Aircraft Noise

- **How noise is measured**
- **Past progress in noise reduction**
- **Future requirements for noise reduction**

Noise and the decibel scale

Definition:

The decibel (dB) is a measure, on a logarithmic scale, of the magnitude of sound pressure with respect to a standardised reference quantity

Consequence: "80dB + 80dB = 83dB"

Decibels don't add arithmetically, but logarithmically

Aircraft noise reduction perception:

Level Reduction	Perception
1-2dB	Barely perceptible
2-3dB	Moderately perceptible
5dB	Clearly perceptible
10dB	Half as loud
20dB	One quarter as loud

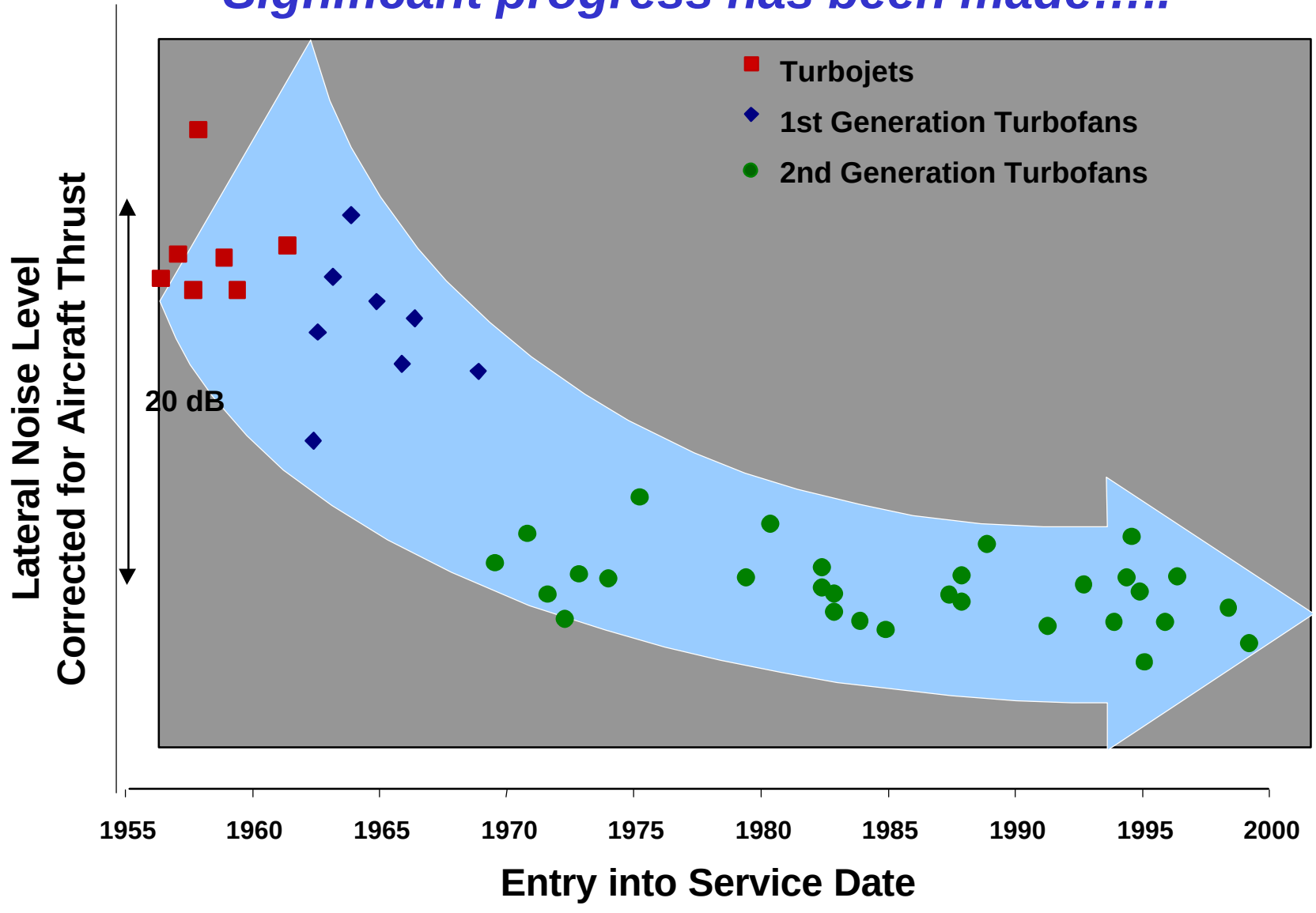
It takes a large amount of acoustic energy reduction to produce a significant perceived difference

