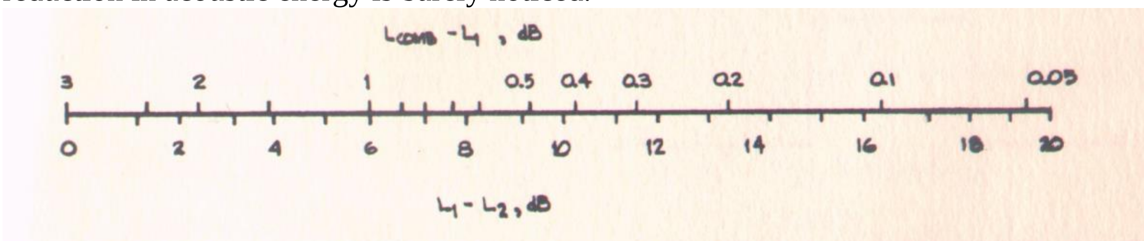
8.7 Aural Signature

In the past 50 years, a large amount of effort has been made in making aircraft quieter. Initially the effort concentrated on engine noise, and engines are now sufficiently quiet that airframe noise may dominate in some flight modes, such as approach. Part of the difficulty in reducing noise is that the human ear is capable of perceiving noise with many orders of magnitude difference in acoustic energy, with the result that a significant reduction in acoustic energy is barely noticed.

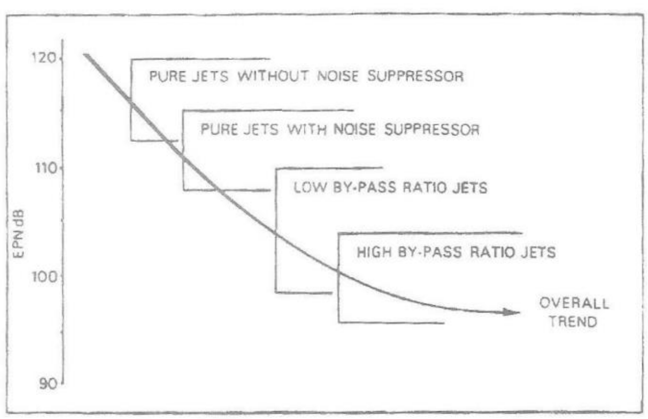


Source: Richard H Lyon – Transportation Noise

Fig. 8.7.1 Adding Noise Sources

The effect of different noise sources must be added logarithmically. For example, if there are two dominant noise sources, L_1 and L_2, of equal perceived noise level, then the combined noise level, L_{COMB}, is only 3 dB above the level of L_1, as illustrated in Fig. 8.7.1. A difference of 3 dB is recognizable by the human ear, but is not particularly noticeable. If L_2 is reduced by 10 dB, which is an order of magnitude less acoustic energy, then the combined noise level is still about 0.4 dB above L_1, with a net noise reduction of 2.6 dB. Thus all dominant noise sources must be reduced to achieve significant noise reduction.

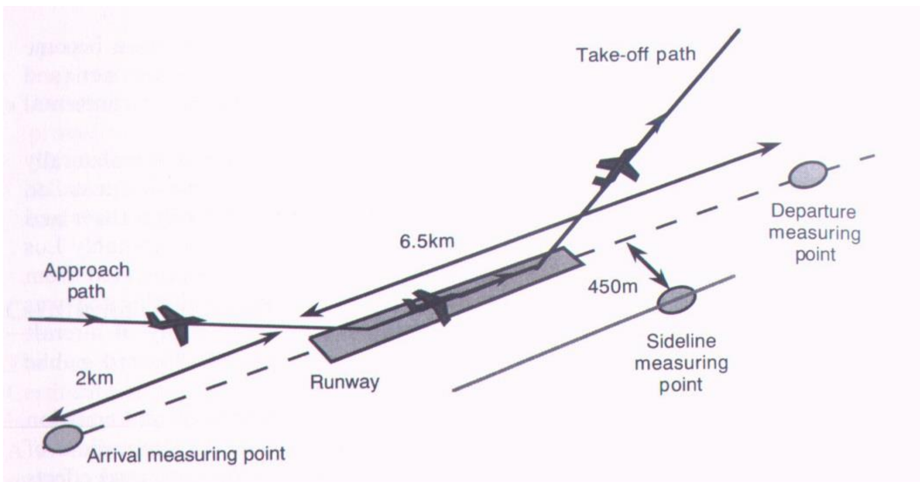
In the 1960s the proliferation of large commercial aircraft with pure jet or low bypass ratio engines started to have a significant impact on noise around airports. In 1969, to ameliorate this noise, commercial aircraft (except for military) became subject to noise limits defined by FAR Part 36. These limits have now been extended to include all other civil aircraft, including helicopters and tilt-wing aircraft.



