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ECHO PERCEPTION IN WIDEBAND TELECOMMUNICATION SCENARIOS – COMPARISON TO E-MODEL'S NARROWBAND ECHO FINDINGS

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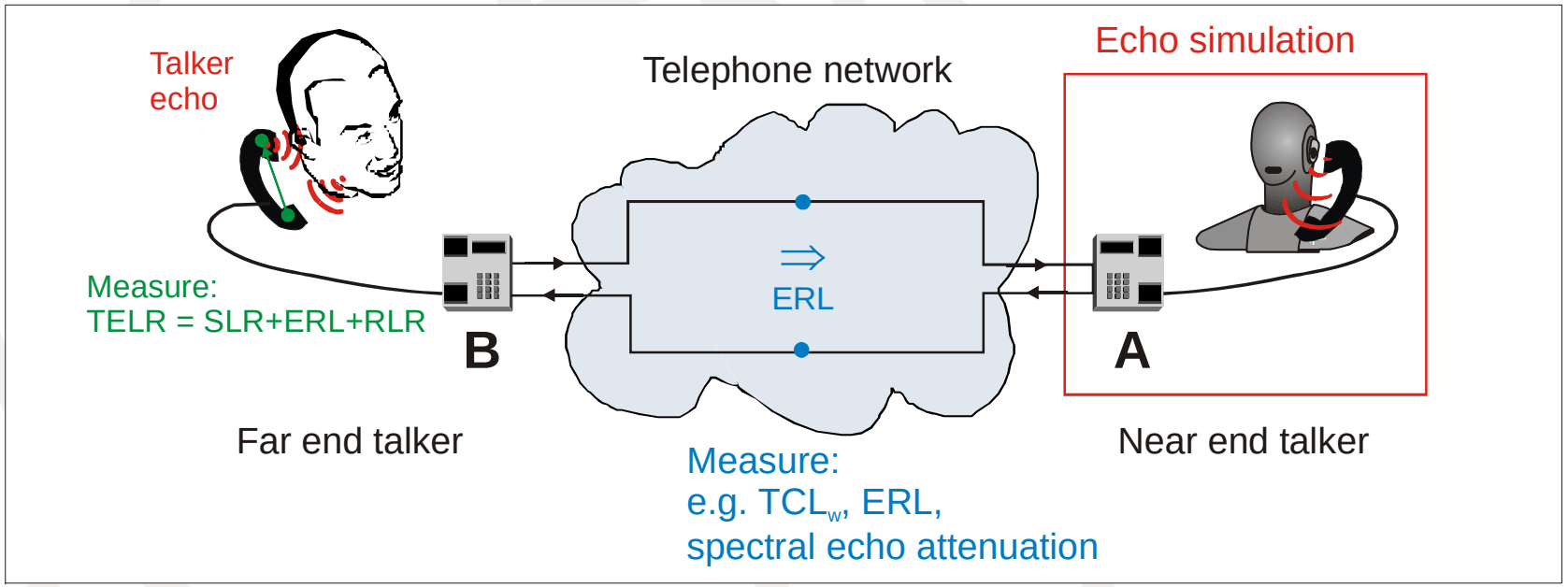
Motivation – The Situation Today

