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Assessment of the Dominant Path Model and Field Measurements for NLOS DTV Signal Propagation

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Abstract. In Brazil, one of the most important telecommunications systems is broadcast television. Such relevance demands an extensive analysis to be performed chasing technical excellence in order to offer a better digital transmission to the user. Therefore, it is mandatory to evaluate the quality and strength of the Digital TV signal, through studies of coverage predictions models, allowing stations to be projected in a way that their respective signals are harmoniously distributed. The purpose of this study is to appraise measurements of digital television signal obtained in the field and to compare them with numerical results from the simulation of the Dominant Path Model. The outcomes indicate possible blocking zones and a low accumulated probability index above the reception threshold, as well as characterise the gain level of the receiving antenna, which would prevent signal blocking.

1. Introduction

The federal decrees no. 4,901 of 26th of November of 2003 and no. 5,820 of 29th of June of 2006 instituted and implemented, respectively, the Brazilian System of Digital Terrestrial Television [1]. At the first days of its implementation conducted by the Ministry of Science, Technology, Innovations and Communications and by the National Agency of Telecommunications, the focus was on the study and development of a high-performance system for the processing, transmission, and reception of digital audio and video signals. This structure should have the capacity to work side-by-side with the Analogue TV system while the transition period between both technologies [2, 3].

Those years of research were published as the Basic Plan of Distribution of Digital TV Channels, with the intention of defining parameters related to coverage and interference with current and future systems [2]. In 2007 the transmission of Digital TV signals started officially in Brazil, in the city of São Paulo, and since then, other cities over the country have been keeping a schedule defined by the Ministry of Communications for new deployments [1]. Because of the significant losses in the quality of services when contrasting digital and the analogue system, the reception power is an important aspect of the digital system [4].

Several prediction models were implemented as well as field measurements were performed around the cities [1, 2]. Those measurements are crucial in order to certify the prediction and to identify areas with a difficult reception. Computational modelling and field measurements are considered complementary approaches [1].

The study in [2], takes place in the main Brazilian capitals, making a comparison between field intensity measurements and numerical results from the implementation of ITU-R P.526, Deygout-Assis, ITU-R P.1546 and CRC Predict models. A similar study is conducted in [1] with 223 measurement points distributed along the metropolitan region of the city of Curitiba.

The purpose of this paper is to evaluate field measurements of Digital TV signal collected in the coastline of the city of João Pessoa and compare them with numerical results obtained from the implementation of the Dominant Path prediction model using the *WinProp Software Suite*.

2. Overview of the Dominant Path Model

Propagation models [5] in wireless communication systems have the objective of predicting the average received signal power at a given distance from the transmitter and, also, the inconsistency of the signal power in a close proximity to a certain location [6].

The Dominant Path Model (DPM) is based on the fact that not all power rays between the transmitter and the receiver contribute with similar energy to the total power received. In fact, only a few propagation paths are dominant in terms of energy input [7].

The DPM can be applied in indoor, urban and rural scenarios. It concentrates only on the dominant paths and does not calculate the paths with small energy contribution. Likewise, it does not consider all the details of the database, requiring less time to pre-process it [3].

The DPM model can be subdivided into two steps:

(i) Determination of the dominant paths (geometry);

(ii) Loss prediction along the paths.

The loss prediction (L) along the path is

$$L = 20\log\left(\frac{4\pi}{\lambda}\right) + 10\,p\log(l) + \sum_{i=1}^{n} f(\varphi, i) + \sum_{j=1}^{m} t_j - \Omega, \tag{1}$$

where L is the path loss in dB, λ is the wavelength in meters, p is the visibility factor for *Line of Sight* and *Non-Line of Sight* conditions, l is the path length in meters, $f(\varphi, i)$ is a function which determines the interaction loss in dB, t_j is the transmission loss of wall number j and Ω is the wave-guiding factor [8].

