City of SeaTac
Port of Seattle

Noise 101 Symposium

Presented by:

Steve Alverson, ESA

January 12, 2019

ESA

ESA is where solutions and service meet.

Today's Syllabus and Schedule

• Welcome/Review of the Syllabus	9:00 – 9:10 am
• Module 1: Principles of Aviation Noise	9:10 – 9:45 am
• Module 2: Quantifying Aircraft Noise	9:45 – 10:30 am
• 10-minute Break	
• Module 3: Aircraft Noise Regulations and Guidance	10:40 – 11:10 am
• Module 4: Principles of Aircraft Noise Control	11:10 – 11:45 am
• Wrap-up and Final Questions	11:45 – 12:00 pm

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Noise 101 Symposium

Principles of Aviation Noise

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Principles of Aviation Noise

- Acoustic principles
- Propagation of sound
- Noise metrics
- Rules of thumb

Acoustic Principles

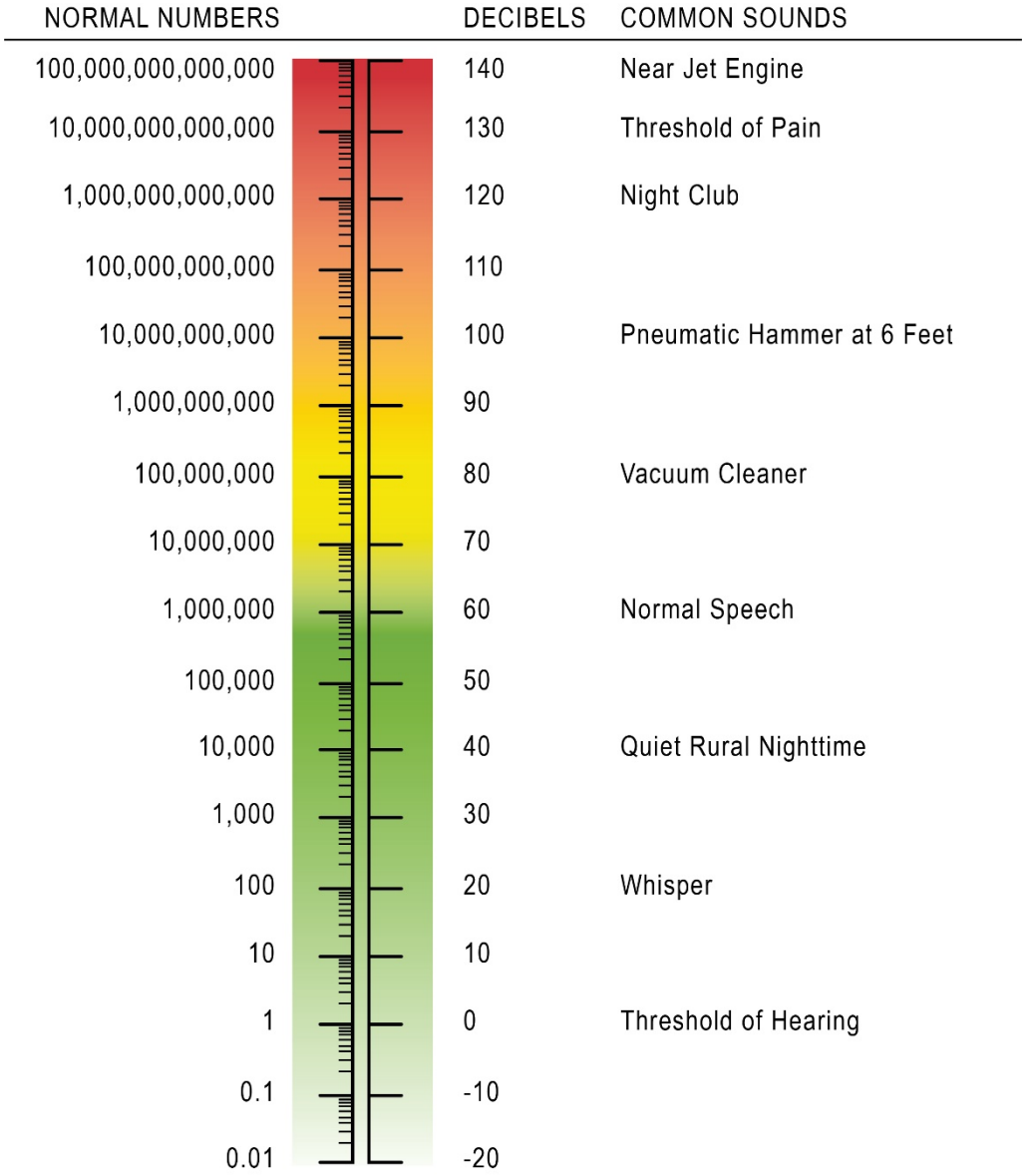
- Sound can be described in terms of its amplitude (pressure) and frequency (pitch)
  - Amplitude is a direct measure of the magnitude of sound without consideration for other factors that may influence the perception of it
  - Frequency is expressed as Hertz (Hz) or cycles per second

Acoustic Principles

- Amplitude
  - Sound pressure ranges are very large, therefore expressed on a logarithmic scale
  - The logarithmic scale compresses the wide range in sound pressures to a more mathematically useable range
  - Standard unit of measurement is the decibel (dB)

Principles of Aviation Noise

The Decibel Scale



Source: U.S. EPA

Acoustic Principles

- Amplitude – continued
  - A sound level of 70 dB has 10 times the acoustic energy as a level of 60 dB, while a sound level of 80 dB has 100 times the acoustic energy as a level of 60 dB
  - A sound 10 dB higher than another is usually judged to be twice as loud

Acoustic Principles

- Decibel Mathematics*
  - 70 dB + 70 dB = 73 dB
  - 70 dB + 50 dB = 70 dB
  - 70 dB x 10 = 80 dB
  - 70 dB x 100 = 90 dB

*Results reflect the exponential nature of the decibel scale and demonstrate that decibels cannot be added using conventional arithmetic.

Acoustic Principles

- Frequency
  - Normal audible frequency range for young adults is 20 Hz to 20,000 Hz
  - Frequency range for aircraft noise is between 50 Hz and 5,000 Hz
  - The human ear is not equally sensitive to all frequencies

Acoustic Principles

- Noise is unwanted sound
  - By its very nature noise is subjective
  - What is music to my ears may be noise to you
  - We measure or model sound levels and relate them to social surveys to assess the potential for annoyance

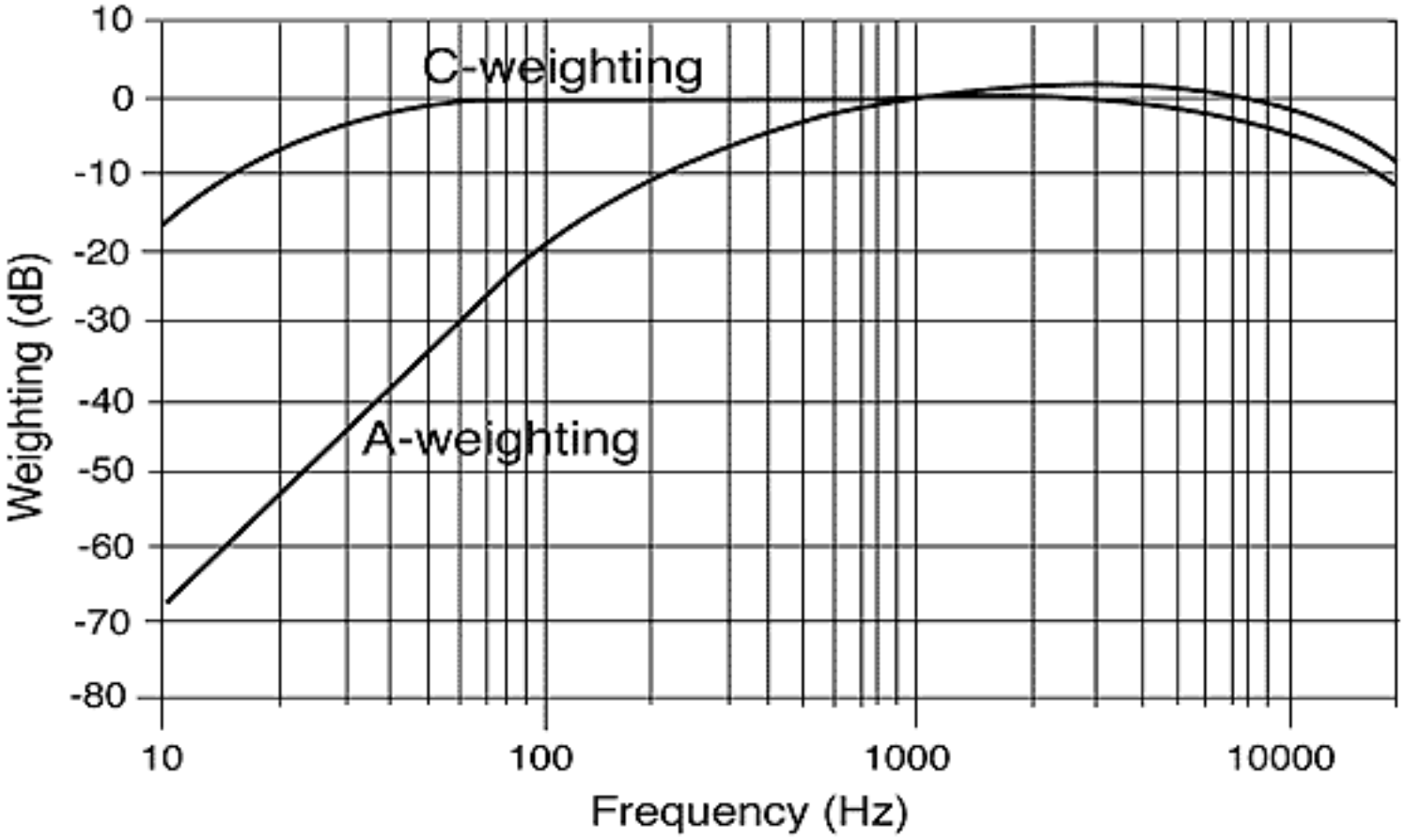
Acoustic Principles

- Noise metrics used in aircraft noise assessments are based upon the following frequency weighting scales:
  - Frequency-weighted contours (dBA and dBC)
  - Effective Perceived Noise Level (EPNL)

Acoustic Principles

- Frequency-weighted contours
  - dBA approximates the sensitivity of the human ear
  - dBC is used for low frequency noise

A and C Frequency Curves



Acoustic Principles

- Effective Perceived Noise Level (EPNL)
  - Originally developed for assessment of aircraft noise
  - EPNL is still used for aircraft noise certification

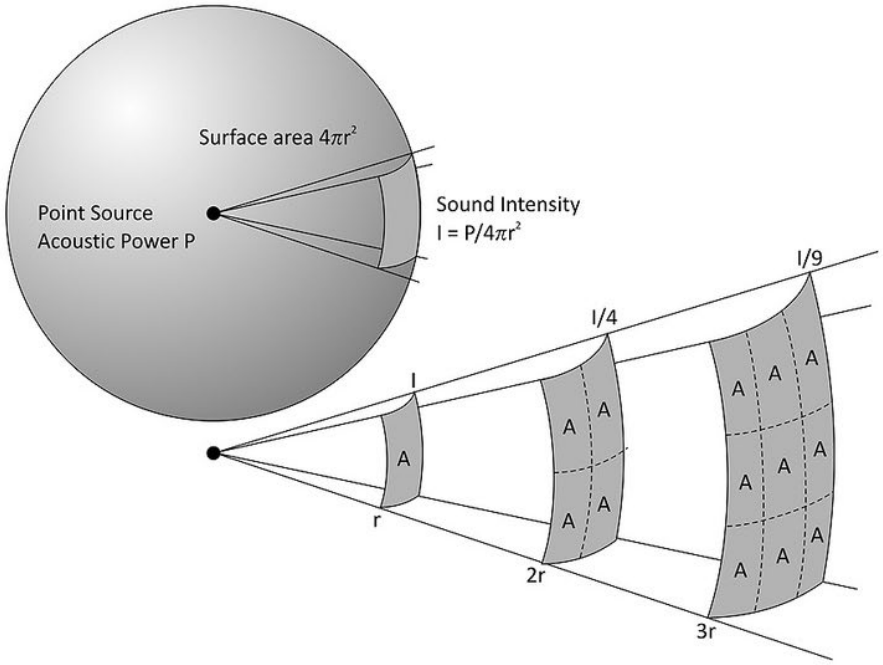
Propagation of Noise

- Sound levels decrease as a function of:
  - Distance from the source
  - Wave divergence
  - Refraction
  - Atmospheric absorption
  - Ground attenuation

Propagation of Noise

- Distance from the source
  - Sound travels as spherical waves
  - Distance allows the sound energy to be distributed over a greater area, dispersing the sound power of the wave
  - Spherical spreading of the sound wave reduces the noise level at a rate of 6 dB per doubling of the distance

Propagation of Noise



Graphic: Sound on Sound Magazine, February 2017

Propagation of Noise

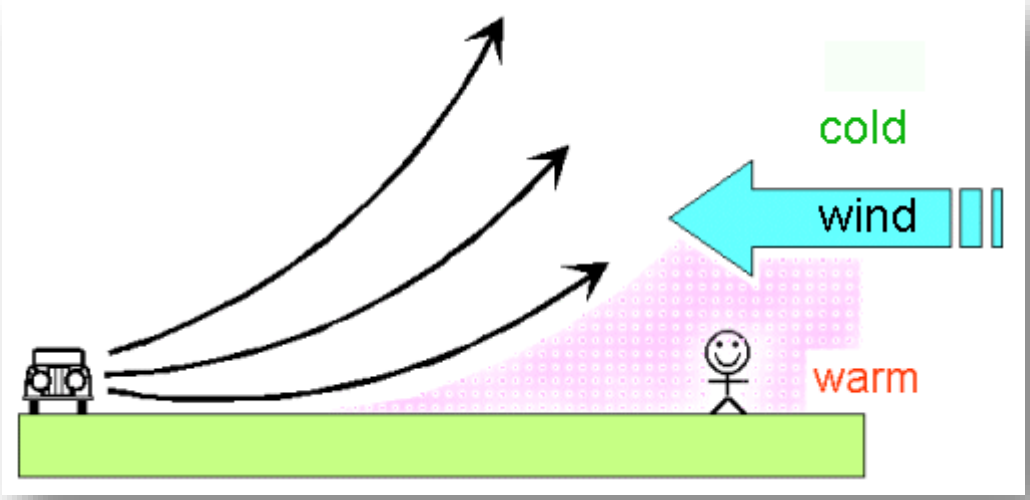
- Refraction
  - Wind gradients, lapse condition, and inversion layers affect sound propagation
    - Downwind and inversion layers refract sound waves down
    - Upwind and lapse conditions refract sound waves up
  - Sound does not “bounce” off clouds or fog, but their presence may indicate an inversion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

Propagation of Noise

- Atmospheric absorption
  - Greater the distance traveled, the 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 level, and air temperature
  - Atmospheric absorption is lowest at high humidity and high temperatures
  - Higher frequencies are more readily absorbed than lower frequencies

