Coverage Impact of Implementing Narrowband Equipment

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Chair TIA TR8.18

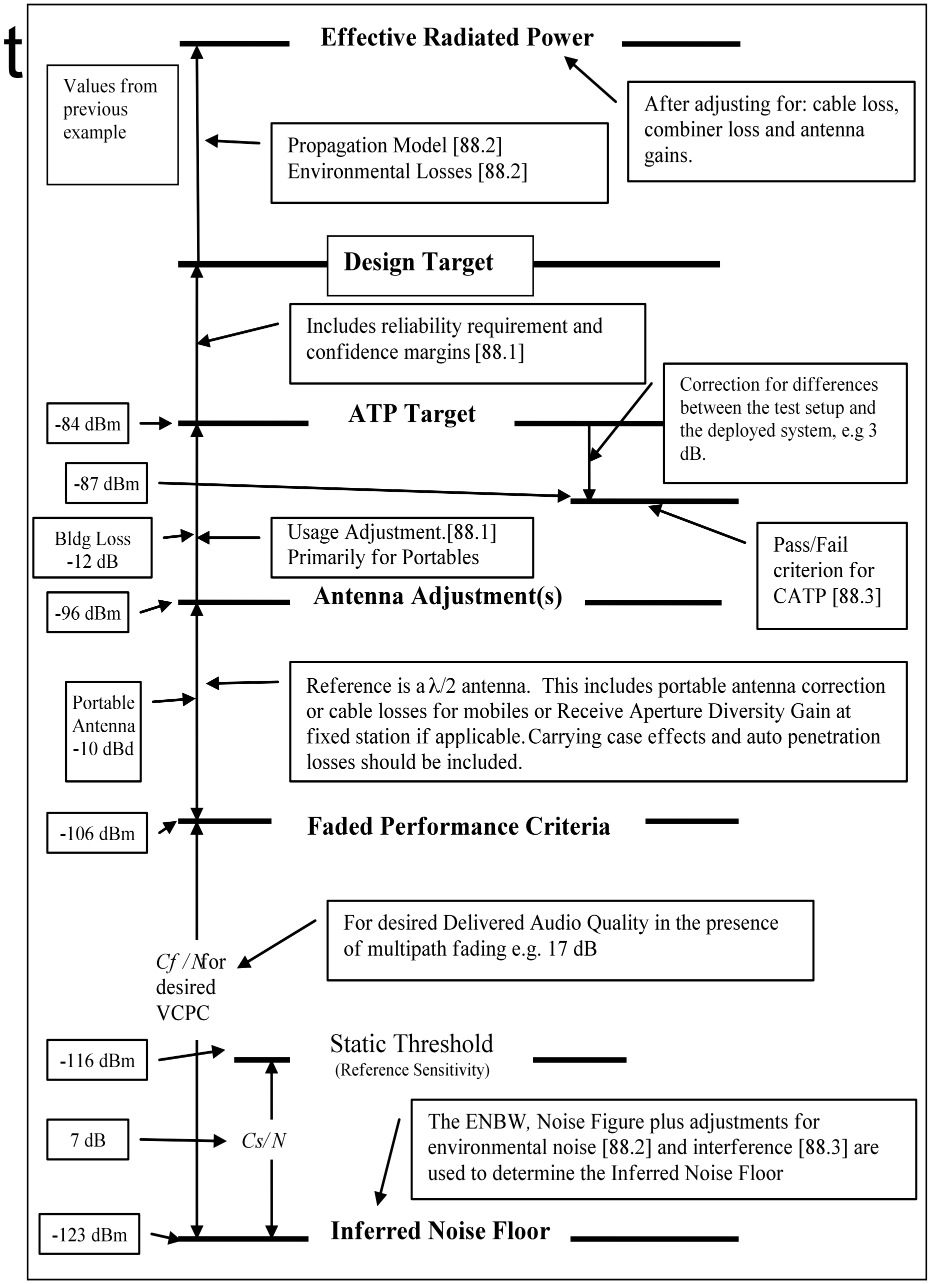
It Depends ON…

- Lots of variables to take into consideration
- Migration process
- Link Budget
- Tradeoff of sensitivity and interference protection (ACRR)
  - Fixed or adaptable receiver IF (ENBW)
- Coverage Area's
  - Terrain and Environmental Factors
  - Power Loss exponent
- Impact on Simulcast

