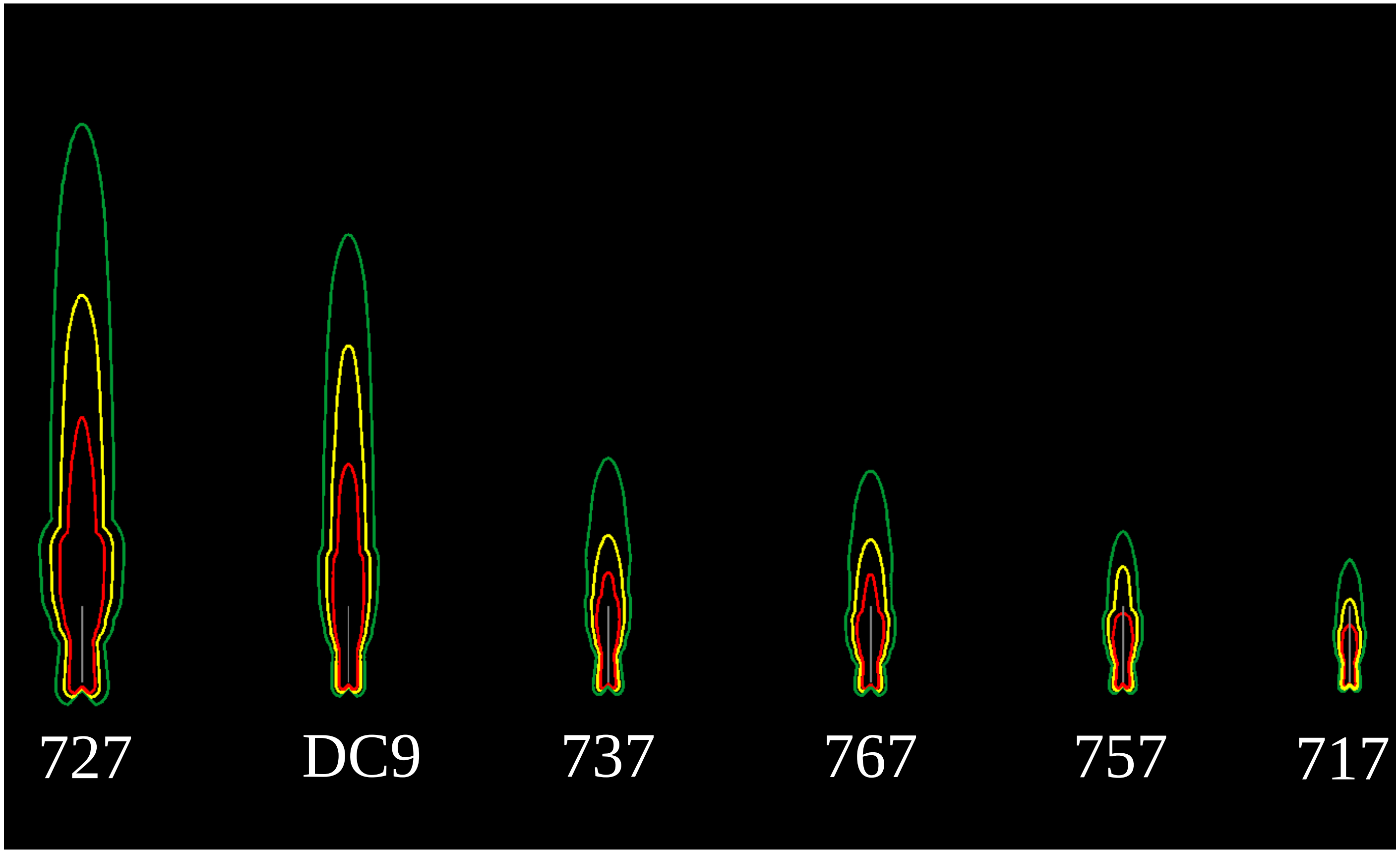
Outdoor Environs



Aircraft Noise Metrics

- Supplemental metrics, such as Sound Exposure Level (SEL) and Maximum Sound Level (Lmax), can be used for evaluation purposes, however, there are no federal or California standards for their use in quantifying aircraft noise impacts