Propagation of Noise

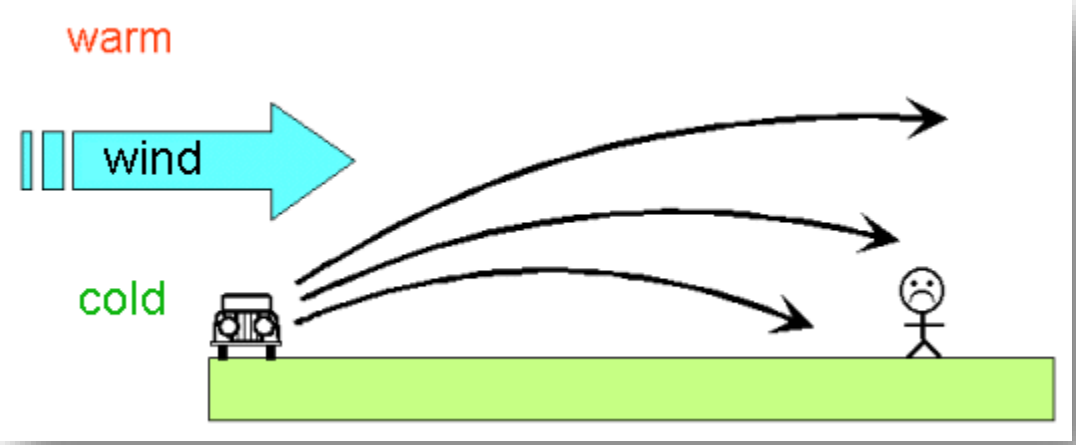
- Lapse/upwind condition



Graphic: Worldpress

Propagation of Noise

- Inversion/downwind condition



Graphic: Worldpress

Propagation of Noise

- Ground attenuation
  - Ground attenuation is important to the study of noise from ground-based 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 pavement or water

Propagation of Noise

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

Noise Metrics

- Single Event Metrics
  - Frequency-weighted metrics (dBA)
  - Maximum Noise Level (Lmax)
  - Sound Exposure Level (SEL)
- Cumulative Metrics
  - Equivalent Noise Level (LEQ)
  - Day-Night Noise Level (DNL)

Noise Metrics

- Supplemental Metrics
  - Time Above (TA)
  - Audibility
  - Percent Noise Level (Ln)

Single Event 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

Single Event Metrics

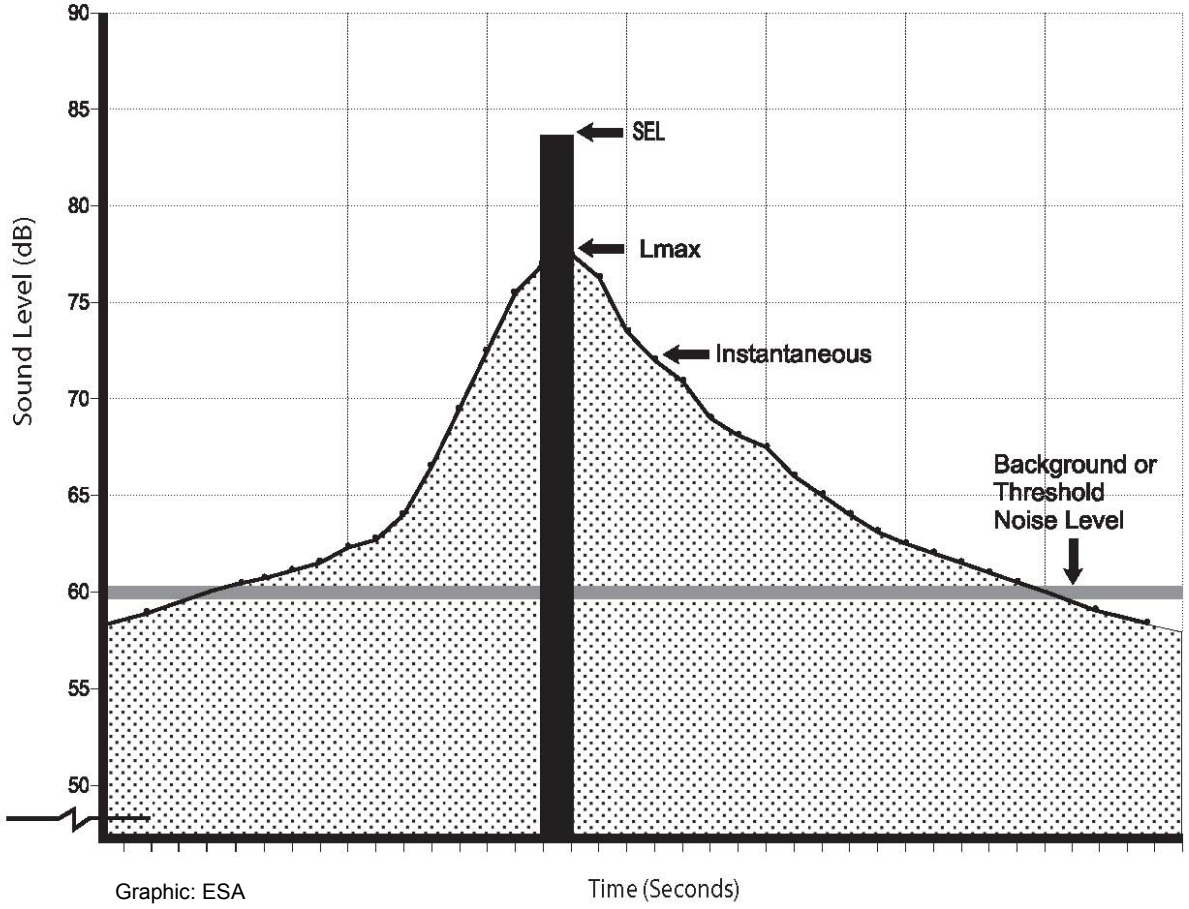
- Frequency-Weighted Metrics (dBA)
  - Shows good correlation with community response and is easily measured
  - Most aircraft noise studies are based upon the dBA scale
  - 14 CFR Part 150 requires the use of A-weighting

Single Event Metrics

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

Principles of Aviation Noise

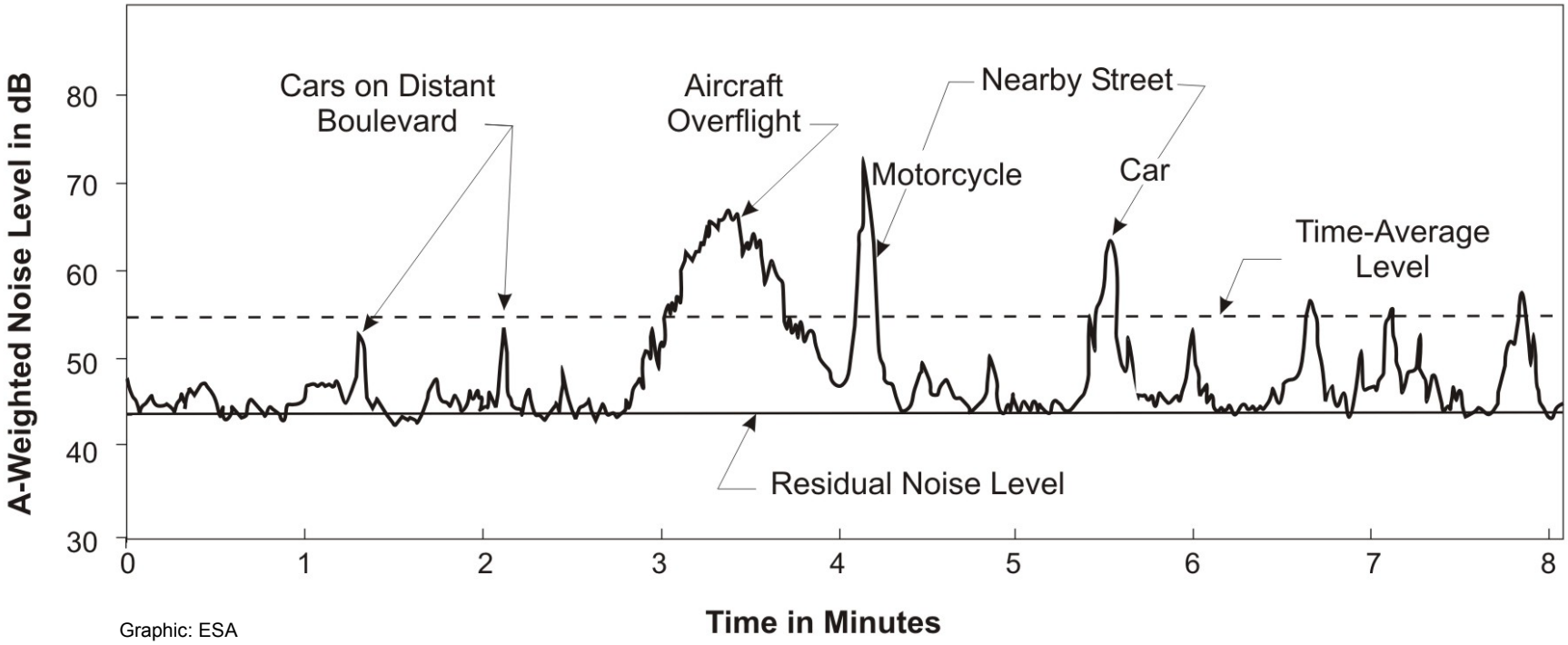
Instantaneous Level, Lmax, SEL, Background Level



Graphic: ESA

Principles of Aviation Noise

Sound Environs

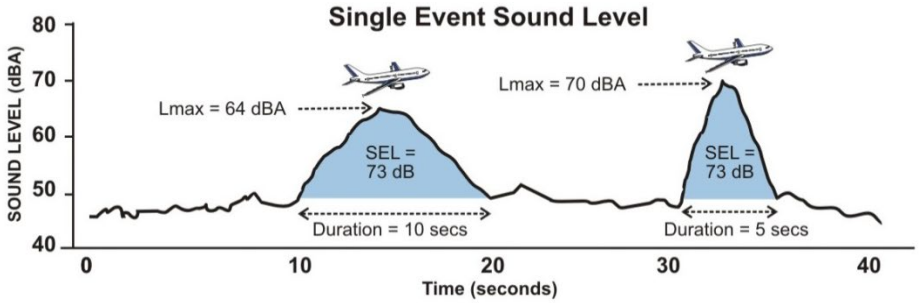


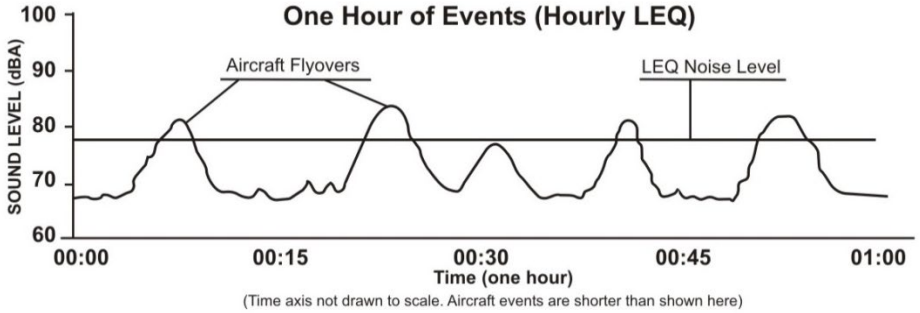
Graphic: ESA

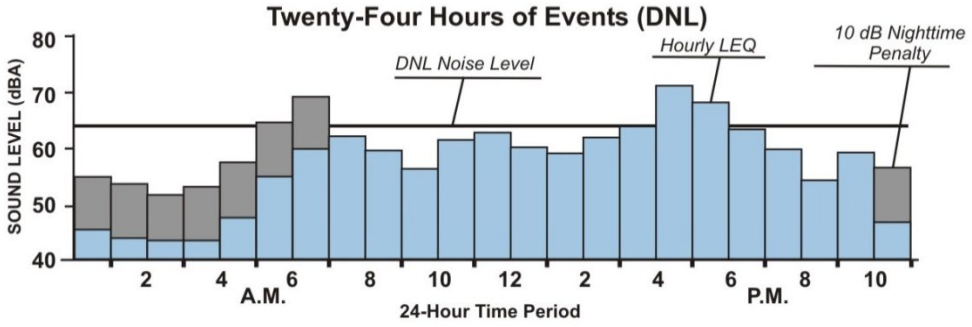
Single Event Metrics

- Sound Exposure Level (SEL)
  - Another metric for aircraft flyovers
  - Computed from dBA sound levels
  - Integration of all the acoustic energy contained within the event
  - Speech and sleep interference research can be assessed relative to SEL data

Principles of Aviation Noise

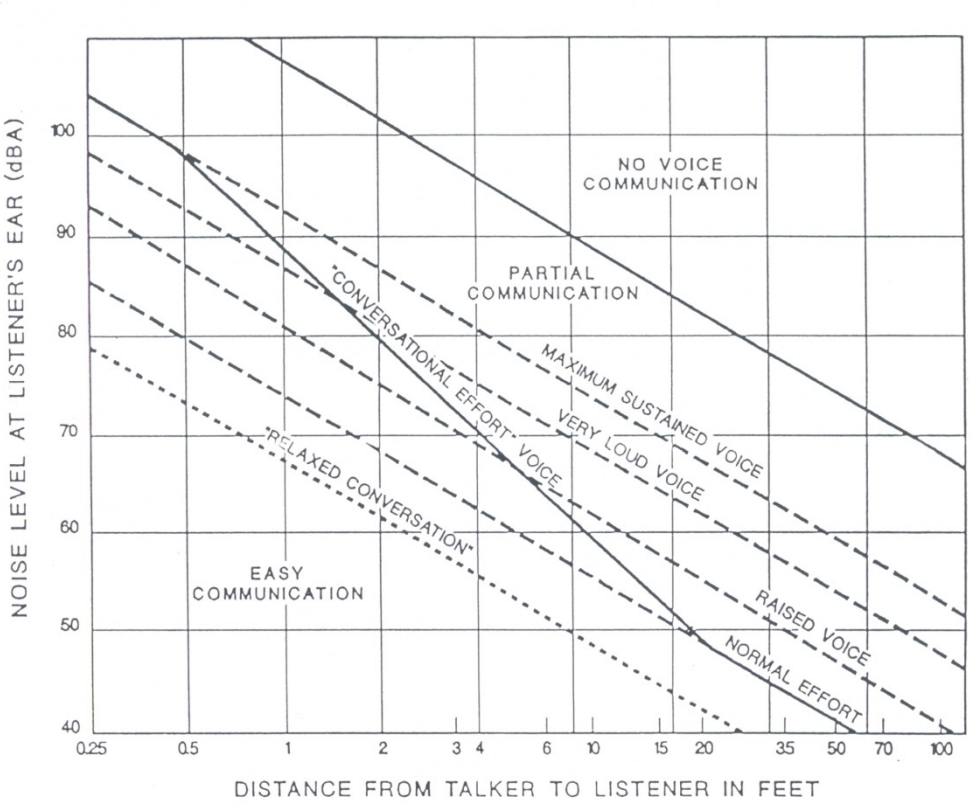






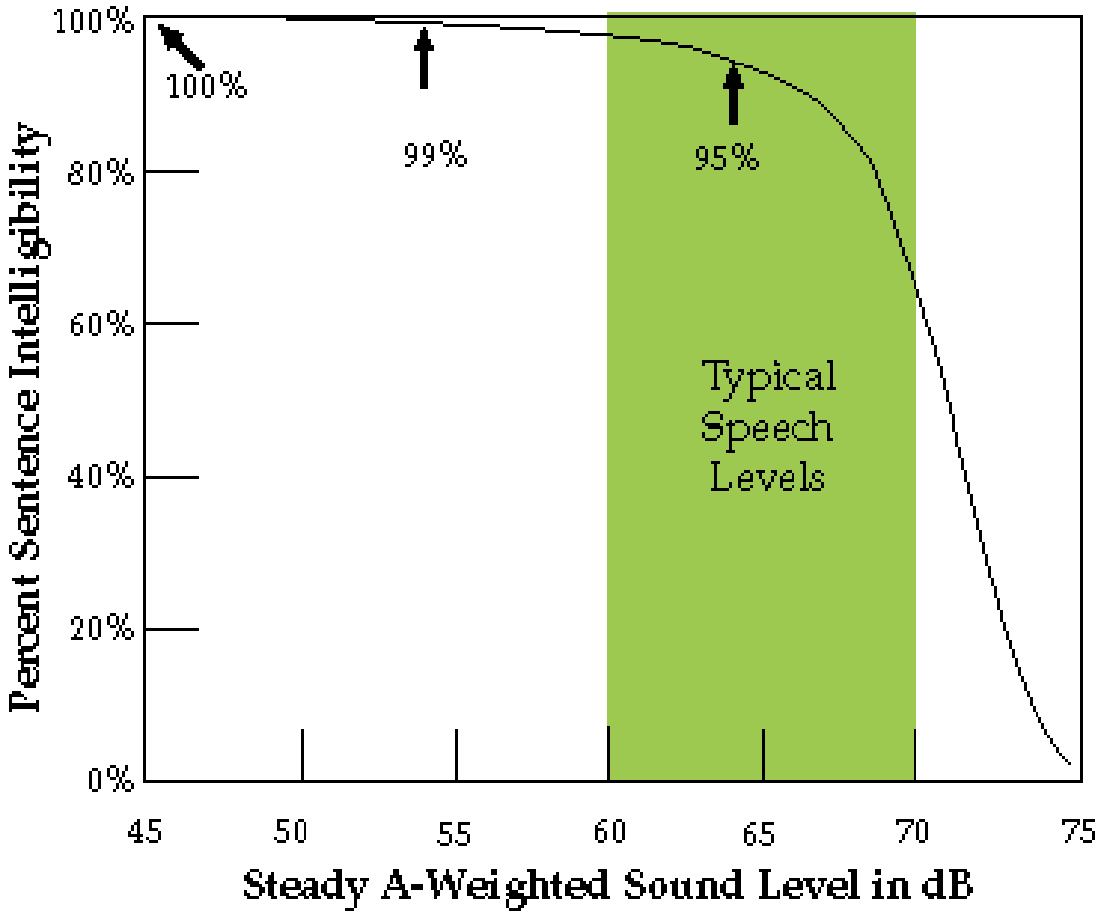
Graphic: ESA

Speech Interference Relationships



Source: Federal Interagency Committee On Noise (FICON)
Federal Agency Review Of Selected Airport Noise Analysis Issues
August 1992 and the U.S. Environmental Protection Agency

