

Volpe Acoustics

Characterization of Background Noise

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Overview

- ❑ Many applicants are incorrectly characterizing the various elements of background noise used in correction and adjustment procedures for aircraft noise certification
- ❑ Such errors can cause the elimination of valid aircraft SPLs, or allow non-valid SPLs to be processed incorrectly
- ❑ This presentation provides detailed technical guidance on the proper characterization and use of background noise



Definitions

Definitions in ICAO Annex 16 and ETM have been revised to clarify elements of background noise (part 36 will be harmonized)

- ❑ Background Noise
- ❑ Ambient Noise
- ❑ Floor Noise
- ❑ Pre-Detection Noise
- ❑ Post-Detection Noise
- ❑ Masking Criteria



Common errors – part I



- ❑ Common problems with applicants' characterization of pre-detection and post-detection background noise:
 - Pre-detection spectrum includes SPLs that are invalid
 - Sometimes due to differences in system gain settings between measurements of ambient and floor
 - Sometimes pre-detection levels are masked by floor or post-detection noise, and are therefore invalid
 - Sometimes applicants are using non-valid pre-detection levels to both:
 - Set masking criteria, and
 - Perform “energy” subtraction on valid aircraft SPLs

Common errors – part 2

- Post-detection levels are frequently being mis-characterized using recordings of microphone simulators, shorted pre-amplifier inputs, “dummy” loads, or other means of characterizing instrumentation floor levels, which typically contain pre-detection noise (additive noise “energy”)
- Masking criteria are being mis-defined, resulting in either:
 - Allowing masked aircraft noise levels to be treated as valid, or
 - Rejecting valid aircraft SPLs and reconstructing them later in the process



