# Third Generation Wireless Signal Profiling

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*Abstract* - **This paper is about third generation, PCS and other cellular signal profiling in a built-up area such as Melbourne CBD. The purpose of this investigation is to determine the variation of the signal strength between a transmitter, 1218-BV Lockable oscillator 900-2000MHz general radio, mounted on top of a RMIT University building and a portable receiver, Protek 3201, covering the streets below the transmitter. It is divided into sectors and the points of data collection are marked in steps of 10 meter. The transmission paths between the transmitter and receiver can be varied from direct Line-of-Sight to a fully blocked by a tree a building or. 3G systems require site-specific propagation modeling due to the high speed signal such as video-conferencing and video streaming. They require reliable and continuous service. Signal profiling is essential for service reliability.**

## I. Introduction

Third generation mobile wireless system will be launched within 2003. High speed and seamless transmissions are major factors in future wireless communication. This may not be possible because there are obstacles in a city environment between the transmitter and the receiver such as trees and buildings. In order to overcome the interference and fading, it is necessary to build up a signal profile of the city for the telecommunication company before base station for the third generation mobile system can be located.

Signal profiling in a city gives an exact picture of reception while a model can only provide a predicted result. There is a place for model because it provides preliminary information while direct signal profiling provides quantitative information about strong and weak signal strengths. To overcome weak signals, re-siting of the transmitter is sometimes done. Sometimes, an increase in transmitter power is necessary. Another technique is to divide the coverage area into smaller cells. In this case, more handoffs have to be used to ensure a good reception. From our study, the area to be profiled is around the Melbourne CBD covering all streets and avenues. First we compare five empirical models as shown in figure 1. SAKAGAMI & KUBOI [1],[5] model was selected to determine the predicted signal strength of the city as shown in figure1because it takes into account more parameters such as the heights of the transmitter and the receiver and the average height of buildings in between.

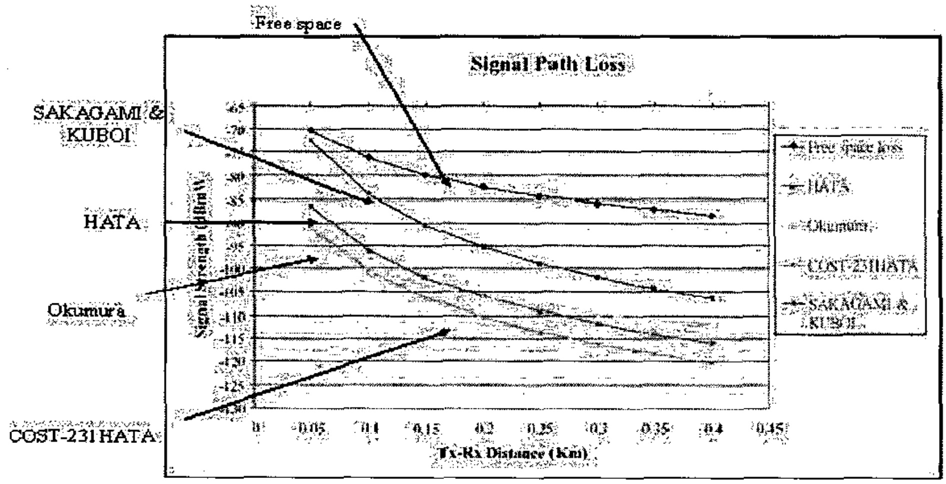


Figure 1. Four Propagation models compared with free space loss for the same signal strength and distance