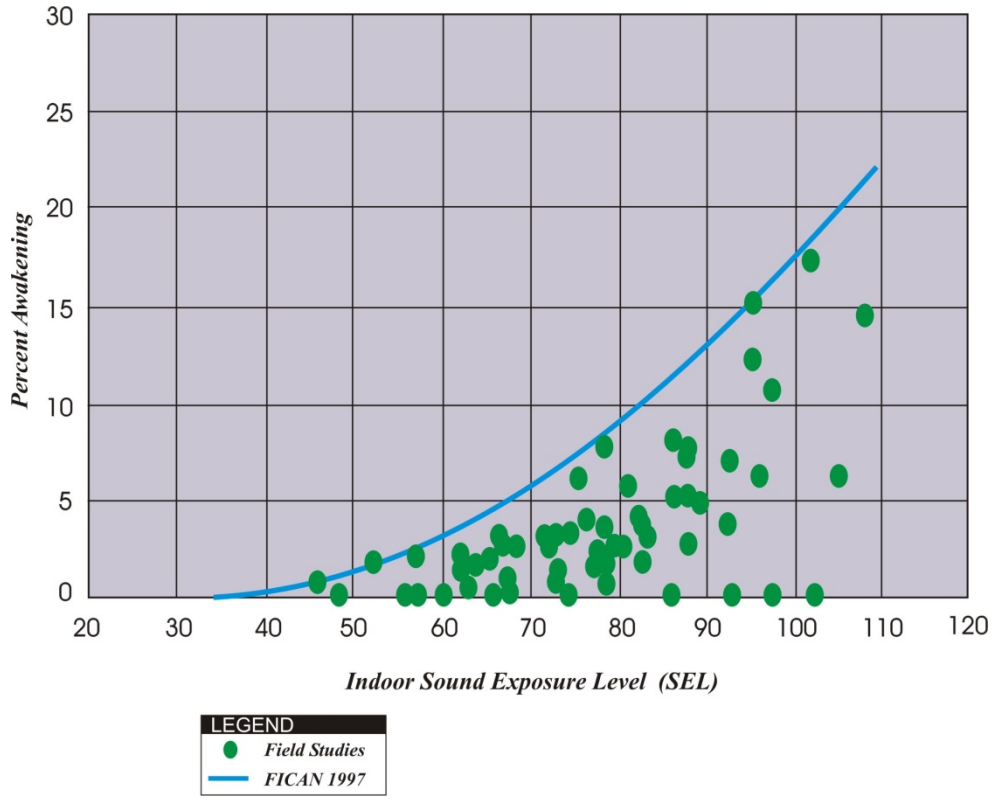
Percent Sentence Intelligibility



Source: U.S. EPA

Principles of Aviation Noise

FICAN Sleep Disturbance Dose-Response Relationship



Source: Federal Interagency Committee On Aviation Noise (FICAN)
Effects Of Aviation Noise On Awakenings From Sleep
June 1997

Cumulative Metrics

- Equivalent Noise Level (LEQ)
  - "Energy" average noise level during the time period of a sample
  - Based on the observation that the 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

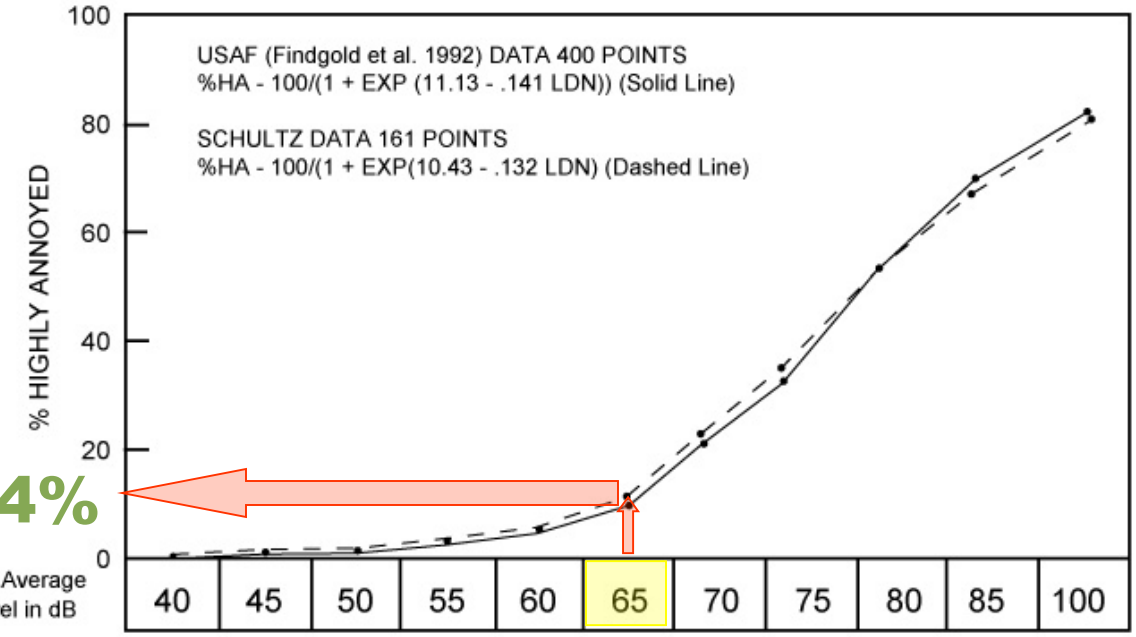
Cumulative Metrics

- Day-Night Average Sound Level (DNL)
  - 24-hour time weighted energy average noise level based on dBA
  - Noise events occurring between 10 pm to 7 am are penalized by 10 dB
  - Penalty was selected to account for the higher sensitivity to noise in the nighttime
  - Penalty also accounts for the expected further decrease in background 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

Principles of Aviation Noise

Cumulative Metrics

Comparison of Schultz Data (1978) and USAF Data (1992) on Annoyance

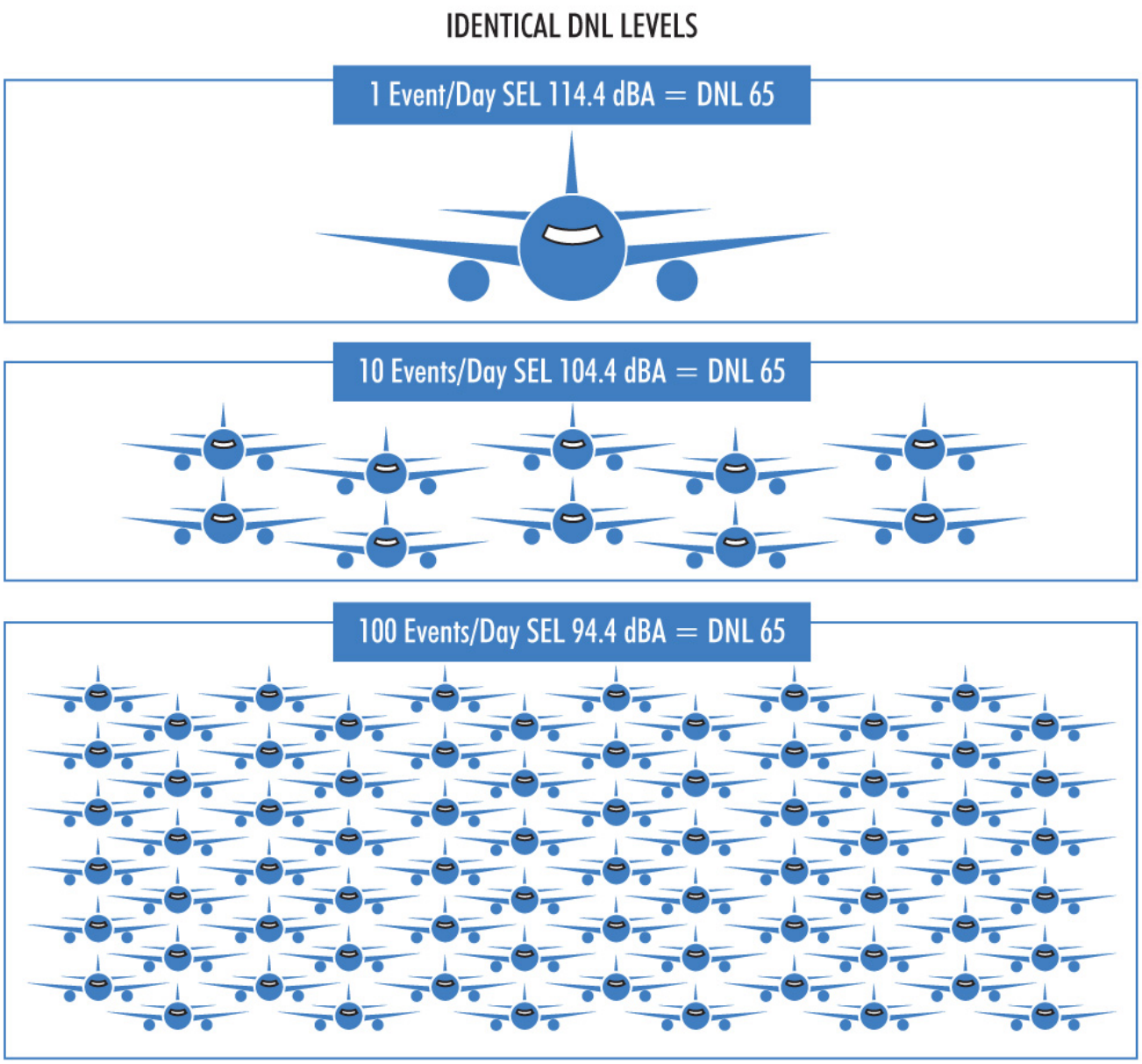


Calculated %HA Points	40	45	50	55	60	65	70	75	80	85	100
USAF	0.41	0.831	1.66	3.31	6.48	12.29	22.1	36.47	53.74	70.16	82.64
SCHULTZ	0.576	1.11	2.12	4.03	7.52	13.59	23.32	37.05	53.25	68.78	81

Source: (USAF, 1992)

FAA's Guideline

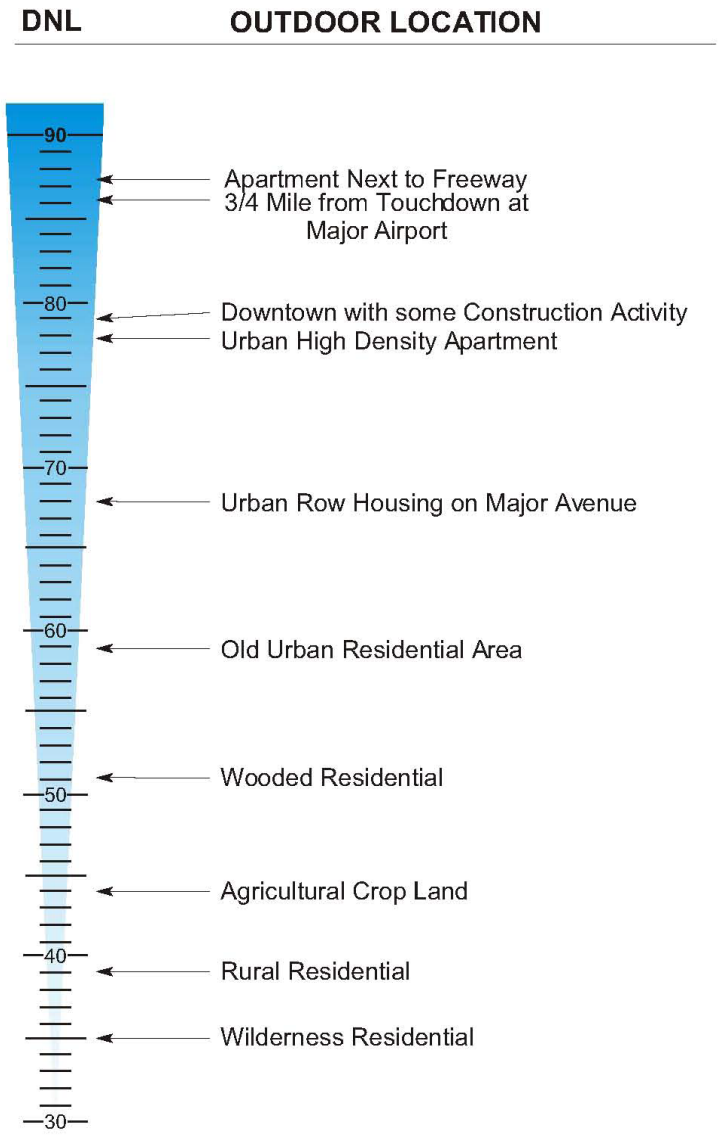
Principles of Aviation Noise



Graphic: ESA

Principles of Aviation Noise

Outdoor Environs



Source: U.S. EPA

Supplemental Metrics

- Supplemental metrics may be used to evaluate activity interference, but there are no federal standards for their use

Supplemental Metrics

- Time Above (TA)
  - Developed by FAA to serve as a second metric for assessing impacts of aircraft noise around airports
  - TA refers to the total time, in seconds or minutes, that aircraft noise exceeds certain dBA noise levels in a 24 hour period
  - Typically expressed as Time Above 75 and 85 dBA
  - Not widely used, but can prove to be useful for airport projects that show a significant increase in noise levels
  - There are no noise/land use standards in terms of the TA index

Supplemental Metrics

- Percent Noise Level (Ln)
  - Method of characterizing noise to account for intermittent or fluctuating noise
  - Ln is the level exceeded n% of the time during the measurement period
  - Typically measured using dBA
  - L90 is the noise level exceeded 90 percent of the time and represents the background noise level
  - L50 is the level exceeded 50 percent of the time and represents the median noise level
  - L10 is the level exceeded 10 percent of the time and represents the peak or intrusive noise level
  - Ln not normally used for transportation noise regulation

Rules of Thumb

- It takes a 3-dB change in the level of a noise source for most people to notice a difference
- A 10-dB increase or decrease 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

- A doubling or halving the airport operations equates to a +/- 3-dB change in DNL
- Using DNL, one nighttime flight is equivalent to 10 flights during the day
- People are more sensitive to changes in exposure than the absolute level

Principles of Aviation Noise - Review

- Acoustic principles
- Propagation of sound
- Noise metrics
- Rules of thumb

Principles of Aviation Noise

Questions?