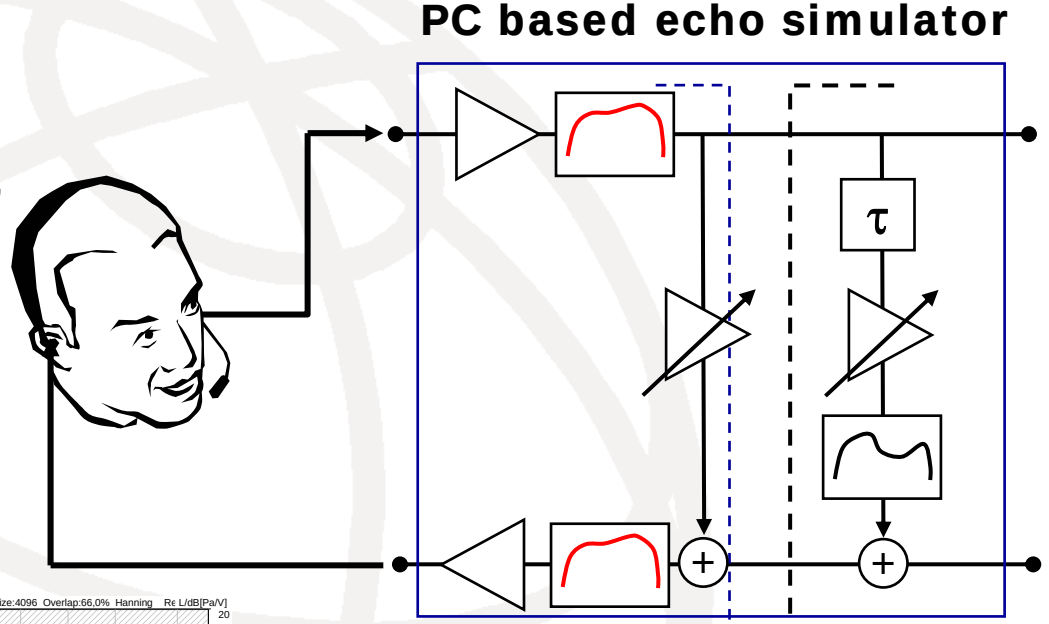
- In the market:
  - Customers expect higher speech quality
  - Networks migrate to wideband
  - Terminal designs need to be adapted to wideband
- In standardization:
  - Echo loss requirements only investigated in narrowband scenarios – ITU-T G.122
  - Echo loss defined as a single value TCLW – no spectral requirement
  - E-model currently covers narrowband scenarios
  - For wideband currently simple extension of narrowband TCLW calculations used (TIA 920, ETSI ES 202 739/740)