TSB-88.1-C Link Budget

Simple Explanation

- Calculate the ERP
- Calculate the propagation loss at the point being evaluated
- Calculate the Inferred Noise Floor from the static threshold and Cs/N.
- Determine the Faded Performance Criteria by adding Cf/N to the noise floor.
- Correct for other factors
  - Building losses
  - Antenna efficiencies
  - Reliability & Confidence Margin
- Only difference involves the C/N values required and receiver ENBW.



Analog Sensitivity Example

25 kHz

- Cs/N = 4 dB
- Cf/N = 17 dB for DAQ=3

Noise Floor

- -144 dBm + 10Log($ENBW_{kHz}$) + Noise Figure
  - -144+10Log(**16**) +10 = -122 dBm
  - Static Sensitivity = -122+4 = -118 dBm (0.282 μV)
  - Faded Sensitivity = -122 +17 = -105 dBm

12.5 kHz

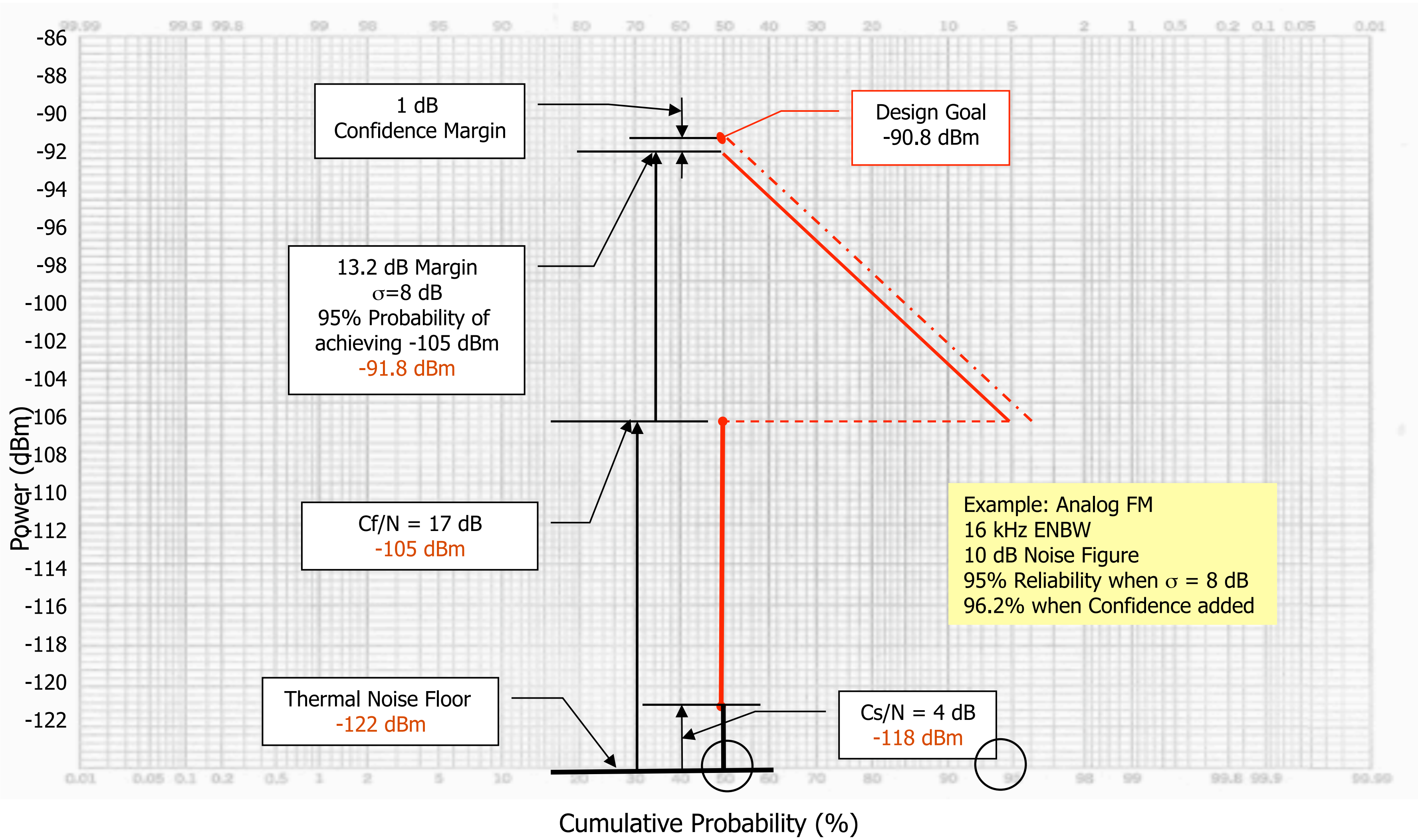
- Cs/N = 7 dB
- Cf/N = 23 dB for DAQ=3

Noise Floor

- -144 dBm + 10Log($ENBW_{kHz}$) + Noise Figure
  - -144+10Log(**8**) +10 = -125 dBm
  - Static Sensitivity = -125 + 7 = -118 dBm (0.282 μV)
  - Faded Sensitivity = -125 +23 = -102 dBm