City of SeaTac
Port of Seattle

Noise 101 Symposium

Quantifying Aviation Noise

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Quantifying Aviation Noise Exposure

- Aircraft noise can be measured and modeled
- Measurements and modeling can describe historical noise levels, but only modeling can predict *future* noise levels
- Measured and modeled noise levels can be compared
- Federal regulations require the use of noise models, not measurements, to quantify aircraft noise exposure
- California regulations require the use of noise measurements to validate the aircraft noise impact boundary

Quantifying Aviation Noise Exposure

- Aircraft noise exposure can be quantified using:
  - Measurements
  - Modeling

Quantifying Aviation Noise Exposure

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

Quantifying Aviation 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 in aircraft noise exposure
  - Modeling can be used to prepare “What If?” scenarios

Noise Measurement Standards

- Noise monitoring equipment and the field measurements must be made in accordance with all applicable standards
  - Federal
  - State
  - Local

Noise Measurement Standards

- 14 CFR FAR Part 150 establishes the noise measurement methods and metrics for conducting aircraft noise measurements

- Local municipalities often specify noise measurement standards in noise ordinances or general plans

Noise Measurement Equipment

- Permanent noise monitors cover a limited area, but provide long-term noise measurement data for analyzing trends
  - Operation is automated requiring very little staff labor
- Portable noise monitors can be moved from location to location for short periods of time and may be returned to the same location to analyze trends
  - Very labor intensive for noise office staff

Noise Measurement Equipment

- Measured noise events can be correlated with aircraft flight track and identification data in an airport's airport Noise and Operations Management System (NOMS)
  - Both portable and permanent noise measurement sites can be entered into an airport's NOMS
  - Noise levels can be tracked over time and can be analyzed by:
    - aircraft type, type of operation, time of day, and noise measurement site

Noise Measurement Equipment

Portable Noise Monitor

Permanent Noise Monitor

Aircraft Noise Modeling Concepts

- Mathematical models are used everyday to depict a variety of real-life situations such as:
  - Bridge loading, aerodynamic performance, fuel economy, and computer animation
- Model accuracy is a function of the modeling algorithms, the empirical databases, and user sophistication
- When used properly, aircraft noise models have proven to be highly accurate

Aircraft Noise Modeling Tools

- Commonly used aircraft noise modeling tools:
  - FAA's Aviation Environmental Design Tool (AEDT)
  - FAA's Integrated Noise Model (INM) (Superseded by AEDT)
  - FAA's Noise Integrated Routing System (NIRS) (Superseded by AEDT)
  - US Air Force's NOISEMAP
  - US Air Force's BOOMAP
- Modeling tools quantify aircraft noise exposure in the vicinity of airports as well as at more distant locations

Aircraft Noise Modeling Tools

- The AEDT is the FAA approved model for use in preparing:
  - Noise elements of airport master plans
  - Noise exposure maps for 14 CFR Part 150 and 14 CFR Part 161 studies
  - Noise elements of federal environmental assessments and environmental impact statements
  - Noise contours for state environmental impact reports

Aircraft Noise Modeling Tools

- NIRS was formerly approved for use in assessing changes in aircraft noise exposure resulting from changes in air traffic procedures over large geographic areas. NIRS has been superseded by AEDT
- NOISEMAP is approved for noise studies involving predominately military aircraft operations
- BOOMAP is for use in modeling sonic booms in military special use areas

Integrated Noise Model (INM)

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

Integrated Noise Model (INM)

- INM had been in use for over 35 years and was continually updated to improve its accuracy
- INM contained 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 for the same time period showing a close correlation

Aviation Environmental Design Tool (AEDT)

- INM was replaced by the AEDT at the end of May 2015
- AEDT combines the capabilities of the Emissions Dispersion Modeling System (EDMS) and INM in a single model
- AEDT allows for assessing the trade offs between air emissions and noise impacts
- AEDT is the FAA-approved tool for aircraft noise modeling

AEDT

- AEDT 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

AEDT Process: Input

- AEDT uses the following inputs:
  - Annual average temperature
  - Airport elevation
  - Airport layout
    - runways, landing areas, run-up locations
  - Surrounding terrain

AEDT Process: Input

- AEDT uses the following inputs:
  - Number of annual-average day operations
    - by aircraft type and time of day
  - Runway use
    - by aircraft type and time of day
  - Approach, departure, and training flight paths
  - Flight path usage
    - by aircraft type and time of day

AEDT Process: Computation

- Each aircraft type "flies":
  - off the runways as they are used
  - departure profiles based on aircraft weight, annual average temperature, and airport altitude
  - the flight tracks as they are used during the year
  - approach profiles as they are flown

AEDT Process: Computation

- AEDT 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”

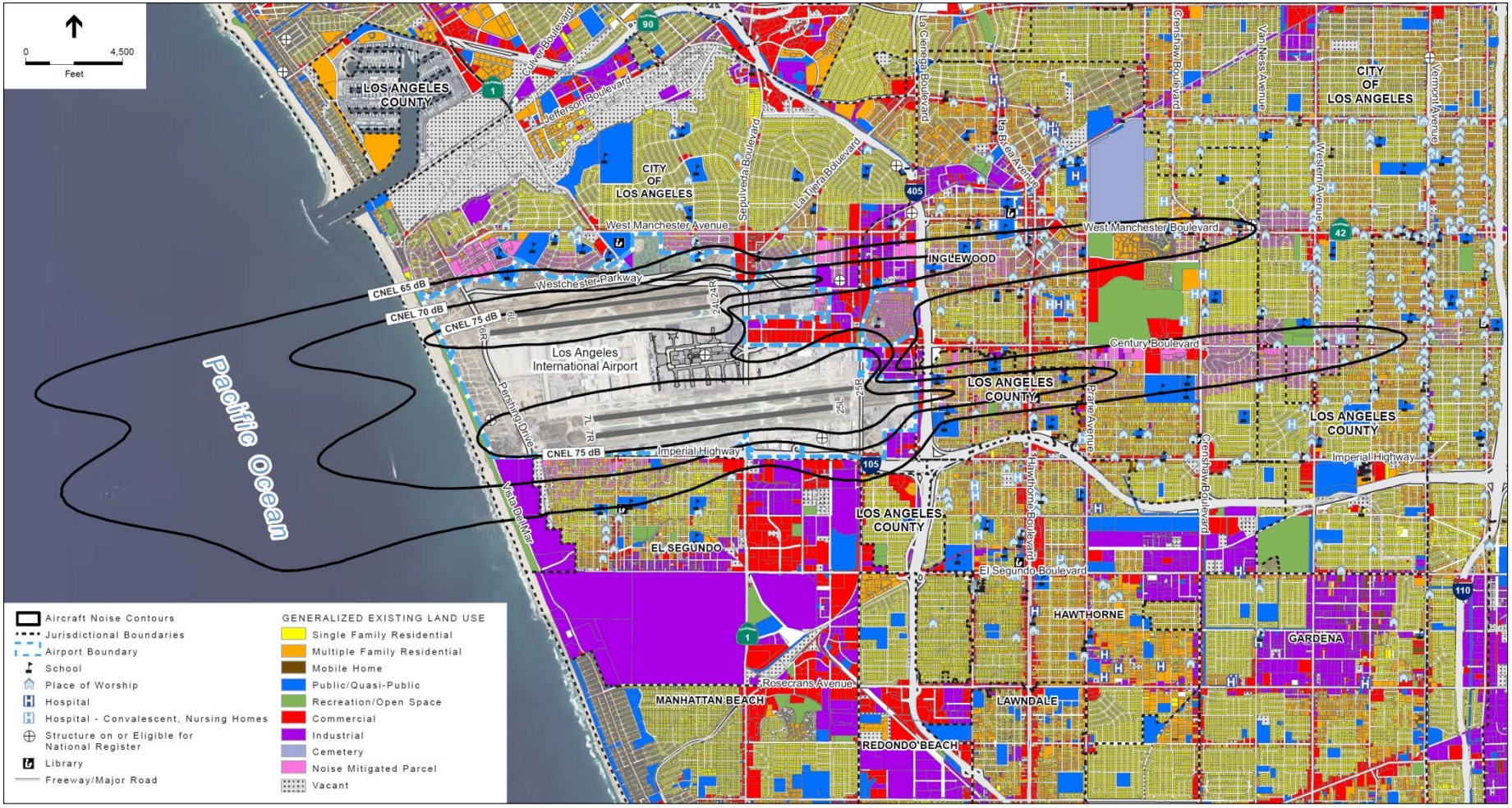
AEDT Process: Output

- Depictions of aircraft noise exposure
  - DNL or CNEL contours
  - SEL or Lmax contours
  - DNL values over a grid
- Noise levels at specific points such as a:
  - home
  - noise monitor
  - school
  - church

Aircraft Noise Model Application

- Aircraft noise modeling tools have many analytical uses:
  - Depicting annual aircraft noise exposure
  - Depicting single-event noise exposure
  - Predicting future aircraft noise exposure
  - Assessing changes in noise impacts resulting from runway configuration changes or new runways
  - Assessing changes in fleet mix and/or number of operations
  - Evaluating operational procedures

Noise Model Output: CNEL Contours



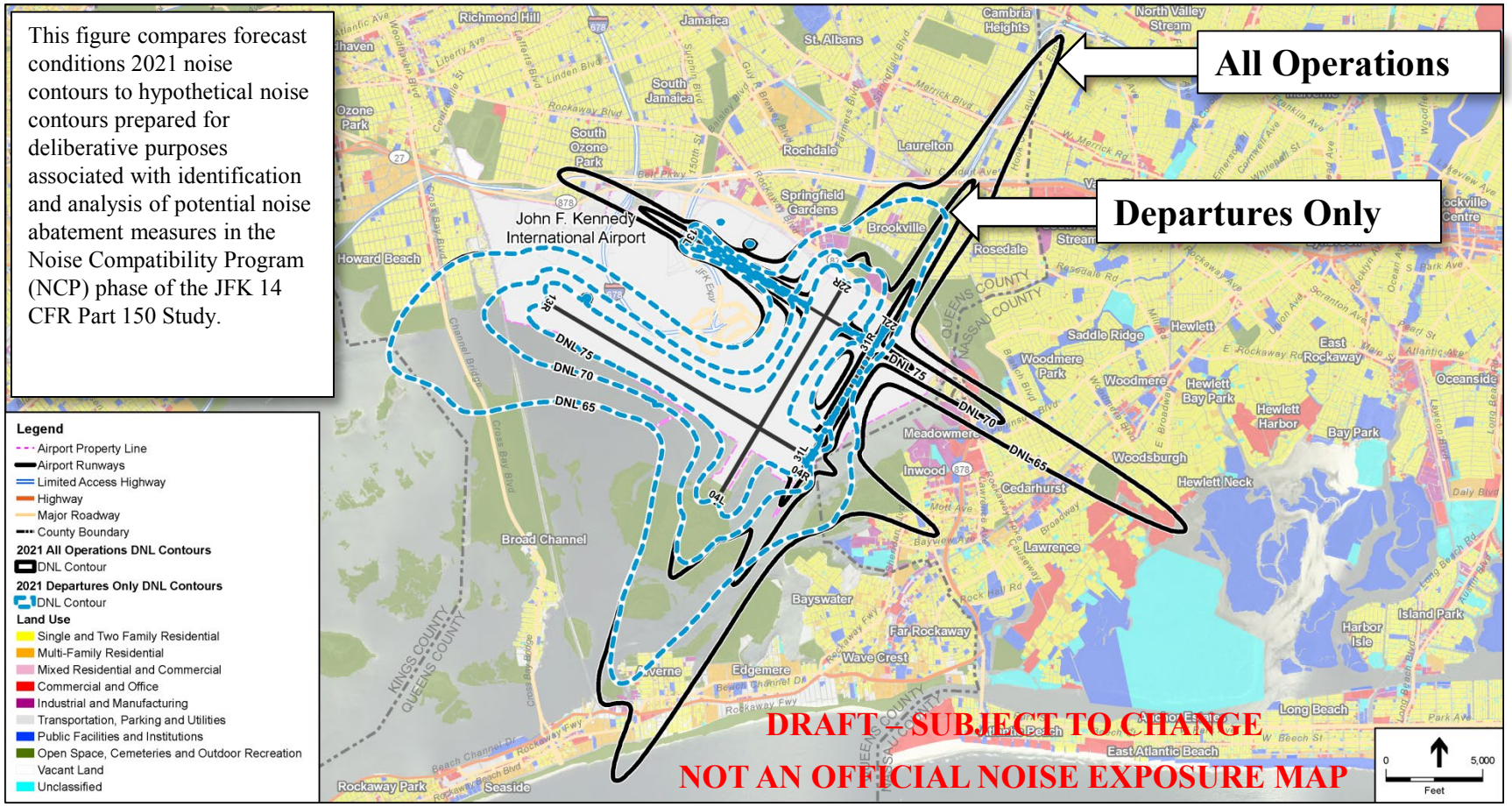
SOURCES: LAWA, 2014; ESA Airports, 2014; ESRI ArcGIS Online, 2011; ESRI World Imagery - Aerial; PCR Services Corporation, 2012
NOTES: CNEL = Community Noise Equivalent Level; dB = Decibel.

Los Angeles International Airport 14 CFR Part 150 Study . 130072.03
Exhibit 5-1
2015 Noise Exposure Map – Los Angeles International Airport

Quantifying Aviation Noise

Noise Contributions: 2021 Departures Only (Excluding Arrivals)

This figure compares forecast conditions 2021 noise contours to hypothetical noise contours prepared for deliberative purposes associated with identification and analysis of potential noise abatement measures in the Noise Compatibility Program (NCP) phase of the JFK 14 CFR Part 150 Study.



SOURCE: New York City Department of City Planning, MapPLUTO 15V1-Tax lot/land use geographic information database, March 2015-June 2015 (adapted by ESA); Nassau County Department of Public Works Planning Division; Property classification and geographic information database, September 2015; ESRI Mapping Services; Environmental Science Associates, 2016; Planning Technology, Inc. 2016.

