Many Unhappy Customers Could be Left Without Indoor Coverage Due To Widespread Assumptions About In-Building Penetration Losses

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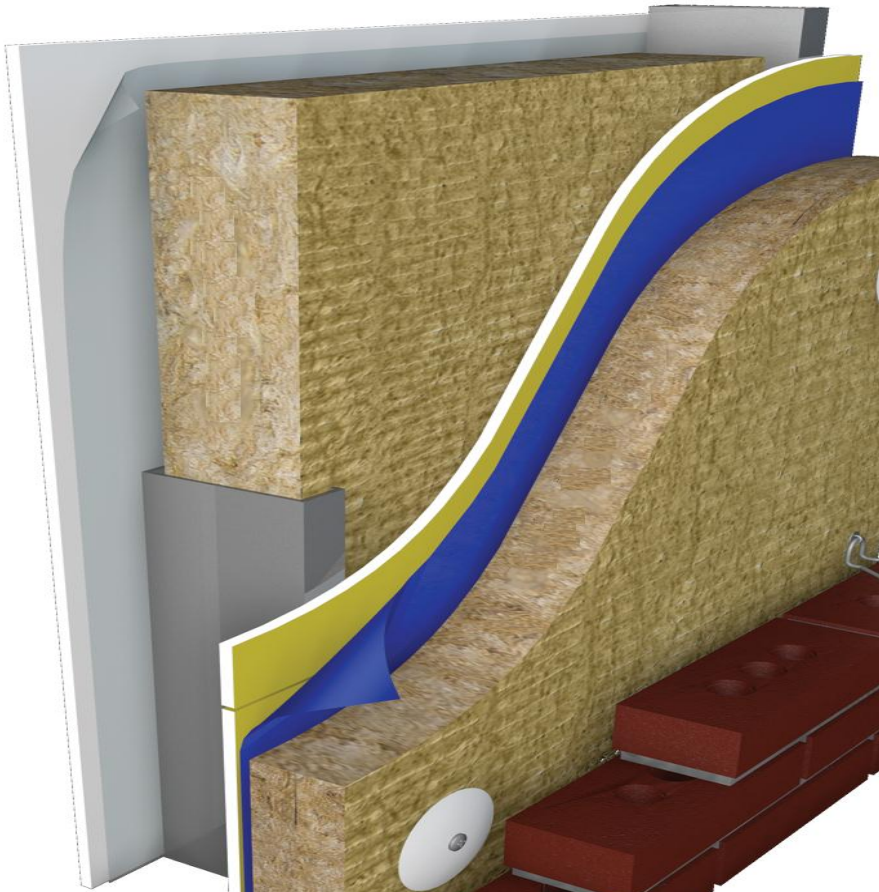
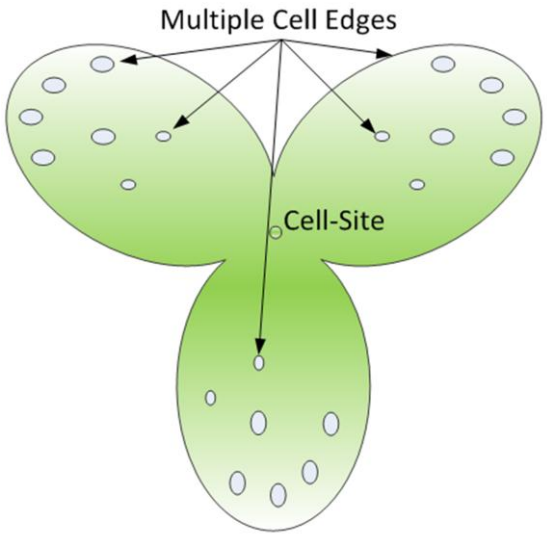


In building penetration losses vary widely. This should be carefully considered when setting the penetration loss in the radio link budget. Rather than using average values, the losses allowed should be adjusted to take account of the required confidence intervals.

