Santa Clara/Santa Cruz Counties Airport/Community Roundtable

Aircraft Noise 101

Presented by:

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ESA

ESA is where solutions and service meet.

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

Principles of Aviation Noise

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
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 Rural Nighttime
1,000	30	
100	20	Whisper
10	10	
1	0	Threshold of Hearing
0.1	-10	
0.01	-20	

Source: U.S. EPA

Acoustic Principles

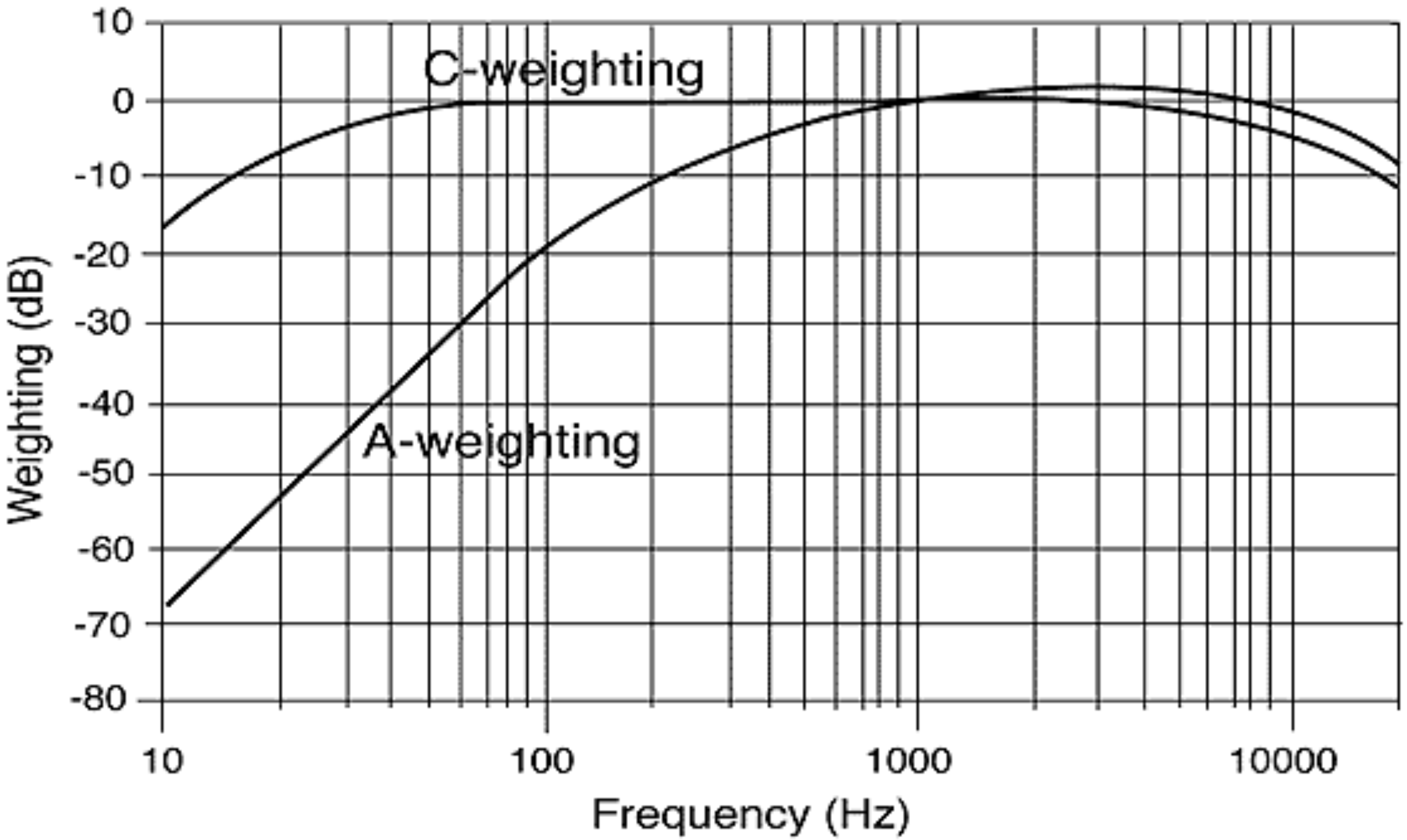
- The Decibel Scale – continued
  - A sound level of 70 dB has 10 times the acoustic energy as a level of 60 dB, while a sound level of 80 dB has 100 times the acoustic energy as a level of 60 dB
  - A sound 10 dB higher than another is usually judged to be twice as loud

Acoustic Principles

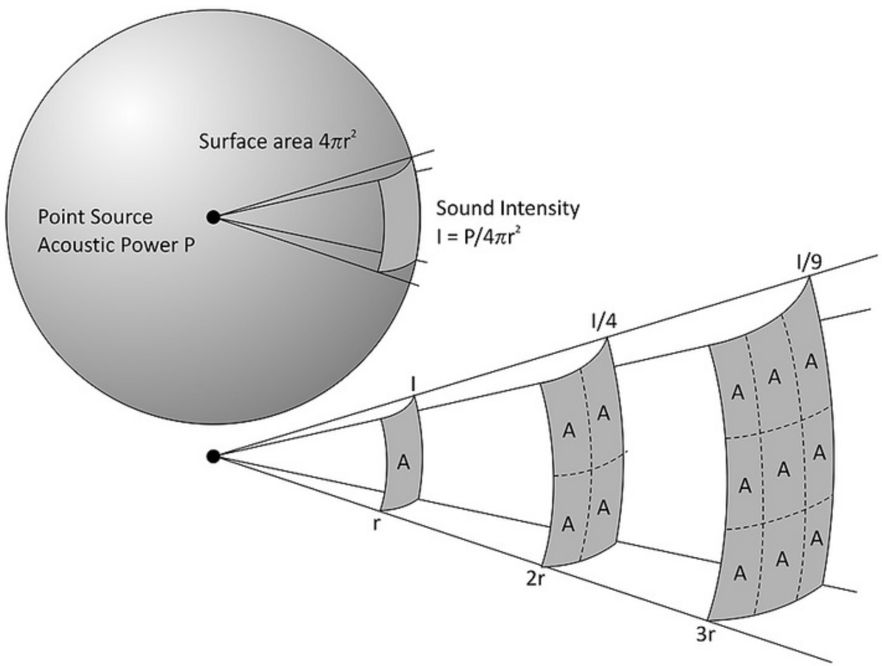
- Decibel Mathematics*
  - 70 dB + 70 dB = 73 dB
  - 70 dB + 50 dB = 70 dB
  - 70 dB x 10 = 80 dB
  - 70 dB x 100 = 90 dB