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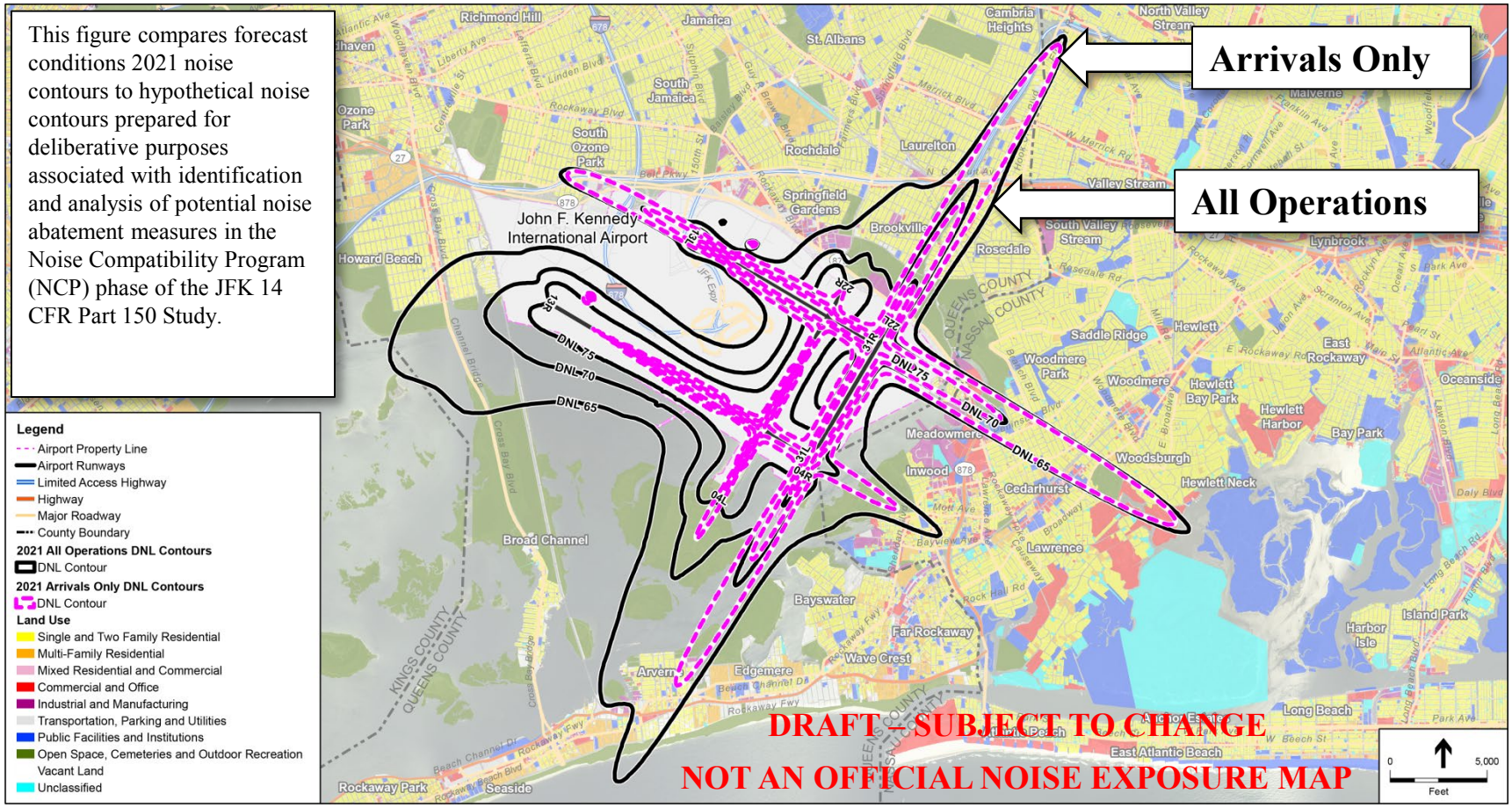

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Comparison of Common Aircraft Types at JFK

EMB-190

CRJ9-ER

A320

737-800

MD-88

757-200

787-8

767-400

A380-800

777-300ER

A340-600

747-8

Quantifying Aviation Noise

A Diverse Airline Aircraft Fleet at JFK

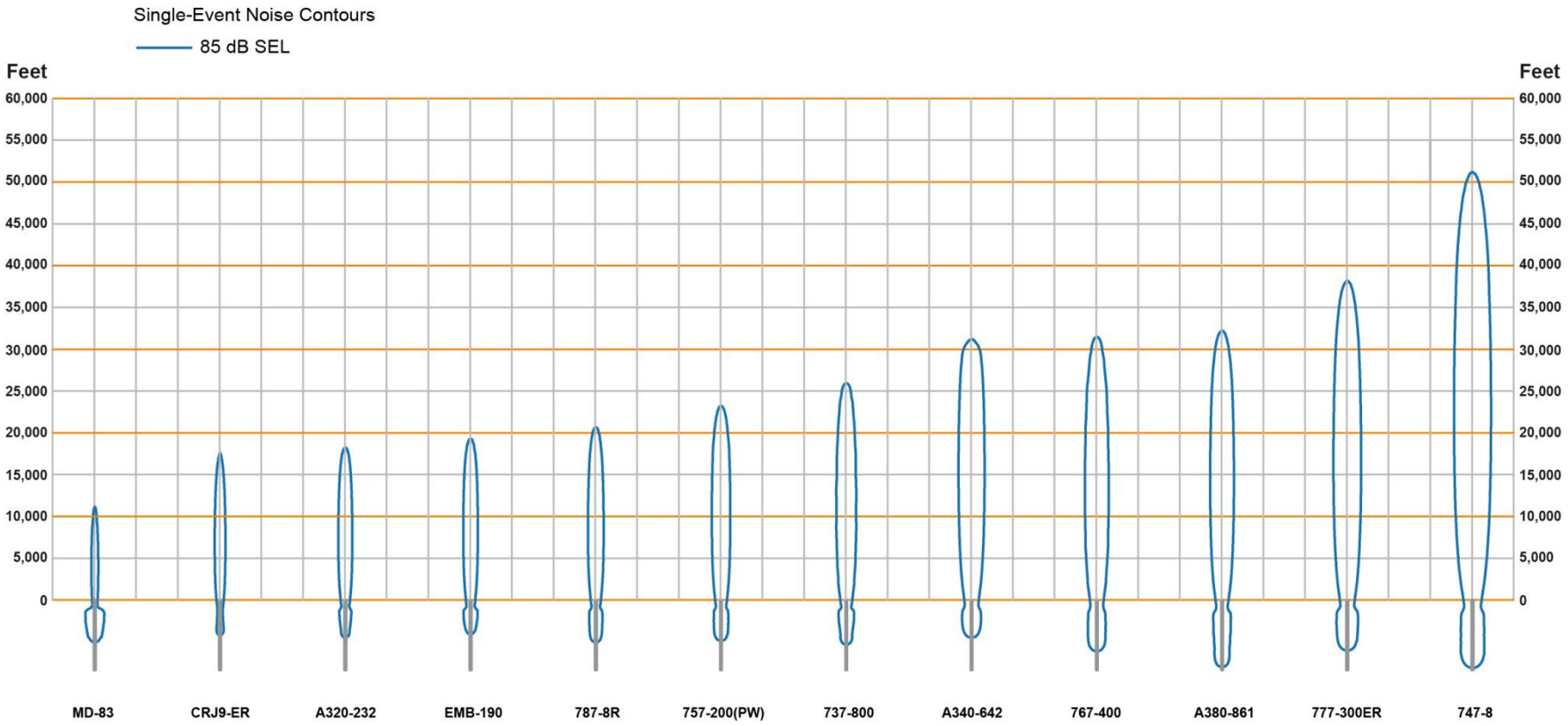
A380-800

EMB-190

	A-380	EMB-190
Seats (two-classes)	644	94
Length	239’	119’
Wingspan	262’	94’
MTOW	1,268,000 lbs	105,000 lbs
MLW	869,000 lbs	95,000 lbs
Range	8,200 nmi	1,850 nmi
Source: Airbus and Embraer		

Quantifying Aviation Noise

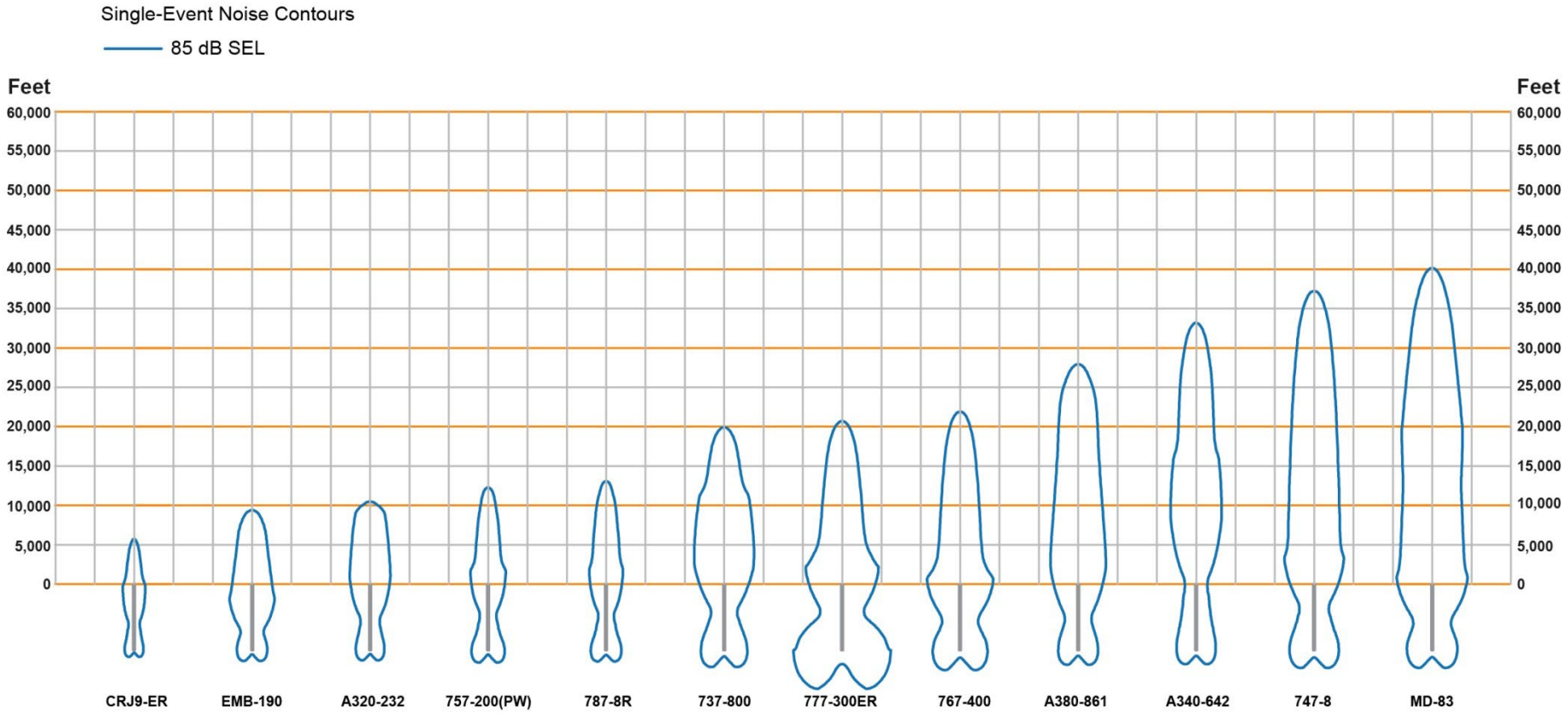
JFK Arrival Sound Exposure Level (SEL) Contour Comparison



Source: INM 7.0d

Quantifying Aviation Noise

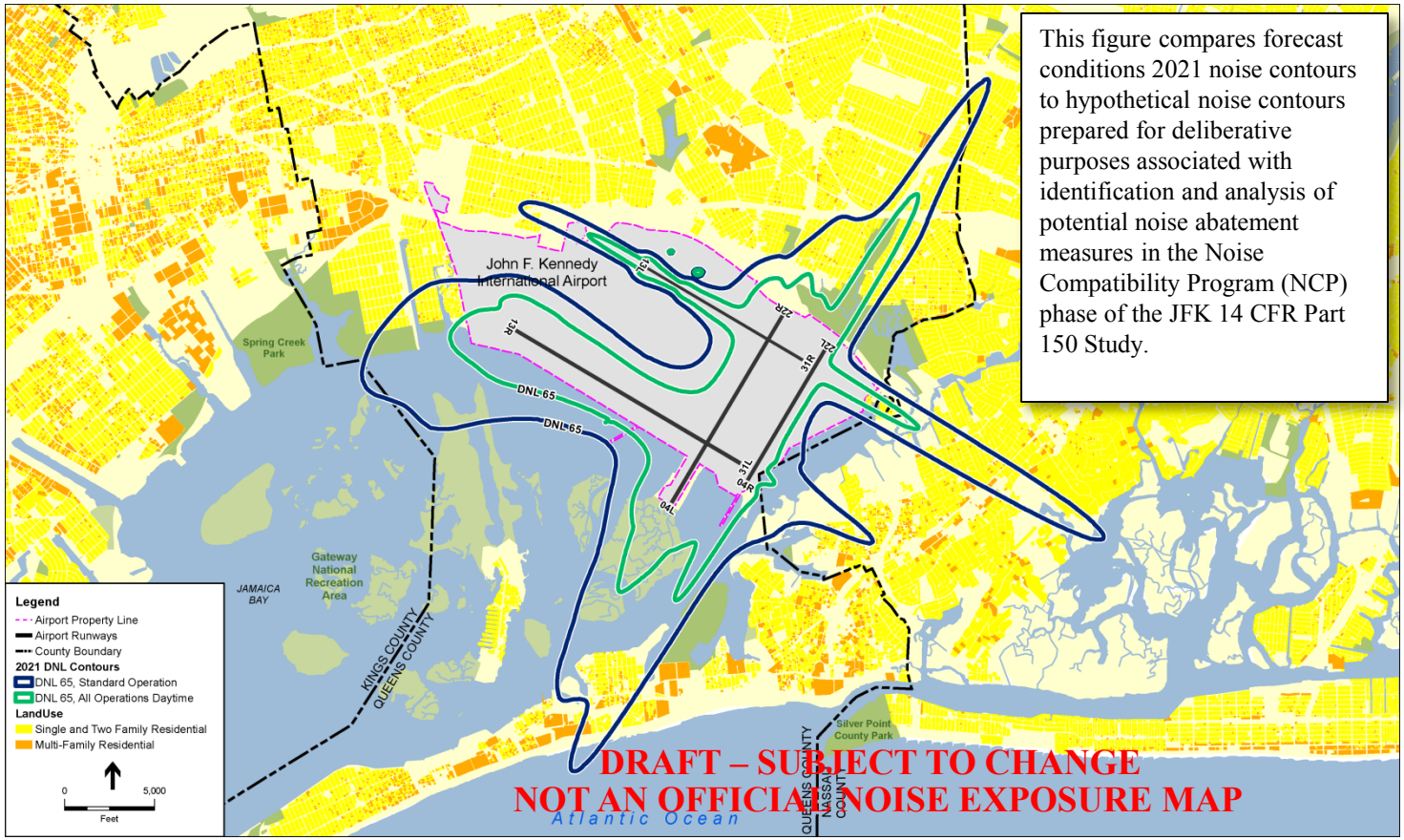
JFK Departure Sound Exposure Level (SEL) Contour Comparison



Source: INM 7.0d

Quantifying Aviation Noise

What if all JFK nighttime flights occurred in the daytime?

