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Studies on Effects of Building Internal Pattern on Downlink Mobile Phone Signal Strengths and Power Loss

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---ABSTRACT---

Quality of Radio propagation and power are governed by mechanisms such as reflection, diffraction and scattering from various objects and building which is dependent on some specific features of its internal structure. This research investigated the two major radio systems used in cell phones which are GSM *(Global System for Mobile communications) and CDMA (Code division multiple access) communication technologies, also four (4) international* Mobile phone service providers (GSM and CDMA) are used for the studies in five (5) different locations studying their signal power strengths through four different buildings/object's made of different materials. The *selected areas are in Kaduna metropolis, Nigeria. HF2025E (700MHz-2GHz) spectrum analyzer was used to carried out the measurements serving as receiver recorded the averaged signal strength level at each point. The downlink frequency bands of five service providers; GSM: Airtel (955-960MHz), MTN (950-955MHz), Glo (945-950MHz), and Etisalat (890-895MHz) while for the CDMA; Starcomm (1883-1888MHz) is considered. Results obtained showed that the mud building/rusted corrugated iron sheet roof presents highest signal losses, followed by mud building/unrusted corrugated iron sheet roof then sandcrete building/rusted corrugated iron sheet while the sandcrete building/unrusted corrugated iron sheet roof presents lowest signal losses Also for each of the network and environment considered, path loss exponent and standard deviation were also determined in each case.*

KEY-WORDS: *-Path Loss, Standard Deviation, Cell Phones, Rusted/Unrusted Building.*

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I. INTRODUCTION

Another source of poor radio performance can be signal absorption by building materials. An extensive study of electromagnetic signals attenuation in construction materials at the different frequencies has been conducted [1]. Modern construction methods and materials for large commercial building have changed quite substantially and can be a source of poor radio performance. Curtain-wall, construction for large high-rise buildings means that the walls are "hung" from the structures (typical steel). These walls are generally glass, frequently reflective to radio signals. The glass material used in the Building height contributes several factors that degrade signal in structures. Propagation through more building materials (floors walls etc) which increases the absorption, reflection and refraction of the radio signals through these materials. [1].In this work, we shall review some existing measurements conducted.Ryszard J.et.al [2] presented new analytical approach to path loss modelling in case of propagation in container environment, based on empirical results from measurement campaign in Gdynia container terminal.Propagation path loss measurement in container terminal was based on fixed reference signal transmitter and mobile receiver equipment placed in many different positions in the area of the container terminal but the research was only restricted to the container that is one location.The study was conducted to predict the effect of walls, office partitions, floors and building layout on path loss at 914MHz. The measured buildings include a grocery store, a retail department store and two multi-story office buildings.
The results obtained shows that the standard deviation between measured, predicted path loss and floor attenuation factors (FAF) which described the additional path. However the study was conducted in multi-floor building and no mentioned was made on the cause of this path loss in this type of building.[3]

II. COMBINNED INDOOR PROPAGATION MODEL

In order to achieve accuracy, the combined approach modelling was adopted

2.1 FREE SPACE PATH LOSS MODELLING.

The free space model provides a measure of path loss as a function of separation when the transmitter and receiver are within range in a free space environment. The model is given by equation below which represents the path loss as a positive quantity in dB [1]

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi d)^2}. \qquad (1).$$

Where

G_t and G_r are the ratio gains of the transmitting and receiving antenna respectively,

λ the wavelength in meters, and d is the separation in meters. Assuming that $G_t = G_r = 1$

The free space path loss equation provides valid results, only if the receiving antenna is in the far-field regions of the transmitting antenna. The far-field is defined by the distance given by equation below.[4]

$$df = 2D^2/\lambda \qquad (2)$$

Where D is the largest linear dimension of the antenna, for a receiver to be considered in the far-field of the transmitter, it must satisfy $d_f >> D$ and $d_f >> \lambda$

2.2 LOG-NORMAL SHADOWINNG MODEL

The log-normal shadowing model predicts path loss as a function of separation also but using equation below [1]

$$P_l(d) = P_l(d_o) + 10n\log(d/d_o) + X_\sigma \qquad (3)$$

Where X_σ is a zero-mean Gaussian random variable, σ is standard deviation.

X_σ attempts to compensate for random shadowing effect that can result from clutter while the values of n and σ are determined from empirical data obtained from measurements through the use of linear regression model.