Source: Schaufele

Fig. 8.7.2 Jet Engine Noise Trends

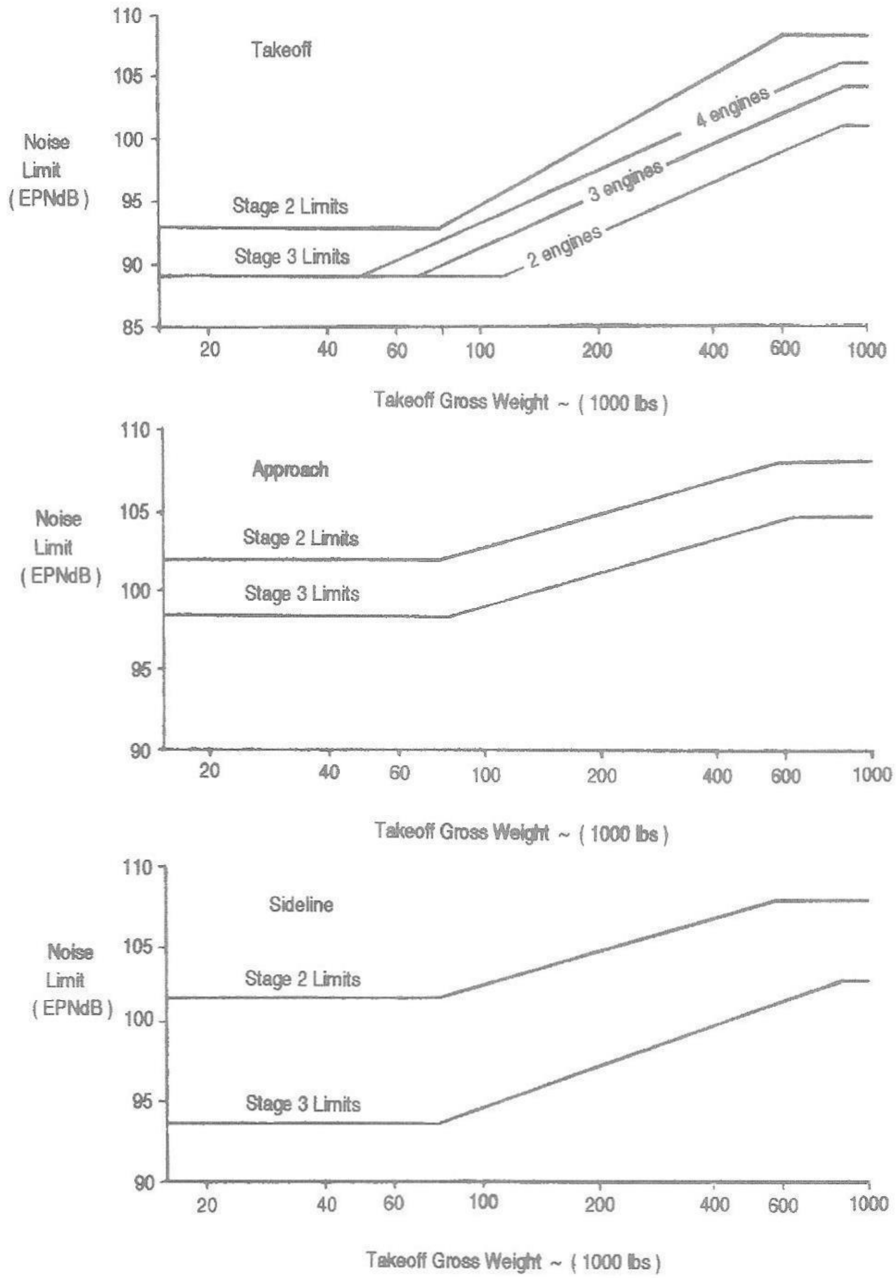
For commercial aircraft, noise limits have been set with multiple stages of increasing stringency. Stage 1 permitted older aircraft to be "grandfathered" into the regulations, although some of the older aircraft had to be modified to meet the regulations. Stage 2 required some noise reduction for current aircraft. Stages 3 and 4 progressively lowered the limits for new aircraft. High bypass ratio engines, as currently used by commercial aircraft, are inherently quieter than the older engines, as illustrated by Fig. 8.7.2, but engine manufacturers still had to work hard to meet the limits.



