Analysis and selection of propagation models for Broadcast and Mobile services in urban areas in Colombia

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Abstract

This document presents a comparison between spectrum measurements and simulations in the UHF TV broadcast band (470-698 MHz) and the mobile communications band (806-898 MHz). The measurements were taken in the urban area in Bogotá, Colombia. The methodology and configuration of the measurements and the simulation and the results of contrasting different propagation models vs. the actual values of the measurements are presented and discussed.

1. Introduction

The electromagnetic fields exposure level, generated by telecommunications transmitters is a matter of high concern to the public. Entities such as ITU[1], ICNIRP and IEEE [2], with the support of World Health Organization, have published various documents and recommendations indicating the values of field strength considered safe for the population.

As a way of increasing the awareness of the public to the results of the campaigns for monitoring the electromagnetic field levels and the compliance with the non-ionizing radiation levels (NIR), the Colombian National Spectrum Agency (ANE) developed a web tool for the presentation of the results of field meters deployed in the country[3]. In order to expand the performance of this web tool, the ANE considered the possibility of adding a functionality that would predict the increase in the NIR level due to the addition of a new telecommunication transmitter at a known location.

The predicting tool must take into account the existing field level generated by the signals of existing telecommunication transmitters, propagation conditions such as weather, topography, urban and natural obstacles and even day and time of the week.

In order to select a proper propagation model for the tool, several measurements were performed and compared with different propagation models. Additional calculations were performed in order to identify the combination of parameters that best fits the type of signal and propagation conditions in the area of interest.

A first set of narrowband measurements were taken using a spectrum analyzer. These were correlated with broadband measurements, obtained from a three axis field probe, in order to determine the largest contributions to the field measured in the vicinity of the transmission systems.

2. Measurement methodology

The measurements were performed in a residential area of Bogota, Colombia, called Suba, covering a rectangle of 20 km^2. Five measurement sites were selected from the area due to their population density and proximity to transmission sites.

The narrowband measurements were performed with a digital spectrum analyzer, Agilent 9340B and a calibrated discone antenna, covering the 400MHz to 4GHz band. The sweep and resolution bandwidth RBW configurations on the instrument, contemplate the characteristics of the existing services in each band. Figure 1 shows the experimental setup.

The measurements concentrated in two bands. The first one ranges from 470 MHz to 698 MHz and corresponds to the UHF TV band in Colombia, composed mostly of 6MHz DVB-T2 digital terrestrial television and some NTSC channels. The second band ranges from 806 MHz to 898 MHz and corresponds to mobile communications services: GSM, 3G and iDEN technologies. Simultaneous to the narrow band measurements, a set of broadband measurements were carried out using a Wavecontrol SMP2 probe. Figure 1 shows examples of the spectrum obtained in the television and mobile services bands.

At each point, three measurements of 6 minutes per band were taken at three different times of the day: morning, afternoon and night. In accordance to the K.52 recommendation, each 6 minutes measurement was integrated, obtaining a single number corresponding to the energy per band.
These measures were performed seven days per week, during in two weeks, totaling 2160 spectrum shots.

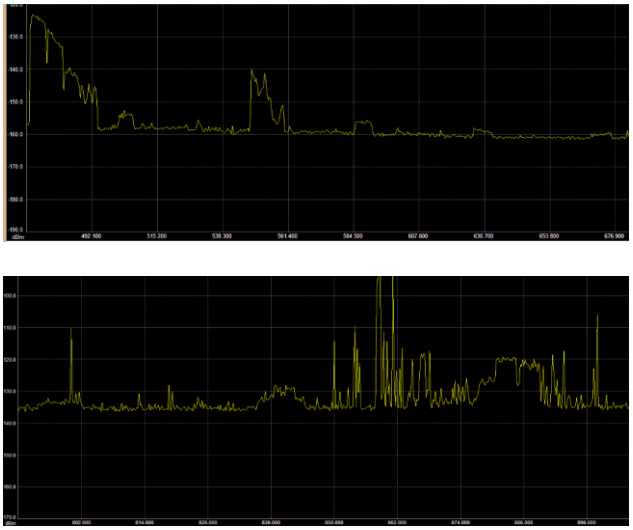

Figure 1 Above, measured UHF TV band spectrum 470 MHz to 698 MHz. Down, mobile band 806 MHz to 898MHz

Due to the reduced bandwidth of some channels, 11 KHz and 12.5 KHz, the Trunking band (857MHz to 869 MHz) was divided into 5 bands of interest by adjusting the center frequencies and bandwidth of each channel to the resolution of the analyzer. Once the measurement was done it was processed so that the highest value was obtained per Trunking channel taking into account the bandwidth, thus obtaining from each station had up to three samples.

The measurement was performed with "Max hold" and "Average" functions in 6-minute periods, in each of the 5 bands. One of this measure is show on Figure 2. Once the value was obtained in each case for the 5 bands, the peaks and data were filtered and discarded between the noise floor and +10 dBuV/m, measured peaks showed around 25 dBuV/m with Average function and 28 dBuV/m with "Max hold" function for all cases.