EPNL = Effective Perceived Noise Level

- **Subjectively weights Sound Pressure Level - SPL (decibels) - to provide Perceived Noise Level (tone corrected) - PNLT (dB)**
  - Over the range of audible frequencies
  - Emphasizes the most annoying frequencies
  - Corrected for annoying strong tones
- **Sums / integrates the weighted spectrum or PNLT over time**
  - Over the duration of the fly-over event
  - For the interval when the Perceived Noise Level is above a threshold level
- **EPNL, among today's existing units, is recognized as the one offering the best correlation between the measured noise level and the perceived noisiness during an aircraft fly-over event**

Progress in noise reduction

Significant progress has been made…..



How aircraft became quieter

➢ **Turbojet to 1st-generation Turbofan - 1950s to 1970s**

- Revolutionary Improvement to Engine Architecture

  Before: Smaller, High-Velocity Jets - High Noise Levels

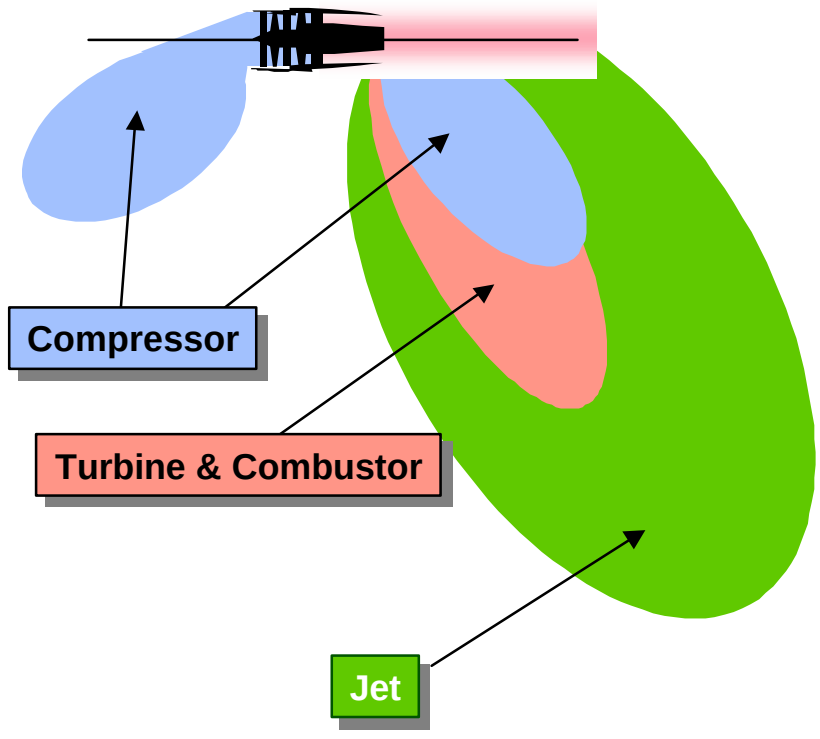
  After: Larger, Low-Velocity Jets - Lower Noise Levels

➢ **1st-Generation to 2nd-Generation Turbofans - 1970s to 1990s**

- Evolutionary Improvements in Reducing Sources of Noise
- Evolutionary Improvements in Noise Suppression Devices
- Evolutionary Improvements in Aircraft and Propulsion Efficiency
- Adoption of Noise Abatement Procedures