25 kHz has 3 dB better faded sensitive

Coverage Prediction



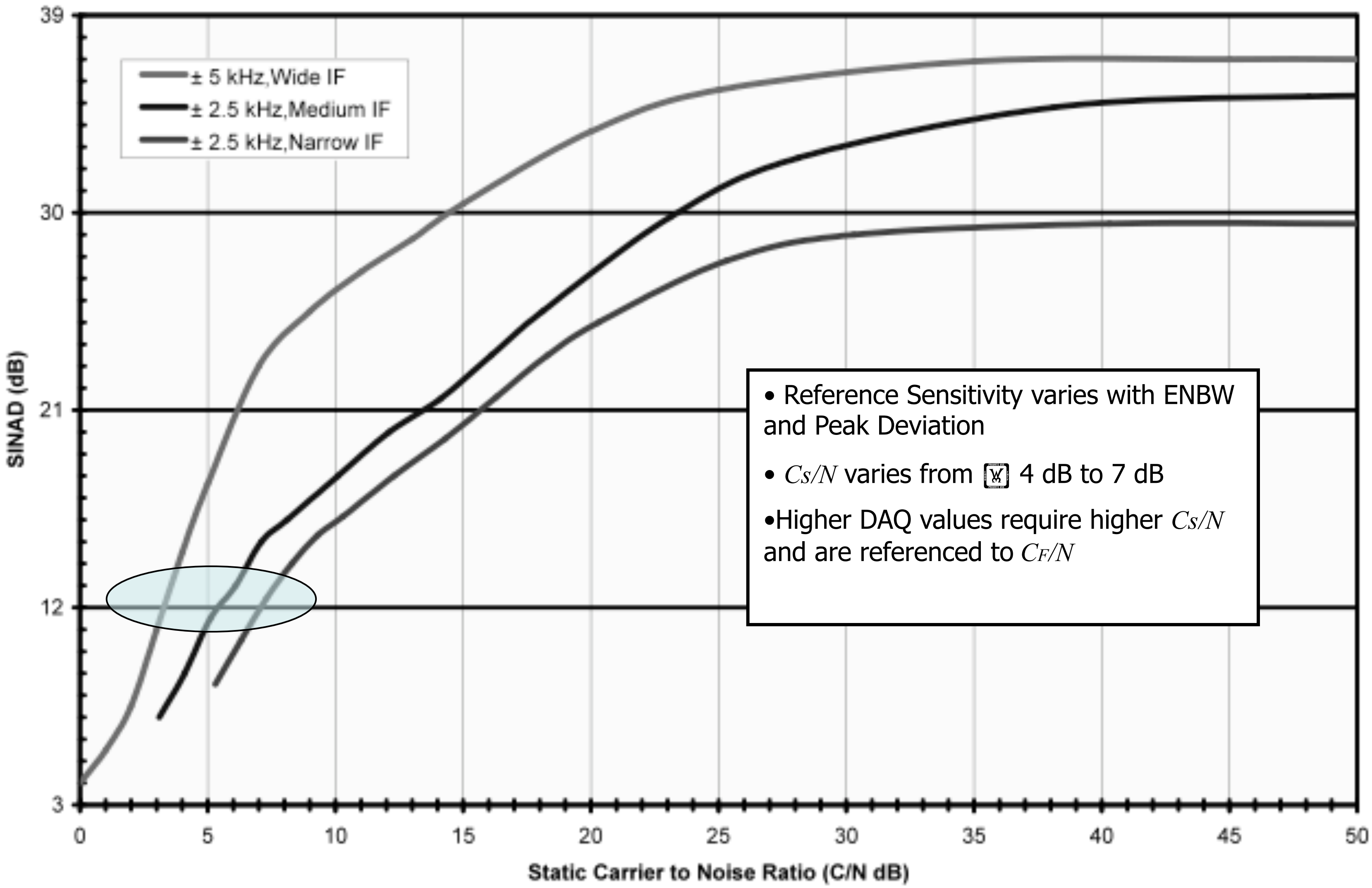
Analog vs. FM vs. Digital

Modulation Type, (channel spacing)	Static $\text{ref} / \frac{C_S}{N}$	DAQ = 3.0 $BER\% / \frac{C_F}{(I+N)}$	DAQ = 3.4 $BER\% / \frac{C_F}{(I+N)}$	DAQ = 4.0 $BER\% / \frac{C_F}{(I+N)}$