In the case of mountainous urban scenarios, the topography of the area should be considered along with the height of the buildings for taking into consideration the visibility factor [8].

3. Materials and Methods

The applied methodology was based on the comparative analysis of field measurements and numerical results obtained from computer simulation using the Dominant Path Model.

The region of interest has an area of 7.73 km $\times$ 4.44 km, and it comprises all the neighbourhoods between the city centre and the coast line of *Cabo Branco* and *Tambaú*.

3.1. Field Measurements

A survey on the reception intensity of Digital TV signal in several points on the coastline of *Cabo Branco* beach and adjacent streets, in the city of João Pessoa, was performed.

Sixty-six measurements were collected *in loco* on the 9th of February of 2017 and divided into three routes: blue (first), green (second) and red (third) routes. The red route is 30 m higher than the other ones and the green route is right at the bottom of that 30-meter hill. Fig. 1 shows how those points were distributed along the routes.

TV Manaíra was the studied TV station, it serves as the João Pessoa city affiliate station of the *Rede Bandeirantes* and operates in the frequency range between 482 MHz and 488 MHz.

Figure 1. Measurement points (numbered from left to right).

3.2. Study of the Coverage Prediction Model

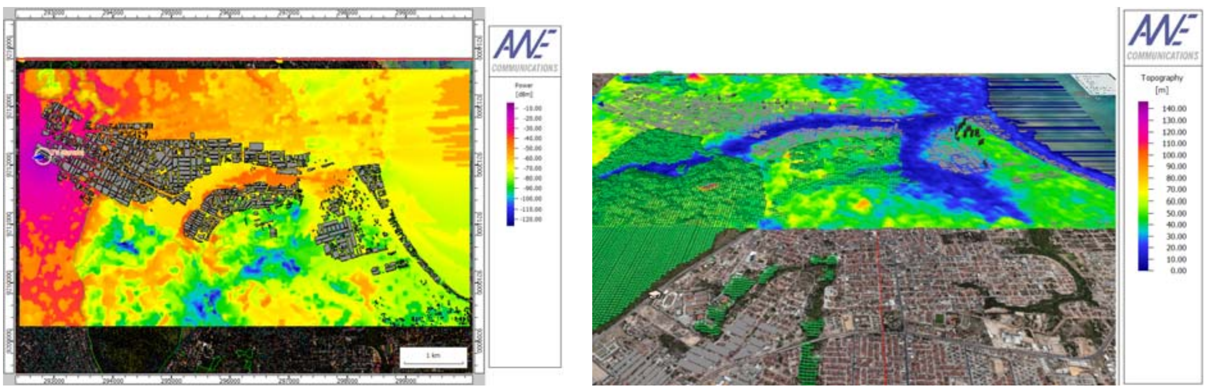
The coverage prediction was executed through the implementation of the Dominant Path Model using the *WinProp Software Suite*.

The simulation scenario was prepared by inserting the topographic information and by building the blocks that represent the various constructions in the region of interest so that the results could be as accurate as possible.

The antenna pattern and its azimuth angle were also taken into consideration as well as its transmission power and tower height. Specifications regarding the TV station can be found in details at the Brazilian National Telecommunications Agency system.

4. Results

The data collected in the field and through computational simulation were organised and assessed by each route. Figure 2 shows an overview of the whole area under simulation. The channel power, the buildings blocks and the location of the transmitter is indicated in both 2D (Figure 2(a)) and 3D (Figure 2(b)) representations.



(a) Channel power in the region of interest. (b) Scenario in 3D.

Figure 2. Channel power and 3D representation of the region of interest.