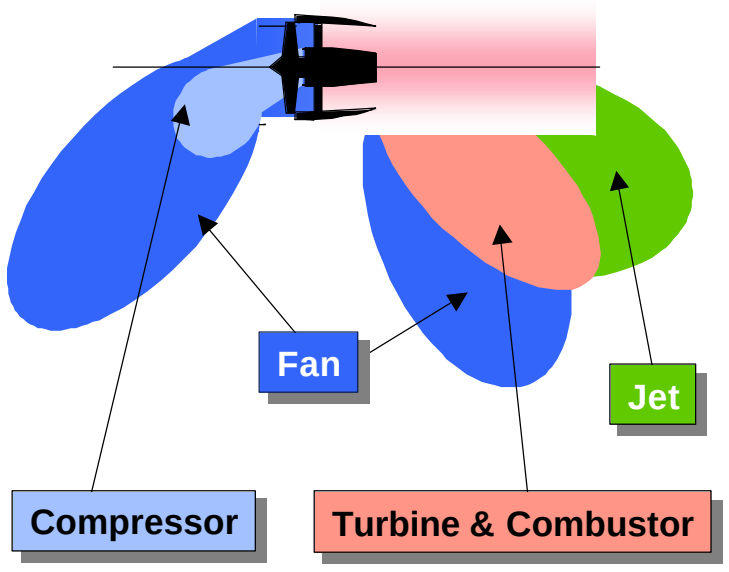
Engine Noise Sources - Old versus New

Noise of a typical 1960s engine



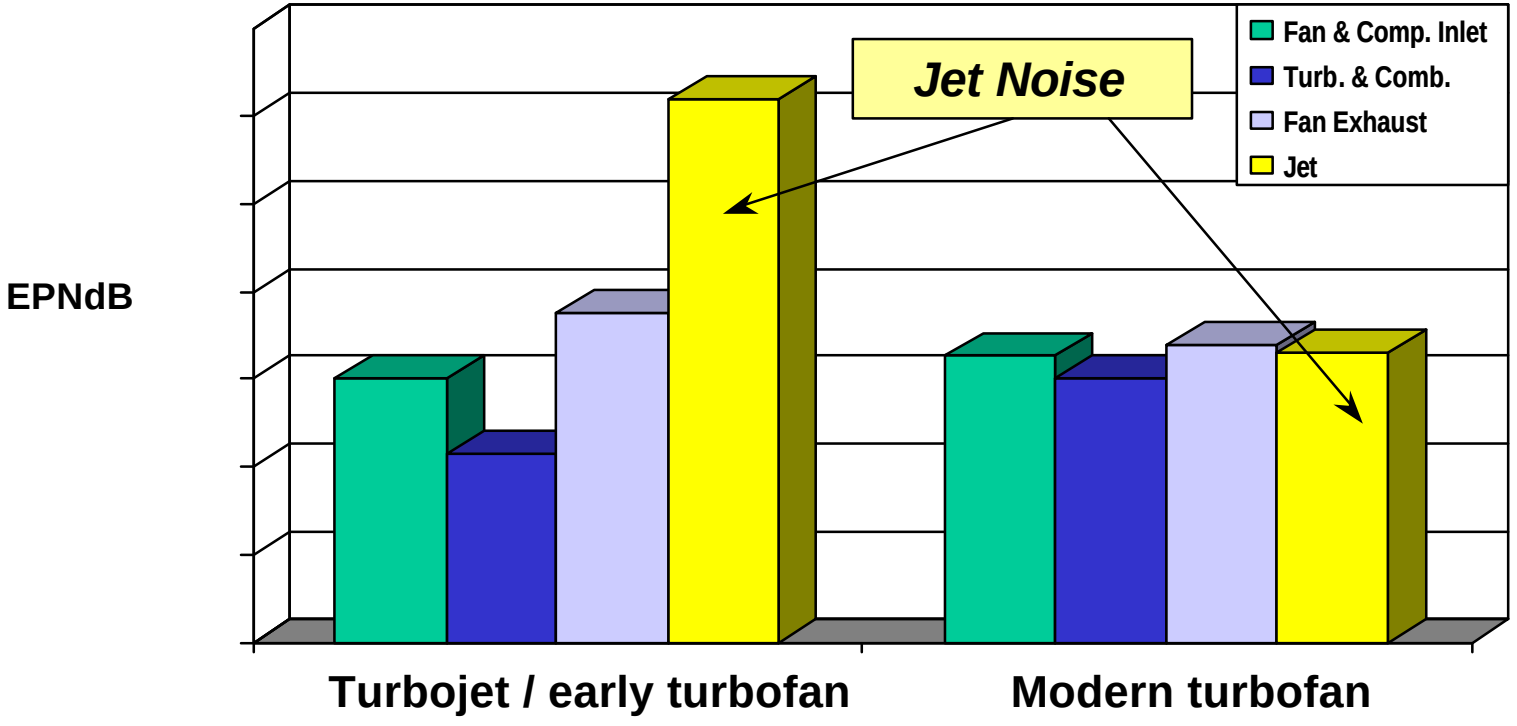
Turbojets dominated by high jet exhaust noise at departure - loud roar, rumble

