Overview of En Route Noise Prediction Using a Integrated Noise Model

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- **Needs for en-route noise prediction**
- Previous studies & insights
- Current prediction capabilities
- Emerging development
- Future development requirements

Background & Needs

- **New, advanced propulsion systems are in development (i.e., open rotor)**
  - Fuel efficient
  - Potential noise issues
    - Produce higher noise levels than conventional aircraft
    - Tonal content at low frequencies
  - A potential challenge for aircraft flying at high altitude (en route) over areas with very low ambient noise levels (parks, wilderness areas, etc.)

Background & Needs

- **En route aircraft noise is often ignored in aircraft noise modeling, because:**
  - Large amount of noise attenuation due to long propagation distances between the aircraft and the receivers on the ground;
  - Reduced power in cruise flight compared to takeoff operations; and
  - Aircraft noise assumed insignificant relative to airport/community ambient noise
- **For this reason, the FAA aircraft noise models currently have the following recommended altitude cutoffs:**
  - Integrated Noise Model (INM) - 3,048 m (10,000 ft) above field elevation (AFE); and
  - Noise Integrated Routing System - 5,486 m (18,000 ft) AFE

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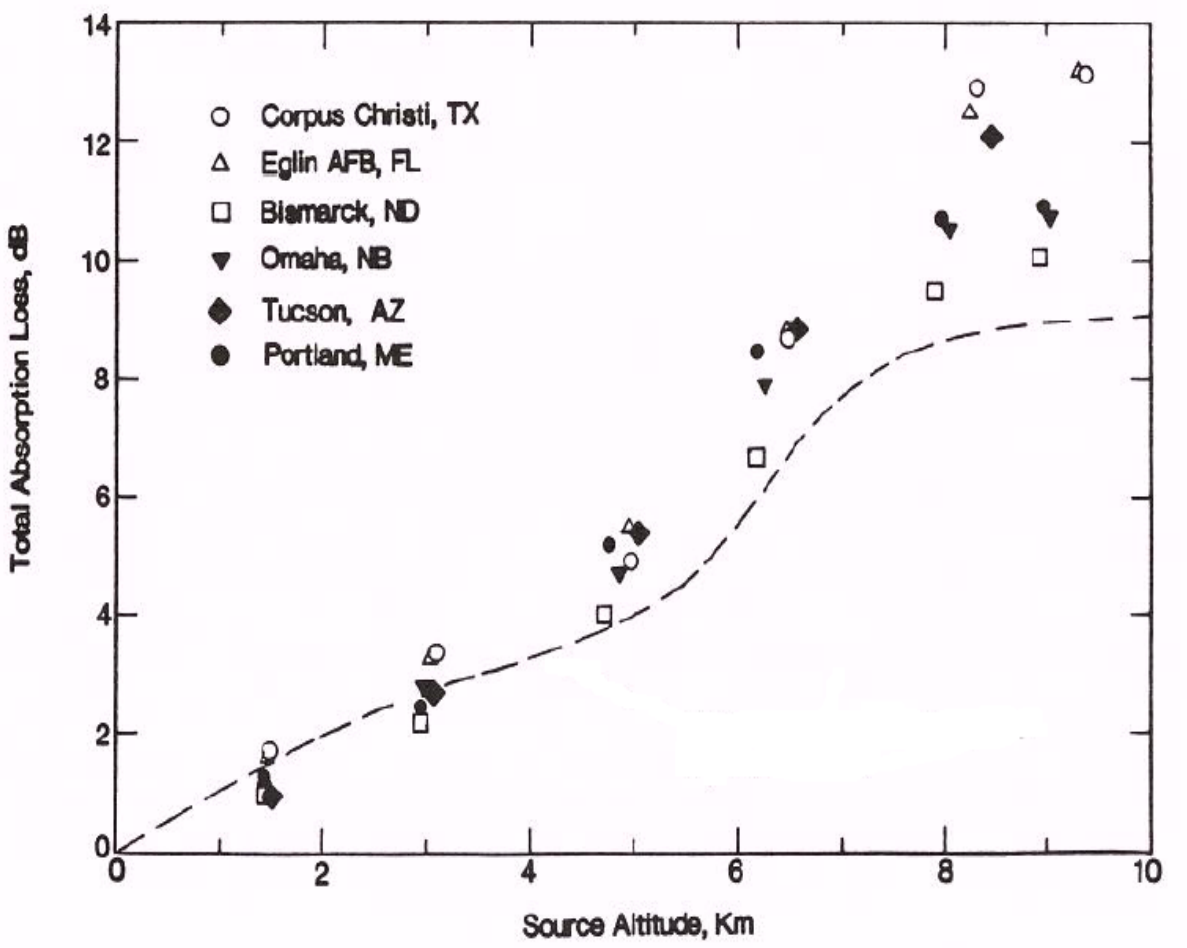
NASA Studies – late 80s