Illustration: Post-detection background noise level determination

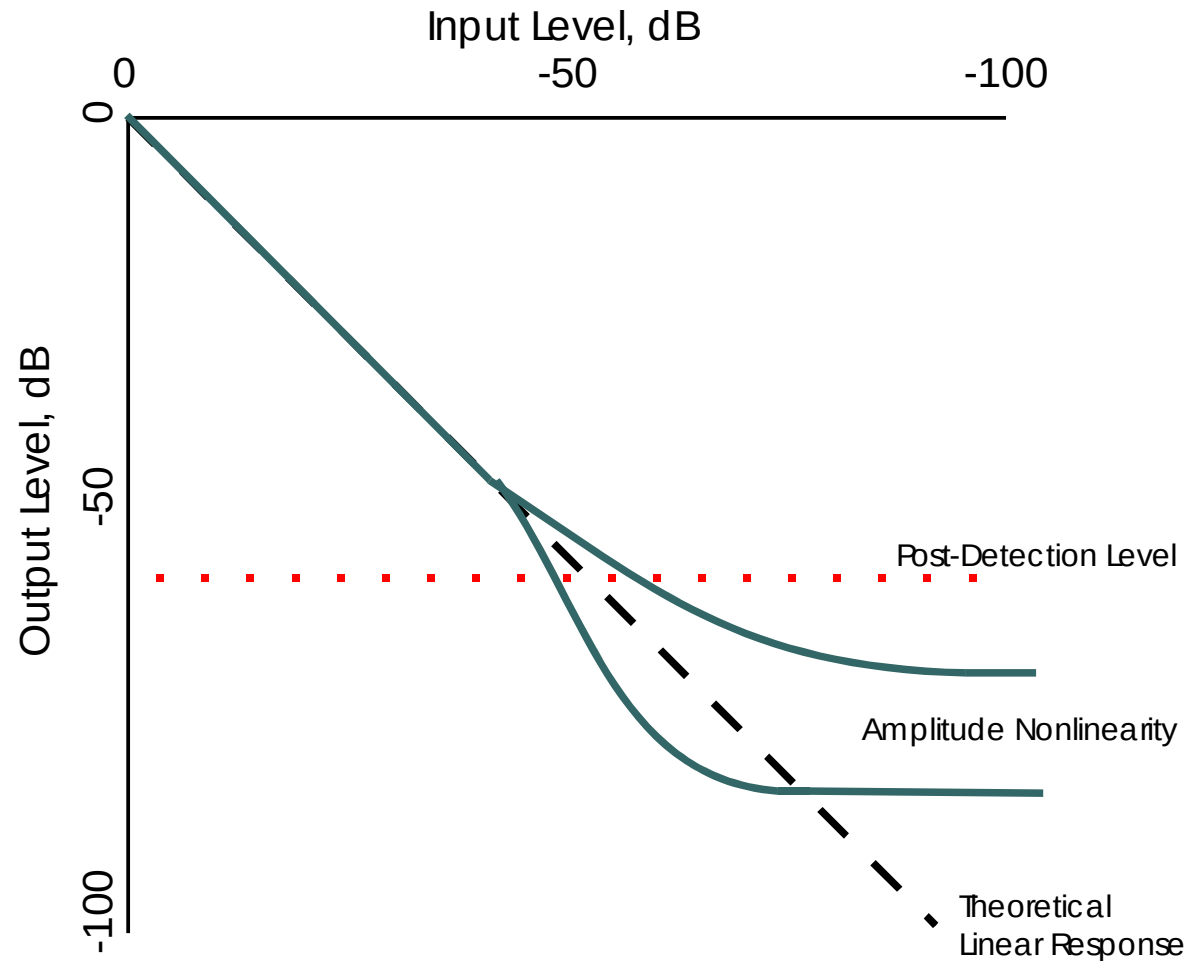
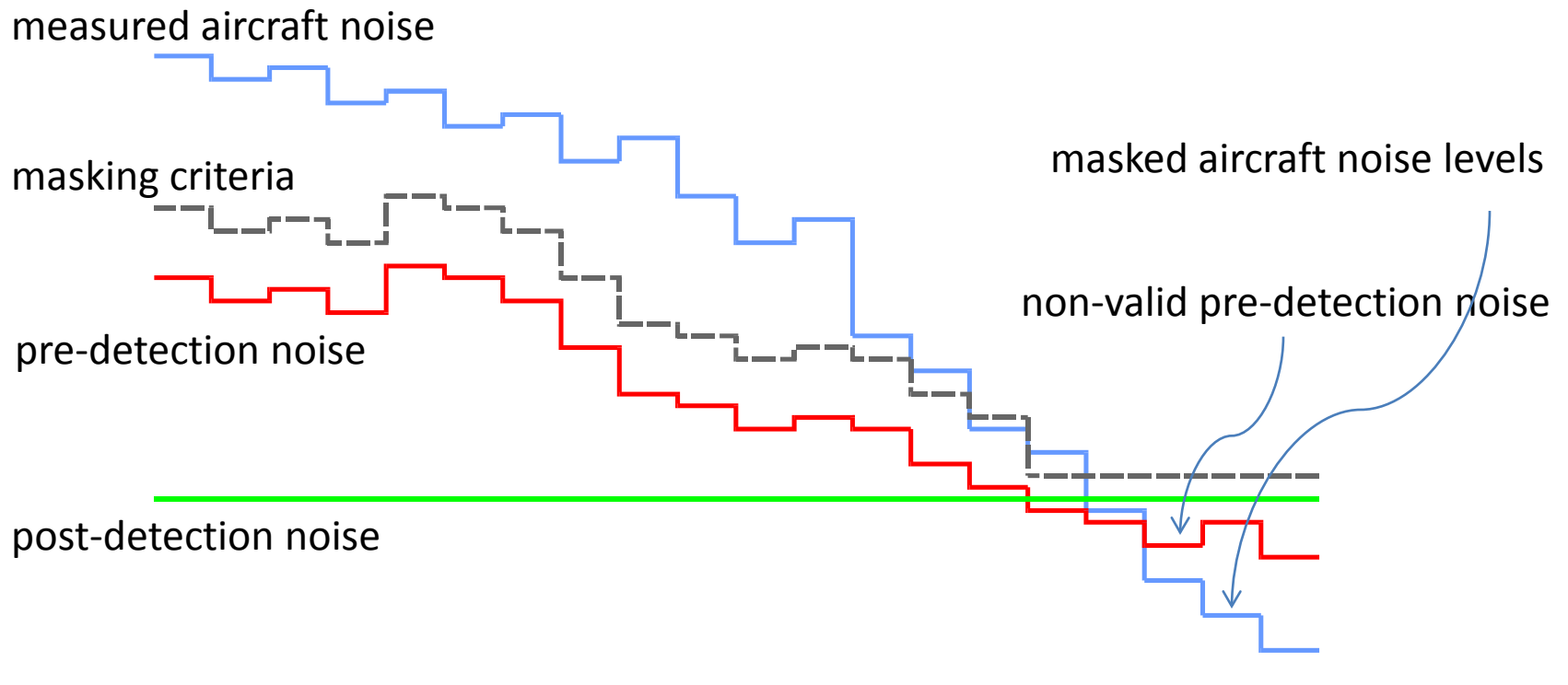