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

A and C Frequency Curves



Propagation of Noise



Graphic: Sound on Sound Magazine, February 2017

- 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

- **Refraction**
  - Wind gradients, lapse conditions, and inversion layers affect sound propagation
    - Downwind and inversion layers refract sound waves down
    - Upwind and lapse conditions refract sound waves up
  - 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)
  - Single Event Noise Exposure Level (SENEL)

- Cumulative Metrics
  - Day-Night Noise Level (DNL)
  - Community Noise Equivalent Level (CNEL)

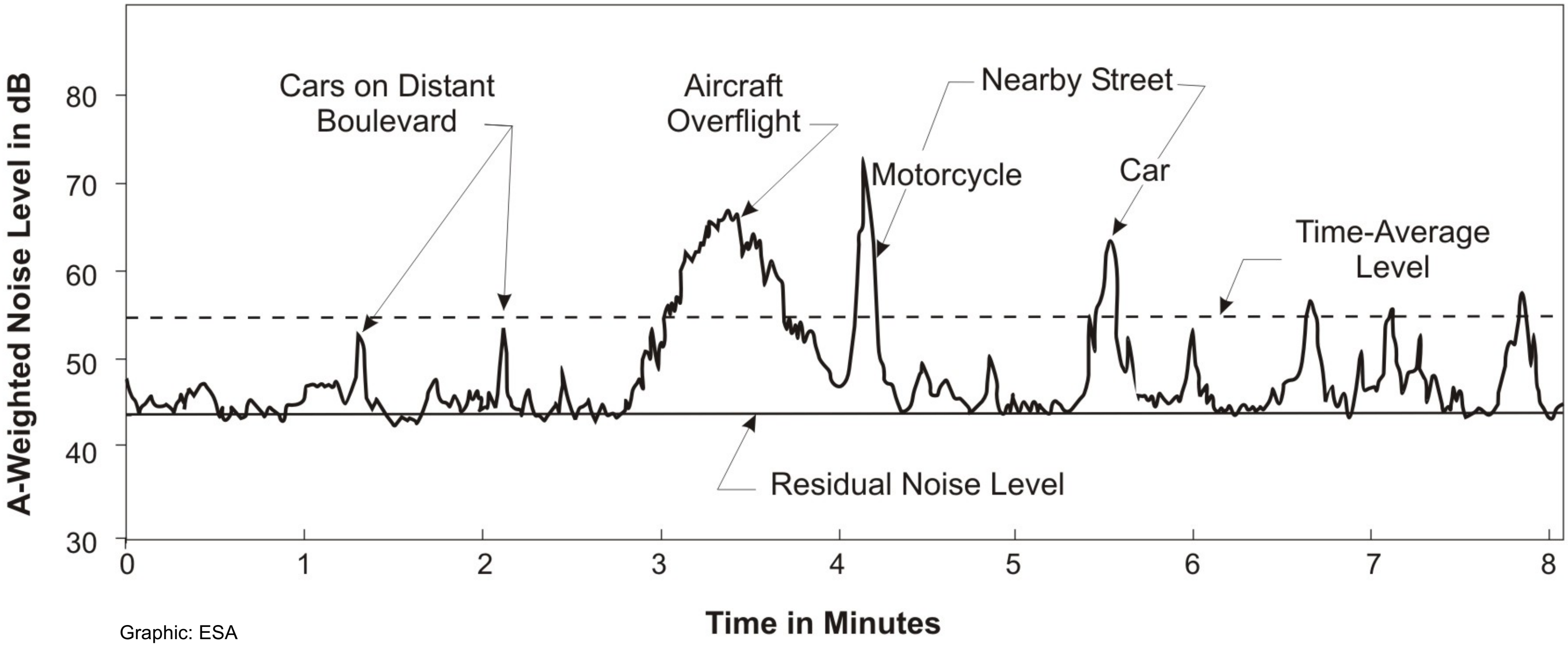
Single Event Metrics

- 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

Single Event Metrics

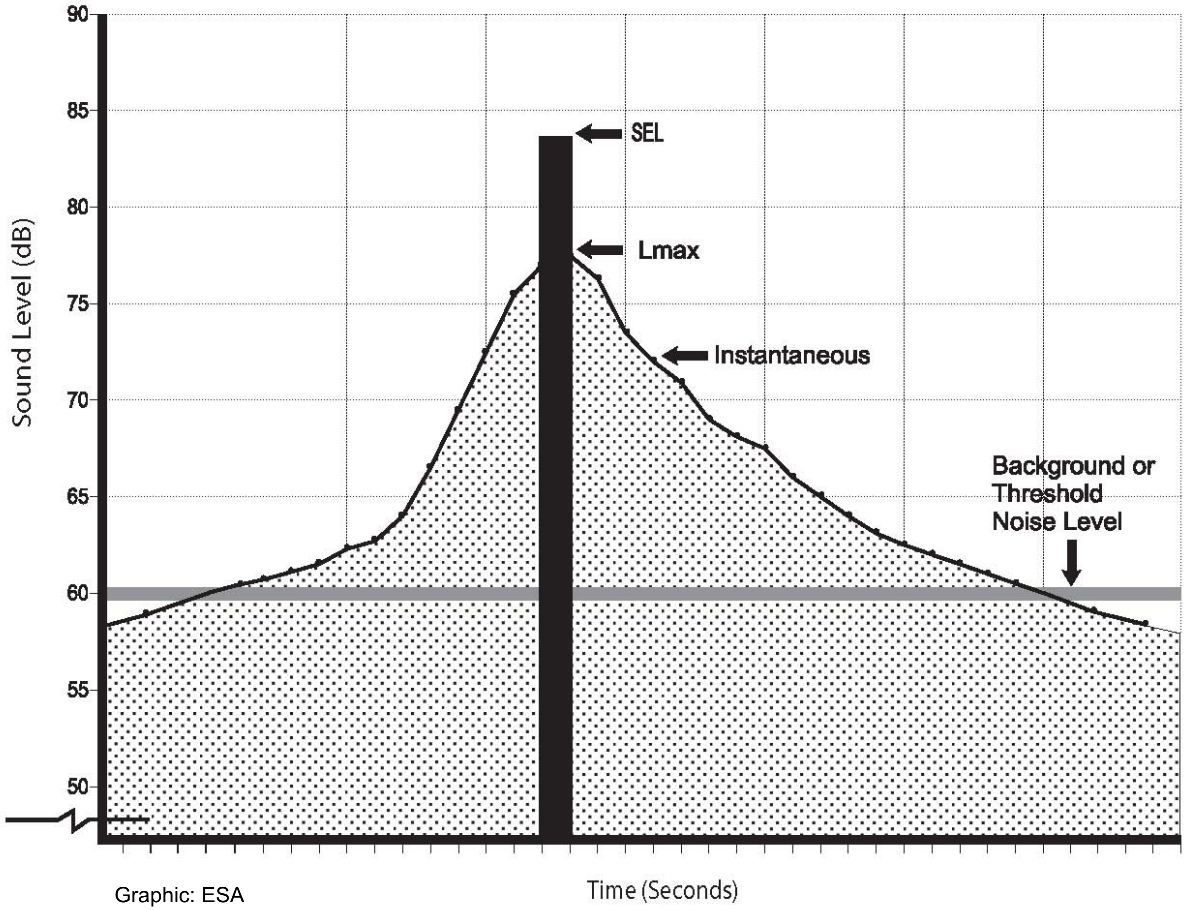
- Sound Exposure Level (SEL)
  - Another metric for aircraft flyovers
  - Computed from dBA sound levels
  - Integration of all the acoustic energy contained within the event into one second
  - Speech and sleep interference research can be assessed relative to SEL data