- **1987 & 1989 - series of flight tests of the Propfan Turboprop Assessment (PTA) aircraft**
  - FAA, National Aeronautics and Space Administration (NASA) and Volpe collected acoustic and weather data during flight test (at altitude and on the ground)
  - Reported on at FAA/NASA en route noise symposium in 1989

Key insights:

- Baseline source data from aircraft flying at cruise altitudes (minor day-to day variation)
- Assess potential variability in received noise levels caused in part by atmospheric effects (large day-to-day variation)
- Source noise characterization very important, but complicated by couplings among design variables.

Sutherland Study (1 of 2)

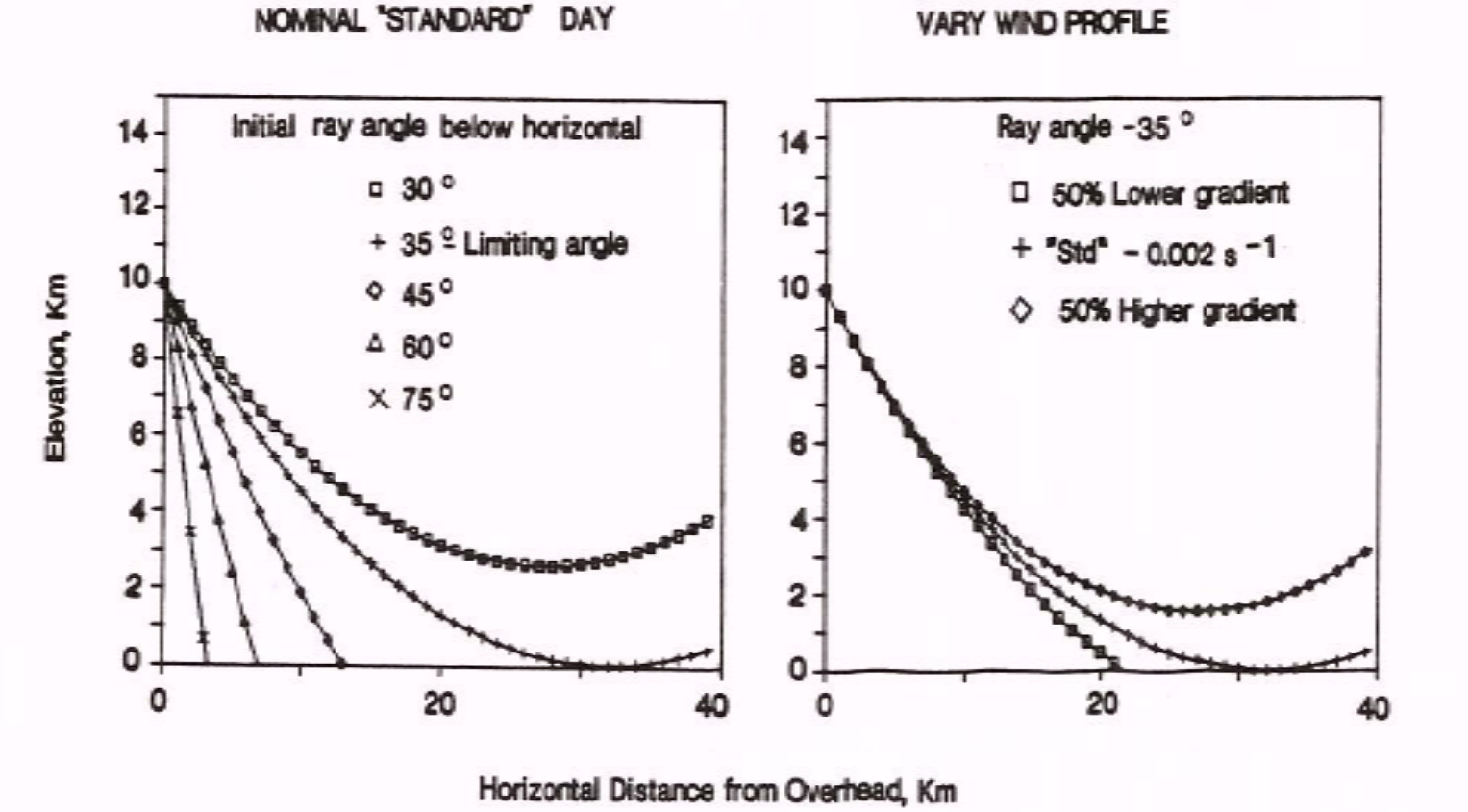


Key insights:

- Rapid increase in absorption 5-7 Km, gradual beyond 7Km.
- Low frequency noise decay much slower.

Cumulative air absorption loss at 250 Hz versus source altitude.
(courtesy of Louis C. Sutherland)

Sutherland Study (2 of 2)



Key insights:

- Source lateral directivity very important
  - Some sound may never propagate to the ground

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Current Capabilities

- **INM (Integrated Noise Model)**
  - Developed since 1978 – based on SAE AIR 1845.
  - A line source noise model and linked to aircraft performance. NPD (Noise-Performance-Data) is the basis.
  - Using surface meteorological data & simple atmospheric absorption algorithms for acoustic adjustments.
  - Takeoff altitude cutoff at 10,000 ft.
  - FAA's preferred model for environmental studies at or near airports.
  - Used both in the US and abroad.

Integrated. vs Simulation Modeling

Descriptions	Integrated Noise Models	Simulation Models
Uses	**Commercial airport land-use and air traffic routing planning, environmental impact studies in various cases including National Parks in the US, regional, national and global noise analysis, policy studies and research.**	**Various applications, some are special - both civilian and non-civilian.**
Source Spectrum	**Representative spectra for typical operations**	**Actual spectrum**
Noise propagation to reference distance(s)	**Multiple distances are pre-defined in NPD. Other distances are inter-/extrapolated.**	**Only to one reference distance, rest to calculate in program**
Atmospheric Absorption	**SAE-ARP-866A[27]**	**ISO 9613[28]**