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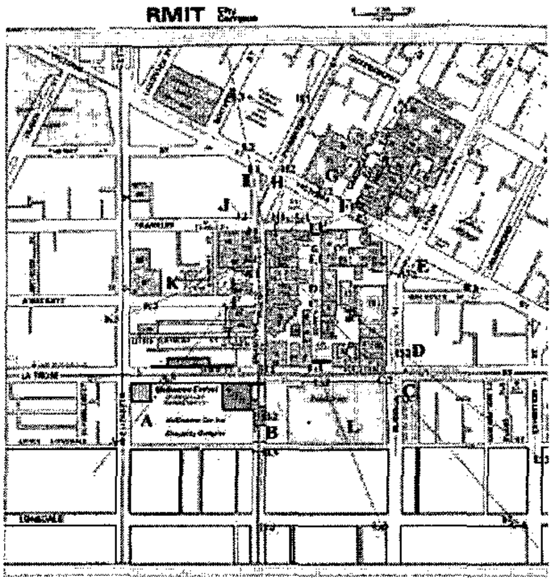


Figure 2. Measurement map

## II. Overview of Empirical Models

There are many of empirical models which are used in determining propagation loss. From Figure 1, Free space, HATA, Okumura, COST-231 HATA and SAKAGMI AND KUBOI models were selected to compare and discuss their performance in order to select the best-match for this signal profiling.

### *A. Free Space Propagation Model*

$$L_f = 32.44 + 20\log f_c + 20\log d \quad (1)$$


Figure 3. Transmitter and receiver Block Diagram

The equation show that free space propagation model only consider frequency and distance from transmitter [1].

### *B. HATA Model*

$$L_{50}(urban)(dB) = 69.55 + 26.16\log f_c - 13.82\log h_{te} - a(h_{re}) + (44.9 - 6.55\log h_{te})\log d \quad (2)$$

HATA model places a good emphasis on antenna height of the transmitter and the receiver but below 2GHz in frequency range [3].

### *C. Okumura Model*

$$L_{50}(dB) = L_F + A_{mu}(f,d) - G(h_{te}) - G(h_{re}) - G_{AREA} \quad (3)$$

Okumura model is similar to HATA model. Here too, the antenna heights of the transmitter and the receiver are the main consideration [4].

### *D. COST-231 HATA Model*

$$L_{50}(urban)(dB) = 46.3 + 33.9\log f_c - 13.82\log h_{te} - a(h_{re}) + (44.9 - 6.55\log h_{te})\log d + C_M \quad (4)$$

COST-231 HATA model is slightly better than the previous model because of the frequency range extends up to 2GHz [4].

### *E. SAKAGAMI AND KUBOI Model*

$$L_f = 100 - 7.1\log W + 0.023\varphi + 1.4\log h_s + 6.1\log h_{ave} - [24.37 - 3.7(\frac{H}{h_{b0}})^2]\log h_b + (43.42 - 3.1\log h_b)\log d + 20\log F + e^{13(\log F - 3.23)} \quad (5)$$

SAKAGMI AND KUBOI model is considered the best model for signal profiling. It considers more parameters which included the height of structure surrounding to the transmitter and the receiver. It is more realistic than other prediction model for city area [5].

## III. Measurement

From Figure 3, there are three main parts for the experiment setup which are the transmitter, the discone antenna and the receiver. The transmitter is 1218-BV Lockable Oscillator (900-2000) MHz General Radio which can generate 1 kHz signal tone at 2GHz, discone antenna designed for 2GHz and Portable receiver Protek 3201 covers the frequency range up to 2GHz. The considered measuring area here is 1200m x 600m. The readings of measurement were taken at every 10 meters in every street in the city area. The database of measurements shows the variation of signal in every street.