The model development is based on the building types under consideration Viz, mud building coupled with rusted zinc roof, and sandcrete building coupled with good zinc roof. The model algorithm generated was totally statistical and the steps followed are outline.

- The average mean power received for the building type was computed.
- The path loss characteristics for the particular buildings type were computed

III. LEAST-SQUARE LINE METHOD

The least-square line method is used to obtain a line of best fit because the best-fit curve is the curve that has the minimal sum of the deviation s squared for a given set of data.

The least square line approximating the set of points ***(X1, Y1), (X2, Y2……………. Xi, Yi)*** has the equation below.[5]

$$Y = a + bx \qquad (4)$$

To approximate the set of data $(x_1,y_1), (x_2,y_2), (x_3,y_3),..,(x_n y_n)$ where n ≥ 2; such that the sum of squares of the distances to this straight line $y = a + bx$ from the set of point is a minimum.

Where we have

$$a = \frac{\left(\sum_{i=1}^{n} y_i\right)\left(\sum_{i=1}^{n} x^2{}_i\right) - \left(\sum_{i=1}^{n} x_i\right)\left(\sum_{i=1}^{n} y_i x_i\right)}{n\left(\sum_{i=1}^{n} x^2{}_i\right) - \left(\sum_{i=1}^{n} x_i\right)^2} \qquad (5)$$

$$b = \frac{n\left(\sum_{i=1}^{n} y_i x_i\right) - \left(\sum_{i=1}^{n} x_i\right)\left(\sum_{i=1}^{n} y_i\right)}{n\left(\sum_{i=1}^{n} x^2{}_i\right) - \left(\sum_{i=1}^{n} x_i\right)^2} \qquad (6)$$

IV. RESULT AND DISCUSSION

Results obtained from field measurements were presented in tables A-E for indoor and outdoor environments with the difference of signal strength when comparing the two environments are presented in appendix A.The results obtained are shown in table 3 in pages (54-56) and figures 4.5 to 4.9 in pages (56-60). They shows the average received signal strength in different parts of Kaduna Metropolis covered by GSM network service providers (i.e Airtel, Glo, MTN, Etisalat, and Starcomm) respectively.At Anguwan Kanawa mud building/rusted corrugated iron sheet roof presents average signal strength of -59.08dBm which has the highest signal attenuation loss for all the network service providers considered in this research. Similarly at Hayen-Danmani results obtained mud building/rusted corrugated iron sheet roof indicate average signal strength of -57.80dBm which has lower signal strength for the entire network service provider mentioned in this study. Furthermore at Anguwan Muazu the same mud building/rusted corrugated iron sheet roof accounted average signal strength of -59.64dBm, also which the highest signal attenuation.At Kabala Costain results obtained mud building/rusted corrugated iron sheet roof presents average signal strength of -58.79dBm which has highest signal loss. However at Mararaban Jos mud building/rusted corrugated iron sheet roof presents average signal strength of -54.74dBm, which has highest signal loss for the entire network service providers considered in this research.From results presented it was evident that mud building/rusted corrugated iron sheet roof presents highest signal attenuation, hence the network service providers should attenuation of signal in this building and include in link budget when planning for network. Substituting the values into equations (5 and 6) above and evaluate for the constants ‘a and b’ We have

$$a = \frac{\left(\sum_{i=1}^{44} -1990\right)\left(\sum_{i=1}^{44} 28699.532\right) - \left(\sum_{i=1}^{44} 1083.32\right)\left(\sum_{i=1}^{44} -50404.08\right)}{44\left(\sum_{i=1}^{44} 28699.532\right) - \left(\sum_{i=1}^{44} 1083.32\right)^2} \quad \textbf{(7)}$$

$$a = -28.40dB$$

$$b = \frac{44\left(\sum_{i=1}^{44} -50404.08\right) - \left(\sum_{i=1}^{44} 1085.52\right)\left(\sum_{i=1}^{n} -1990\right)}{44\left(\sum_{i=1}^{44} 28699.53\right) - \left(\sum_{i=1}^{44} 1085.52\right)^2}$$