Noise of a typical 1990s engine



High-bypass-ratio turbofans dominated by fan noise - whine, whistle - and lower jet exhaust noise - roar, rumble

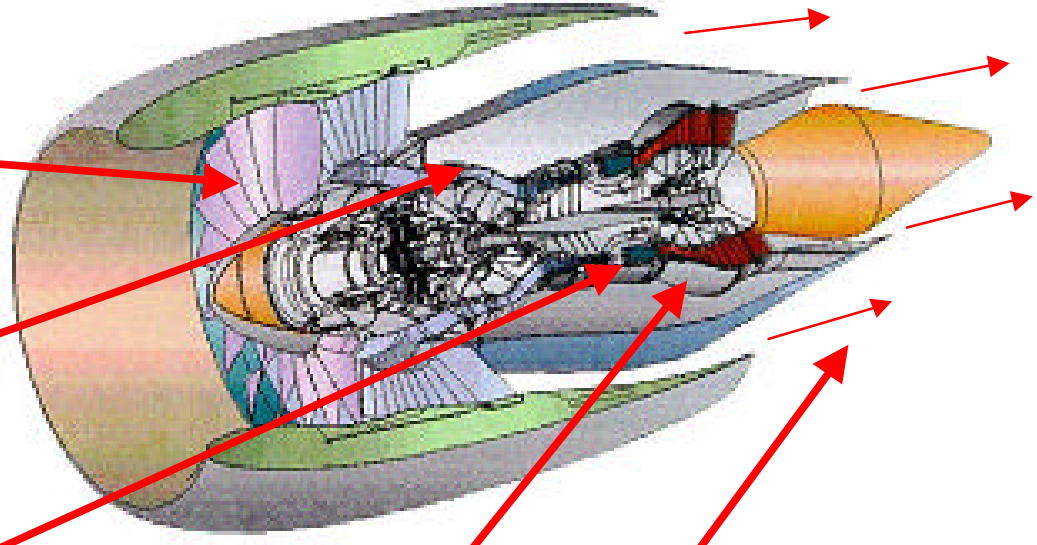
Old versus New Engine Noise Sources



As bypass ratio has increased, jet noise has become less dominant
<u>Noise reduction is now needed for all components</u>

Engine Noise Source Identification

Fan:
- Tones (All frequencies)
- Broadband Noise
- “Buzz-Saw” Noise



Compressor:
- Tones (High frequency)
- Broadband Noise

Combustor:
- Broadband Noise (Low frequency)