Sound Environs



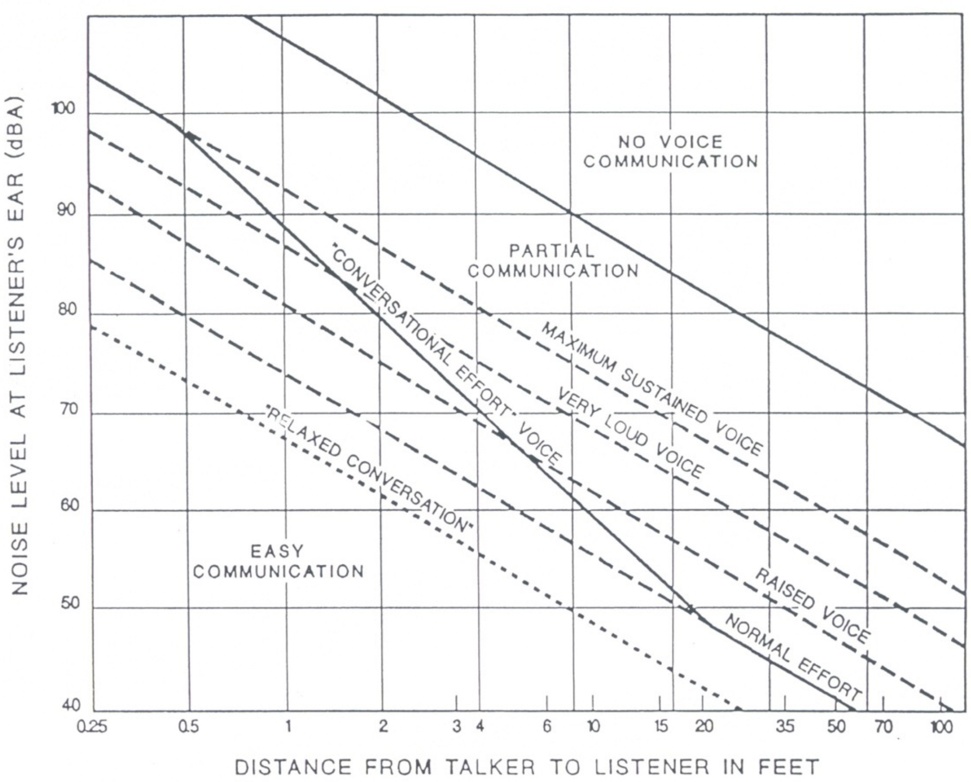
Graphic: ESA

Instantaneous Level, Lmax, SEL, Background Level



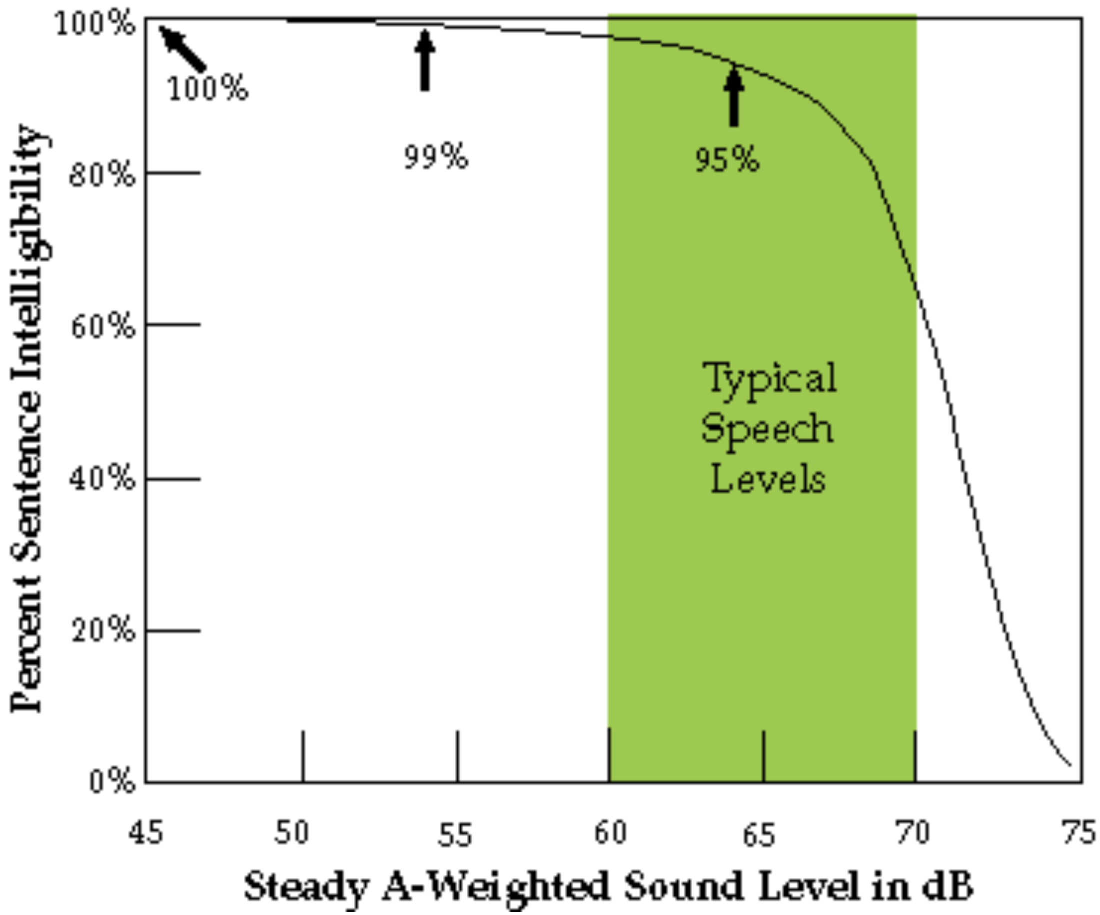
Graphic: ESA

Speech Interference Relationships