Analog FM ± 5kHz (25 kHz)	12 dBS/4 *dB*	NA/17 *dB*	NA/20 *dB*	NA/27 *dB*
Analog FM ± 2.5kHz (12.5 kHz)	12 dBS/7 *dB*	NA/23 *dB*	NA/26 *dB*	NA/33 *dB*
C4FM (IMBE) (12.5 kHz)	5%/7.6 *dB*	2.6%/16.5 *dB*	2.0%/17.7 *dB*	1.0%/21.2 *dB*

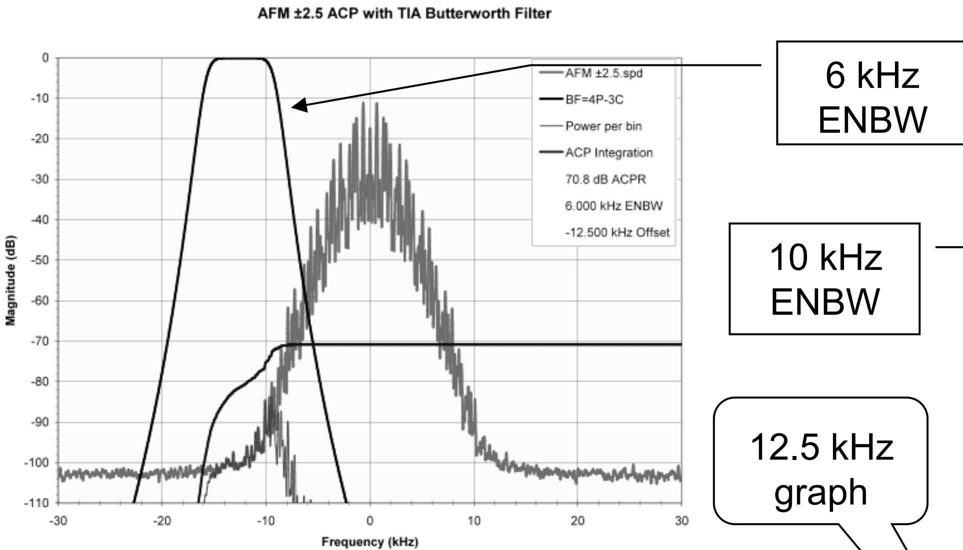
~6 dB consistent difference between Wide Analog and Narrow Analog in fading