Illustration: Elements of background noise



Guidance on characterization of and use of background noise – part I

- ❑ Always measure background noise at same gain sensitivity settings as for aircraft noise
 - Ambient noise measurements should be performed for all system gain settings used during a group of aircraft noise measurements
 - Ambient noise should be collected frequently enough to adequately represent the prevailing background noise conditions during each aircraft noise measurement
 - Prior to establishing masking criteria or performing “energy” subtraction, pre-detection noise levels must be tested for validity:
 - For each 1/3 octave band, compare the pre-detection level to the associated post-detection level. If the pre-detection level is greater than the post-detection level (or post-detection level +1 dB), then the pre-detection level for that band is valid



Guidance on characterization of and use of background noise – part 2

- Non-valid pre-detection levels should be eliminated from further processing, including establishment of masking criteria and “energy” subtraction of background noise from aircraft noise levels
- Post-detection levels should be determined via laboratory testing, using discrete or swept sine tones, and calibrated measurement and gain control instrumentation
 - Post-detection levels may be based on:
 - Display or resolution limits of analysis instrumentation (including “underload” windowing)
 - Lower limit of acceptable amplitude non-linearity (such testing is required for all digital recording and analysis instrumentation)
 - Any other non-additive elements which influence minimum levels



Guidance on characterization of and use of background noise – part 3

- o Post-detection levels must also be determined at the system gain (sensitivity) settings used for each aircraft noise measurement
- o When more than one component in the measurement and analysis system imposes such lower limits on measured noise levels, the most restrictive must be used for each 1/3 octave band, therefore, a post-detection noise spectrum may be comprised of:
 - 24 identical values, based on displayed or theoretical values
 - A varying spectrum based on testing and or calculated values
 - Some combination of these



Guidance on characterization of and use of background noise – part 4

- Establishment of masking criteria:
 - Greater of:
 - Valid pre-detection +3 dB, or
 - Post-detection +1 dB
- Determination of masked aircraft noise levels:
 - IF $SPL(i) \leq MaskCrit(i)$ THEN SPL is masked and invalid
 - Masked SPLs must be tracked and reconstructed if possible in one of the following ways:
 - For low-frequency bands –
 - » Average of adjacent bands for single masked band
 - For high-frequency bands –
 - » Frequency-extrapolation
 - » Time-extrapolation