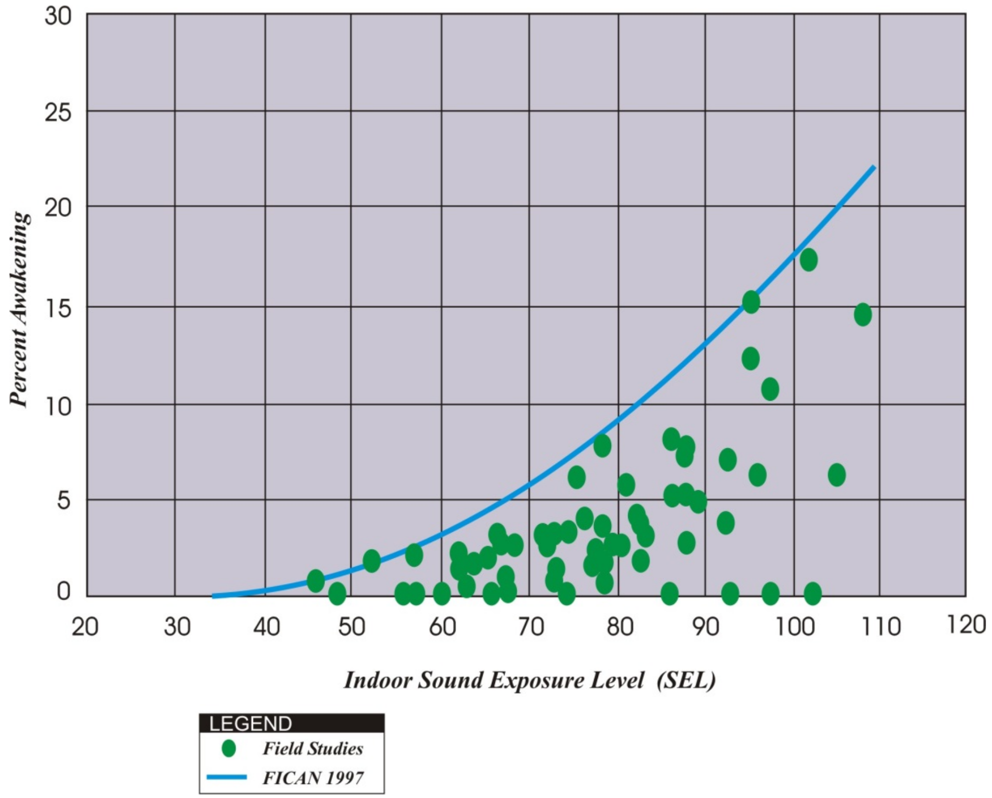
Source: Federal Interagency Committee On Noise (FICON) Federal Agency Review Of Selected Airport Noise Analysis Issues August 1992 and the U.S. Environmental Protection Agency