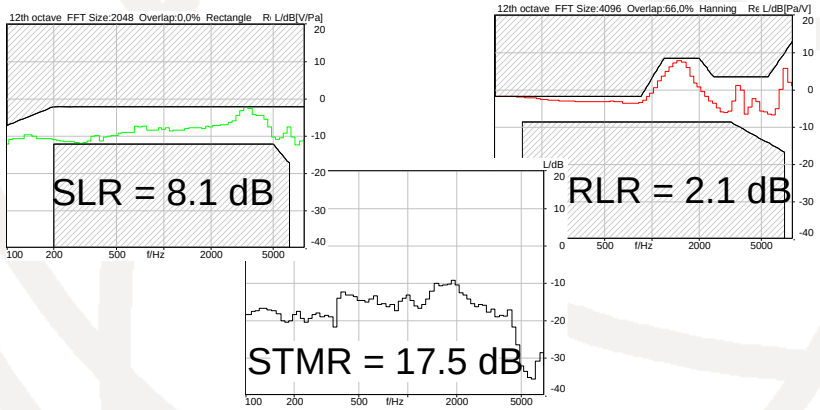
Introduction



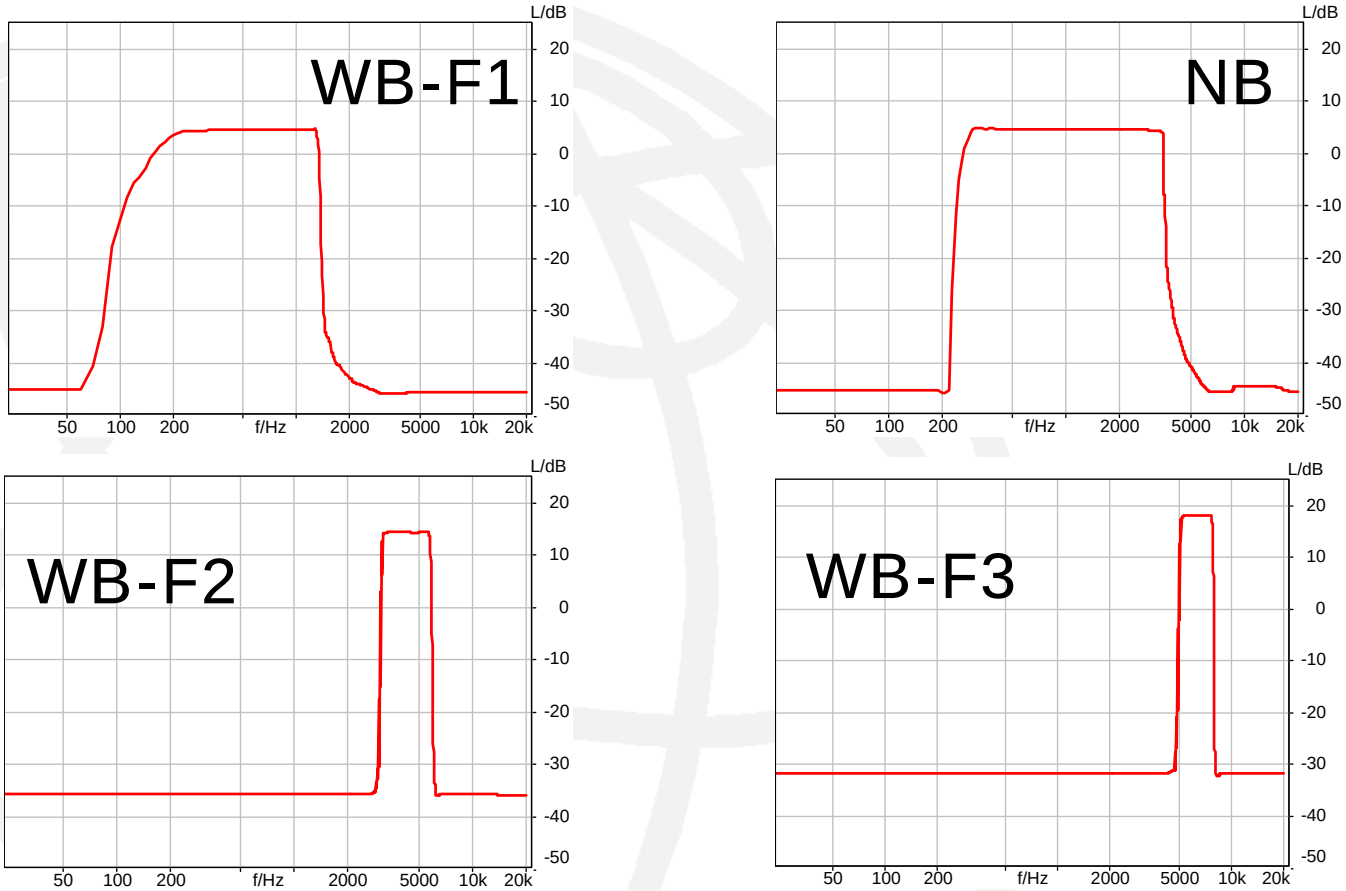
Test Setup

- Use of echo simulator:
  - PC with connected headset (Sennheiser PC130)
  - Simulation of different echo delays, attenuations and spectral shapes
- Connected headset is simulating a wideband phone providing typical phone characteristics:





Gain Functions for Echo Shaping Filters



Filter chosen such that the measured echo loss with speech as an input signal is identical for all filters