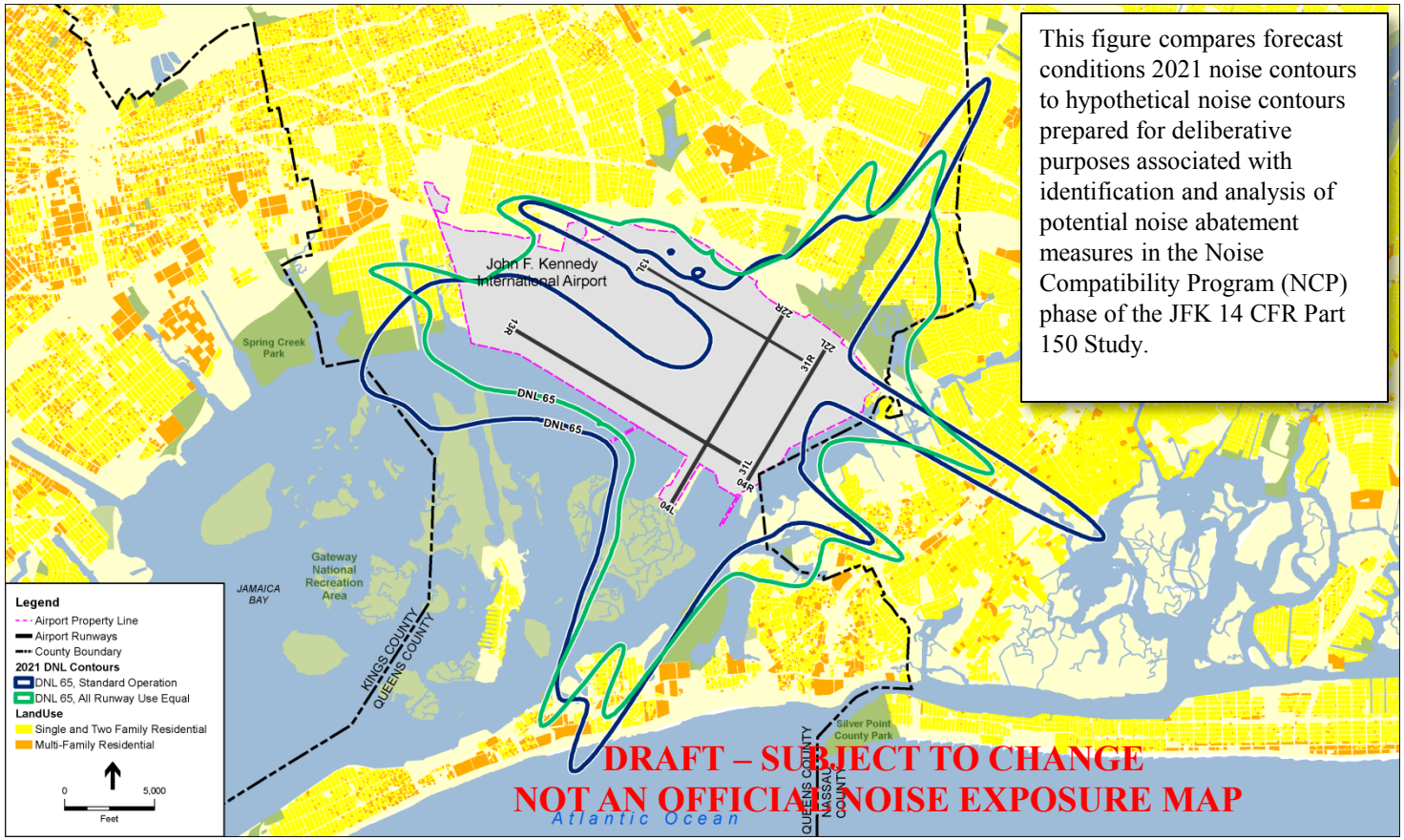


This figure compares forecast conditions 2021 noise contours to hypothetical noise contours prepared for deliberative purposes associated with identification and analysis of potential noise abatement measures in the Noise Compatibility Program (NCP) phase of the JFK 14 CFR Part 150 Study.

SOURCE: New York City Department of City Planning, MapPLUTO 15V1-Tax lot/land use geographic information database, March 2015-June 2015 (adapted by ESA); Nassau County Department of Public Works Planning Division; Property classification and geographic information database, September 2015; ESRI Mapping Services; Environmental Science Associates, 2016.

Quantifying Aviation Noise

What if each runway end is used equally?



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Aircraft Noise Model Application

- FAA Orders 1050.1F and 5050.4B require the use of noise models for the quantification of aircraft noise impacts in environmental assessments (EAs) and environmental impact statements (EISs)

- Noise measurements may be made for 14 CFR Part 150 studies, EAs, and EISs to provide supplemental information, but they may not be used to “calibrate” the noise models

Comparing Measured and Modeled Levels

- Measured single event levels (Lmax and SEL) can be compared to the single event levels predicted by the model
  - Measurements should be observed or correlated with radar data and of sufficient quantity
- Measured cumulative noise levels (DNL or CNEL) can be compared to modeled cumulative levels
  - Ideally, compare one year of aircraft noise measurement data to the same year modeled

Comparing Measured and Modeled Levels

- Modeled annual-average day DNL contours will not always match short-term measured values due to variables such as:
  - Runway use
  - Fleet mix
  - Wind and weather conditions
  - Pilot/controller techniques
  - Ambient community noise levels

Quantifying Aviation Noise Exposure

- Aircraft noise can be measured and modeled
- Measurements and modeling can describe historical noise levels, but only modeling can predict *future* noise levels
- Measured and modeled noise levels can be compared
- Federal regulations require the use of noise models, not measurements, to quantify aircraft noise exposure

Quantifying Aviation Noise

Questions?

City of SeaTac/Port of Seattle

Noise 101 Symposium

Regulating Aviation Noise

Presented by:

Steve Alverson, ESA

January 12, 2019

ESA

ESA is where solutions and service meet.

Presentation Outline

- Introduction
- Airport Noise – Roles and Responsibilities
- Regulatory Framework
- Federal Aviation Noise Regulations
- Recent Aviation Noise-Related Legislation
- Summary

Introduction

- Aircraft/Airport noise regulations and policies are not static
- Careful balance between federal and local authority
- FAA sets many rules and controls funding
- Local governments have an important role to play through the regulation of land use

Roles and Responsibilities

- Roles and Responsibilities – Airport Noise Control*
  - Federal Aviation Administration
  - Airport Proprietor
  - Local Governments
  - Aircraft Operators
  - Others

*DOT/FAA Aviation Noise Abatement Policy, November 18, 1976

Roles and Responsibilities

Federal Aviation Administration

- 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

Federal Aviation Administration

- Exclusive authority to certify aircraft and pilots
- Exclusive authority to control aircraft in the air and on runways/taxiways*

*Control of aircraft in flight is shared with the pilot-in-command

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
  - Land acquisition
  - Restrictions on airport use (reasonable, nonarbitrary and not unjustly discriminatory restrictions)*

*Subject to ANCA and potentially 14 CFR Part 161, which may limit the airport proprietor's ability to restrict aircraft operations.

Roles and Responsibilities

Local Governments

- Can
  - Promote compatible land use through zoning
  - Prohibit incompatible land uses
  - Require real estate disclosure
  - Include current noise data in municipal code
- Cannot
  - Directly restrict aircraft operations or regulate “routes, rates or service” of air carriers
  - Tax airport passengers

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

Others

- Pilot in command has sole responsibility for the safe operation of his or her aircraft
- Aviation system users pay for the entire aviation system including the adverse impacts of noise
- Users finance 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 run-up enclosures

Roles and Responsibilities

Others

- Prospective residents should become informed about aircraft noise impacts and should act accordingly

Regulatory Framework

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

- State laws establish compatibility planning guidelines and noise standards, but aircraft in flight are exempt

Regulatory Framework

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

FEDERAL LAW PREEMPTS STATE AND LOCAL REGULATIONS

Federal Aviation Noise Regulations

- 14 CFR Part 36 and 14 CFR Part 91
- U.S. Department of Transportation Aviation Noise Abatement Policy
- Aviation Safety and Noise Abatement Act of 1979
- 14 CFR Part 150
- Airport Noise and Capacity Act of 1990 and 14 CFR Part 161
- FAA Orders 5050.4B and 1050.1F
- FAA Order 5100.38D and FAR Part 158
- Advisory Circular 150/5020-1

14 CFR Part 36 – Noise Standards: Aircraft Type and Airworthiness Certification

- Adopted in 1969 in response to the Federal Aviation Act enacted by Congress in 1968
- Prescribes noise standards for issuance of new aircraft type certifications
- Amended in 1973 in response to the Noise Control Act of 1972
- Amended again in 1977 and 2003
- In November 2017, FAA issued Stage 5 regulations mirroring the ICAO Chapter 14 Standards with two effective dates for small (2020) and large aircraft (2017)
  - The dividing line between large and small is 121,254 pounds

14 CFR Part 36 – Noise Standards: Aircraft Type and Airworthiness Certification

- Aircraft may be certified as Stage 1, Stage 2, Stage 3, Stage 4 or Stage 5 based on their noise level, weight, number of engines, and in some cases – number of passengers
- Stage 1 and Stage 2 are no longer permitted to operate in the United States
- FAA has indicated it does not intend to propose a phase out of Stage 3 aircraft in the foreseeable future

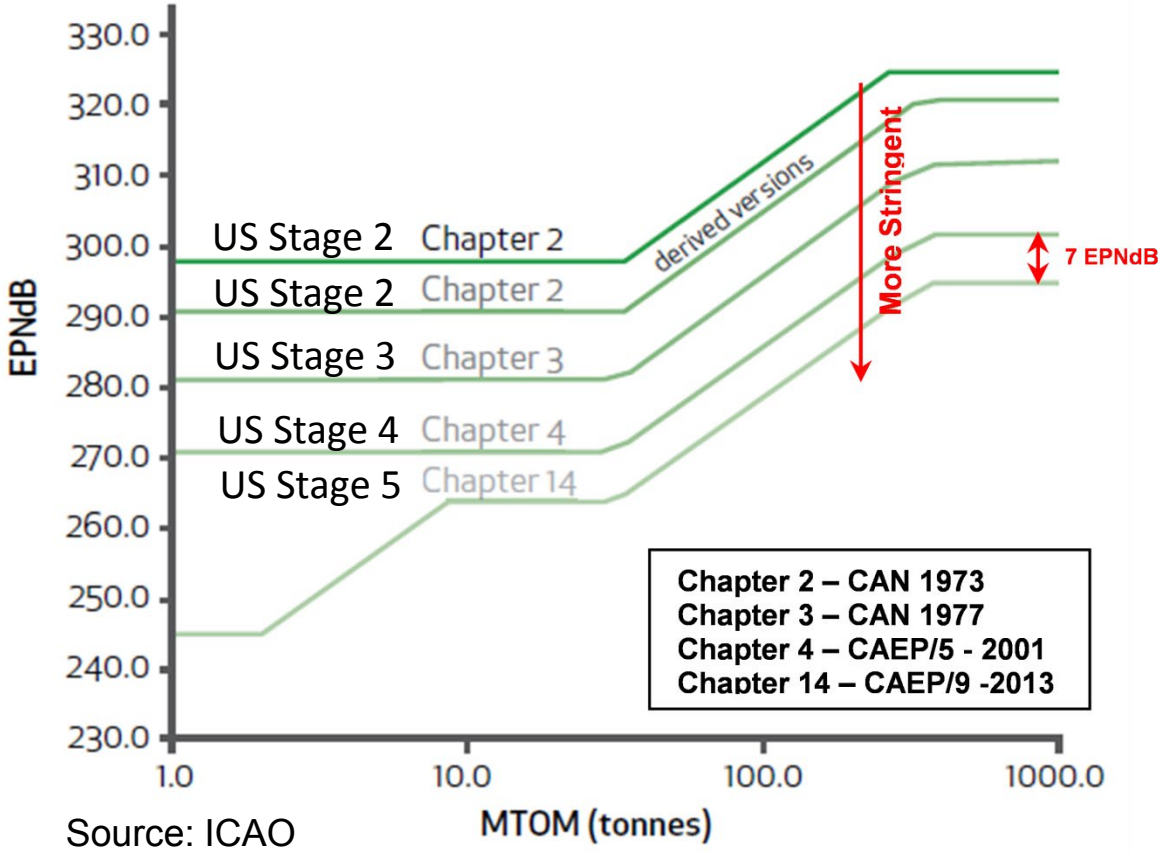
Regulating Aviation Noise

International Civil Aviation Organization (ICAO)

- Committee on Aviation Environmental Protection (CAEP) promoted more stringent noise certification standards
- CAEP agreed on and forwarded to the full ICAO assembly new Chapter 14 noise levels
- The new levels went into effect for newly manufactured large aircraft on January 1, 2018
- The new standard is 7 EPNdB below the Stage 4 standard

Regulating Aviation Noise

International Civil Aviation Organization (ICAO)



Source: ICAO

14 CFR Part 91 – General Operating and Flight Rules

- Addresses the operation of aircraft in flight
- Establishes airspace classifications
- Establishes operating conditions (IFR, VFR, etc.)
- Addresses the operation of supersonic aircraft within the United States
- Amended in 1990 to address the phase-out of large Stage 2 aircraft

U.S. Department of Transportation Aviation Noise Abatement Policy (1976)

- Set forth noise abatement authorities and responsibilities of the federal government, airport proprietors, state and local governments, air carriers, air travelers and shippers, and airport area residents and prospective residents
- FAA's primary role is regulating noise at its source (the aircraft), plus supporting local efforts to develop noise abatement plans
- Role of state and local governments, along with airport proprietors, to undertake land use and operational actions to promote compatibility

Aviation Safety and Noise Abatement Act of 1979

- Further strengthened FAA's supporting role in noise compatibility planning
- Stated purpose "To provide assistance to airport operators to prepare and carry out noise compatibility programs."
- Established funding for noise compatibility planning
- Sets requirements by which airport operators can apply for funding
- Does not require any airport to develop a noise compatibility program

14 CFR Part 150 – Airport Noise Compatibility Planning

- Adopted FAA regulations for implementing the Aviation Safety and Noise Abatement Act of 1979
- Published noise and land use compatibility charts to be used for land use planning with respect to aircraft noise
- Residential land use deemed acceptable for noise exposure up to 65 dB DNL
- Allows airport sponsors to access federal funds for noise mitigation programs

Airport Noise and Capacity Act of 1990 (ANCA)

- Established a method to review aircraft noise, airport use, or access restrictions imposed by airport proprietors
- Instituted a program to phase-out Stage 2 aircraft over 75,000 lbs. by December 31, 1999
- No phase-out of Stage 2 aircraft under 75,000 lbs.
  - The FAA Modernization and Reform Act of 2012 instituted a phase-out of Stage 1 and Stage 2 aircraft under 75,000 lbs. by January 1, 2017

Airport Noise and Capacity Act of 1990 (ANCA)

- Applies to all local noise restrictions that were proposed after October 1990
- Grandfathered all aircraft noise and access restrictions that existed prior to November 1990
- Established a process for proposed aircraft noise and access restrictions (14 CFR Part 161)

14 CFR Part 161 – Notice and Approval of Airport Noise and Access Restrictions

- Defines the requirements for enacting noise and access restrictions on Stage 2 and Stage 3 aircraft greater than 75,000 lbs.
- Severely limits an airport proprietor's ability to enact restrictions on aircraft operations
- Encourages voluntary agreements to control aircraft noise
- Airport proprietor imposed restrictions must be considered a last resort when all other efforts have failed to eliminate the incompatible land uses

14 CFR Part 161 – Notice and Approval of Airport Noise and Access Restrictions

- Identifies three types of restrictions
  - Negotiated restrictions
  - Stage 2 aircraft restrictions
  - Stage 3 aircraft restrictions
- Each type of restriction is treated differently
- Even though the ANCA phase-out did not apply to aircraft under 75,000 lbs., the FAA has determined that 14 CFR Part 161 applies to smaller aircraft with regard to proprietors' restrictions authority

FAA Orders 5050.4B and 1050.1F

- Guidelines developed by the FAA pertaining to environmental analysis under the National Environmental Policy Act (NEPA)
- FAA Order 1050.1F provides overall NEPA guidance for all FAA divisions
- FAA Order 5050.4B provides guidance to the Airports Division of the FAA which oversees the review of airport development projects
- The FAA's 1050.1F Desk Reference provides additional information regarding compliance with NEPA and special purpose laws

FAA Orders 5050.4B and 1050.1F

- FAA considers only those noise impacts that occur at 65 dB DNL/CNEL or greater
- Increases in noise levels for noise sensitive areas over 1.5 dB DNL/CNEL, within the 65 dB DNL/CNEL contour, are considered “significant”
- If an action causes a significant impact over noise sensitive areas, additional analysis should be conducted between 60 dB DNL/CNEL and 65 dB DNL/CNEL to determine if an increase of 3 dB DNL/CNEL occurs
- A 3-dB increase is not considered “significant”, but must be disclosed for informational purposes

FAA Orders 5050.4B and 1050.1F

- Areas where quiet is an expected characteristic of the setting such as such as national parks, wildlife refuges, and cultural/historical sites may require special consideration below 65 dB DNL
- The FAA official responsible for the project decides which supplemental metrics, if any, should be used in noise impact analysis
- Airport proprietors/communities should work with the FAA to identify those metrics

