LAX Airport/Community Noise Roundtable

# Aircraft Noise 101: Part 1

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

# The Decibel Scale

- 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, 20 dB higher is judged four times as loud

| 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 | |

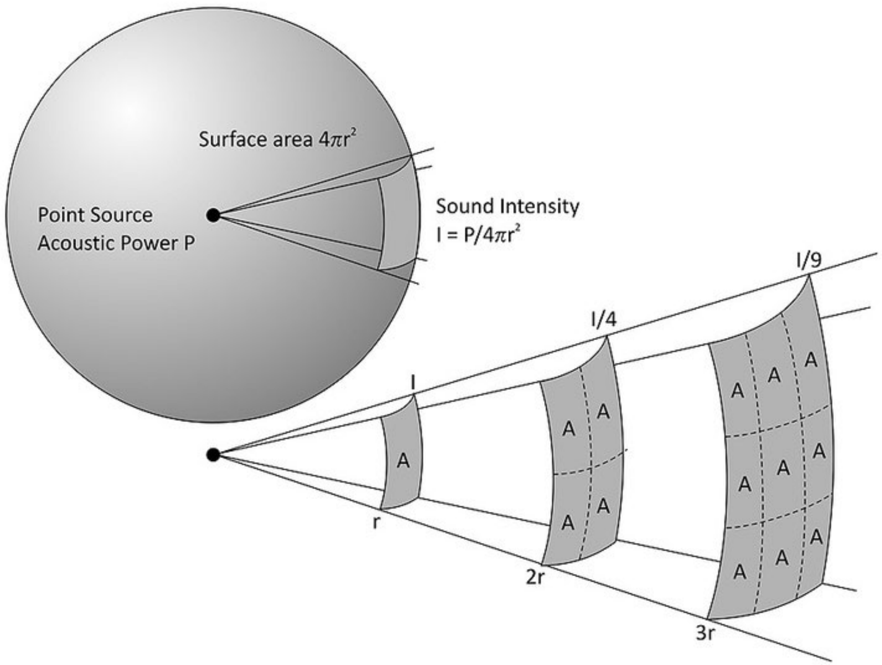
Source: U.S. EPA

# Acoustic Principles

- 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.

# Propagation of Noise

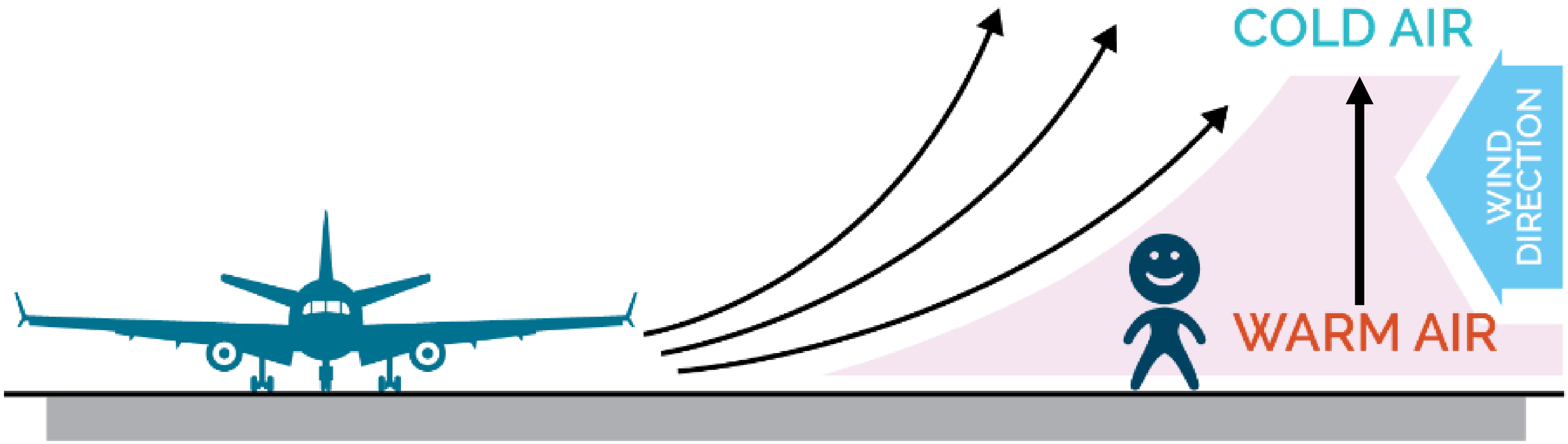



Graphic: Sound on Sound Magazine, February 2017

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

# Propagation of Noise

## Effect of Lapse or Upwind Conditions




Graphic: ESA

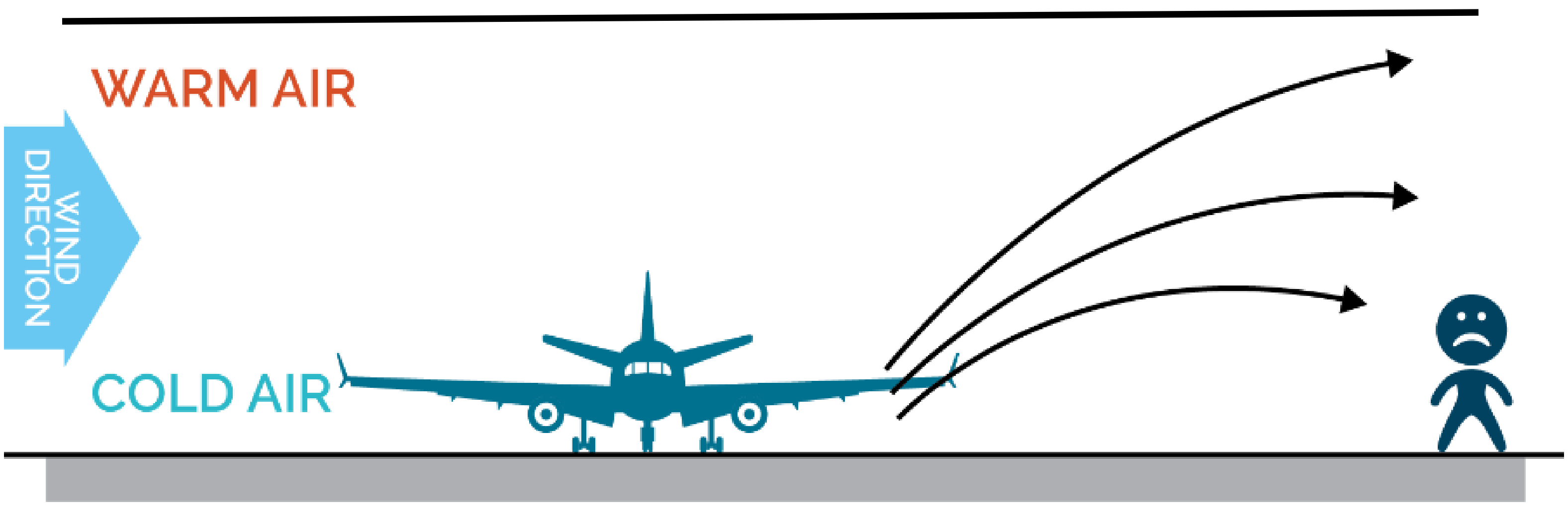
- Lapse or upwind conditions can *decrease* noise levels by over 20 dB