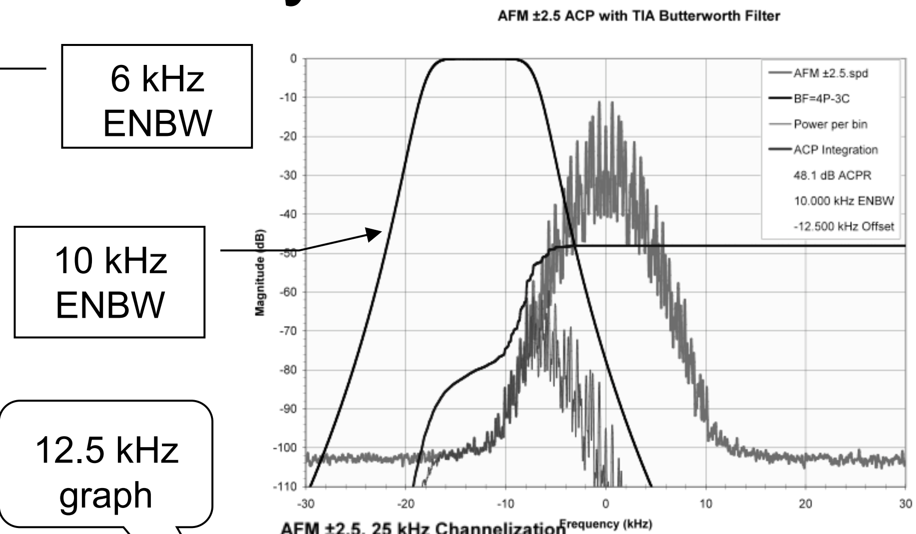
Digital and Wide Analog nearly equivalent at DAQ 3.0 but digital better at higher DAQ values