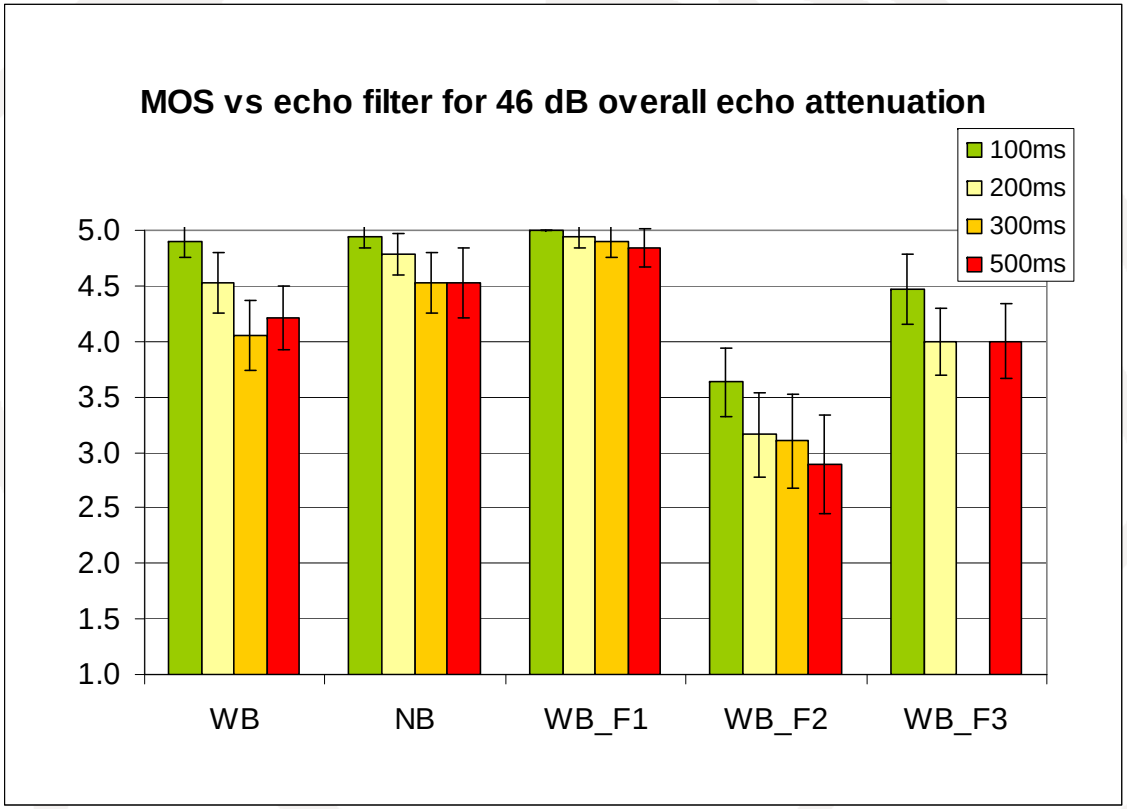
Test Conditions

- (round-trip) delays:
  100 ms, 150 ms, 200 ms, 250 ms, 300 ms, 400 ms, 500 ms
- Echo attenuations:
  25 dB, 30 dB, 35 dB, 40 dB, 46 dB, 50 dB, 55 dB
- In combination with different shaping filters
- => 129 test conditions

Subjective Tests

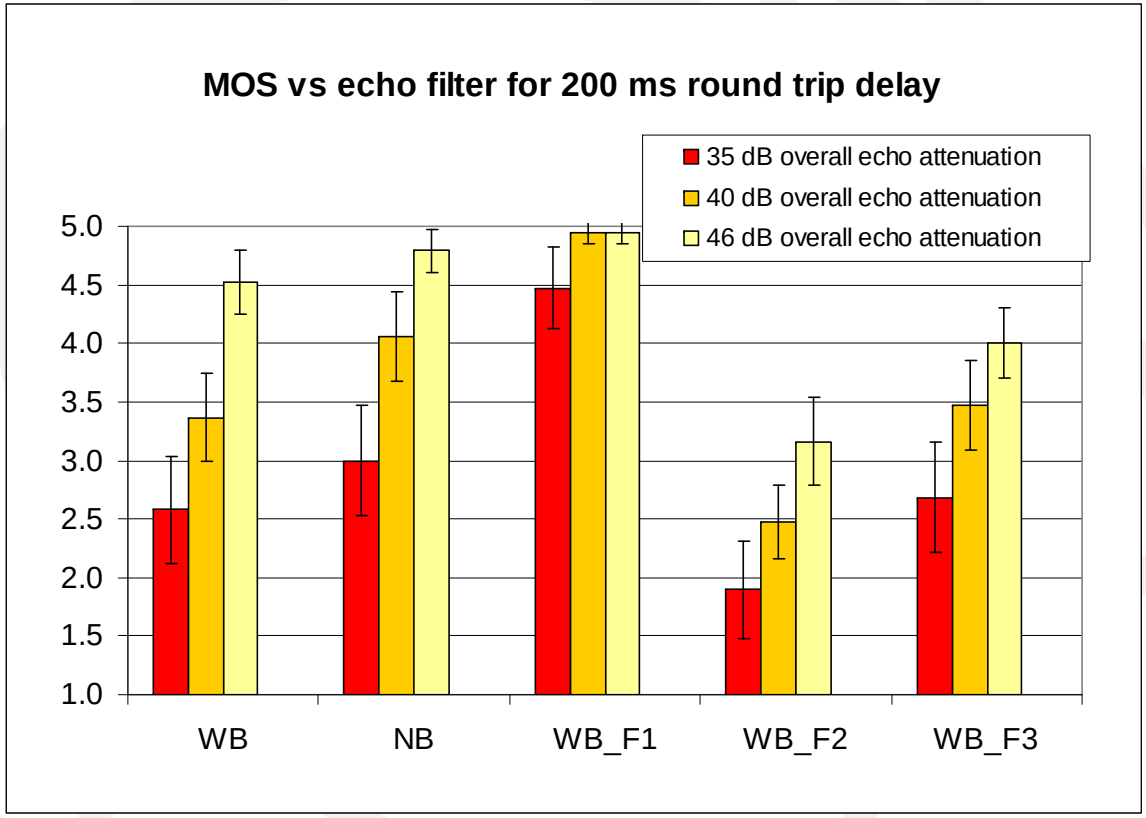
- Talking & Listening Tests (TALT) – acc. to ITU-T P.83, DCR Scale:
  - 5 - Echo is not perceptual
  - 4 – Echo is slightly perceptual, but not annoying
  - 3 - Echo is slightly annoying
  - 2 – Echo is annoying
  - 1 – Echo is very annoying
- 6 experts, 13 naïve test persons
- Monaural presentation
- Salutation at the beginning of a call