(8)

$$b = -6.8dB$$

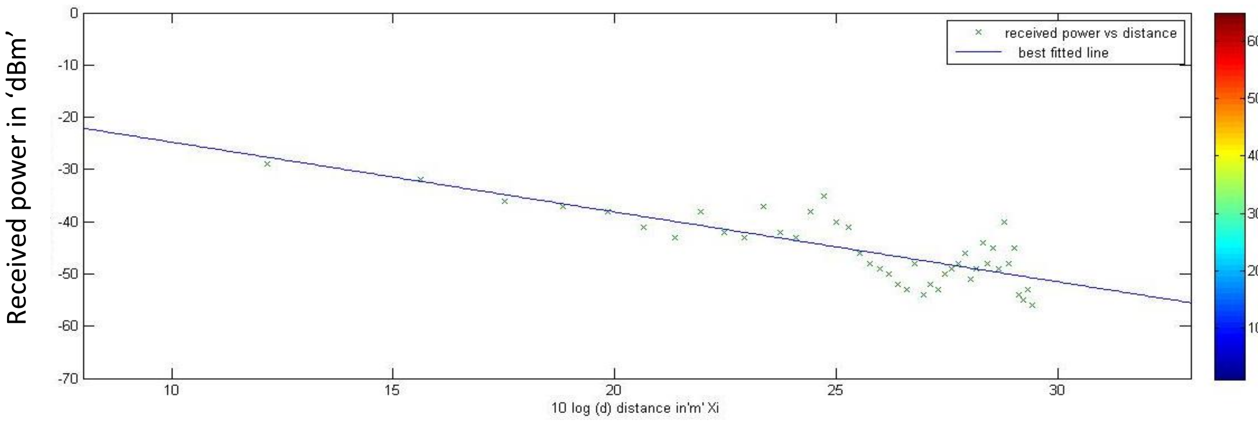

Figure 1. Scatter point’s best fit for Airtel network at Hayen-Danmani

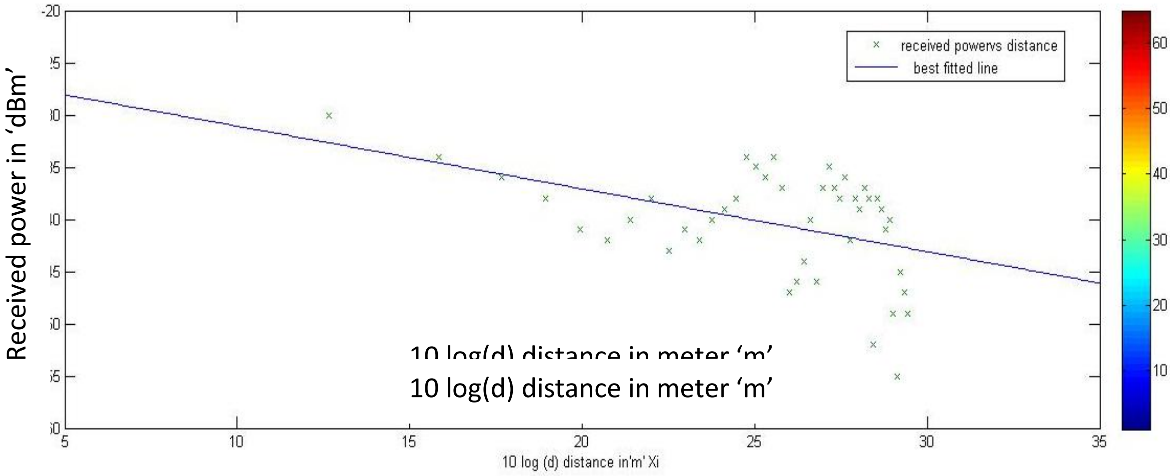

Figure 2 Scatter point's best fit for MTN network at Hayen –Danmani.