Static SINAD vs. C/N for various Analog ENBWs



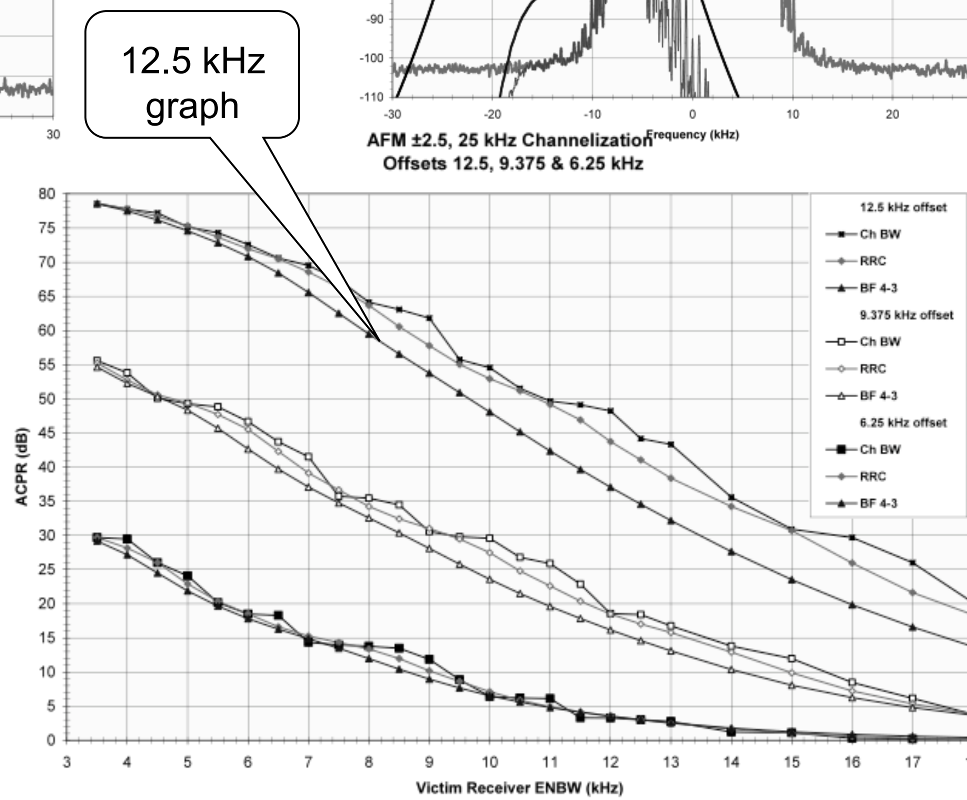
Tradeoff – Sensitivity vs. ACRR





$$\text{Receiver ACRR} = ACPR - \frac{C_S}{N}$$

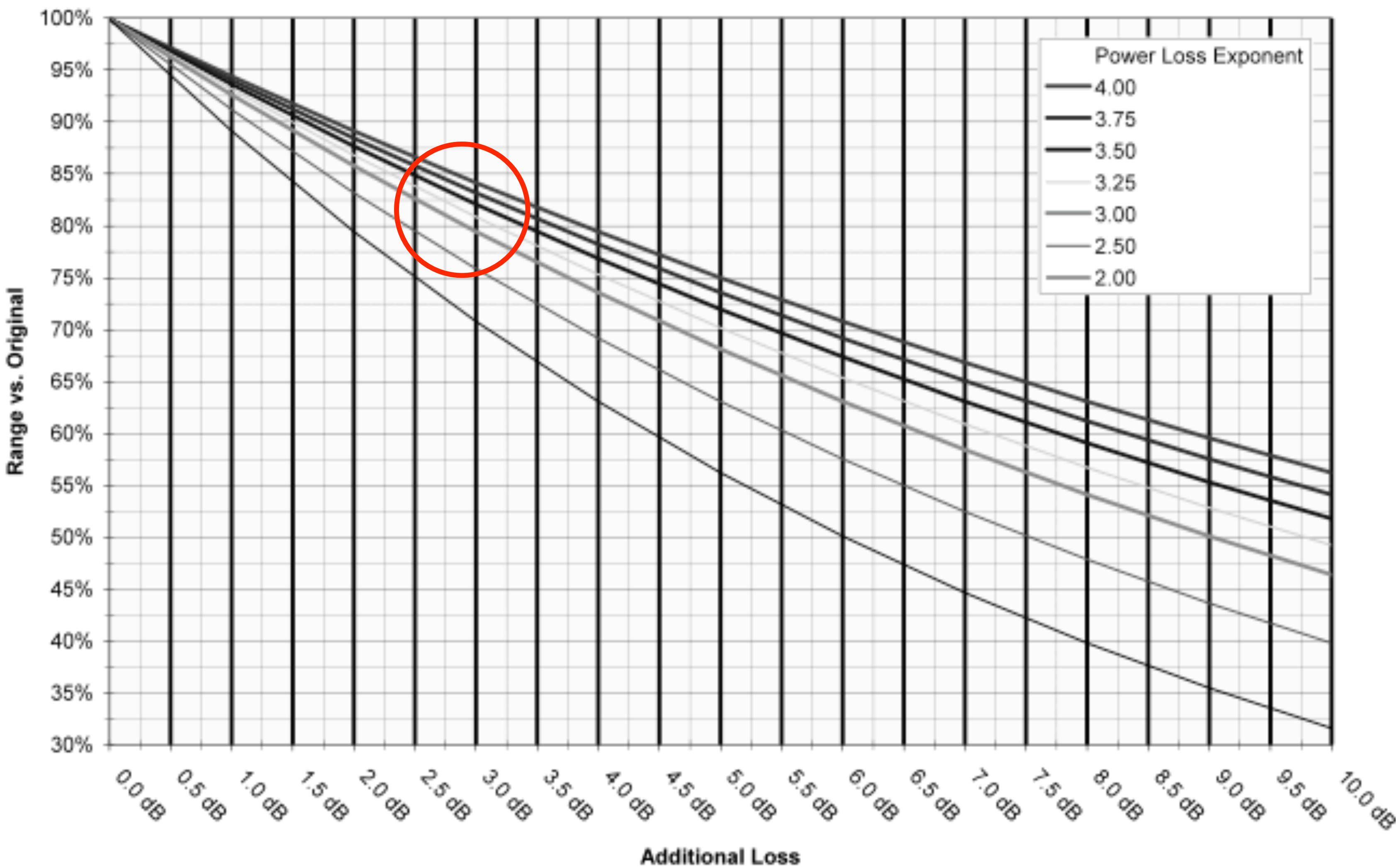
Source TSB-88.1-C



“Estimating” Loss of Coverage

- If “terrain limited”, probably little loss due to rapid increase of loss due to terrain features.
- If not terrain limited, then the estimation is based on the propagation model, assuming all the other elements remain constant
- View this as a loss of probability of achieving the desired DAQ or a loss of DAQ throughout the coverage area.
- Reduction in simulcast delay spread
  - Loss of sensitivity
  - Increases sensitivity to level setting variations

% of Original Range vs. Link Budget Loss



Potential Solutions

- Digital rather than analog for narrowbanding
  - Digital delay spread not as robust but easier to control