MOS vs. Echo Shaping Filter



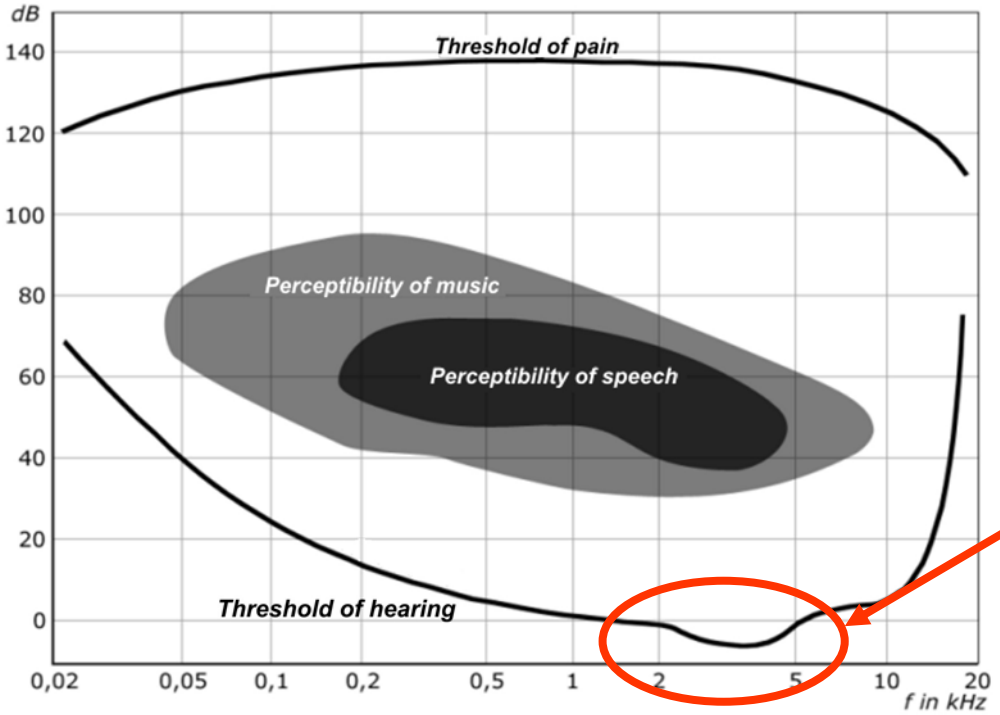
- Significant lower MOS values for WB_F2
- WB echo attenuation worse than NB
- Low frequency echo (WB_F1) introduces less impairments

MOS vs. Attenuation with 200ms Round Trip Delay



- Significant lower MOS values for WB_F2 and WB_F3
- WB echo attenuation (slightly) worse than NB
- Low frequency echo (WB_F1) introduces negligible impairments