# Propagation of Noise

- Effect of Lapse or Upwind Conditions
  - Lapse conditions are indicative of normal temperature conditions; typical of a clear, warm, summer day
    - Sound waves are refracted upward as warm air rises
  - Upwind conditions exist when the wind is blowing from the receiver to the noise source
    - Sound waves are refracted upward by the wind flow
  - In both instances, noise levels may decrease by over 20 dB
  - Lapse or upwind conditions are considered *favorable* from the receiver's perspective

# Propagation of Noise

## Effect of Inversion or Downwind Conditions



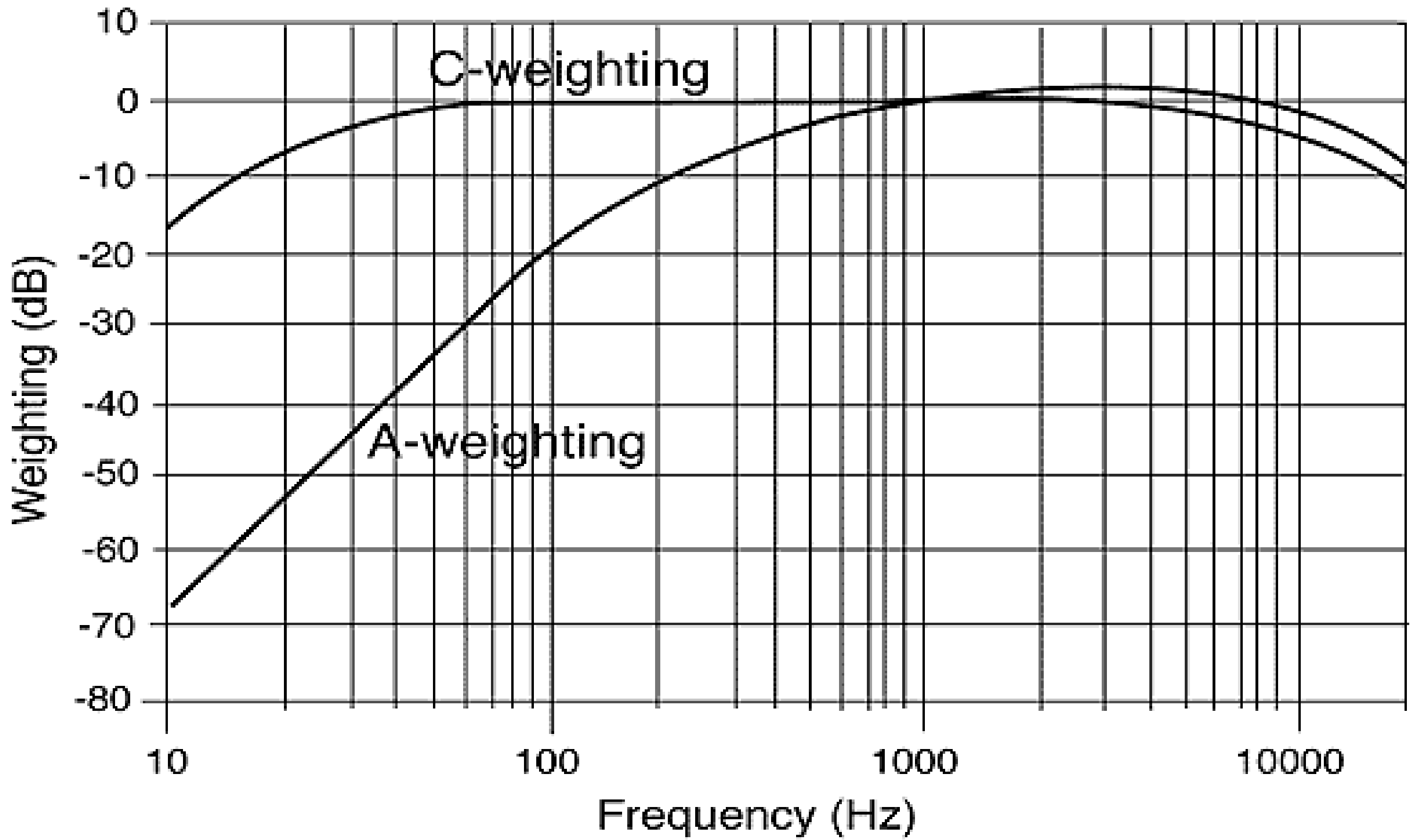

Graphic: ESA

- Temperature inversions or downwind conditions can *increase* noise levels by over 20 dB