Departure Lmax Contours



Quantifying Noise Exposure

- Noise exposure can be quantified using:
  - Measurements
  - Modeling

Quantifying Noise Exposure

- Measuring sound levels will accurately tell us:
  - The sound levels at a specific location for the time period measurements were made
  - Historical record of the sound levels at a specific location
  - Historical trends; but measurements do not predict future noise levels

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Quantifying Noise Exposure

- Modeling sound exposure accurately tells us the sound levels
  - Over broad geographic areas as well as at specific locations for a specific time period
  - Modeling can produce a historical record
  - Modeling can be predictive by showing expected trends

Integrated Noise Model (INM)

- FAA's standard tool since 1978 for determining the predicted noise impacts around airports
- INM handles fixed wing and rotary wing aircraft and is the FAA's state-of-the-art aircraft noise model
- Model produces noise exposure contours that are used for determining land use compatibility

Integrated Noise Model (INM)

- INM has been continually being updated to improve its accuracy – 7.0c current version
- INM contains an extensive aircraft performance and noise level database derived from actual noise measurements of aircraft in flight
- INM results have been validated on several occasions with overall modeled and measured levels falling within a couple of decibels of each other

Integrated Noise Model (INM)

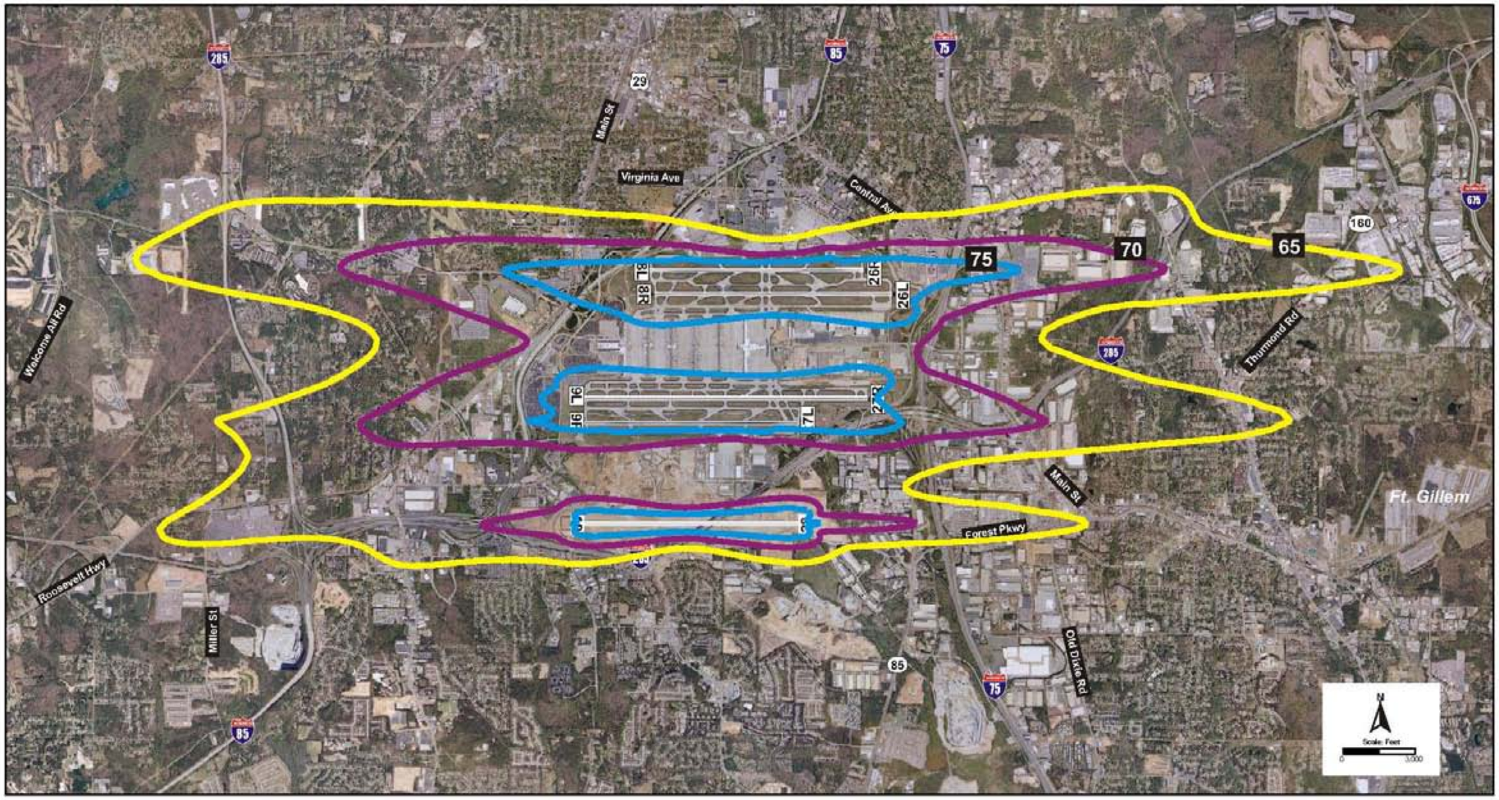
- INM can also predict noise at a specific location that may be sensitive to noise impacts (school, hospital, noise measurement sites, etc.)