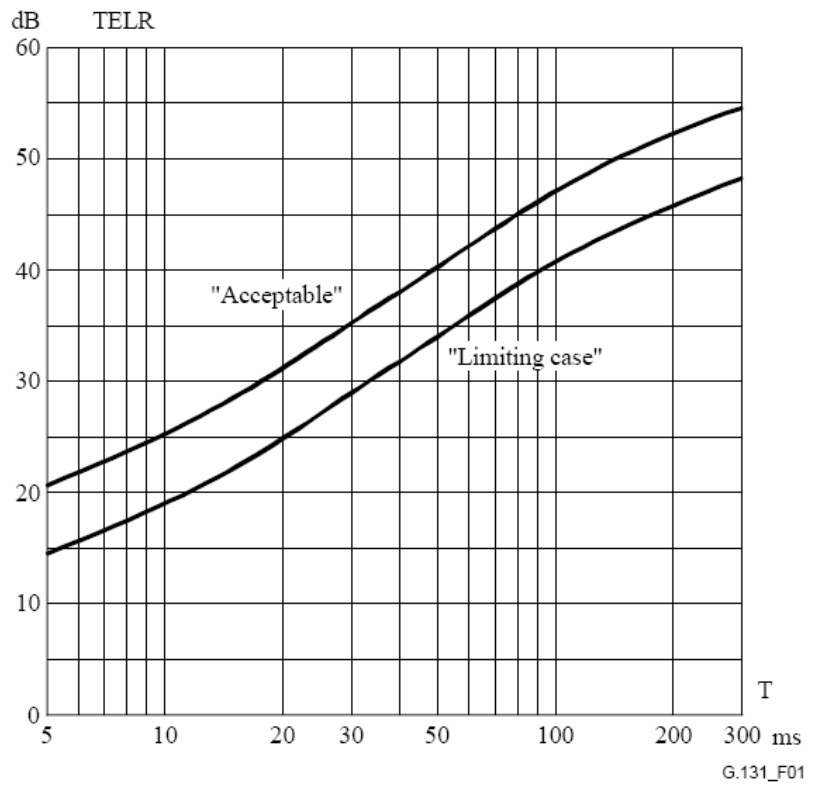
Possible Explanations



- 200Hz - 1300 Hz less critical due to high self masking
- 3.1 kHz – 5.6 kHz very critical due to lowest Hearing threshold and lower self-masking

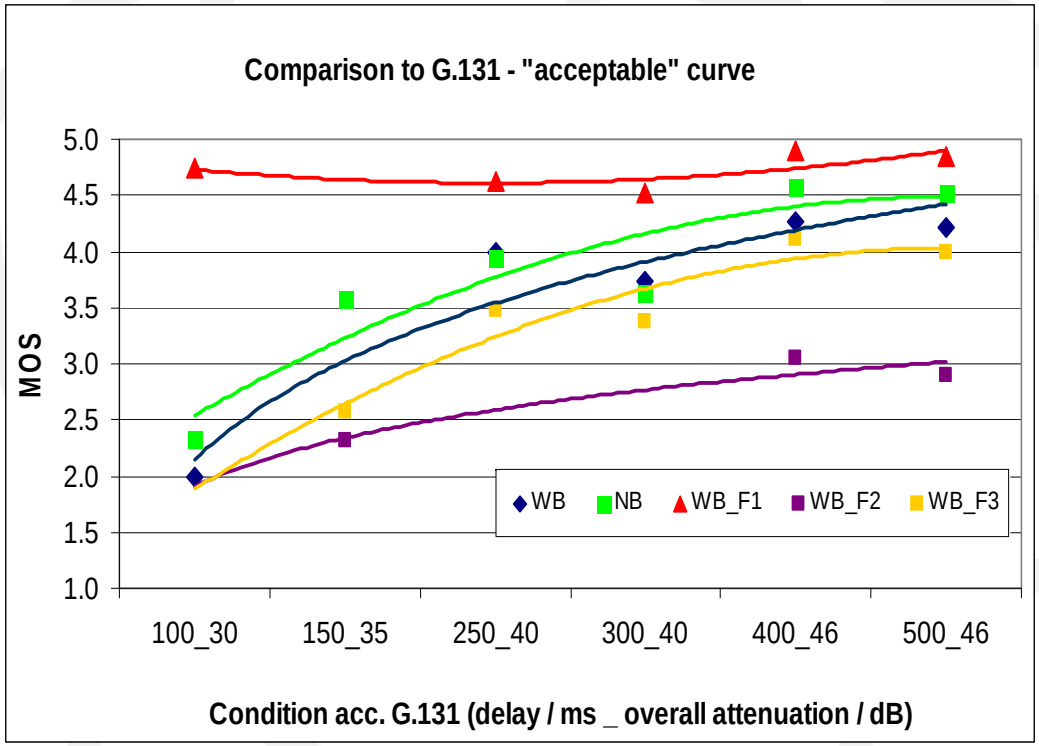
Comparison to G.131 and E-Model

- Assumption:
- Acceptable echo performance <-> MOS 4.0 – 4.6
- NB echo loss should correspond to G.131 basic experiments