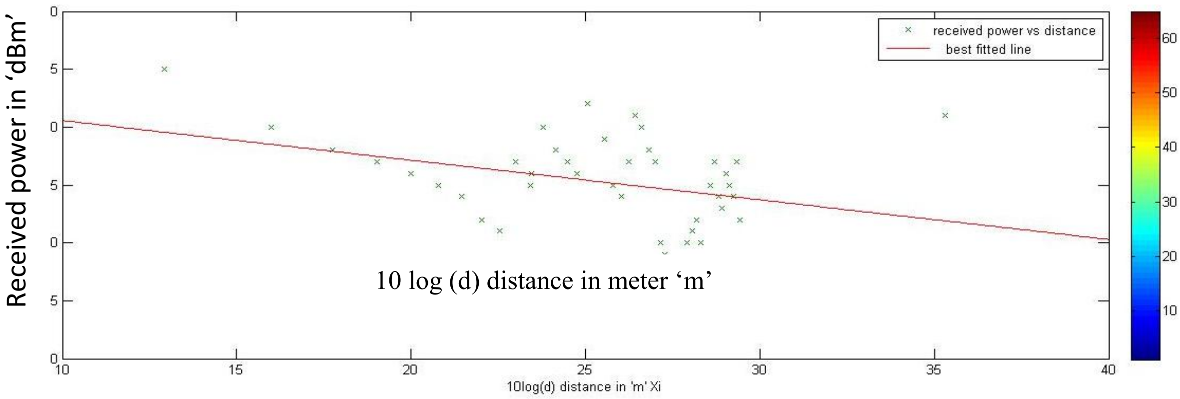

Figure 3 Scatter point's best fit for Airtel network Anguwan Kanawa

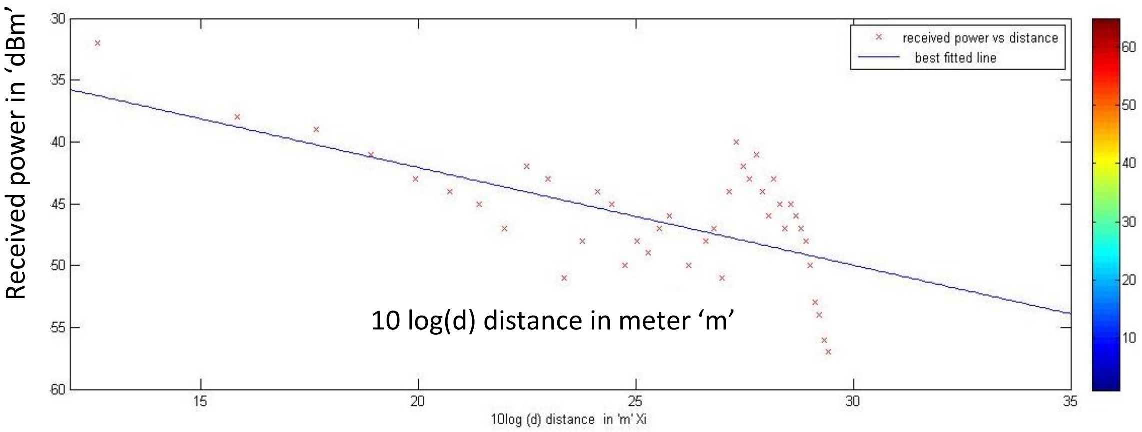

Figure 4 Scatter point's best fit for MTN network at Anguwan Kanawa.

Table 1 Path Loss Exponent and Standard Deviation.

Locations	Network providers	Path loss exponent 'n"	Standard deviation 'σ' in dB
AnguwanKanawa	Airtel	6.8	3.70
Anguwa Kanawa	MTN	5.2	3.74
Hayen-Danmani	Airtel	6.8	3.98
Hayen –Danmani	MTN	6.7	3.86
Kabala Costain	Airtel	1.5	4.50
Kabala Costain	MTN	3.4	3.93
Kabala Costain	Etisalat	2.8	4.49

Table 2 Anguwan Kanawa Signal Strength Loss

Network provider	Mud building / rusted corrugated iron sheet roof	Mud building/ unrusted corrugated iron sheet roof	Sandcrete building / rusted corrugated iron sheet roof	Sandcrete building / unrusted iron sheet roof
Airtel	-54.11	-52.99	-52.84	-47.03
MTN	-48.07	-46.54	-45.25	-42.34
Glo	-53.41	-49.44	-47.98	-44.97
Etisalat	-69.23	-53.65	-47.67	-41.62
Starcomm	-70.757	-67.70	-69.70	-61.94

Table 3 Hayen-Danmani Signal Strength Loss

Network provider	Mud building / rusted corrugated iron sheet roof	Mud building/ unrusted corrugated iron sheet roof	Sandcrete building / rusted corrugated iron sheet roof	Sandcrete building / unrusted iron sheet roof
Airtel	-58.34	-50.41	-47.23	-45.55
MTN	-51.00	-49.92	-42.66	-41.47
Glo	-58.55	-57.69	-52.01	-50.05
Etisalat	-57.44	-54.21	-48.91	-43.02
Starcomm	-63.69	-62.40	-63.10	-53.83