FAA Order 5100.38D – AIP Handbook

- Provides guidance and requirements for FAA funding of noise-related projects:
  - Noise and land use planning studies, sound insulation, noise barriers, ground run-up enclosures, mitigation measures, noise monitoring systems, land acquisition
- Defines solicitation and selection process
- Identifies performance standards for project funding
- Incorporates the guidance in Program Guidance Letter 12-09

Federal Aviation Administration Program Guidance Letter (PGL) 12-09

- Clarified guidance on sound insulation program funding
- Requires a dwelling unit be within the 65 dB DNL/CNEL contour and have an interior noise level greater than 45 DNL/CNEL
- Eliminated homes assumed to be previously eligible
- This clarification is incorporated into FAA Order 5100.38D

14 CFR Part 158 – Passenger Facility Charges

- Implements the provisions of ANCA related to the creation of a passenger facility charge (PFC)
- Reducing noise or mitigating noise is eligible for PFC funding at a level of $1, $2, or $3 per Section 158.15 of FAR Part 158
- An application has to be approved for the amount of the PFC, but unlike AIP grants, airport proprietors may use PFC funds for noise mitigation without an FAA-approved 14 CFR Part 150 Noise Compatibility Program, as long as the airport's noise exposure maps have been prepared under the procedures specified in 14 CFR Part 150

Regulating Aviation Noise

Advisory Circular 150/5020-1, Noise Control and Compatibility Planning for Airports

- Provides general guidance for noise control and compatibility planning for airports
- Provides specific guidance for preparation of airport noise exposure maps and airport noise compatibility programs in accordance with 14 CFR Part 150
- The FAA is currently in the process of updating the Advisory Circular which was issued in 1983

Advisory Circular 150/5020-1, Noise Control and Compatibility Planning for Airports

- The premise of the update is to catch up with the current state of the regulations and to provide a "How to Prepare a Part 150 Study" manual
- Aviation industry groups have provided input to the FAA supported by consultants and airports that have gone through the FAR Part 150 process
- Look for this revised Advisory Circular in the future

Airport Cooperative Research Program (ACRP)

- Funded by the FAA and administered by the National Academy of Sciences
- Research on a variety of aviation issues including aircraft noise
  - Improvements in aircraft noise modeling
  - Helicopter noise research
  - Sound insulation programs
  - Public outreach

Recent Aviation Noise-Related Legislation

The FAA Reauthorization Act of 2018, which was signed on October 5, 2018, contains 13 aviation noise-related provisions

- Subtitle D, Airport Noise and Environmental Streamlining, of the Act contains the following noise provisions:

Recent Aviation Noise-Related Legislation

- Section 172. Authorization of certain flights by Stage 2 aircraft.
  - Establishes a pilot program for the operation of Stage 2 aircraft between not more than 4 medium hub or non-hub airports, with specific characteristics.
- Section 173. Alternative airplane noise metric evaluation deadline.
  - Requires that the FAA complete an evaluation of alternative metrics to the current Day Night Average Sound Level (DNL) 65 standard within one year of the date of enactment.

Source: Airports Council International – North America, October 2018

Recent Aviation Noise-Related Legislation

- Section 174. Updating airport noise exposure maps.
  - Builds on the current requirement that a noise exposure map – for those airports that have one – must be updated when there is a change in the surrounding area, such as a significant new noncompatible use, or a change in the operation of the airport would significantly reduce noise over existing noncompatible uses. Additional language has been added clarifying that if one of the listed changes occurs, an updated noise exposure map is only required if the change either comes into effect during the forecast period of the existing noise exposure map, or during the implementation period of the airport operator's noise compatibility program.

Source: Airports Council International – North America, October 2018

Recent Aviation Noise-Related Legislation

- Section 175. Addressing community noise concerns.
  - Requires the FAA to consider the feasibility of implementing dispersal headings for new RNAV departure procedures below 6,000 AGL if: (1) the airport requests it, (2) it would not have safety or efficiency implications, and (3) it would not significantly increase noise over other noise-sensitive areas.
- Section 176. Community involvement in FAA NextGen projects located in metroplexes.
  - Requires the FAA to prepare a review (within 180 days) of FAA's community involvement practices for NextGen projects located in Metroplex. That review is to be followed by a report (within 60 days) containing: (1) recommendations for improving community involvement for NextGen projects in Metroplexes; (2) discussion of how and when the FAA will engage airports and communities in PBN proposals, and (3) lessons learned from NextGen projects.

Source: Airports Council International – North America, October 2018

Recent Aviation Noise-Related Legislation

- Section 179. Airport noise mitigation and safety study.
  - Requires the FAA to conduct a study to review and evaluate existing studies and analyses of the relationship between jet aircraft approach and takeoff speeds and corresponding noise impacts on communities surrounding airports. It would also look at whether reduced approach or takeoff speeds would jeopardize aviation safety and/or: cause the National Airspace System (NAS) to operate less efficiently; impact capacity; and increase fuel burn.
- Section 180. Regional ombudsmen.
  - Requires the FAA to designate a Regional Ombudsman for each region who would serve as a liaison with the public to address “issues regarding aircraft noise, pollution, and safety” and make recommendations to the Regional Administrators to address concerns raised by the public.

Source: Airports Council International – North America, October 2018

Recent Aviation Noise-Related Legislation

- Section 181. FAA leadership on civil supersonic aircraft.
  - Directs the FAA Administrator to exercise leadership in the creation of Federal and international policies, regulations, and standards relating to the certification and safe and efficient operation of civil supersonic aircraft. It directs the FAA to obtain aerospace industry stakeholders input regarding regulatory framework, and issues related to standards and regulations for the type certification and safe operation of civil supersonic aircraft, including noise certification. This provision also directs FAA to exercise international leadership. FAA is required to issue a notice of proposed rulemaking by March 31, 2020, for civil supersonic noise standards.

Source: Airports Council International – North America, October 2018

Recent Aviation Noise-Related Legislation

- Section 186. Stage 3 aircraft study.
  - Directs GAO to undertake a review of the potential benefits, costs, and other impacts that would result from a phase out of covered Stage 3 aircraft. The review must include:
    - Inventory of covered Stage 3 aircraft
    - Benefits, costs, and impacts to a variety of stakeholders, including air carriers, GA operators, airports, communities surrounding airports, and the general public
    - Lessons learned from the phase out of Stage 2 aircraft
    - Costs and logistical challenges associated with recertifying stage 3 aircraft capable of meeting Stage 4 noise levels
    - Stakeholder views on the feasibility and desirability of phasing out covered Stage 3

Source: Airports Council International – North America, October 2018

Recent Aviation Noise-Related Legislation

- Section 187. Aircraft noise exposure.
  - Requires the FAA to conduct a review of the impact of noise exposure on communities around airports. The FAA would be required to submit a report to Congress on their findings within 2 years, including FAA's recommendations for revisions to their land use compatibility guidelines in Part 150 of Title 14 CFR.
- Section 188. Study regarding day-night average sound levels.
  - Directs the FAA to evaluate alternative metrics to the current average day-night level standard. (Note, this is similar to Section 173, except that it adds the requirement of consideration of actual noise sampling and other methods, and an accelerated schedule.)

Source: Airports Council International – North America, October 2018

Recent Aviation Noise-Related Legislation

- Section 189. Study on potential health and economic impacts of overflight noise.
  - Requires the FAA to engage a university to conduct a health study in a number of metropolitan areas (Boston, Chicago, the District of Columbia, New York, the Northern California Metroplex, Phoenix, the Southern California Metroplex, Seattle, or such other area as may be identified by the FAA), focusing on "incremental health impacts on residents living partly or wholly underneath flight paths most frequently used by aircraft flying at an altitude lower than 10,000 feet, including during takeoff or landing"; and "an assessment of the relationship between a perceived increase in aircraft noise, including as a result of a change in flight paths that increases the visibility of aircraft from a certain location, and an actual increase in aircraft noise, particularly in areas with high or variable levels of non-aircraft-related ambient noise."

Source: Airports Council International – North America, October 2018

Recent Aviation Noise-Related Legislation

- Section 190. Environmental mitigation pilot program.
  - Provides for FAA grants of up to $2.5 million to six airports to carry out pilot environmental mitigation programs that would “measurably reduce or mitigate aviation impacts on noise, air quality, or water quality at the airport or within 5 miles of the airport.” The federal share of this project would be up to 50%, and projects must be carried out by a consortium of entities that includes two or more of the following: businesses, educational or research organizations, state or local governments, and/or federal laboratories.

Source: Airports Council International – North America, October 2018

Summary

- Introduction
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- Regulatory Framework
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Regulating Aviation Noise

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Principles of Aircraft Noise Control

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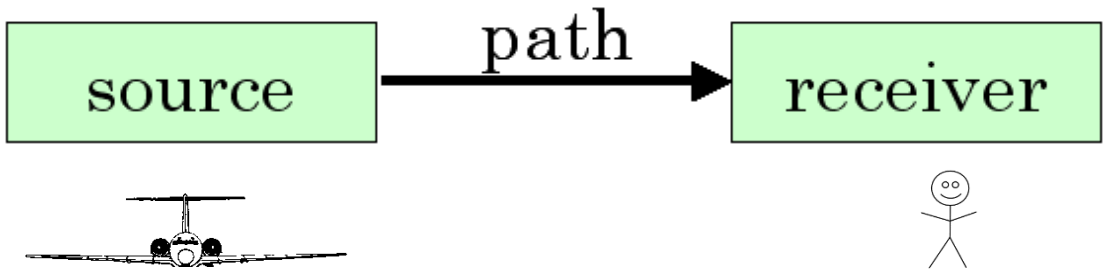
Presentation Outline

- Principles of Aircraft Noise Control
- Noise Abatement Options
  - Airfield Design
  - Operational
  - Restrict Operations
  - Management
- Noise Mitigation Options
  - Preventive
  - Remedial

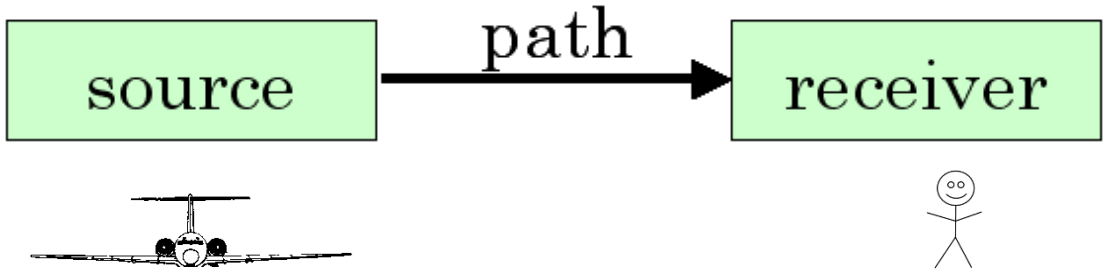
Principles of Aircraft Noise Control

- Source
- Path
- Receiver



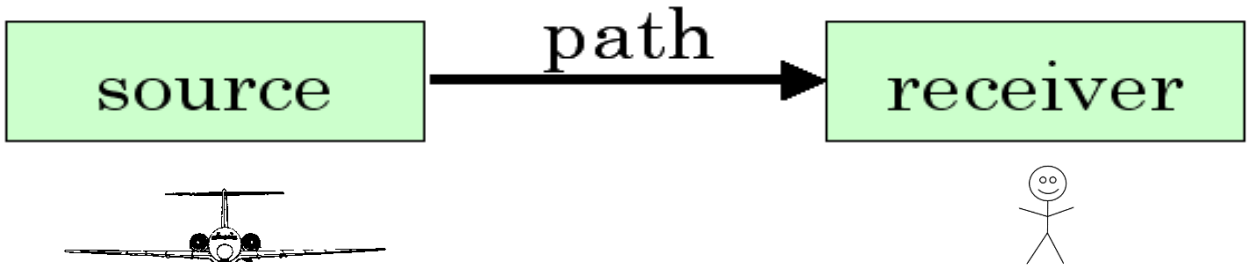
Principles of Aircraft Noise Control

- Reduce the source level
  - FAA is responsible for aircraft noise certification
  - Pilots may use reduced thrust
  - Ground crews can minimize APU use
  - Reduce or eliminate engine run-ups



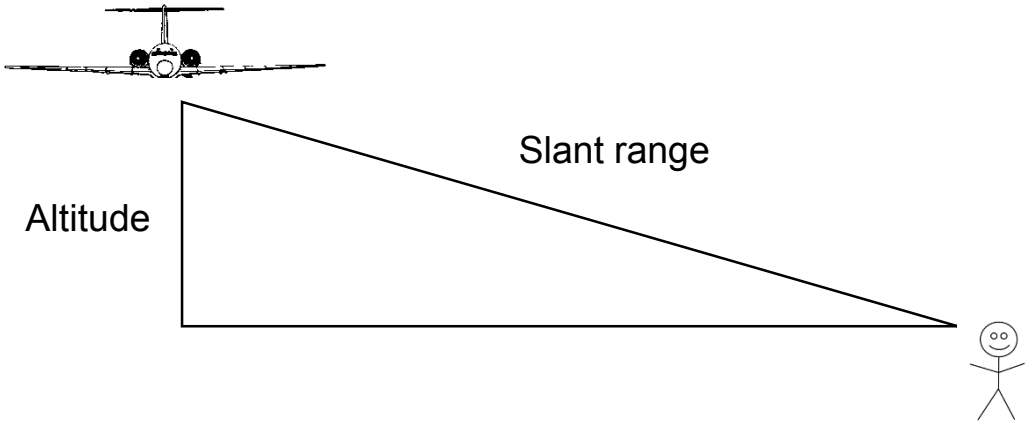
Principles of Aircraft Noise Control

- Move the source or the receiver
  - Relocated runways, relocated taxiway, relocated run-up areas
  - Displaced takeoff or landing thresholds
  - Relocate noise sensitive uses



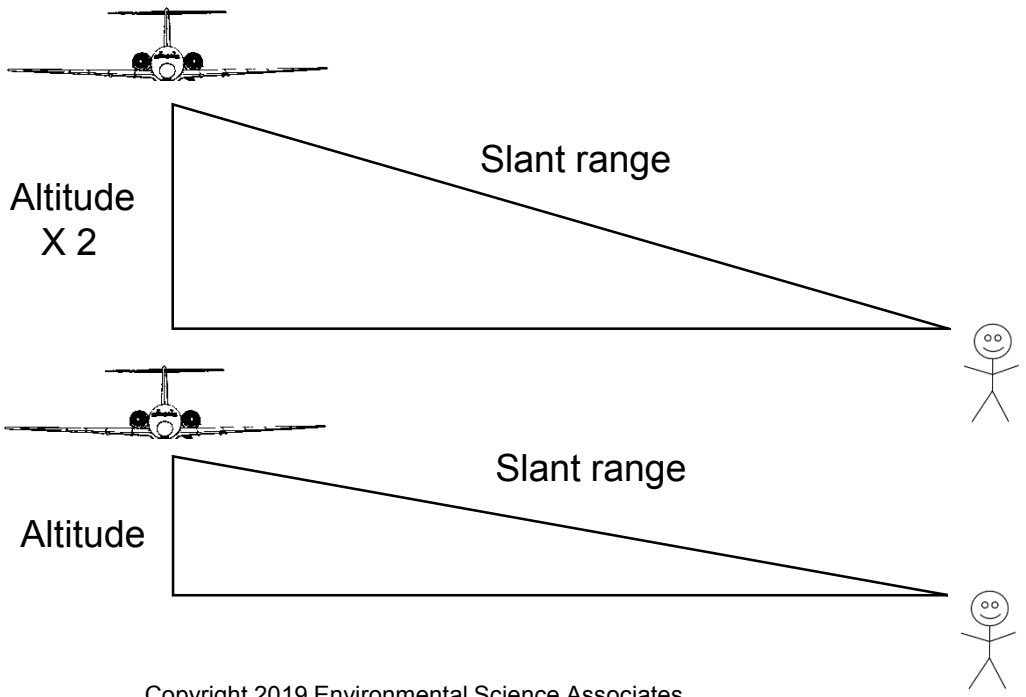
Principles of Aircraft Noise Control

- Remember: when moving aircraft away from residents, it takes a doubling of the distance to achieve a 6-dB reduction in the noise level
- Except for direct overflight, slant range is more important than altitude