Percent Sentence Intelligibility



Source: U.S. EPA

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

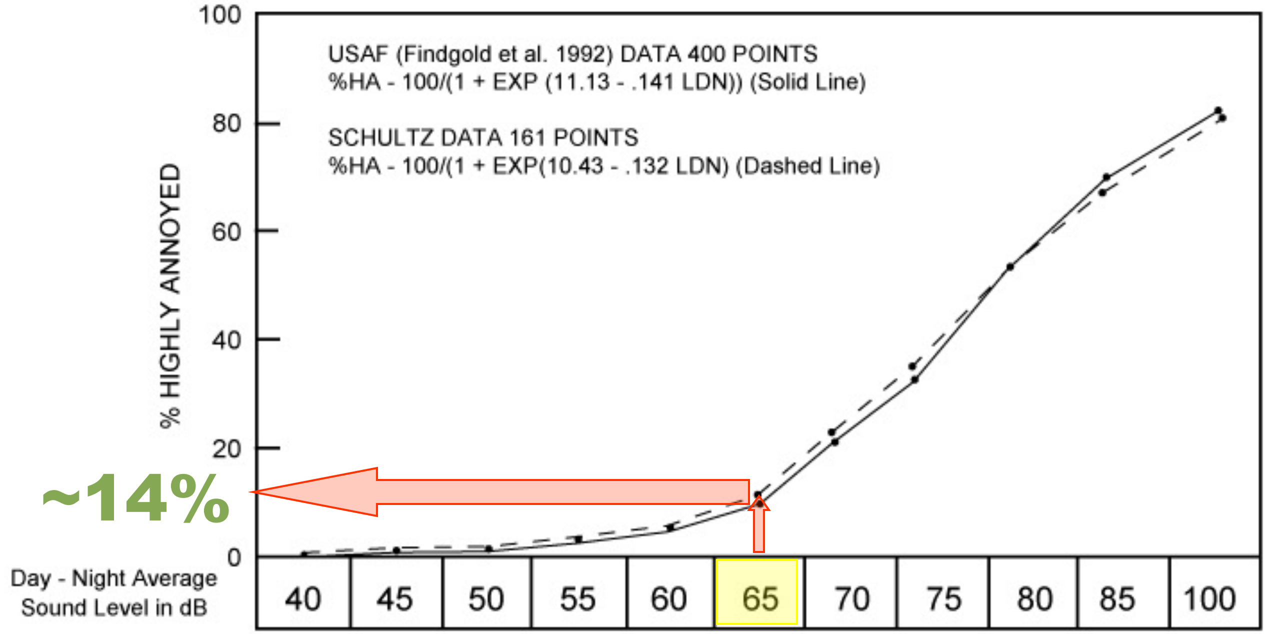
- Day-Night Average Sound Level (DNL)
  - 24-hour time weighted energy average noise level based on dBA
  - Noise events occurring between 10 pm to 7 am are penalized by 10 dB
  - Penalty was selected to account for the higher sensitivity to noise in the nighttime
  - Penalty also accounts for the expected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

Cumulative Metrics

- Cumulative Noise Equivalent Level (CNEL)
  - 24-hour time weighted energy average noise level based on dBA
  - Evening noise events occurring between 7 pm and 9:59 pm am are multiplied 3, which equated to a 4.77 dB penalty
  - Noise events occurring between 10 pm to 7 am are multiplied 10, which equals a 10 dB penalty
  - These penalties were selected to account for the higher sensitivity to noise in the nighttime as well as the decrease in background sound levels
  - FAA specifies DNL for federal aircraft noise studies and accepts CNEL in California
  - Environmental Protection Agency (EPA) specifies DNL for community noise and airport noise assessment

Cumulative Metrics

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



Calculated %HA Points											
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

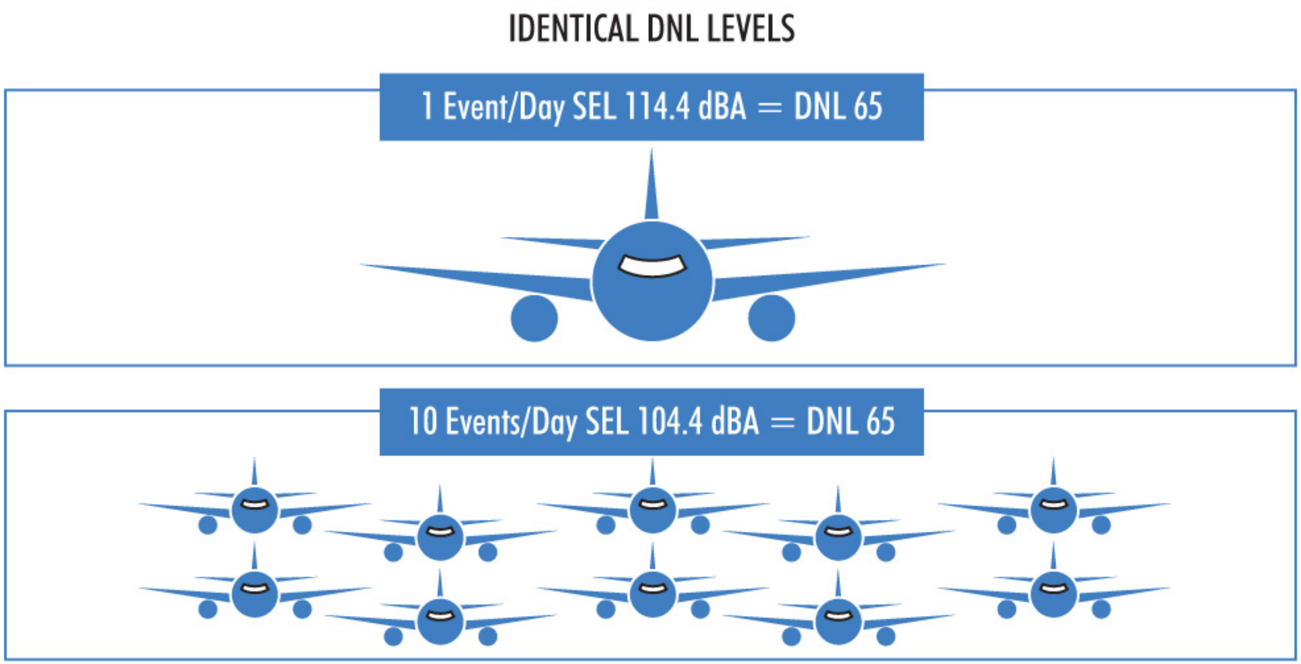
Source: (USAF, 1992)