# Propagation of Noise

- Effect of Inversion or Downwind Conditions
  - Inversions conditions are indicative of abnormal temperature conditions; fog and/or rain clouds are often indicative of an inversion layer
    - Sound waves are refracted downward as warm air “traps” the cold air below it
  - Downwind conditions exist when the wind is blowing from the noise source to the receiver
    - Sound waves are refracted downward by the wind flow
  - In both instances, noise levels may increase by over 20 dB
  - Inversion or downwind conditions are considered *unfavorable* from the receiver’s perspective

# A and C Frequency Curves



# A-Weighting

- A-weighting equates well with human hearing; it deemphasizes low frequencies and emphasizes mid-range to high frequencies
  - It correlates well with the frequencies we speak at
  - It captures sources with mid-range and high-frequency components (e.g., an aircraft on climb out or arrival) quite well
  - It deemphasizes the low-frequency noises (e.g., start of takeoff roll) that we don't hear well, but often experience as a rumble
  - It is recommended by the EPA and had been adopted by the FAA in its regulations and orders
  - It is the required weighting for conducting aircraft noise analyses under state and federal law

# C-Weighting

- C-Weighting was developed to measure low-frequency noise sources; it emphasizes the low-frequency portion of noise events
  - It does not equate well with how we hear, but identifies low-frequency noise levels that often cause objects in homes to vibrate (e.g., items on shelves, pictures on walls)
  - It has been used to study low-frequency noise associated with the start of takeoff roll and use of thrust reversers after landing
  - It is not required for aircraft noise analyses under state and federal law
  - Specific written permission would be required to include it in state and federally-funded noise studies

# Single Event Metrics

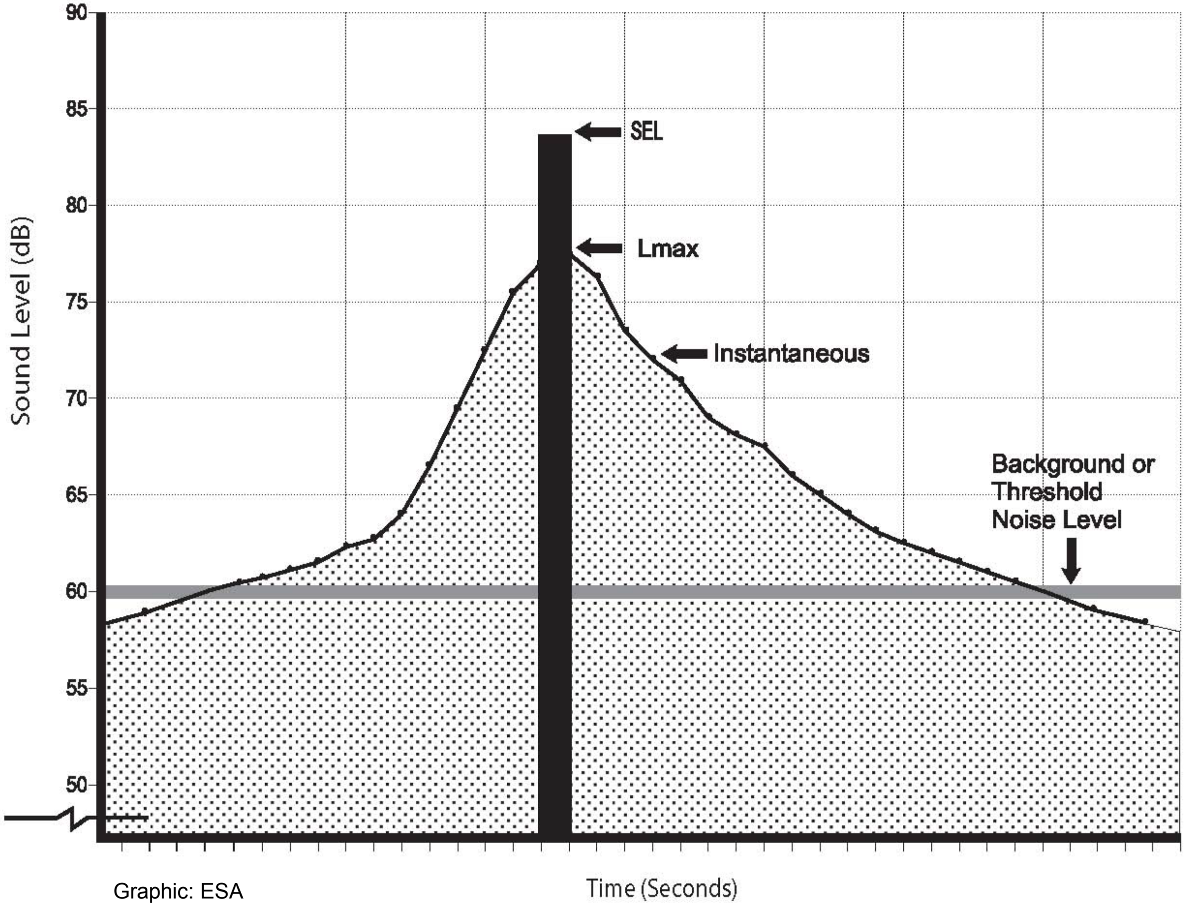
- Maximum Noise Level (Lmax)
  - Highest noise level reached during a noise event
  - Lmax achieved when aircraft is at its closest point (typically, directly overhead)
  - Generally, it is this metric that people instantaneously respond to when an aircraft flyover occurs

