

The Impact of Environmental Noise on Customer Experience in GSM and CDMA Networks

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Introduction

This paper presents the results of large-scale measurements of background noise in live GSM and CDMA calls in US networks and discusses the noise's impact on customer experience according to the ITU-T G.107 E-model [1].

The paper also examines the differences between Ditech's Adaptive Noise Cancellation (ANC) feature, which is part of a network-based Voice Quality Assurance (VQA™) solution for GSM and CDMA networks, and the noise suppression that is mandatory in CDMA [2]¹.

Noise Measurements of Live Calls in GSM and CDMA Networks

Ditech Networks recently performed trials with two major GSM and CDMA carriers in the US. Noise levels were measured for millions of live calls using Ditech's new Experience Intelligence™ (EXi) feature. The EXi feature uses the non-intrusive ITU-T G.107 E-model to assess the impact of common voice quality impairments, such as environmental noise, on the overall customer experience.

The E-model defines a metric for overall voice quality called the Transmission Rating (R) Factor. The R Factor has a scale between 0 and 100, where 100 represents an ideal call with no impairments and calls with $R < 50$ are not recommended. According to this scale, a perfect PSTN call has $R = 94$, which can be translated into a Mean Opinion Score (MOS) of about 4.2.

Figure 1 shows the measured uplink distribution of noise impairments that affect listening quality for GSM and CDMA calls:

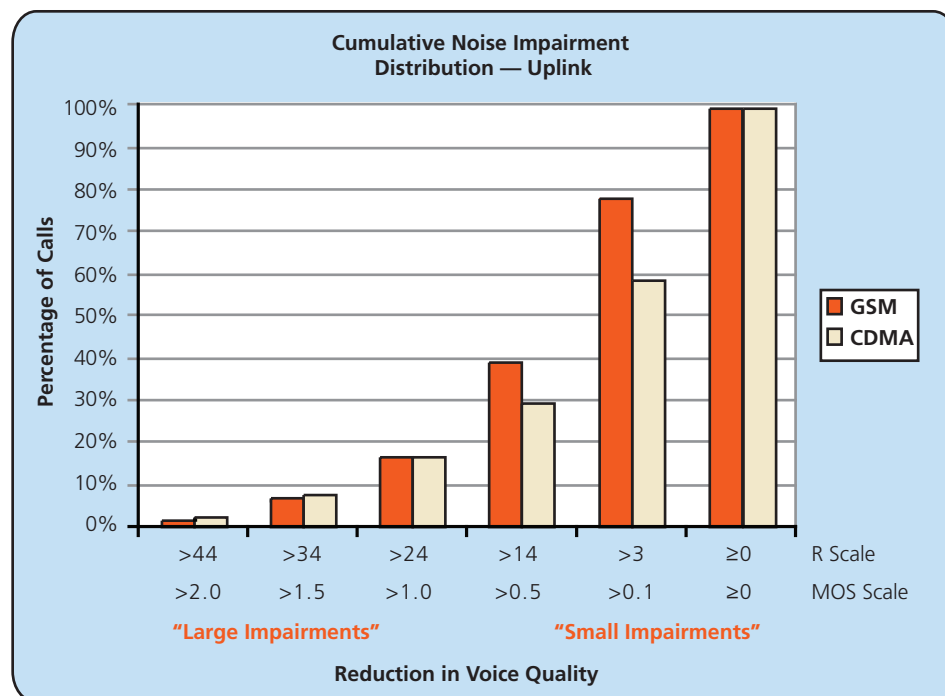


Figure 1 : Cumulative Noise Impairment Distribution of GSM and CDMA Calls in Two Major US Networks

¹ Reference [2] provides technical requirements on the recommended noise suppressor for EVRC. Actual implementations in CDMA handsets may differ from this specification.

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As shown in **Figure 1**, about 40% of GSM calls (red bars) and 30% of CDMA calls (beige bars) have listening quality impairments due to environmental noise that exceed 14 points on the R scale. This corresponds to degradations of about 0.5 points or more on the MOS scale.

CDMA calls perform better than GSM for impairments of less than 24 points on the R scale. However, the CDMA noise suppression does not appear to be as effective with heavily impaired calls, where the impairment exceeds 24 points (no significant difference between GSM and CDMA calls). According to **Figure 1**, these calls represent more than 15% of all calls.

Figure 2 includes the measured results of GSM combined with Ditech's VQA solution (green bars). As can be seen, VQA technology removes significant amounts of background noise, particularly in very noisy environments, thanks to its advanced Adaptive Noise Cancellation (ANC) feature.