Table 4 Anguwan Muazu Signal Strength Loss

Network provider	Mud building / rusted corrugated iron sheet roof	Mud building/ unrusted corrugated iron sheet roof	Sandcrete building / rusted corrugated iron sheet roof	Sandcrete building / unrusted iron sheet roof
Airtel	-52.70	-51.53	-50.36	-51.53
MTN	-53.72	-52.02	-49.42	-39.17
Glo	-55.89	-50.65	-43.39	-40.21
Etisalat	-69.47	-56.41	-46.47	-41.07
Starcomm	-66.44	-62.84	-58.98	-57.11

Table 5 Anguwan Muazu AREA2 Signal Strength Loss

Network provider	type of buildings			
	mud building/rusted corrugated iron sheet roof	mud building/unrusted corrugated iron sheet roof	sandcrete building/rusted corrugated iron sheet roof	sandcrete building/unrusted corrugated iron sheet roof
Airtel	-52.70	-51.53	-50.36	-40.62
MTN	-53.72	-52.02	-49.42	-39.17
Glo	-55.89	-50.65	-47.39	-40.21
Etisalat	-69.47	-56.41	-46.47	-41.07
Starcomm	-66.44	-62.84	-58.98	-57.11
Network provider	type of buildings			

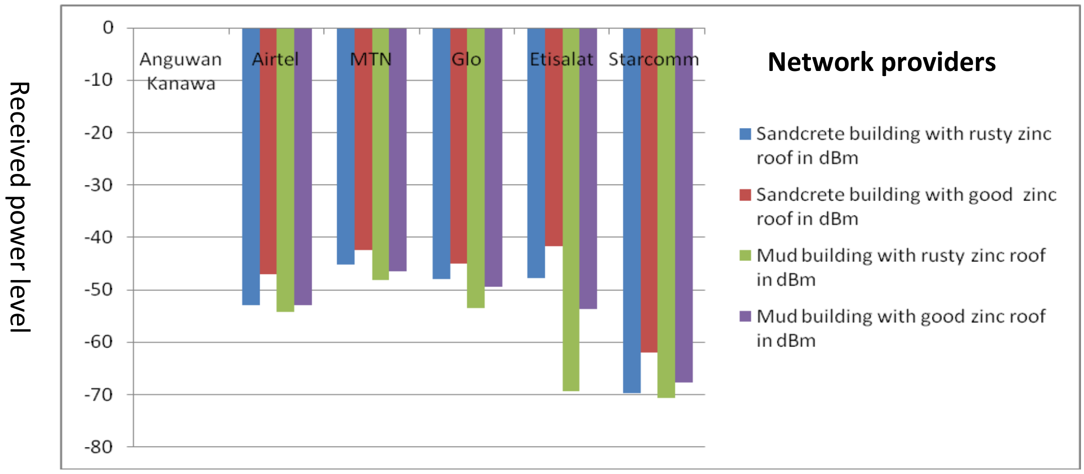

Figure 5 Comparison of signal strength variations for Anguwan Kanawa.

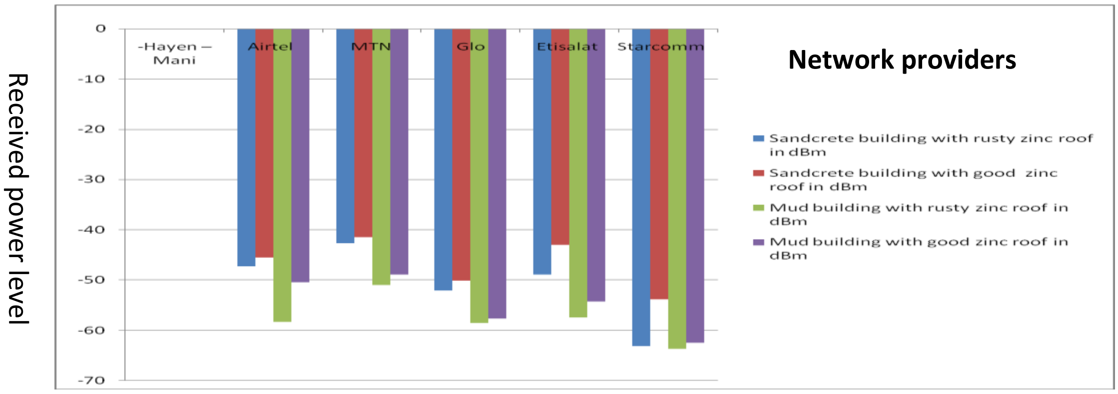

Figure 6 comparison of signal strength variations for Hayen-Danmani.