Introduction

The most common approach to designing a cellular network for indoor coverage is to define an outdoor reference signal level. This reference level takes account of losses estimated for the signal to penetrate to the inside of the building in question. Standard values exist for these losses and are used in many reference texts and equipment vendor link budgets. Some interesting modelling of indoor coverage can be seen in the work by Berg (1999) for both line-of-sight and non-line-of-sight conditions.

The link budget is used to determine the maximum allowed path loss to achieve the desired service level at the cell edge. The network specifications are set to define the required cell-edge and cell- area coverage probability.



The cell-edge is distributed unevenly

When considering indoor coverage the cell edge is not a smooth curve at a given radius from the base station location. Rather, multiple cell edges exist at various points within the cell, typically inside buildings and behind terrain obstructions. Therefore, the assumptions made about the correct allowance for in-building penetration loss affect users both near and far from the cell site location. Typically link budgets assume 15dB penetration loss at 2100Mhz as used by Holma and Toskala (2006) and in many vendor link budgets.

The Project

Vilicom recently carried out a study to refine the values used for in-building penetration loss and understand how they might have changed in recent years. Changes in construction methods and insulation materials are being driven by efforts to reduce carbon emissions and energy costs. The effects of low-emissivity glass with metallic oxide coatings and foil-backed insulation were of particular interest. The study involved over 1,600 measurements inside houses, apartments and offices in five Irish cities. Measurements were taken at the front and back walls, both inside and out as well as at the centre of the building.

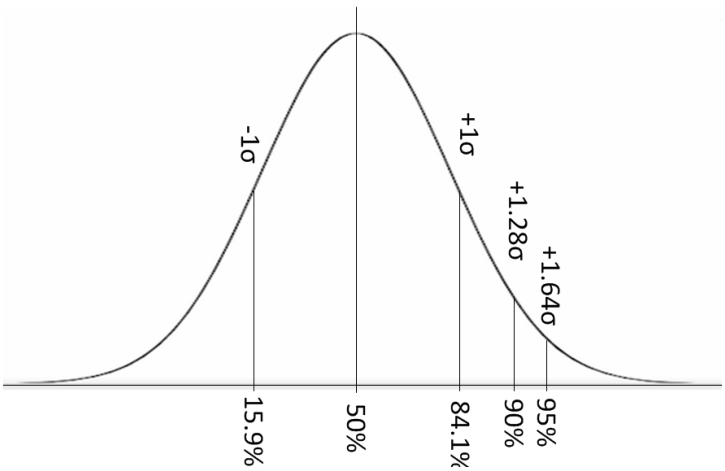
Findings and Recommendations

The measurement results were normally distributed and some noteworthy findings were obtained. The median penetration losses found were slightly lower than those used in the standard link budgets, but the standard deviation was particularly interesting.

	2100 Mhz	1800 Mhz	900 MHz
Mean Loss ($\bar{x}$)	~12 dB	~11 dB	~9 dB
Standard Deviation (σ)	7 dB	7 dB	6 dB
95% Confidence (1.28 σ)	21 dB	20 dB	17 dB
95% Confidence (1.64 σ)	24 dB	23 dB	19 dB

Losses observed in suburban homes

The standard deviation of the collected data was 6-7dB. To ensure 90% and 95% confidence of achieving indoor coverage, the penetration loss assumed in the link budget must account for the variance of penetration losses encountered in real buildings as shown in the figures above. It is recommended that the standard link budget for areas tested in this project be adjusted to take account of this distribution. This will influence the radio design by increasing the required site count. Further study is also needed to examine the effects of combining this with the shadow fading margin.



Relationship between standard deviation and cumulative percentages

References:

Holma, H., Toskala, T., 2004. *HSDPA/HSUPA for UMTS.* Wiley. p. 189

Berg, J.E., In: Damosso, E., Ed., 1999. *Digital Mobile Radio Towards Future Generation Systems, European Commission.* pp. 167-174

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