FAA's Guideline

IDENTICAL DNL LEVELS

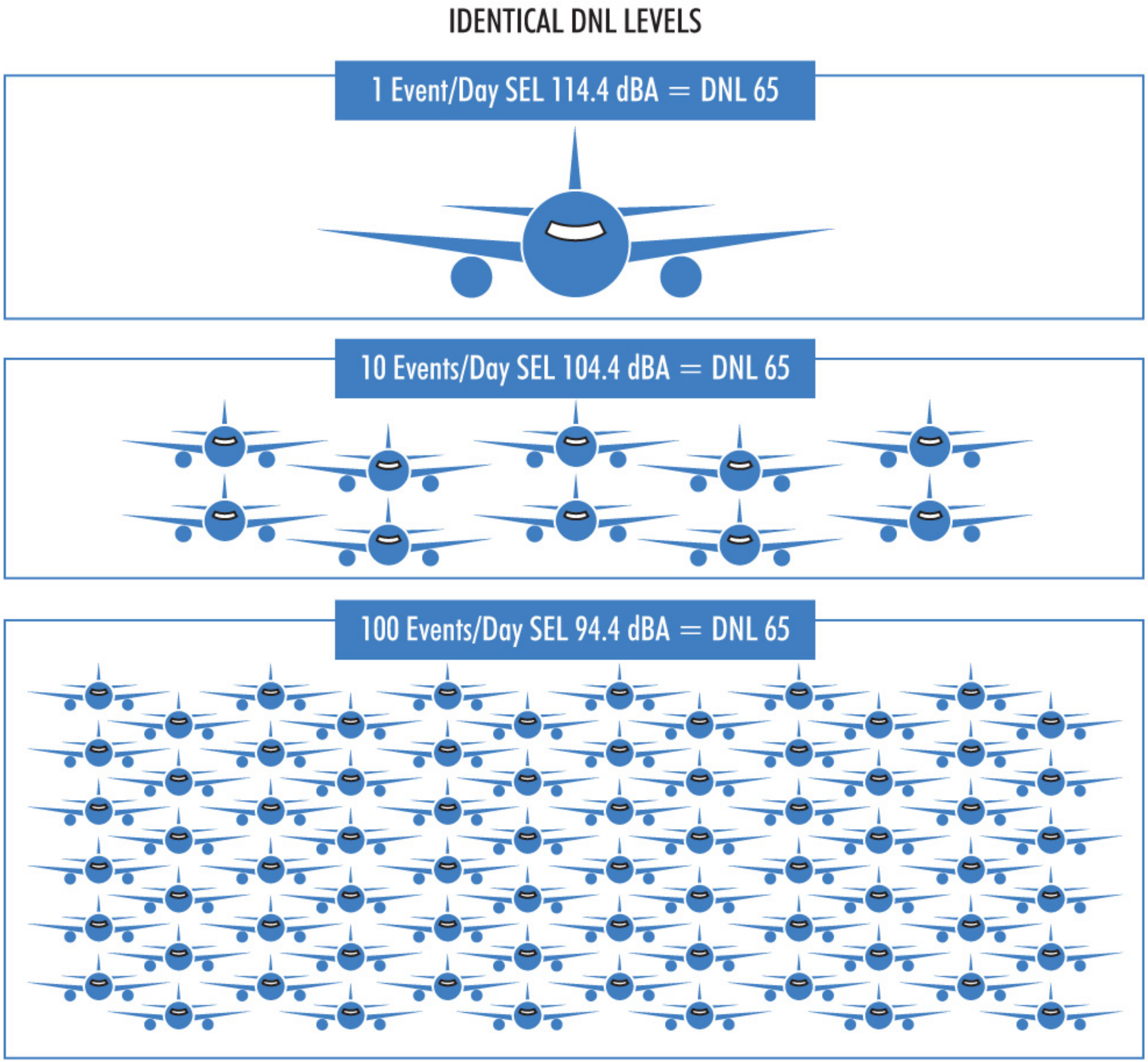
Graphic: ESA

Principles of Aviation Noise



Graphic: ESA

Principles of Aviation Noise



Graphic: ESA

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

Acoustical 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

Acoustical Rules of Thumb

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

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

- 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

- 14 CFR FAR Part 150 establishes the noise measurement methods and metrics for conducting aircraft noise measurements for federal noise studies
- Title 21 of the State Aeronautic Act sets the noise standards for quantifying aircraft noise in California
- Local municipalities often specify noise measurement standards in noise ordinances or general plans

Aircraft in flight are exempt from local noise ordinances

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

Aviation Environmental Design Tool

- The Aviation Environmental Design Tool (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

Integrated Noise Model (INM)