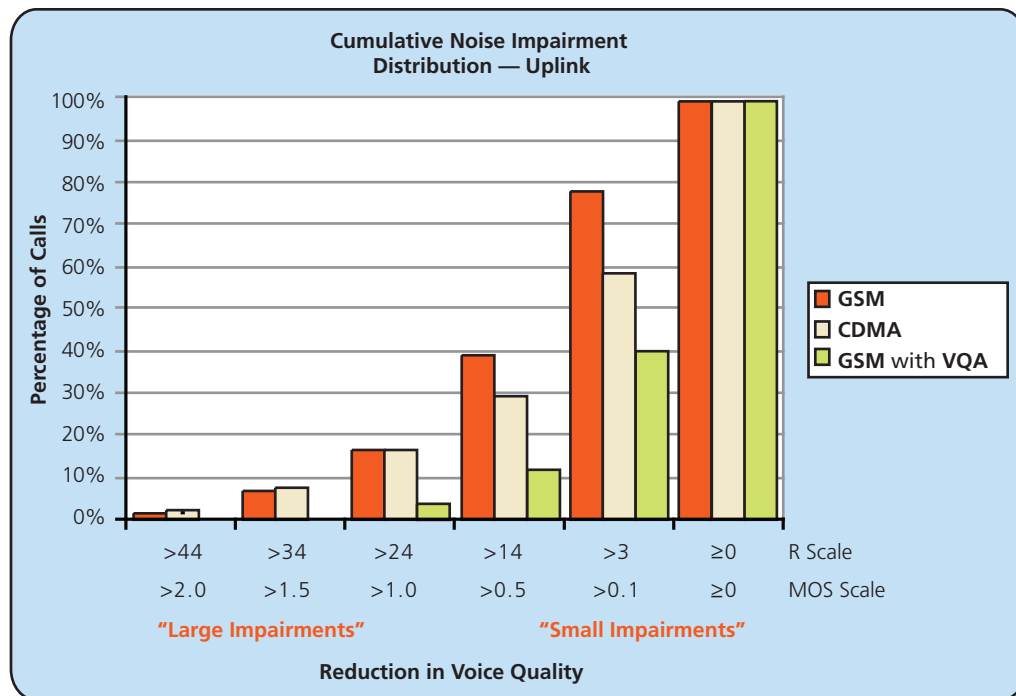


Figure 2 : Cumulative Noise Impairment Distribution of GSM, CDMA, and GSM with VQA Calls in Two Major US Networks

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A Comparison between Ditech's ANC and CDMA's Noise Suppression

Results Summary

The results in **Figure 1** indicate that about 40% of GSM calls and 30% of CDMA calls have significant listening quality impairments due to environmental noise that exceed 14 points on the R scale. In addition, more than 15% of both GSM and CDMA calls suffer very large impairments, exceeding 24 points on the R scale. This corresponds to degradations of 1.0 or more on the MOS scale.

These results suggest that the CDMA noise suppression can address smaller environmental noise impairments, but it is less effective with larger noise impairments.

Key Benefits of Ditech's ANC

Figure 2 shows that Ditech's network-based VQA solution with advanced bidirectional Adaptive Noise Cancellation (ANC) successfully addresses noise impairments at all levels, and as a result, performs better than the EVRC noise suppression in CDMA.

This can be explained by the following key characteristics of Ditech's ANC solution:

- Ability to continuously and adaptively remove a wide variety of background noise of different types and strengths, including non-stationary noise, with little speech distortion.
- Adaptive Signal-to-Noise Ratio (SNR) mode that applies maximum noise reduction to low SNR inputs and moderate or minor reduction to higher SNR inputs.
- Ability to preserve background noise characteristics with a configurable comfort noise floor to avoid the "dead air" problem after noise removal.
- Fast convergence time that is usually less than 700 ms, even for calls with SNR as low as 0 dB.
- Potential to upgrade the ANC feature and overall VQA platform with new software features and performance improvements, benefitting all subscribers in the network, regardless of handset type and model.

Both Ditech's ANC and EVRC noise suppression in CDMA handsets use spectral domain methods to remove noise. However, Ditech's ANC employs a more advanced spectral subtraction technique based on the masking properties of the human auditory system. This means that Ditech's solution achieves a higher SNR improvement for low SNR inputs than CDMA noise suppression does, while masking annoying artifacts such as "musical noise" that can remain after noise removal.

In addition, Ditech's solution generally has a shorter convergence time than CDMA noise suppression and a better ability to track and remove background noise in demanding conditions where the background noise changes quickly (non-stationary noise).

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The Need for Advanced Noise Suppression in GSM

Call impairments due to environmental noise are larger in GSM networks compared to CDMA. This is because CDMA's inherent noise suppression is able to remove the smaller noise impairments.

The 3GPP standardization body for GSM recognized the problem associated with environmental noise early on, but unfortunately was not able to specify a mandatory noise suppression method for its latest Adaptive Multi-Rate (AMR) codec [3], [4].

Ditech Networks addresses the lack of a mandatory noise suppression method in the GSM standard with an advanced ANC feature that is a component of an overall VQA solution. Ditech's VQA is typically deployed on the A Interface, between the MSC and BSC, ensuring that all calls benefit from noise cancellation, regardless of handset type and model.

Conclusion

Measurements of millions of live GSM and CDMA calls indicate that environmental noise has a significant impact on customer experience. CDMA networks suppress noise better than GSM networks due to the built-in noise suppression in CDMA.

GSM carriers can address the issue of environmental noise by deploying a network-based noise cancellation solution such as Ditech's VQA. Using Ditech's solution, GSM carriers can provide a voice quality performance that clearly exceeds that of a regular CDMA network in terms of background noise removal.

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References

- [1] ITU-T G.107 Recommendation: The E-Model, a computational model for use in transmission planning.
- [2] 3GPP2 C.S0014-0 Version 1.0: Enhanced Variable Rate Codec (EVRC).
- [3] 3GPP TR 06.78: Results of the AMR Noise Suppression Selection Phase.
- [4] 3GPP TS 26.077: Minimum Performance Requirements for Noise Suppressor.

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