  - Sensitivity much better than narrow analog
- Receiver Voting (Enhanced Handheld coverage)
- Antenna/transmission line changes to increase ERP
- Portable carrying case option change
- Mobile gain antennas
- Fixed equipment amplifiers to decrease receiver noise figure (improve base sensitivity)
- Compander
  - Don’t mix various manufacturer’s versions

Analog Simulcast

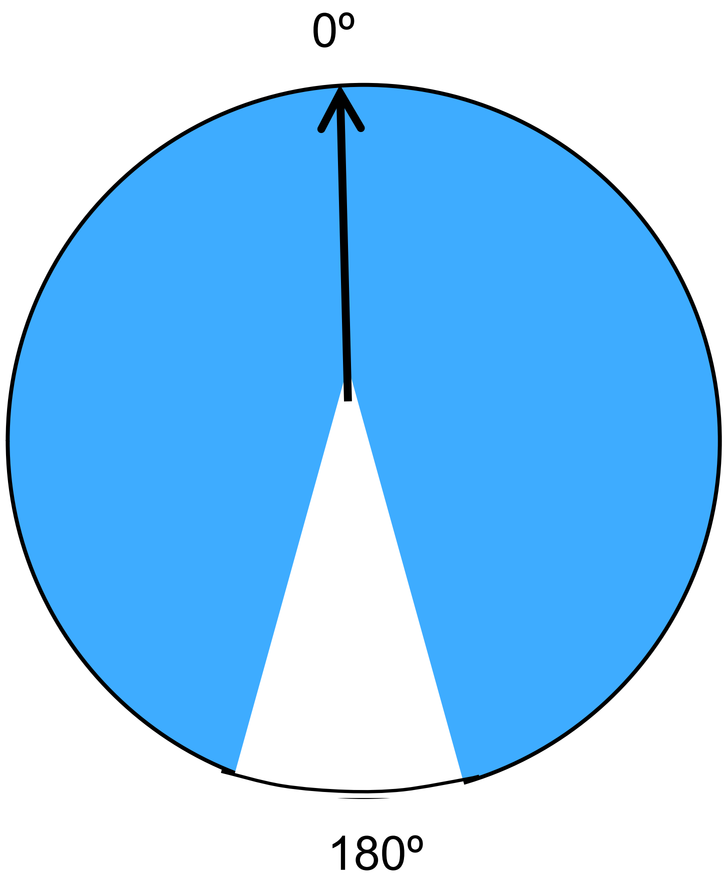
- Analog is more sensitive to levels and frequency response of the audio distribution system than digital
- Loss of sensitivity for narrow analog FM
- Analog has a flatter delay spread curve that is also wider than digital but degrades from level and frequency response issues.
- Receiver IF bandwidth affects the delay spread performance
- High DAQ performance requires simulating the entire system to include the distribution system. No published recommendation