# 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

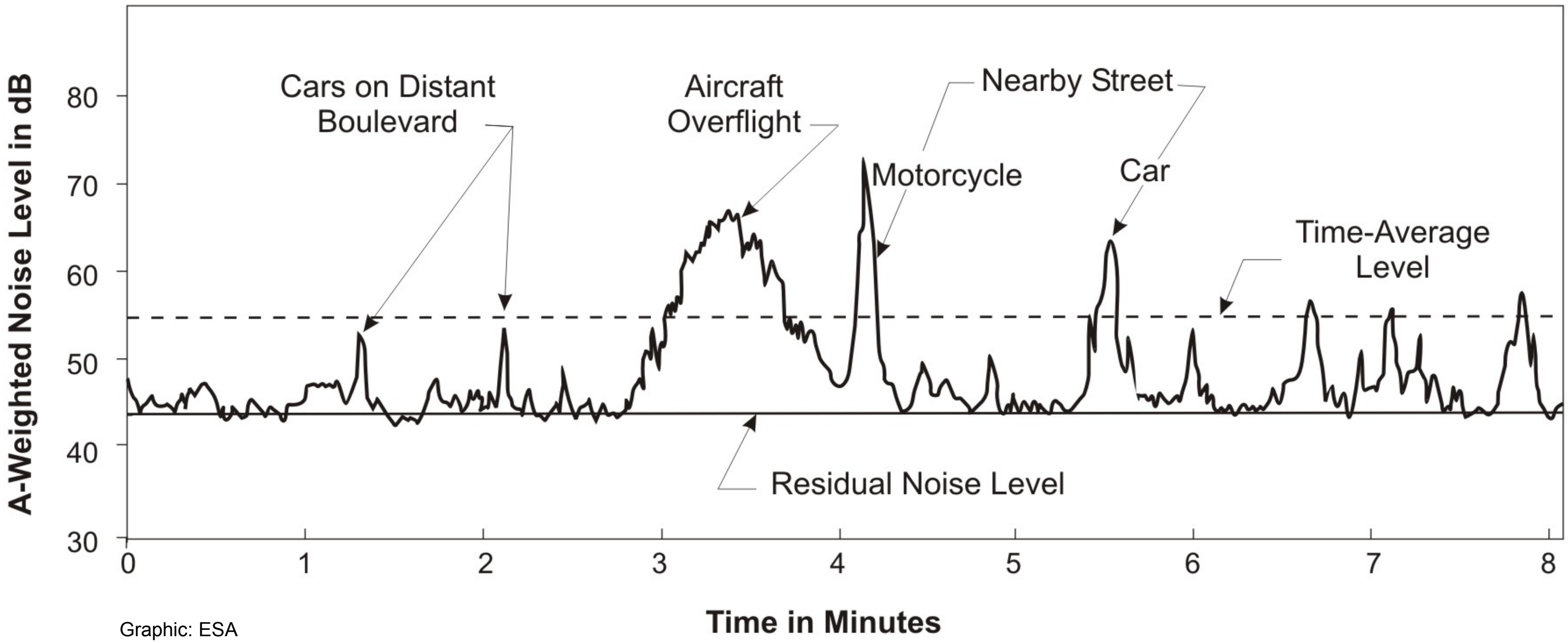
# Principles of Aviation Noise

## Instantaneous Level, Lmax, SEL, Background Level



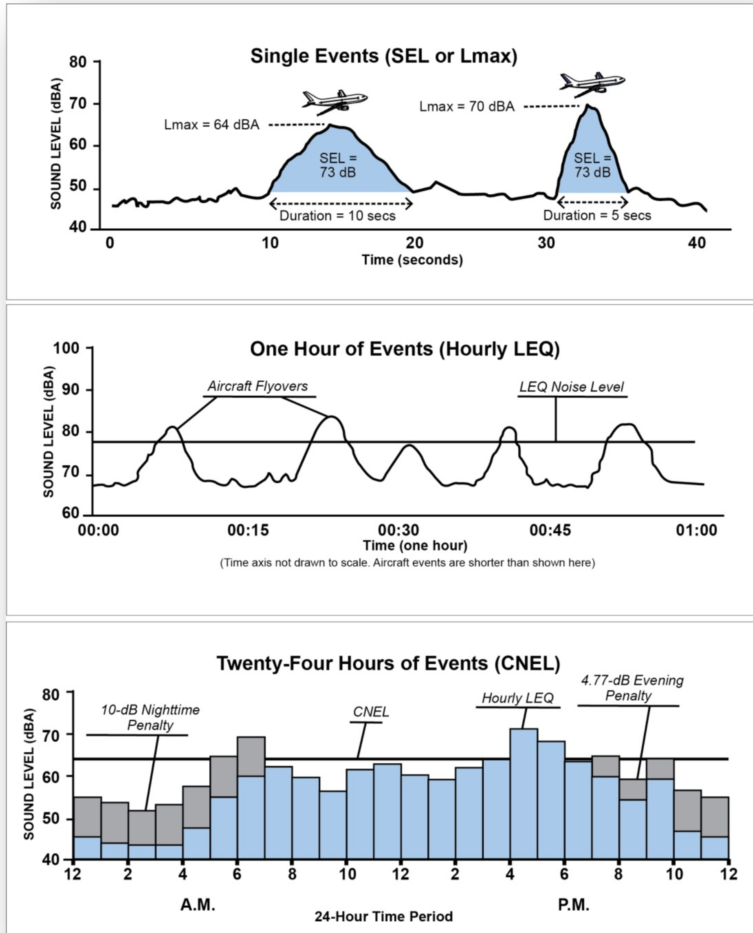

Graphic: ESA

# Sound Environs




Graphic: ESA

# Cumulative Noise Exposure




Graphic: ESA

# Cumulative Metrics - Federal

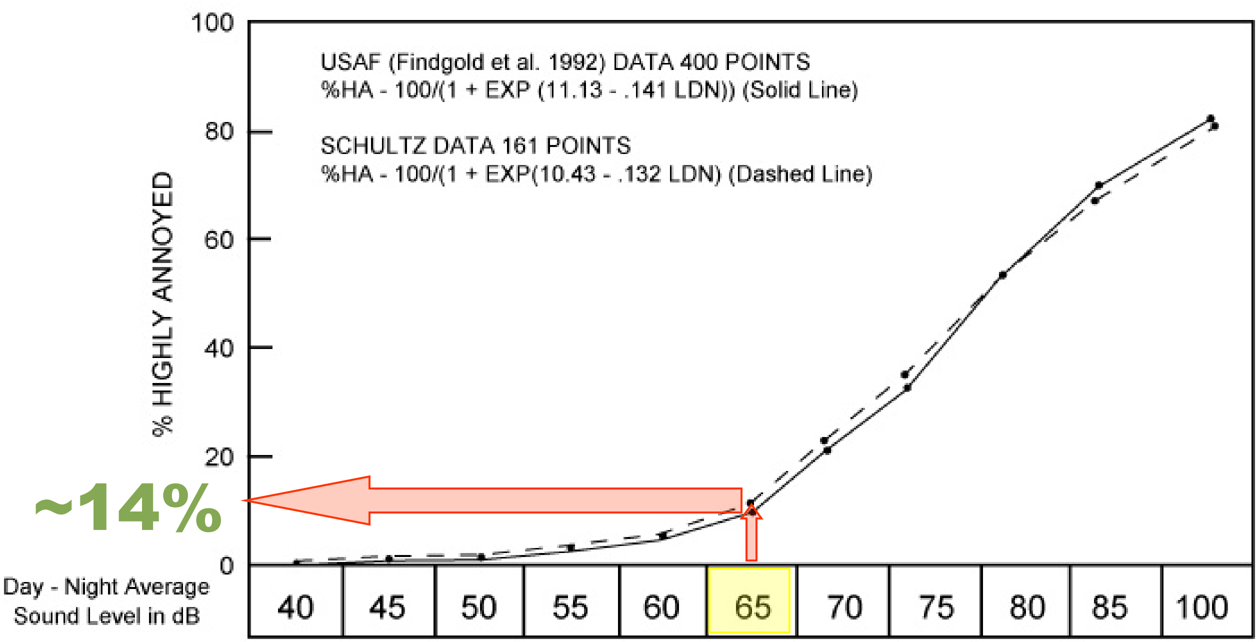
- Day-Night Average Sound Level (DNL)
  - 24-hour time weighted energy average noise level based on dBA
  - Noise events occurring between 10 pm to 7 am are penalized by 10 dB
  - Penalty was selected to account for the higher sensitivity to noise in the nighttime when background sound levels decrease and most people sleep
  - FAA specifies DNL for airport noise assessment
  - Environmental Protection Agency (EPA) specifies DNL for community noise and airport noise assessment