- AEDT is based on the 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

- 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

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

Aircraft Noise Regulations

- 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

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

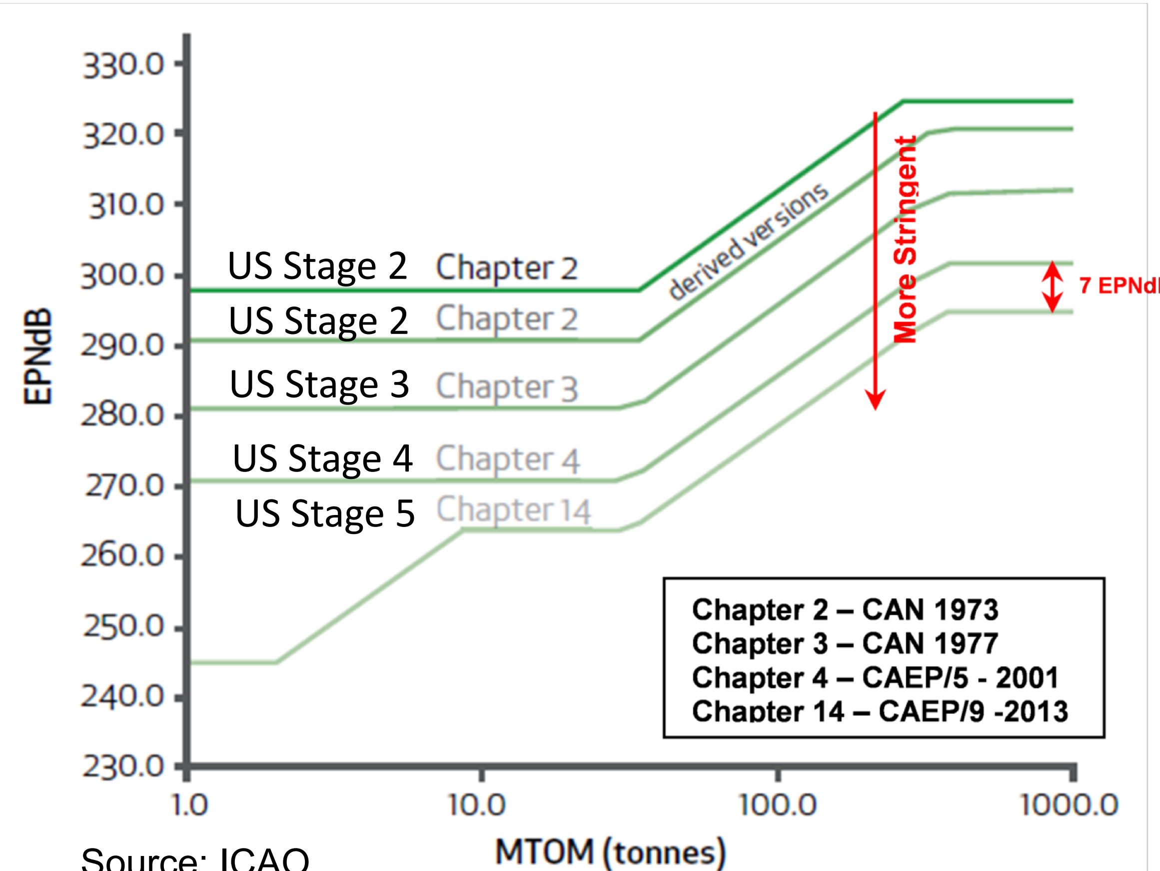
- Local noise ordinances set local noise standards and provide for compatible land use planning, but aircraft in flight are exempt

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
- Recent Aviation-Related Legislation

14 CFR Part 36 and ICAO Noise Limits



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 proprietor 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)

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/CNEL
- 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

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 all of the noise provisions

Recent Aviation Noise-Related Legislation

- Section 172. Authorization of certain flights by Stage 2 aircraft.
- Section 173. Alternative airplane noise metric evaluation deadline.
- Section 174. Updating airport noise exposure maps.
- Section 175. Addressing community noise concerns.
- Section 176. Community involvement in FAA NextGen projects located in metroplexes.
- Section 179. Airport noise mitigation and safety study.

Source: Airports Council International – North America, October 2018

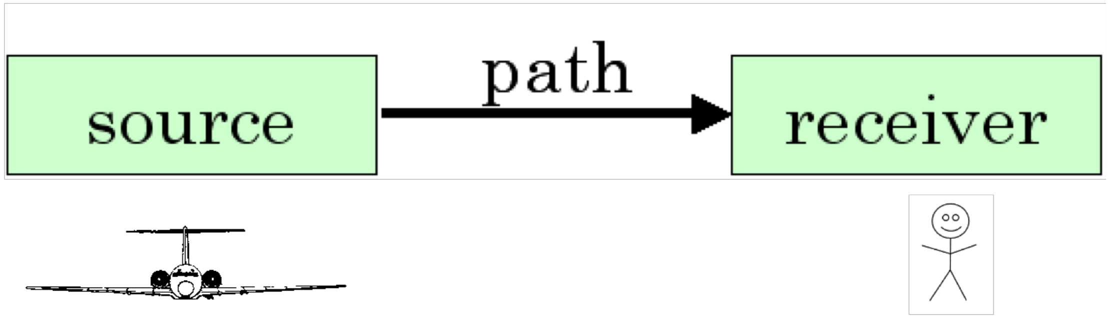
Recent Aviation Noise-Related Legislation

- Section 180. Regional ombudsmen.
- Section 181. FAA leadership on civil supersonic aircraft.
- Section 186. Stage 3 aircraft study.
- Section 187. Aircraft noise exposure.
- Section 188. Study regarding day-night average sound levels.
- Section 189. Study on potential health and economic impacts of overflight noise.
- Section 190. Environmental mitigation pilot program.