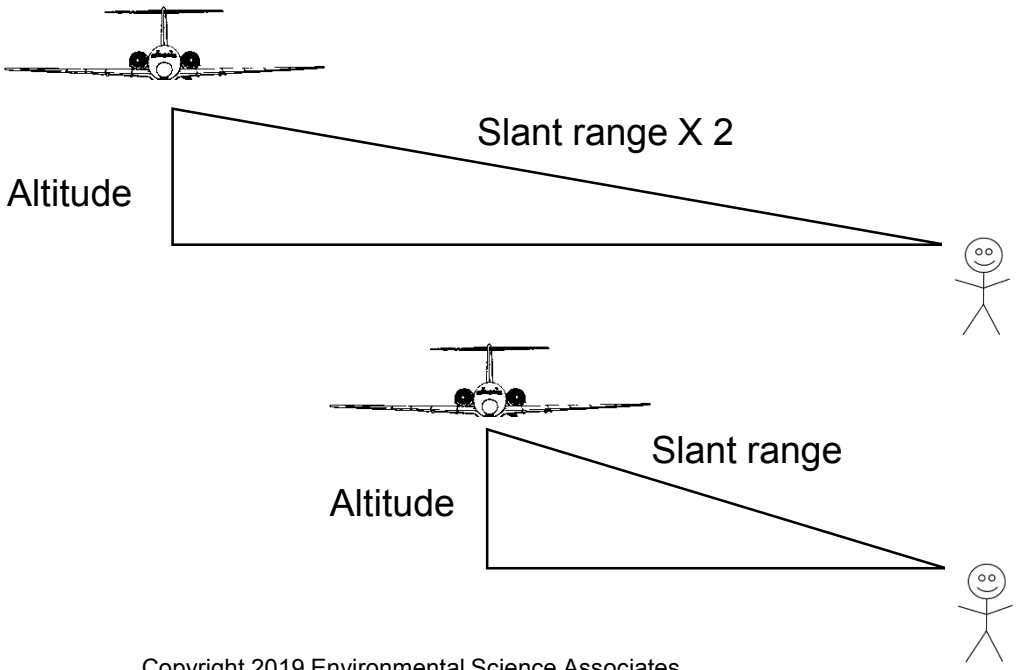
Noise Abatement – Aircraft in Flight

- Example: Double the altitude



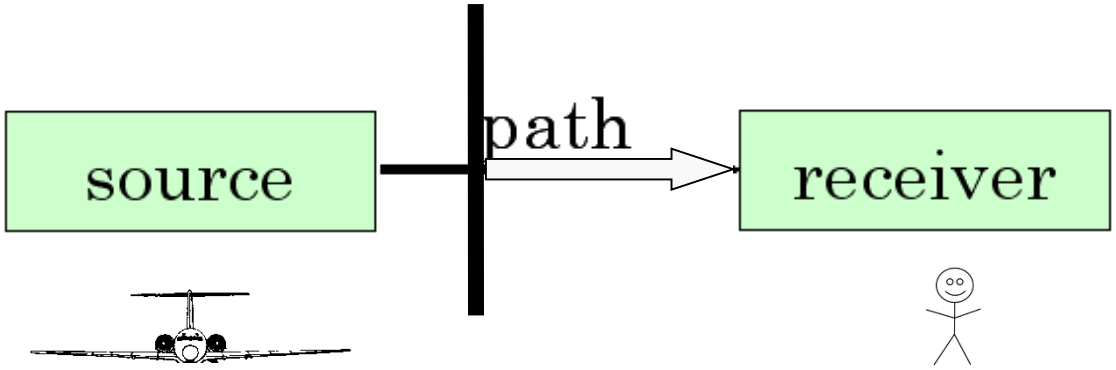
Noise Abatement – Aircraft in Flight

- Example: Double the slant range



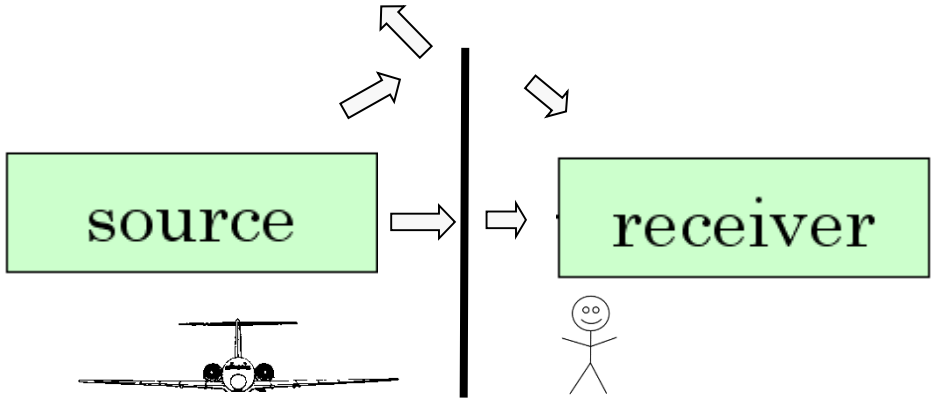
Principles of Aircraft Noise Control

- Block the path – insertion loss
  - Barriers, berms, buildings



Principles of Aircraft Noise Control

- Maximum insertion loss is achieved when the source and receiver are close to the barrier
  - Highway noise barriers, ground run-up enclosures



Principles of Aircraft Noise Control

NCP Measures That Are Required to Be Considered (14 CFR Part 150, Section B150.7)

Noise Abatement	**Noise Mitigation**
Preferential runway system	Property acquisition and avigation easements
Noise abatement flight procedures and flight tracks	Noise barriers and acoustical shielding
Aircraft operating restrictions based on noise characteristics*	
Other actions to control or abate noise recommended by stakeholders	
Other actions recommended for airport-specific analysis by the FAA	

* Subject to further notice, review, and approval requirements in 14 CFR Part 161.

Major NCP Strategy Options

Noise Abatement

- Noise abatement flight tracks
- Preferential runway use
- Arrival/departure procedures
- Airport layout modifications
- Runup enclosures
- Use restrictions*
- Other actions proposed by stakeholders

Land Use

- Remedial Mitigation
  - Land acquisition
  - Sound insulation
  - Avigation easements
- Preventative Mitigation
  - Land use controls
  - Zoning
  - Building codes
  - Comprehensive plans
  - Real estate disclosures
- Other actions proposed by stakeholders

Programmatic

- Implementation tools
- Promotion, education, signage, etc.
- Monitoring
- Reporting
- NEM update
- NCP revision
- Other actions proposed by stakeholders

* Subject to further notice, review, and approval requirements in 14 CFR Part 161.

Noise Abatement Options

- Noise abatement techniques can be applied to address:
  - Ground noise
  - Noise from aircraft in flight
- Techniques should be safe, cost effective, environmentally balanced, and capable of being implemented to be successful

Noise Abatement Options

- Standard evaluation criteria
  - Level of noise reduction
  - Effects on airfield capacity and aircraft delay
  - Effects on airspace/air traffic control procedures
  - Consistency with FAA safety and other standards
  - Other environmental effects (e.g., air quality)
  - Operational effects and costs
  - Financial feasibility
  - Consistency with policies adopted by Airport Proprietor

Noise Abatement Options

- Airfield Design
  - Runway extensions, new runway construction
  - Decommission existing runways
  - Relocate runway thresholds
- Operational
  - Dispersing departure flight tracks
  - Advanced navigational technologies
  - Change departure flight profiles
  - Modify arrival flight profiles
  - Rotational runway use
  - Ground run-up facility

Noise Abatement Options

- Restrict operations*
  - Ground run-up restrictions
  - Curfews
  - Noise level restrictions
  - Noise budget
  - Limit number of operations

*Subject to ANCA and potentially 14 CFR Part 161, which may limit the airport proprietor's ability to restrict aircraft operations.

Noise Abatement Options

- Management
  - Pilot awareness program
  - Fly Quiet program
  - Noise sensitive areas noted in navigation charts

Noise Abatement Options

- Ground noise can come from several sources:
  - Start of takeoff roll
  - Aircraft taxiing on the airfield
  - Reverse thrust on landing roll out
  - Maintenance activities on the airfield
  - Ground equipment for aircraft servicing
  - Auxiliary power units

Noise Abatement Options

- Noise abatement techniques to consider for addressing noise from taxiing aircraft:
  - Changes in runway location, length, or strength
  - Installation of high-speed exit taxiways
  - Terminal relocation
  - Noise barriers or berms
  - Establish preferential runway use
  - Establish restrictions on ground aircraft movement*
  - Establish use restrictions (e.g., single-engine taxiing)*
  - Tug to runway ends or into gates

Noise Abatement Options

- Noise abatement techniques to consider for addressing noise from ground support equipment:
  - Relocation of terminals or aircraft parking stands
  - Ground power plug-ins
  - Noise barriers
  - Establish limits on the use of ground equipment
  - Establish use restrictions

Noise Mitigation Options

- Remedial
  - Property acquisition
  - Redevelopment programs
  - Sound insulation
  - Avigation easements
  - Transaction assistance
- Preventive
  - Comprehensive planning
  - Growth management
  - Noise overlay zones
  - Property disclosure statements

Noise Mitigation Options

Property Acquisition

- This strategy is generally used for properties located within areas exposed to the highest noise levels (> 75 dB DNL)
- Properties are purchased and residents are relocated
- Some local communities dislike this practice because the purchase of the property removes it from the local tax roll
- However, the new compatible uses can be tax generating

Noise Mitigation Options

Property Acquisition (cont.)

- Need to evaluate the potential for fragmentation or elimination of neighborhoods
- Only way airport operator can be assured of long-term protection for compatible land use
- This strategy can be very costly
- Public relations value of the program can be very positive or very negative

Noise Mitigation Options

Sound Insulation

- This strategy is generally used for properties located within noise levels between 65 DNL and 75 DNL and interior noise levels greater than 45 DNL
- Homes receive new doors, windows, sealing of leaks, and other treatments to bring the interior noise level in the home to at least 45 DNL
- The general condition, age, and home state of repair will determine degree of soundproofing needed

Noise Mitigation Options

Sound Insulation (cont.)

- FAA also requires at least a 5-dB reduction in the exterior-to-interior sound level

- FAA Order 5100.38D requires that the home be both within the FAA-accepted 65 DNL contour and the interior noise level be greater than 45 dB DNL

Noise Mitigation Options

Sound Insulation (cont.)

- Avigation easements are often secured in return for accepting the sound insulation package. The avigation easement typically conveys a property right to the airport proprietor allowing a defined level of aircraft noise. The homeowner is precluded from suing the airport for airport noise falling within the defined level.

- This strategy is generally favored by most airports due to lower cost and community acceptance when compared to acquisition, but can be costly

Noise Mitigation Options

Avigation Easements

- Airport operator pays the property owner a monetary sum in exchange an agreement that the property owner will not sue the airport for damages associated with aircraft noise
- Not a popular option with most airports because it does not change the incompatibility with aircraft noise levels
- FAA has stopped funding this option for the reason stated above

Noise Compatibility Programs

- All measures must:
  - Reduce incompatible land use and prevent or reduce future incompatible land use
  - Ensure safety and efficiency
  - Be consistent with the powers and duties of the FAA
  - Be subject to revision if necessary

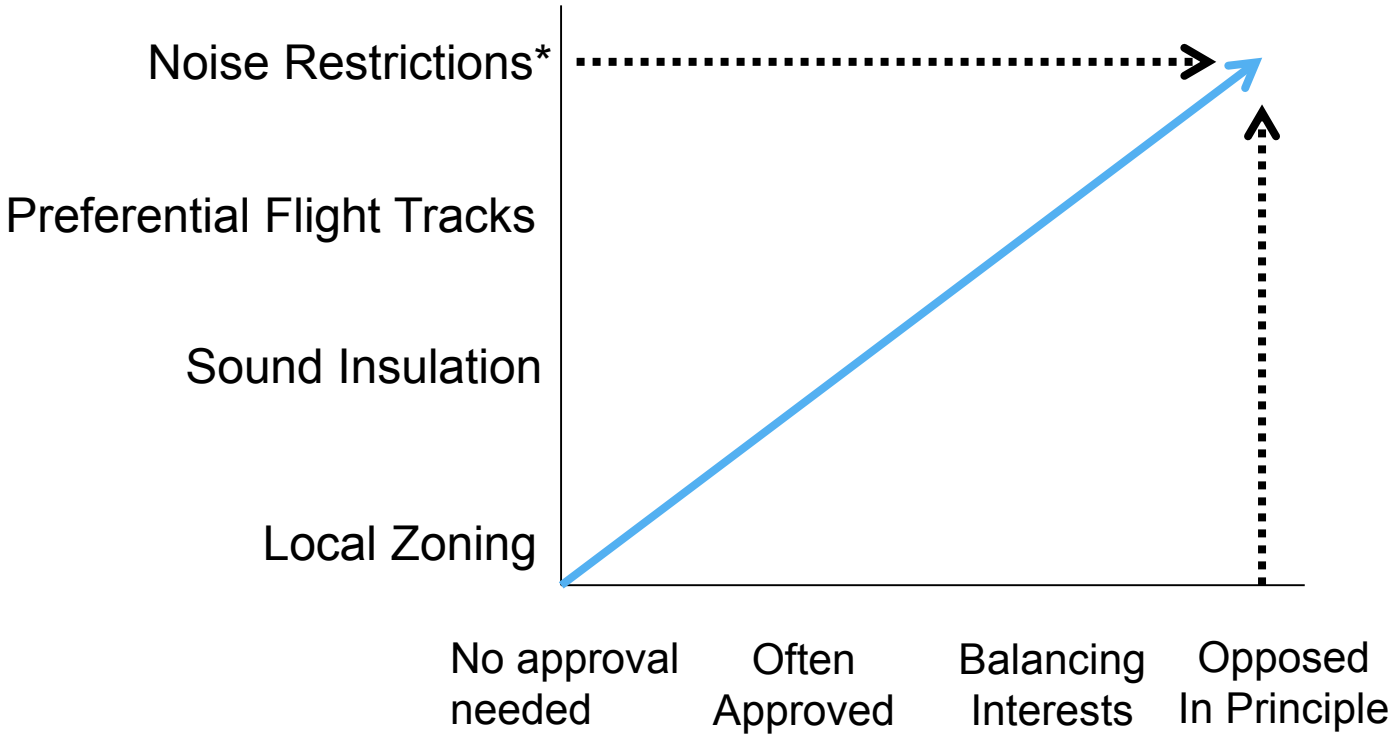
Noise Compatibility Programs

- Noise restrictions or rules must:
  - Not unjustly discriminate
  - Not impose an undue burden on interstate commerce (requires balancing of interests)
  - Meet both local needs and national air transportation system needs

Noise Compatibility Programs

- May be subject to ANCA and 14 CFR Part 161
  - Curfews, noise limits, etc.
  - FAA does not approve noise rules and restrictions through the 14 CFR Part 150 process
- Even if not subject to 14 CFR Part 161, must withstand rigorous scrutiny
  - Reduce existing land use incompatibility above DNL 65
  - Be reasonable and not unjustly discriminatory
  - No undue burden on interstate commerce

Noise Compatibility Programs
Difficulty of Obtaining FAA Approval



*Subject to ANCA and potentially 14 CFR Part 161, which may limit the airport proprietor's ability to restrict aircraft operations.

Presentation Outline

- Principles of Aircraft Noise Control
- Noise Abatement Options
  - Airfield Design
  - Operational
  - Restrict Operations
  - Management
- Noise Mitigation Options
  - Preventive
  - Remedial

Principles of Aircraft Noise Control

Questions?