Source: Jenkinson, Simpkin and Rhodes – Civil Jet Aircraft Design

Fig. 8.7.3 FAR Part 36 Noise Measurement Points

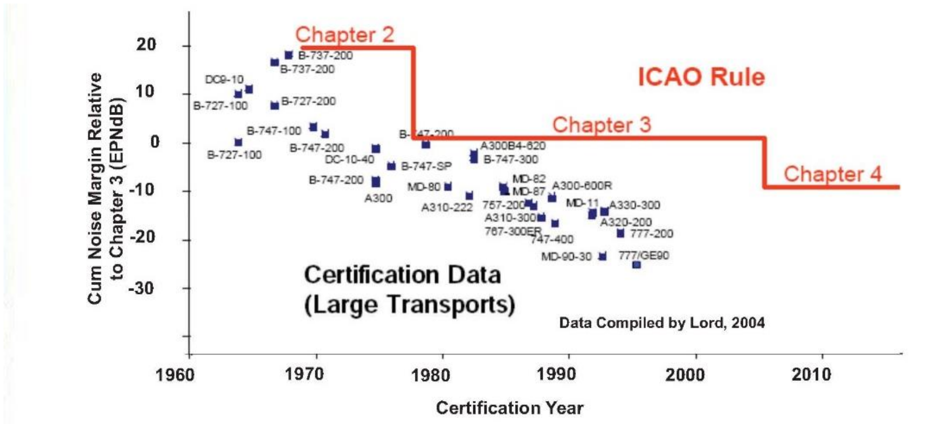
Under FAR Part 36 rules, noise is measured as Effective Perceived Noise in decibels (EPNdB), a unit of noise that accounts for the subjective effect of noise with weighting according to frequency, tones, and duration. For fixed-wing aircraft, noise is measured at three locations relative to the runway threshold (Fig. 8.7.3). The sideline measuring point is at the loudest value of all points along the sideline (this requires an array of microphones along the line). Note that the scale for Takeoff Gross Weight is logarithmic.



Source: Schaufele

Fig. 8.7.4 FAR Part 36 Noise Limits

The International Civil Aviation Organization (ICAO) is responsible for noise certification worldwide. ICAO Annex 16 has adopted FAR Part 36 rules for Stage 2 and Stage 3 as Annex 16 Chapters 2 and 3 (Fig. 8.7.4). Chapter 4 was adopted in 2006 and requires that the sum of the required values at the three measurement points be reduced by 10 EPNdB. The vertical axis of Fig. 8.7.5 shows the cumulative noise margin of airplane types relative to the Chapter 3 requirement for the TOGW of that aircraft. For example, it shows that the 747-400 is well below its Chapter 3 limit. However, its noise level is not below that of the A310-300. It is just that the A310-300 is closer to the limit value for its TOGW.



Source: Baldwin – Harris Miller Miller and Hanson

Fig. 8.7.5 ICAO Annex 16 Rules