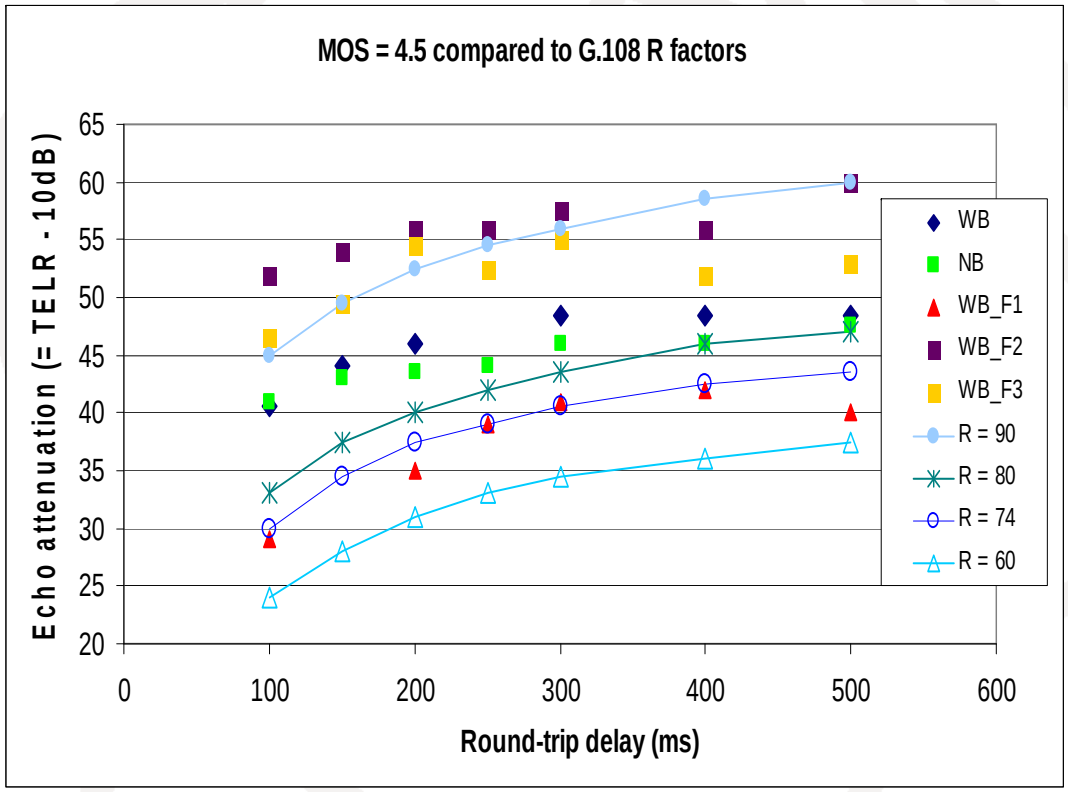
T Mean one-way transmission time
TELR Talker Echo Loudness Rating

Comparison to G.131 – “Acceptable Curve”



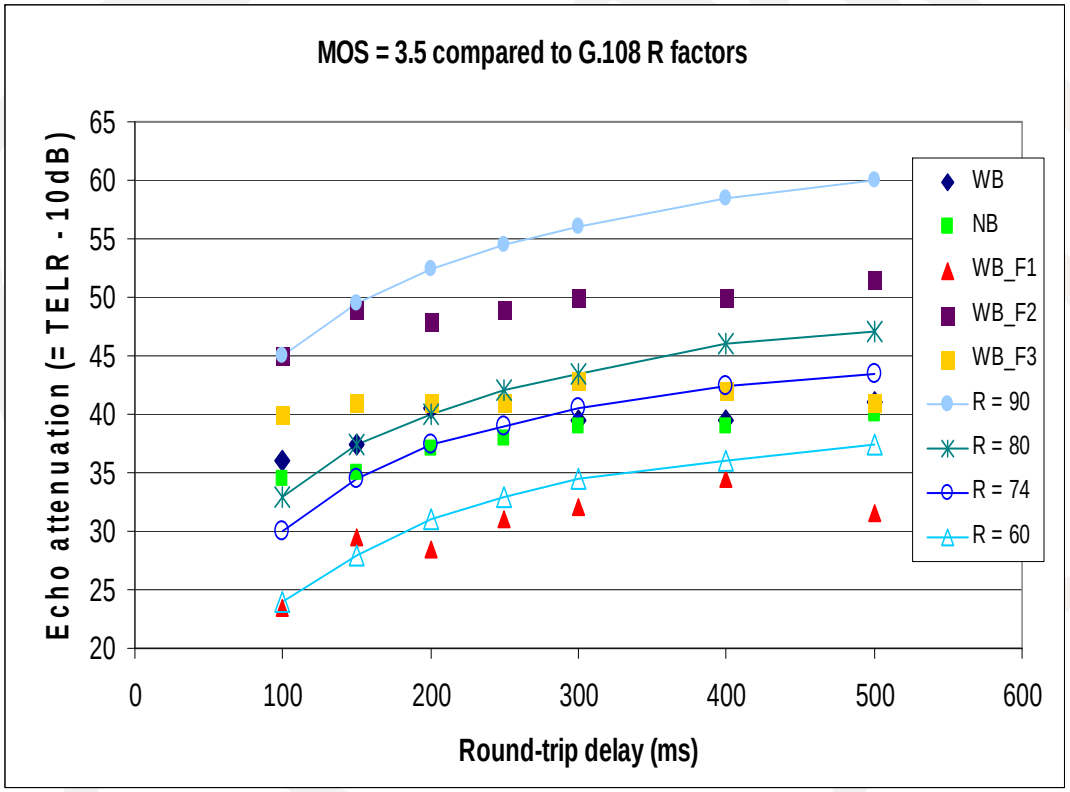
- NB curve does not fit to G.131 for conditions < 300ms
- WB_F1 curve fits to G.131
- WB_F2 curve leads to much worse subj. rating