# Cumulative Metrics - California

- 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 equates 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 evening when people are at home enjoying family time and nighttime when background sound levels decrease and most people sleep
  - 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**

# FAA's Aircraft Noise Standard

*"For the purpose of compliance with this part, all land uses are considered to be compatible with noise levels less than Ldn 65 dB."* - 14 CFR Part 150, Part A., Section A150.101(d).

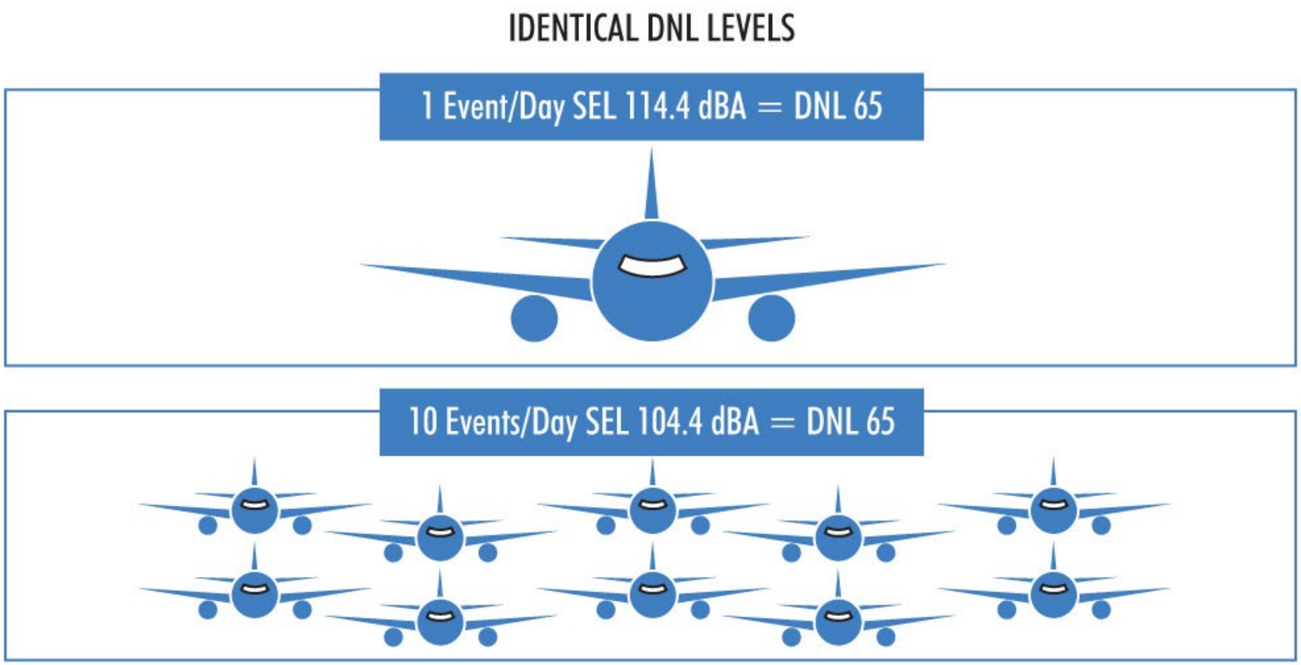
# California's Aircraft Noise Standard

*"The level of noise acceptable to a reasonable person residing in the vicinity of an airport is established as a community noise equivalent level (CNEL) value of 65 dB for purposes of these regulations."* - State Aeronautics Act, Title 21, Section 5006.