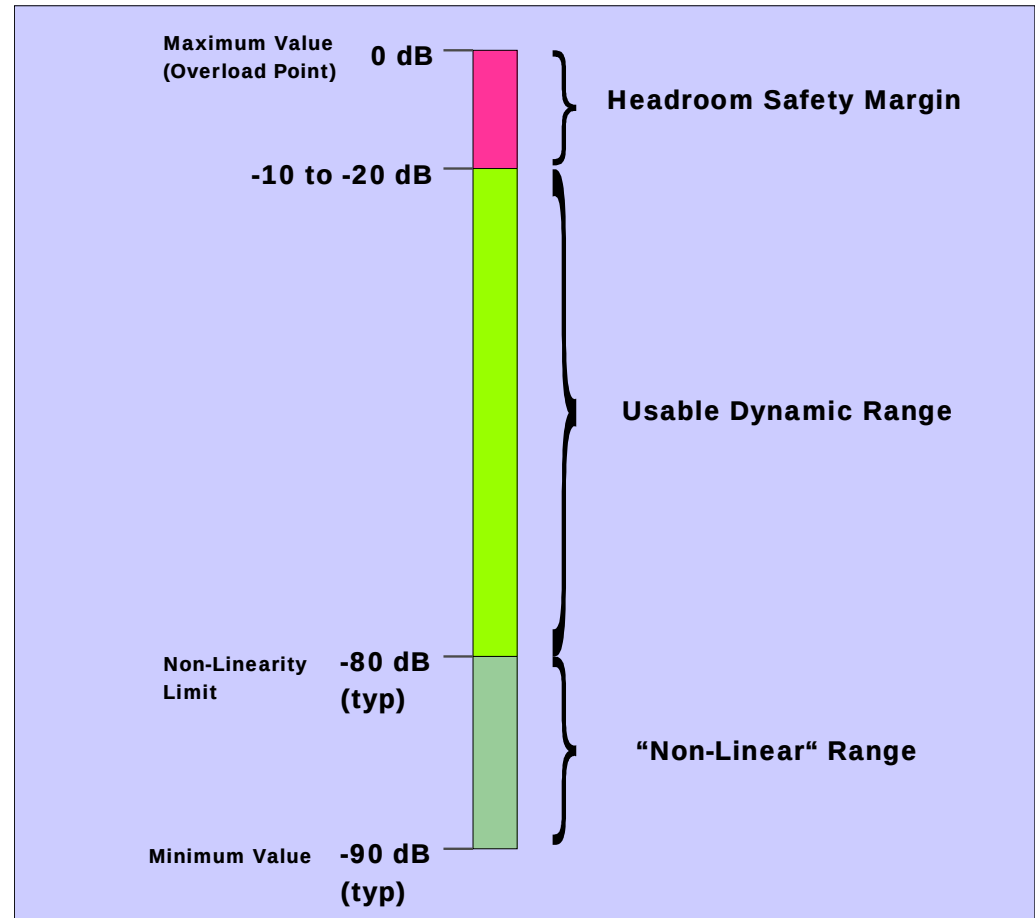
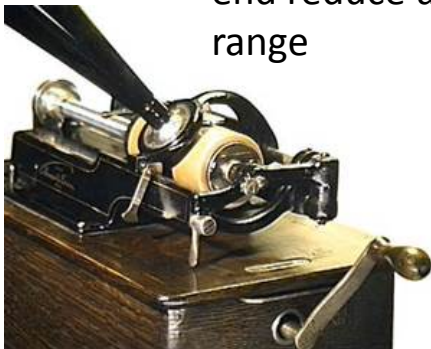
Guidance on characterization of and use of background noise – part 5

- “Energy” subtraction of valid pre-detection levels from valid aircraft levels:
 - $SPL_{adj} =$
$$10 * \text{LOG}_{10} [10^{(\text{aircraft SPL} * 0.1)} - 10^{(\text{valid pre-detection level} * 0.1)}]$$
 - Do NOT perform “energy” subtraction using:
 - Masking criteria
 - Post-detection noise
 - Non-valid pre-detection noise
 - Do NOT perform “energy” subtraction when:
 - Aircraft SPL < (pre-detection level + 3 dB)
 - » For this case, set aircraft SPL = pre-detection level



Background noise in the digital age of “high dynamic range”

- Why worry about background noise in a digital audio system, when a bit-depth of 16 provides a theoretical 92 dB of dynamic range?
- Combination of “headroom” at upper end and non-linearity at lower end reduce available range



Conclusion

Volpe encourages questions and comments from the aircraft noise certification community

Volpe Acoustics Website



[Under Construction]

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