History on Analog Level Impact*

- Analog simulcast necessitates that **$\Delta\beta \leq 1$**
- Low frequency components are most critical
  - Sub-audible Signaling, Low speed data, CTCSS, CDCSS
- Exceeding **$\Delta\beta \leq 1$** causes noise pops
- Narrow analog is more sensitive to audio level differences due to reduced deviation

*1990 APCO Presentation

Modulation Amplitude Control



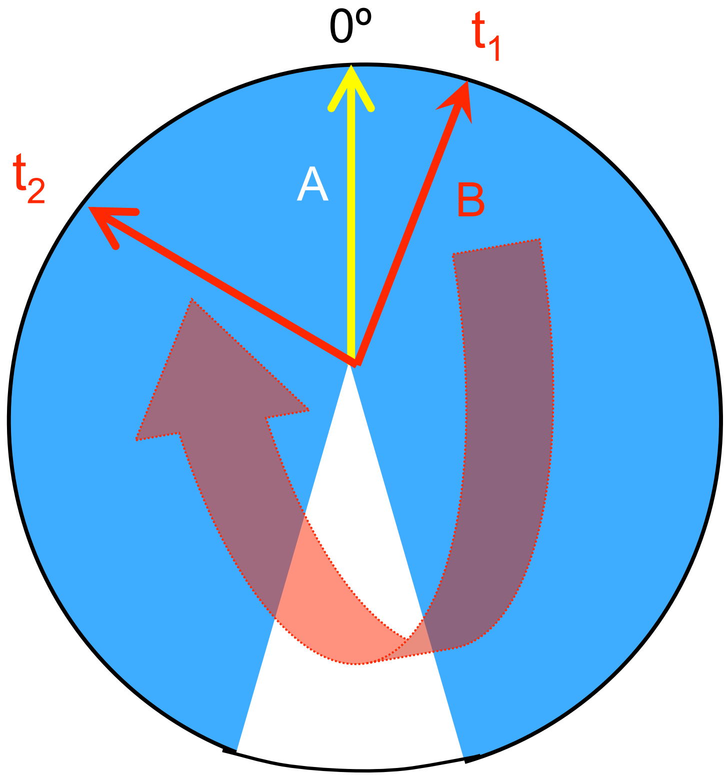
To minimize rotations through 180º at a stationary position, the difference in modulation index must be kept to ≤ 1

$\Delta\beta \leq 1$ where β is the index of modulation

$$\beta = \frac{\text{Frequency Deviation}}{\text{Frequency Modulation}}$$

Low Speed signals are the critical parameter.

Sub-Audible Signaling Control



The difference in amplitude causes carrier B to pass through 180º out of phase with carrier A resulting in a noise pop

TSB-88.1-C General Recommendations- Annex G

- Utilize high performance parameters for:
  - Frequency Stability
  - Amplitude Equalization
  - Audio Phase Equalization
  - Signal Launch Delay Optimization
- Adjust ERP, HAAT and antenna patterns for Signal Launch Delay Equalization
- Do not mix transmitter types on any given frequency of a system, i.e.
  - Different manufacturer
  - Same manufacturer, different model
    - Analog systems, never
    - Digital systems, recommend homogenous equipment on the same simulcast channel (frequency)

Simulcast Summary

- Design based on an optimized specific configuration rather than rules of thumb
  - Mobile/Portable
  - # Sites
  - Defined Service Area
  - DAQ required
  - CPC Area Reliability
- Simple user interface at ‘subscriber’ unit
- Spectrally efficient
  - Requires Frequency coordination for Adjacent Channel Coupled Power
  - Widened Pulses enhance delay spread tolerance versus wider channel bandwidth
- Narrow C4FM parametric values shown in TSB-88B
  - LSM added in TSB-88.1-C.
  - Additional modulations to be added to TSB-88.1-D
- Delay spread measurement defined in TIA 102.CAAA-C (§2.1.6)