IDENTICAL DNL LEVELS

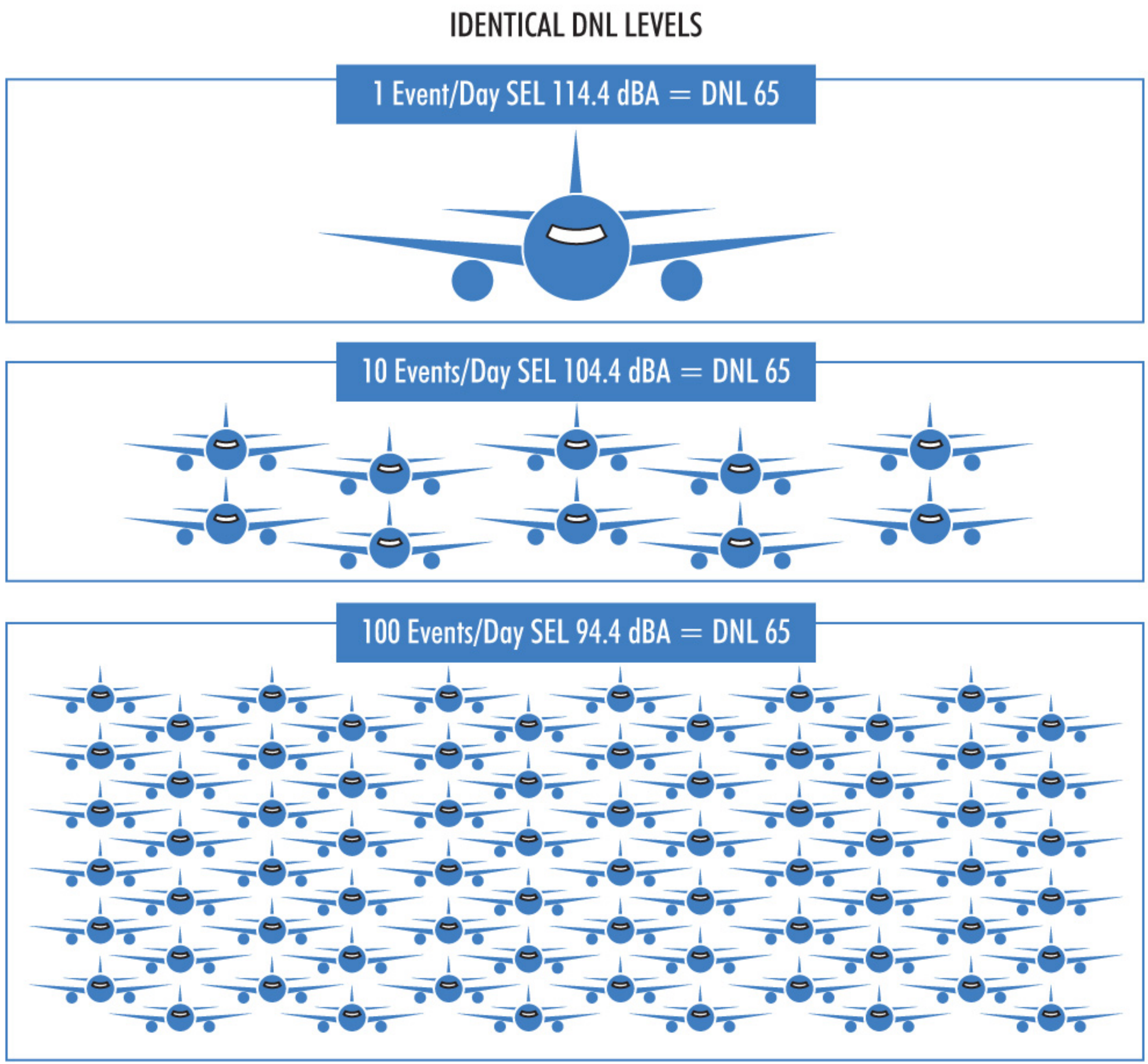

Graphic: ESA

# Principles of Aviation Noise




Graphic: ESA

# Principles of Aviation Noise




Graphic: ESA

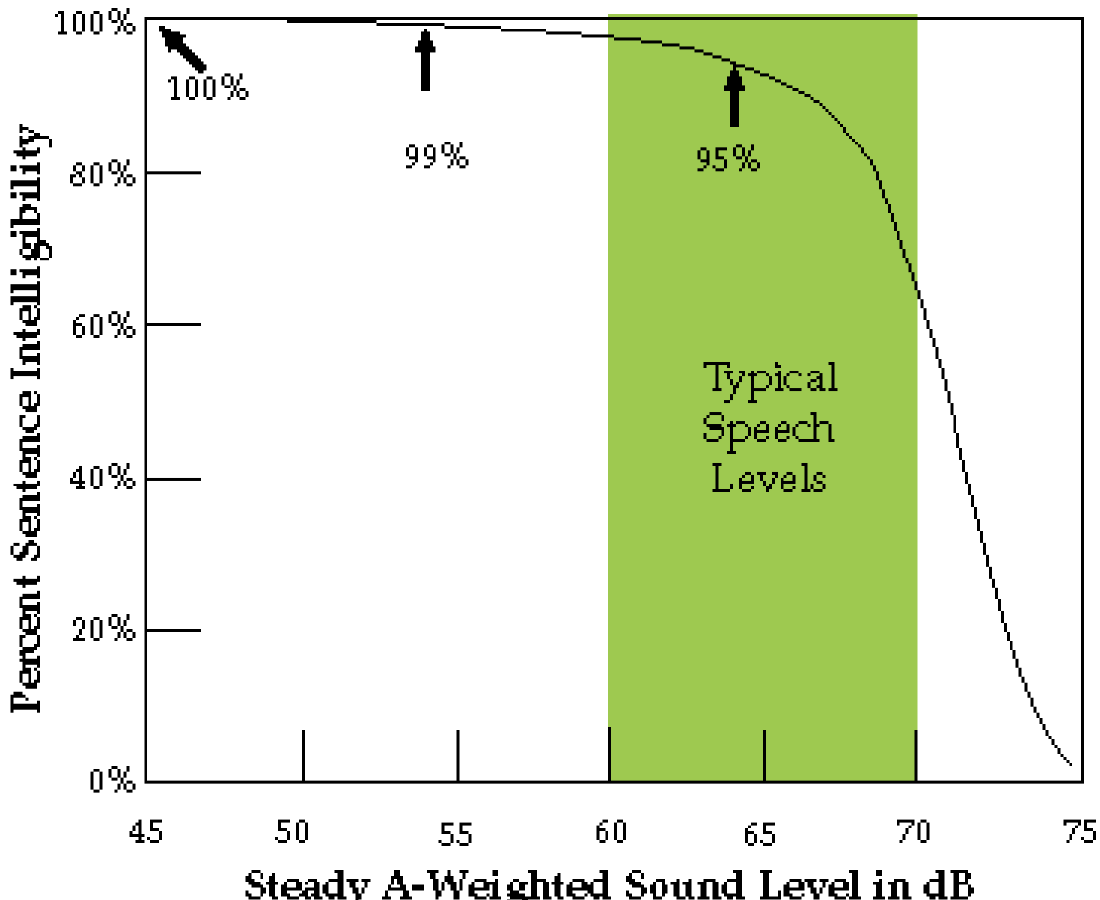
# Supplemental Metrics

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

# Supplemental Metrics

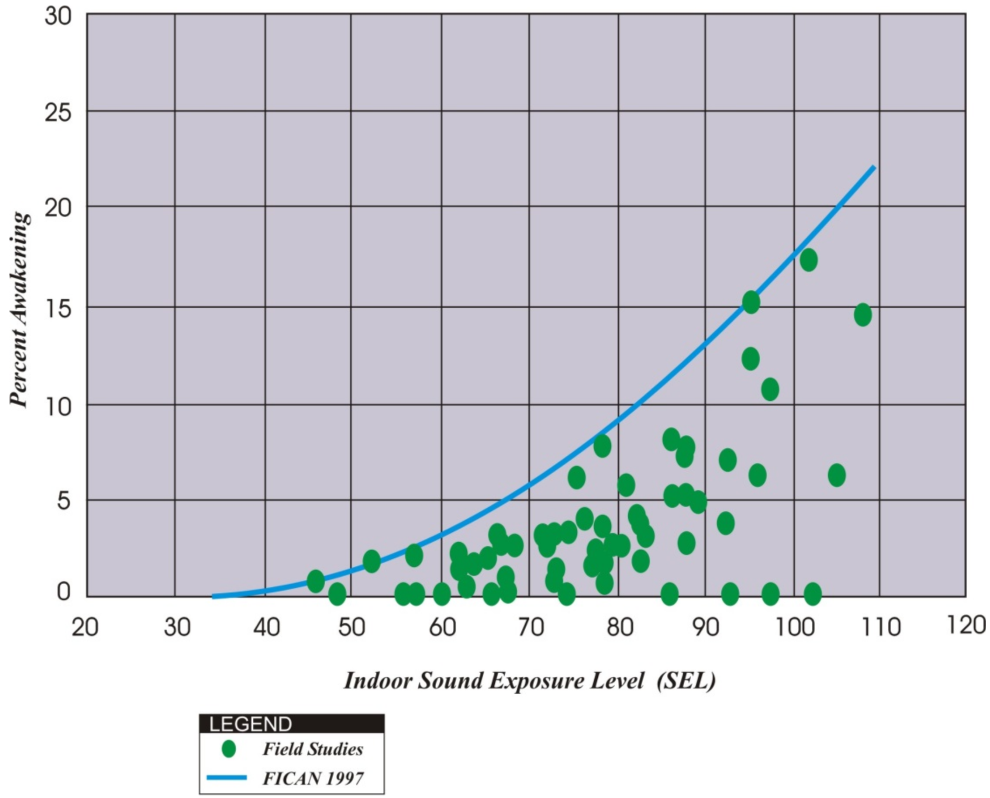
- Time Above (TA)
  - Developed by FAA to serve as a second metric for assessing impacts of aircraft noise around airports