Figure 3 presents the data collected in the field and the data obtained from computer

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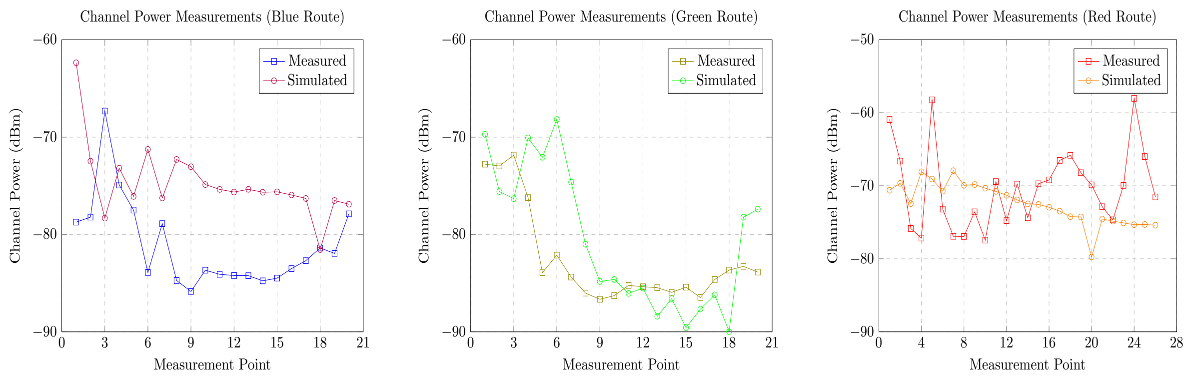
simulations for each of the three routes, Blue (Figure 3(a)), Green (Figure 3(b)) and Red (Figure 3(c)).



(a) Blue Route. (b) Green Route. (c) Red Route.

Figure 3. Channel power measurements.

The numerical results, besides the comparative analysis, also calculated the accumulated probability index and it shows the probability in which a channel power might be below a certain reception power. On the condition that we are dealing with Digital TV signal, the reception threshold is -77 dBm, and it was calculated that the probability of it to be below this threshold is 20%.

5. Conclusion

In order to verify the accuracy of this work, line graphs were plotted (Figure 3). Figure 3(b) presents the worst scenario in which most of the measured and simulated points are below the reception threshold.

The accumulated probability index also shows us that only 80% of the region of interest has a coverage above the threshold of -77 dBm. Because the ideal percentage is to get as close as possible to 100% coverage, this is considered a very low percentage of the total region.

Based on these results, besides being a model that requires a low computational effort, the Dominant Path Model also showed itself as a reliable and accurate tool. For future works, it would be important to evaluate the same region of interest using other coverage prediction models.

References

[1] Vasco C L and de Borba M A C 2013 *Novas Técnicas e Ferramentas Aplicadas ao Sistema Brasileiro de TV Digital* ed Fonseca K V O and de Almeida Prado Pohl A (Curitiba, PR: Omnipax) chap 2, pp 39–88 1st ed ISBN 978-85-64619-14-2
[2] Silva F S, Matos L J, Peres F A C and Siqueira G L 2013 *Microwave Optoelectronics Conference (IMOC), 2013 SBMO/IEEE MTT-S International* pp 1–5
[3] Melo A A, Rodrigues F P, Farias K C S and Silva E F 2013 *XLI Congresso Brasileiro de Educação em Engenharia, 2013. COBENGE 2013. ABENGE*
[4] Arthur R, Iano Y, M S R and F R 2007 *IEEE Latin America Transactions* **5** 573–578 ISSN 1548-0992
[5] Sah N and Kumar A 2009 *International Journal of Computer and Electrical Engineering* **1** 464–472 ISSN 1793-8163
[6] Sharma H K, Sahu S and Sharma S 2011 *International Journal of Computer Applications* **19** 36–42
[7] Aschrafi A, Wertz P, Layh M, Landstorfer F M, Wolfle G and Wahl R 2006 *2006 IEEE 63rd Vehicular Technology Conference* vol 6 pp 2681–2685 ISSN 1550-2252
[8] Wahl R and Wolfle G 2006 *2006 First European Conference on Antennas and Propagation* pp 1–6 ISSN 2164-3342