Comparison of MOS= 4.5 to E-Model R-Factors



- NB curve does fit to R=80 for delays >250 ms
- Echo loss requirement for R=90 too high for purely WB or NB echo
- Echo loss requirement for R=90 approximates well the case of high frequency echo (WB_F2, WB_F3)
- Echo loss requirement for NB and WB nearly identical (re. full bandwidth)
- WB_F2 and WB_F3 requirements similar up to 300 ms delay

Comparison of MOS= 3.5 to E-Model R-Factors



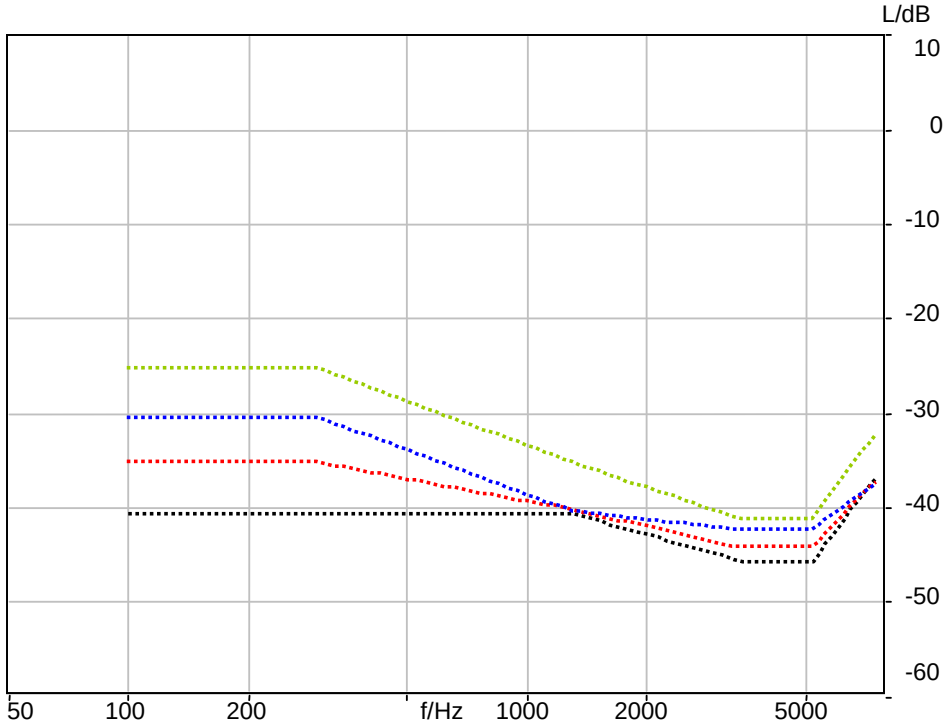
- Echo loss requirement corresponds to R=74 for purely WB or NB echo
- Again, echo loss requirement for high frequency echo is significantly higher than for pure NB or WB echo
- Echo loss requirement for NB and WB nearly identical
- Echo loss requirement for WB_F2 significantly higher than for WB_F3

Conclusions I

- Echo in the frequency band 3.1 kHz – 5.6 kHz is most critical
- Echo below 1.3 kHz is less critical
- Influence of attenuation is stronger than influence of Delay
- E-model estimation of NB echo is clearly on the safe side
- New weighting for TCLW wideband required
- Investigation of spectral echo very important

Conclusions II

- Proposal for wideband spectral echo loss requirement



Requirements for

100 ms

200 ms round-trip delay

300 ms

500 ms