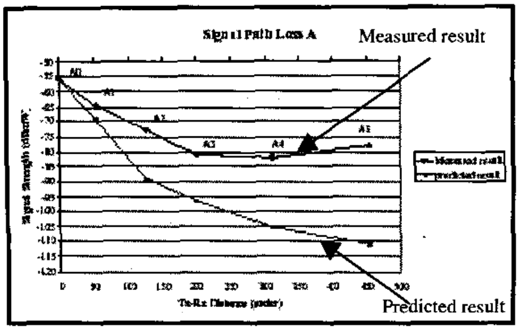


Figure 4. Signal path loss A

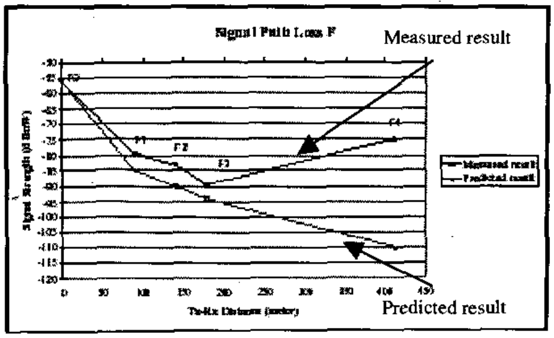


Figure 6. Signal path loss F

## IV. Discussion

The signal paths are shown from A to Z shown in Figure 2. There is sufficient detail in the data to make it

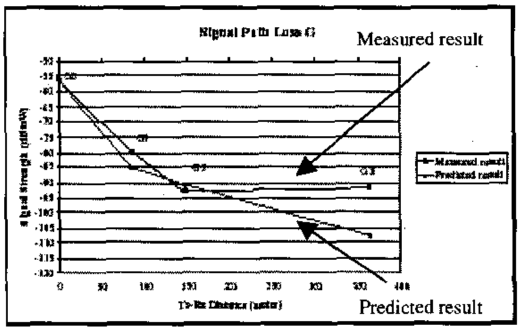


Figure 5 Signal path loss G

easier for extrapolating the signal strength in a particular area. For instance considered path A, comparing the experiment results with those predicted by SAKAGAMI & KUBOI model are shown in Figure 4. It is seen that the curve was decreased with distance as the receiver gets further away from the transmitter. This trend is similar to SAKAGAMI & KUBOI model. However, at point A4 and A5, the signal increases probably due to the additive interference of the direct and reflected signal from building (window surface) surroundings. Perhaps it is because once the radio wave impinges on a rough or smooth surface, the reflected energy usually spread out in all directions. Therefore, this provides additional radio energy.

From Figure 5 and Figure 6, the measured values are very closed to SAKAGAMI & KUBOI model prediction in first 100 meters but there is approximately 25-30 dB difference at a distance 400 meters distance shown in signal paths G and F.

## V. Interferences

There are three main contributing factors that affect the signal propagation. These are reflection, diffraction and scattering.

### *A. Reflection*

Reflection occurs when a propagation electromagnetic wave impinges upon an object that has very large dimensions compared to the wavelength of the propagating wave [1] and the surface has a high reflectivity and low absorption.

### *B. Diffraction*

Diffraction occurs when a radio path between the transmitter and the receiver impinges upon a sharp corner having a dimension comparable to the wavelength [1]. The secondary wave resulting from the obstructing corner spread throughout the space and including behind the obstacle, to give rise to a bending of waves around the obstacle

## IV. Conclusion

3G systems require site-specific propagation modeling due to the special needs for signal optimization at the receiver. Signal profiling is necessary to pinpoint black spots in service areas and hence changes in siting and system parameters can be made to meet system requirement for a reliable service. Hand-off and hand-on algorithms are sometimes needed for specific areas when weak signals are encountered. In general, SAKAGAMI & KUBOI model can be used for distance up to 100 meters based on our results. Signal profiling can give an exact picture of the location of poor or good reception to a network designer. Changing of transmitted power levels or dividing service area into smaller cells is dedicated by signal profiling in order to provide better service. Signal profiling can assist with minimizing call dropouts and in-building coverage. In third generation wireless systems, signal profiling will be a key factor for assisting the engineer to provide a seamless service. Site-specific propagation model is necessary in third generation wireless system, which is earmarked to provide high speed transmission rate. SAKAGAMI & KUBOI model in general is a good model to create a preliminary signal profiling for third generation wireless system.

## Acknowledgment

The authors wish to acknowledge the assistance and support of RMIT staff and technicians from the School of Electrical and Computer Engineering, RMIT University.

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