Source: Airports Council International – North America, October 2018

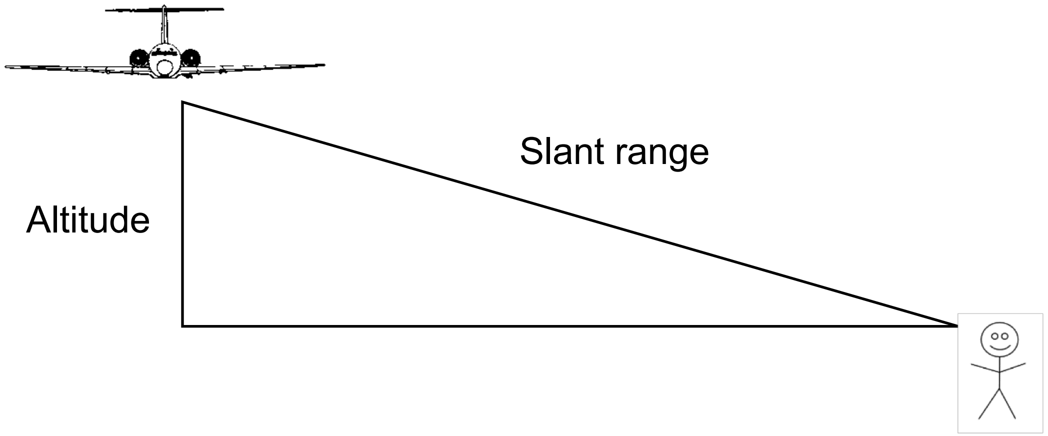
Principles of Aircraft Noise Control

- Source
- Path
- Receiver



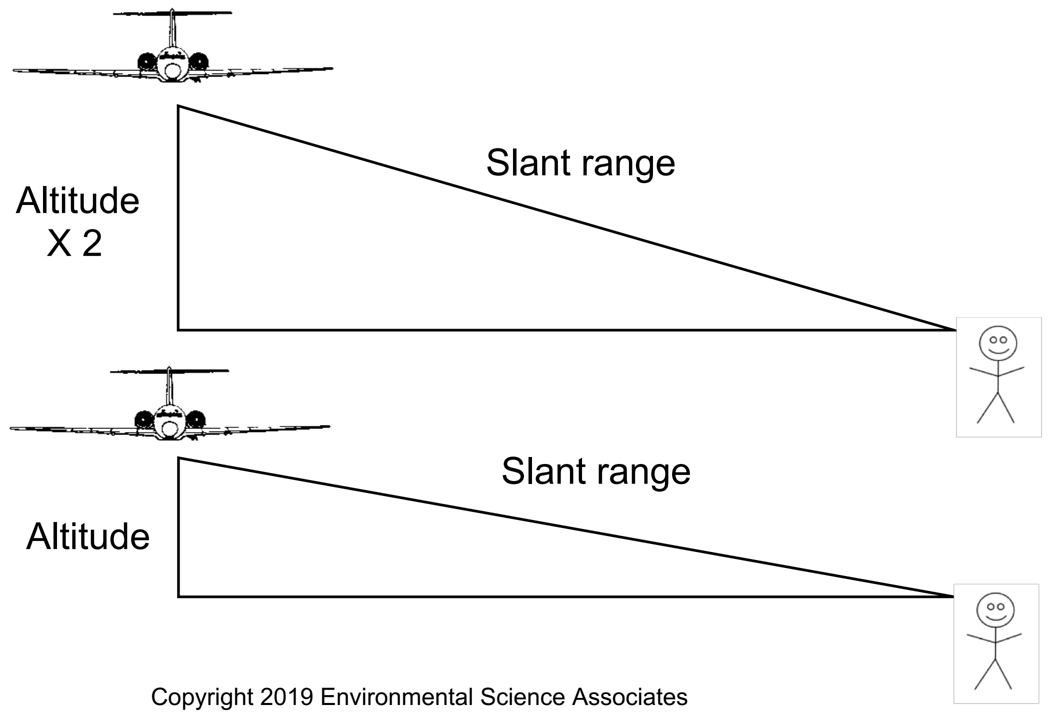
Principles of Aircraft Noise Control

- 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



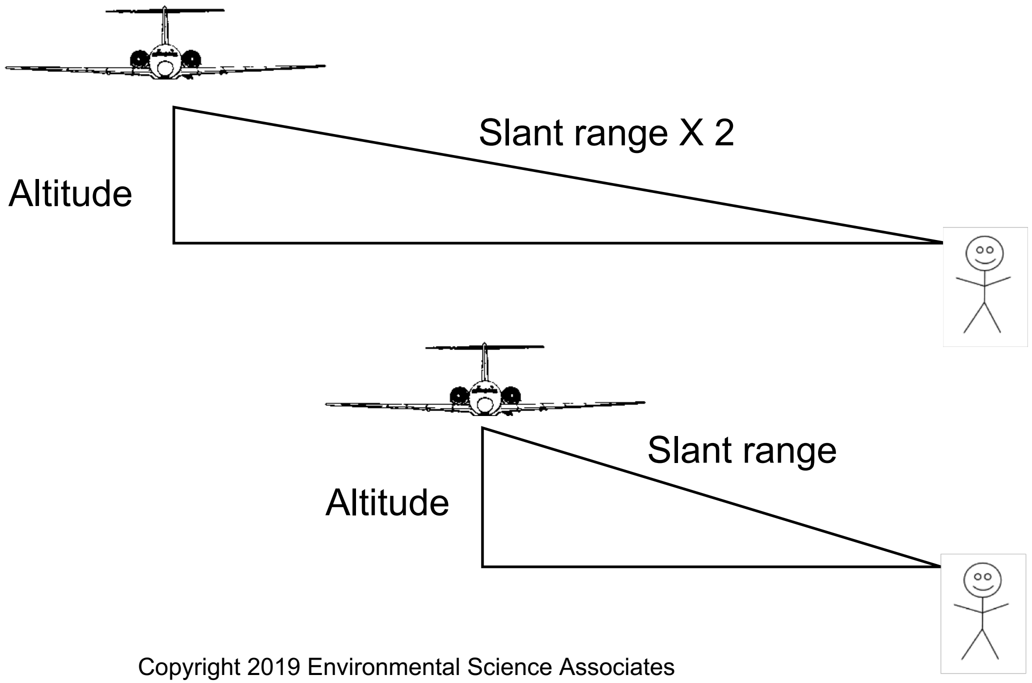
Noise Abatement – Aircraft in Flight

- Example: Double the altitude



Noise Abatement – Aircraft in Flight

- Example: Double the slant range



Questions?