Educational Series: Sound Propagation and Noise Contours

March 2023

Sound Propagation (How Sound Travels)

- Geometric spreading of sound
- Meteorological effects
- Ground effects
- Barrier Effects

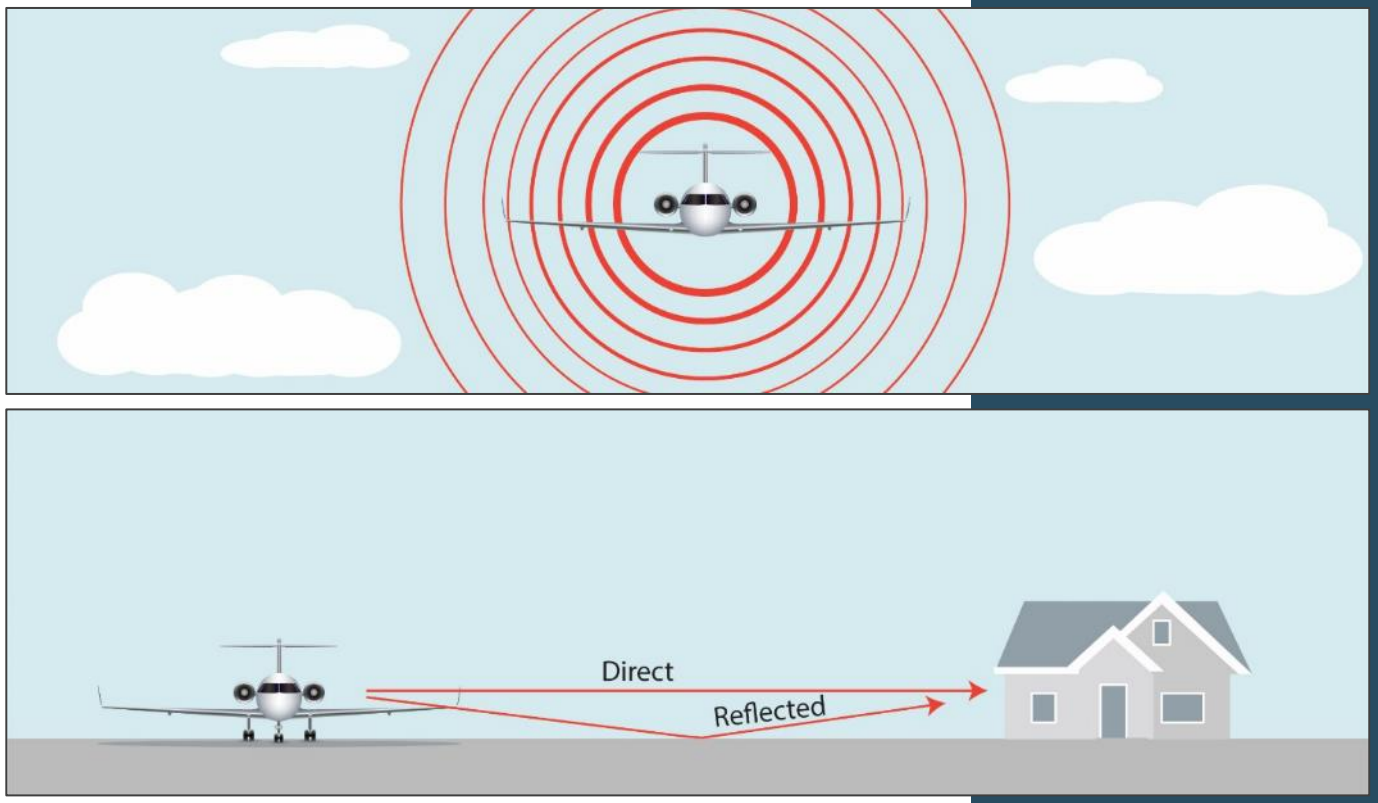
Sound Propagation

Spherical Spreading:

- Sound level decreases by 6 dB per doubling of distance
- Additional losses due to atmospheric absorption

Ground Effect:

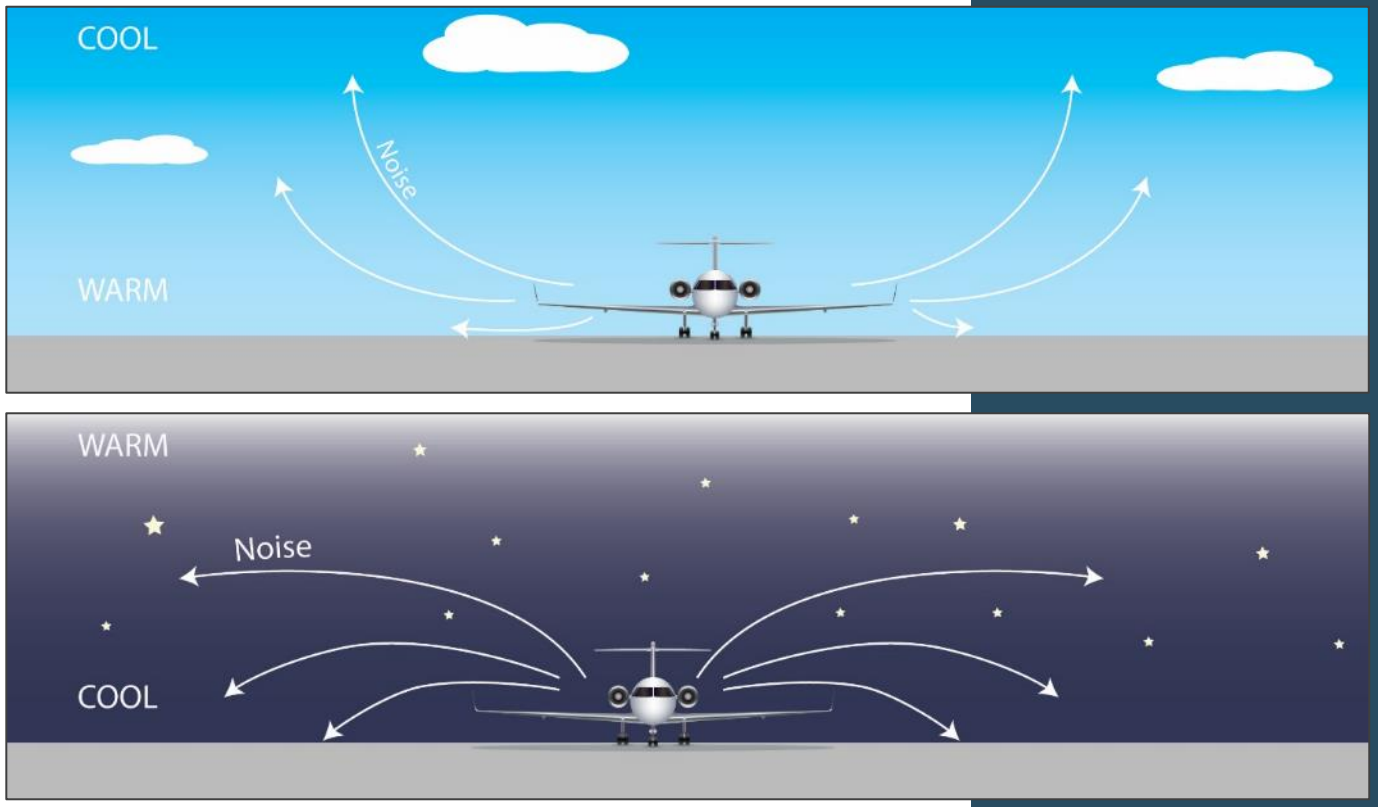
- Sound levels are lower when reflected off soft ground vs. hard ground



Sound Propagation

Refraction due to Temperature:

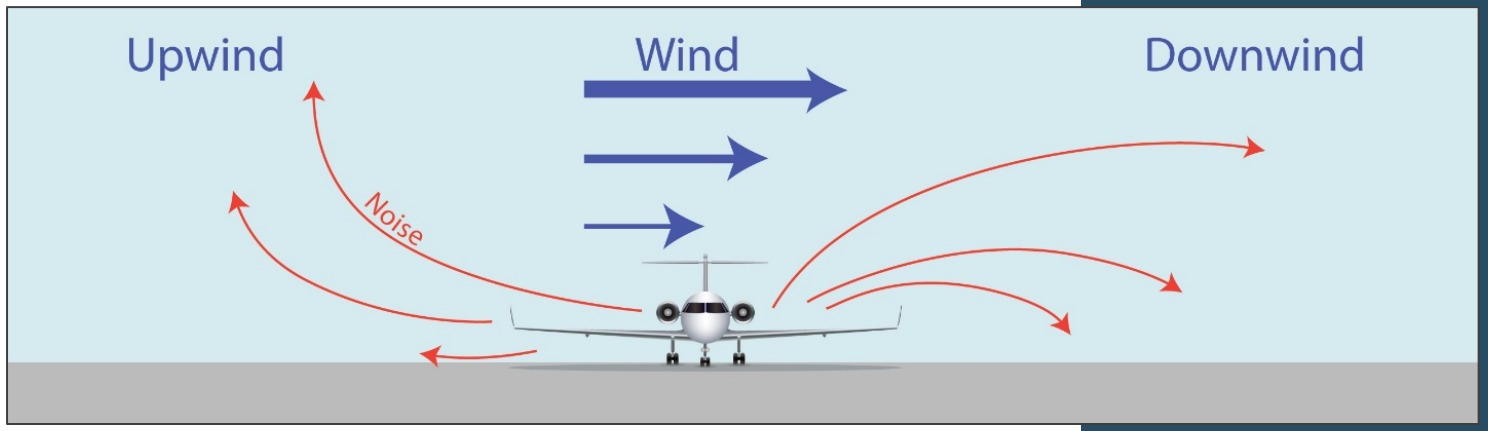
- Gradients in temperature cause the bending of sound paths
- Sound bends upward during a temperature lapse (cool air over warm)
- Sound bends downward during a temperature inversion (warm air over cool)



Sound Propagation

Refraction due to Wind:

- Gradients in wind speed cause the bending of sound paths
- Sound bends upward causing sound shadows in the upwind direction
- Sound bends downward increasing sound levels in the downwind direction
- Differences between upwind and downwind directions can be 20 dB



Sound Propagation Fog/Light Rain

Sound “carries” well due to:

- Low winds, no sun
- Very little upward refraction
- Thus no sound “shadows”

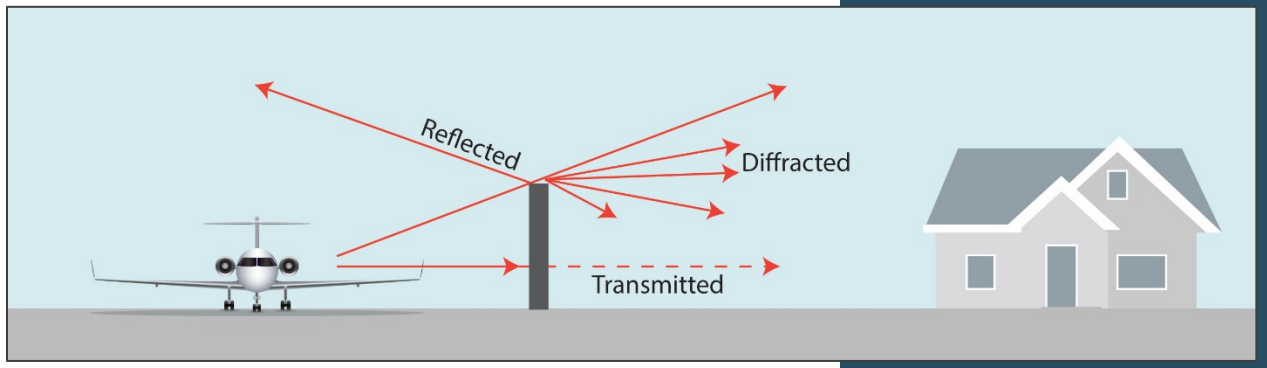
Sound Propagation Ground Effects

Sound propagation over ground is affected by reflective or absorptive properties of the ground: soft vs hard