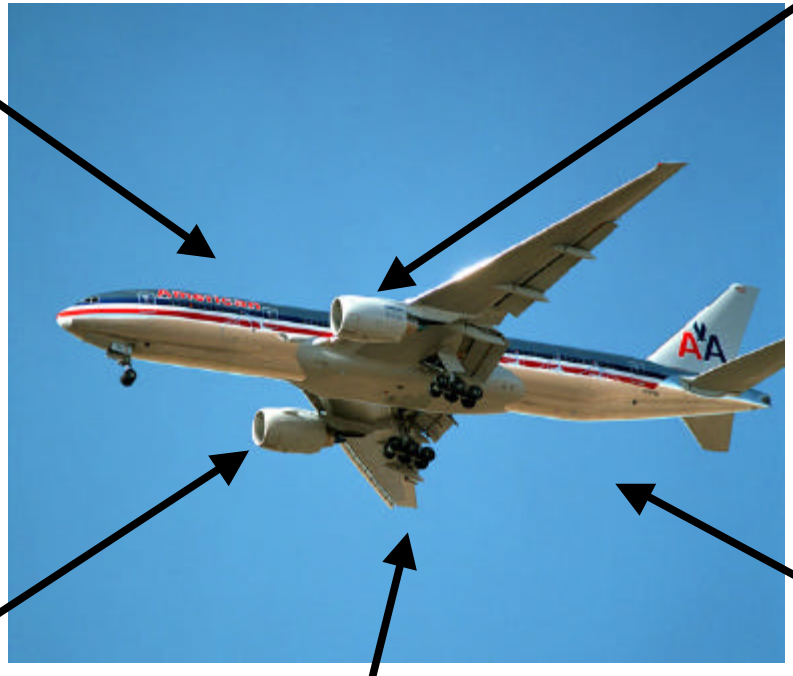
Jet:
- Broadband Noise (Low frequency)

Turbine:
- Tones (High frequency)
- Broadband Noise (High frequency)

Noise is the result of the optimisation of the aircraft as a global system

Low speed performance

Nacelle acoustic performance



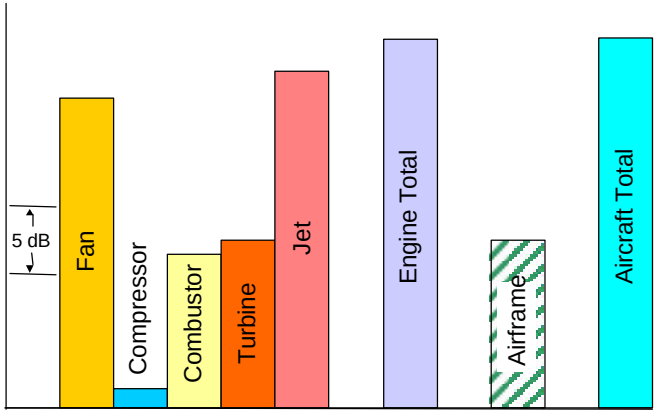
Engine noise

Airframe noise

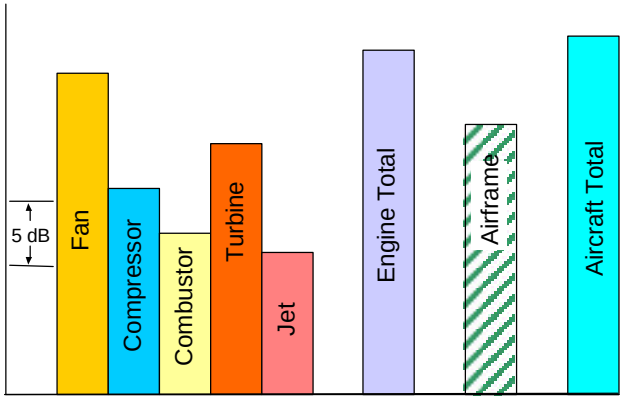
Noise abatement procedures capability

Source noise component contributions

- ***Jet and Fan Noise important at Departure***
- ***Fan, Airframe, and Turbine Noise important at Arrival***



Typical Departure Noise Distribution



Typical Arrival Noise Distribution

Summary

- Human sensitivity to sound is reflected in the logarithmic EPNLdB metric. As a consequence, a challenging reduction in noise energy is required to achieve a significant improvement.
- Aircraft noise is made up of many complex sources. Further aircraft noise reduction relies on progress on all these noise components.
- Technology has delivered major reductions in noise, but further progress will require sustained investment.