  - TA refers to the total time, in seconds or minutes, that aircraft noise exceeds certain dBA noise levels in a 24 hour period
  - Typically expressed as Time Above 75 and 85 dBA
  - 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

# Speech Interference




Source: U.S. EPA

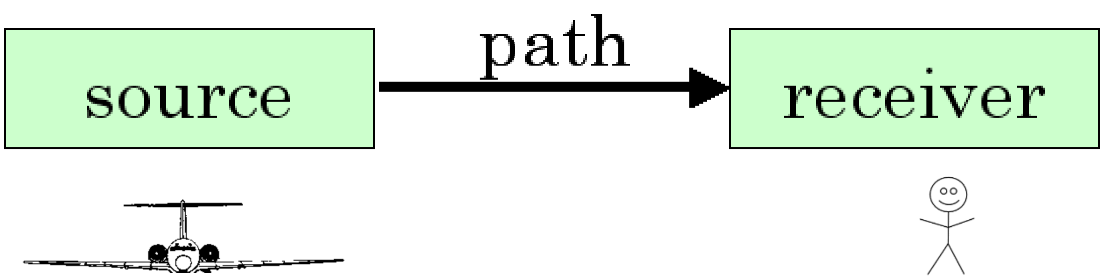
# FICAN Sleep Disturbance Dose-Response Relationship