- This effect is important when aircraft are on or near the ground (elevation angle < 30 degrees)
- Hard ground (including water) is reflective and can increase sound levels
- Soft ground is absorptive and attenuates noise – depends on distance
- Freshly-fallen snow absorbs sound well

Sound Propagation Barrier Effects

- Obstacles can attenuate and/or reflect sound
- Barriers are effective when they
  - Block line of sight between source and receiver
  - Are made of dense materials with no gaps
  - Are close to source or receiver
- Barriers' effectiveness can be reduced by winds
- Barriers are not effective for airborne sound sources



Noise Exposure Contours (Federal vs. State Requirements)

- Development
- Use
- Updating

Applicable Federal and State Regulations

- Federal Regulation
  - Title 14 of the Code of Federal Regulations **Part 150** "Airport Noise Compatibility Planning"
  - Noise Exposure Map (NEM) documents the noise exposure from aircraft operations and the resulting land use compatibility – all land use compatible outside the 65 DNL (CNEL) contours
  - ***Voluntary program for airports to participate to be eligible for federal funding*** to support the implementation of land use compatibility measures, e.g., sound insulation

- State Regulation
  - **Title 21** subchapter 6 – California Airport Noise Standards, Department of Aeronautics within Caltrans (California Department of Transportation)
  - County designates an Airport as having a "Noise Problem" and then must submit quarterly noise reports to the State with:
    - A map showing the noise impact boundary (65 CNEL)
    - The annual noise impact area (incompatible land uses w/in 65 CNEL)
    - Daily CNEL measurements
    - *Form DOA 617* (inventory of aircraft operations, number of people exposed to 65 CNEL and above, etc.)

Noise Contour Development

- Federal (Part 150)
  - Use FAA noise model – AEDT
  - Input annual-average day of aircraft operations
- State (Title 21)
  - Use noise model[1]
  - Input annual-average day of aircraft operations
  - Use annual CNEL noise measurements to determine the extent (closure points) of the 65 CNEL contour

[1]Title 21 states to use noise measurements *OR* use a noise model and noise measurements to determine the noise impact boundary (65 CNEL contour).

Noise Contour Use

- Federal (Part 150)
  - Assess incompatible land use
  - Implement noise mitigation measures to address incompatible land use (e.g., sound insulation)
- State (Title 21)
  - Determine noise impact boundary
  - Determine noise impact area
    - Area of incompatible land use within the noise impact boundary

Noise Contour Updates

- Federal (Part 150)
  - Every five years or sooner if a significant change to noise exposure is expected
    - Significant change is 1.5 dB in terms of DNL (CNEL in California)
- State (Title 21)
  - Prepare Quarterly Noise Report including an updated 65 CNEL contour with a full one year of measurements (rolling year ending in the quarter of the Report)

Noise Contour Summary

- Federal (Part 150)
  - *Developed* using AEDT for annual-average day of aircraft operations
    - No adjustments allowed based on noise measurements
  - *Used* to assess incompatible land uses and to implement noise mitigation measures
  - *Updated* every five years or sooner if significant change is expected

Note: federal funds available to implement noise mitigation programs

- State (Title 21)
  - *Developed* using noise measurements OR using a noise model and noise measurements
    - Contour extents determined using noise measurements
  - *Used* to determine the noise impact boundary and noise impact area (incompatible land uses)
  - *Updated* every quarter (three months) based on 12 months of data

Note: no funding mechanism to assist with noise mitigation

Questions/Discussion

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