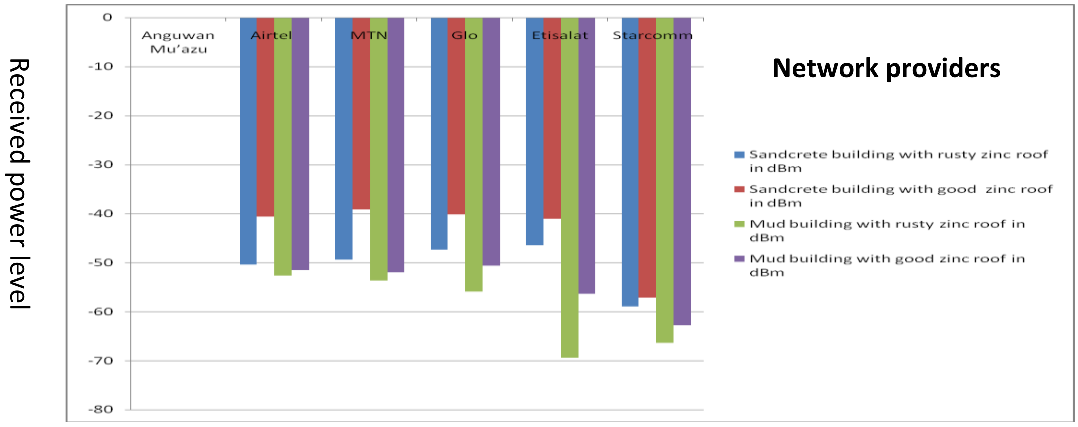

Figure 7 comparisons of signal strength variations for Hayen-Danmani

V. CONCLUSION:

In conclusion results obtained showed the effect of compositional nature on mobile phone signal power losses and signal strength variation of each of the building types and shown the effects of rusting. Furthermore for each of the network and environment considered, path loss exponent and standard deviation were determined. Results obtained for each of the network and environment, indicate path loss exponent of between 1.5 to 6.8 with a reasonable Standard deviation varied between 3.70dB to 4.49dB.

REFFERENCES

[1] Theodore S. Rappaport "wireless communications principles and practice" second edition, PHI learning private limited New delhi-110001 2009, pp (105-177).

[2] Ryszard J. kasulsk, Jacek Stefanski and Jaroslaw Sadowsk "propagation path loss modelling in container terminal environment" Journal of telecommunications and information technology 3/2008 (proceedings of VTC 2008-fall. IEEE 68th vehicular technology conference pp (1-4) , ISBN:978-1- 4244-1721-6.

[3] Ashok Chandra " comparative study of path losses from propagation measurements at 450MHz, 900MHz, 1.35GHz and 89GHz in the corridors of a multi-floor laboratory-cum office building " IEEE proceedings of VTC 99 Vol.51 No1 January 2003..

[4] J.D Parsons, "The mobile radio propagation channel second edition copyright 2000 John Wiley and son Ltd print ISBN 0-471-98857-x pp190-195.

[5] S.C Gupta 'Fundamentals of Statistics' Himalaya publishing house PVT. Ltd six editions 20011 (pp9.10).

[6] R.Hope, G Wolfle, and F.M Landstorfer "measurement of building loss and propagation models for radio transmission into buildings.htt://www.ihf.uni-stuttgart.de

[7] A.F de TOLEDO and A.M.D Turkmani "propagation into and within buildings at 900MHz, 1800MHz and 2300MHz" ; IEEE Calgary 21-24 September, 2008 Canada.

[8] Greg Durgin, Theodore S. Rappaport and Hao Xv" radio path loss and penetration loss measurement in and around homes and trees at 585GHz"IEEE Transaction on communication Vol46.No11 November 1998.