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

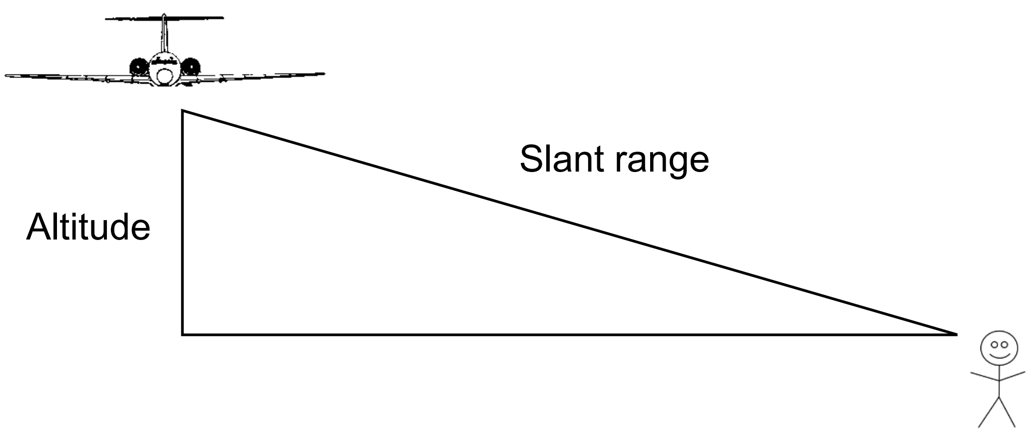
# Principles of Aircraft Noise Control

- Source
- Path
- Receiver



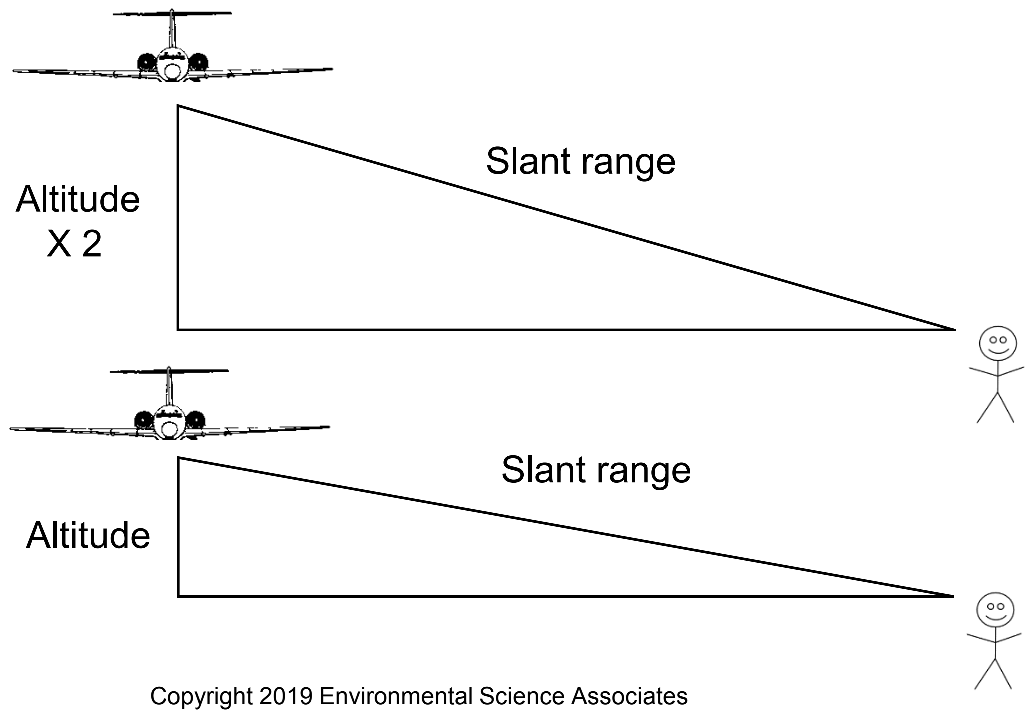
# Principles of Aircraft Noise Control

- 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



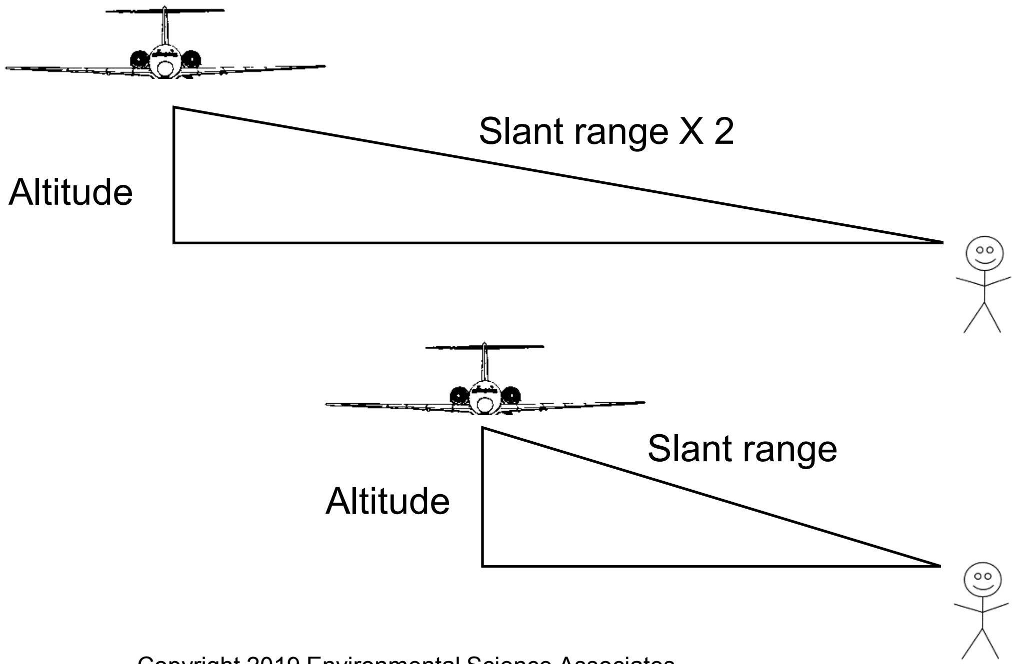
# Noise Abatement – Aircraft in Flight

- Example: Double the altitude



# Noise Abatement – Aircraft in Flight

- Example: Double the slant range



# Acoustical Rules of Thumb

- It takes a 3-dB change in the level of a noise source for most people with good hearing to notice a difference in a laboratory setting
- *Doubling* the distance between the source and the receiver results in a 6-dB *reduction* in sound level
- *Halving* the distance between the source and the receiver results in a 6-dB *increase* in sound level
- A 10-dB increase or decrease in sound level is typically perceived as doubling or halving of the loudness, respectively

# 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

ESA Airports



*Questions?*