Directivity – lateral	**Aircraft-type specific adjustment outside NPD based on SAE-AIR-5662**	**Defined at source**
Directivity – longitudinal	**Reflected in the closest point approach and associated adjustments[13,19, 20,21]**	**Defined at source**
Sources of aircraft data	**Mostly from aircraft manufacturers following guidance in SAE-AIR-1845[13]. Occasionally via special measurements by software development team[19].**	**Mostly through special measurement by software development team and stakeholders. Occasionally derived from integrated noise model database**

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Emerging Development

- **AEDT (Aviation Environmental Design Tool)**
  - Environmental impacts model
    - Models noise, emissions, fuel burn, climate change and their interdependencies
    - Will replace INM in 2013
  - Models aircraft en route and cruise performance through the use of Eurocontrol's Basis of Aircraft Data (BADA).
    - Used for runway-to-runway fuel burn analysis.
    - Weather module
    - Limited research has begun to investigate modeling noise from high-altitude flights in AEDT.

Emerging Development

- **ANOPP 2 (NASA model)**
  - Single aircraft operation noise model
    - Includes component noise and source directivity
    - Accounts for the effects of atmospheric wind and temperature gradients
    - Accounts for future aircraft

AEDT and ANOPP2 can be used in conjunction with each other.

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Future Development Requirements

- **Use and users**
  - Environmental studies/policy support
  - Integrates with the existing FAA noise modeling tools
- **Precision**
  - Predictive of effect / data availability
- **Accuracy**
  - Predictive of contribution and levels
- **Runtime management**
  - Need to address receptors in a large area
  - Need to develop approximation techniques
- **Interface/consistency with other modules**
- **Verification and validation**
- **Other**

Concluding Remarks

En route noise prediction is needed but there are many challenges and technical gaps. Coherent strategy is important and development requirements are outlined so that the existing and emerging capabilities can be leveraged.

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