- 16 predefined noise metrics are supported, including:
  - DNL
  - CNEL
  - Lmax
  - Leq
  - SEL
  - SENEL

INM Process: Computation

- INM computes the exposure of each operation:
  - as it would be measured in the airport environs accounting for the annual-average use
- The noise exposure of each aircraft operation is:
  - energy-summed over a user-specified grid to determine the annual average noise exposure
- Values of equal noise exposure are connected using “contour lines”

INM Output: DNL/CNEL Contours



AERIAL SOURCE: GlobeXplorer, January 2004

Propagation of Noise

- Overall, atmospheric conditions play a significant role in affecting the sound levels on a daily basis and how these sounds are perceived by the public

Propagation of Noise

- Refraction
  - Wind gradients, lapse condition, and inversion layers affect sound propagation
    - Downwind and inversion layers refract sound waves down
    - Upwind and lapse conditions refract sound waves up
  - Sound does not “bounce” off clouds or fog, but may indicate an inversion condition

Propagation of Noise

- Atmospheric absorption
  - Greater distance traveled, greater influence of atmosphere
  - Atmospheric absorption becomes important at distances greater than 1,000 feet
  - Degree of absorption is a function of the frequency of sound, humidity, and temperature of the air
  - Atmospheric absorption is lowest at high humidity and high temperatures
  - Higher frequencies more readily absorbed than lower frequencies

Propagation of Noise

- Ground attenuation
  - Ground attenuation is important to the study of noise from airfield operations
  - Function of the height of the source and/or receiver and characteristics of the terrain
  - Closer source of noise is to ground, the greater ground absorption
  - Soft surfaces, such as vegetation, provide for more absorption than hard surfaces like water

Rules of Thumb – Single Event Noise

- It takes a 3 dB change in the level of a single noise source for most people to notice a difference
- A 10-dB increase or decrease in the level of a single noise source is typically perceived as doubling or halving of the loudness, respectively
- Doubling or halving of the distance from the source the receiver equates to +/- 6 dB sound level change

Rules of Thumb – Cumulative Noise

- A doubling or halving the airport operations with the same fleet mix equates to a +/- 3 dB change in CNEL

- A 1.5 dB change in noise sensitive areas exposed to 65 CNEL or greater is considered significant in FAA Orders 1050.1E and 5050.4B

- People are more sensitive to changes in exposure than the absolute level

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Aircraft Noise 101 Review

- Aircraft Noise Roles and Responsibilities
- Regulatory Framework
- Aircraft Noise Metrics
- Quantifying Noise Exposure
- Propagation of Noise
- Noise “Rules of Thumb”