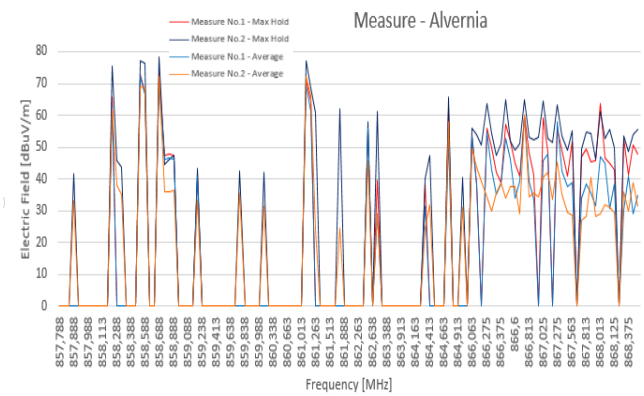

Figure 2 One of the 5 Trunking Bands measured by site, with 6-minute Max Hold and Average functions

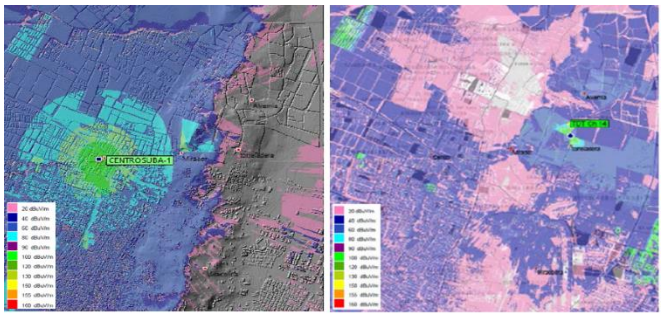

Figure 3 Left, simulation of iDEN Trunking channel on 806 MHz to 898 MHz Band. Right simulation of channel 14 of TDT.

3. Simulations

In order to find the appropriate propagation model for the zone and frequencies of interest, we considered the deterministic model ITU-R.P525, also the Okumura / Hata / Davidson which is a statistical model and finally the ITU-R.P1546 which is an empirical model for Broadcast.
Diffraction losses were calculated and taken into account in the models. These were calculated using Bullington, Deygout and ITU-R.P526 round Mask methods.[4][5]

The resolution of the cartography used was of 5 m and was counted on the clutter with information of the use of the soil. All of the existing TV and Trunking mobile transmission systems in the area of interest were included in the simulations.

4. Analysis and comparison of results

The quantity of values was reduced by averaging between measures of the same nature: day, hour or type of value according to the analyzer sample, reaching a value per channel. This value is the one that will lead to the comparison with the results of the software simulator for each one of the models

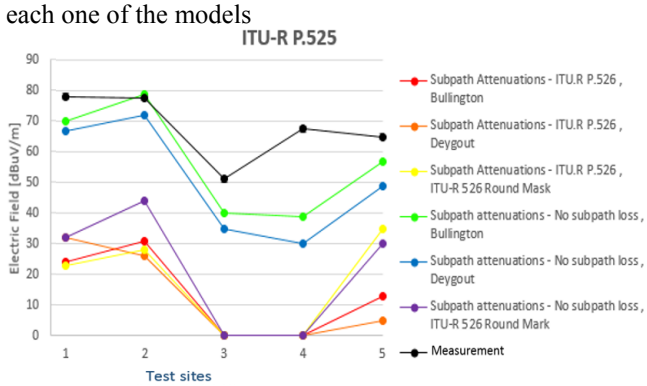

Figure 4 Measurement and ITUR-P525 propagation model simulation comparison with diffraction and sub path losses for 5 different sites

The behavior of the measurements showed that there are no significant differences in traffic and spectrum observed

between the different working days and Saturdays. It was evident an important reduction of the occupied spectrum and field level on Sundays. Tables 1 and 2 present the final comparisons between simulations and measurements.

In the case of TV Broadcast, the most approximate model was ITU-R.P525 supplemented with ITU-R.P526 round mask. Differences between simulations and measurements were always less than 5dB.

For the mobile Trunking service the most approximate model was the ITU-R.P525 supplemented with Bullington diffraction model. The average deviation between the present 11 dB at best case.

Table 1. Comparison between measurements and simulations for the 470 MHz to 698 MHz UHF TV band. Differences between simulation and measurements for each one of the 5 sites, regarding 2 propagation models and 3 diffraction method are presented.

Prop Model	Difraction Meth.	Site 1	Site 2	Site 3	Site 4	Site 5	Δ dB
ITU -R.P525	Bullington	3.23	9.75	15.18	4.49	5.93	7.72
	Deygout	0.62	5.21	10.69	4.16	12.31	6.60
	526 Round Mask	3.62	4.25	5.07	4.73	4.40	4.41
ITU -R.P1546	Bullington	8.13	37.66	3.61	11.64	6.27	13.46
	Deygout	8.13	37.66	3.61	11.64	6.27	13.46
	526 Round Mask	8.13	37.66	3.61	11.64	6.27	13.46

Table 2. Comparison between measurements and simulations for the 806 MHz to 898 Band. Differences between simulation and measurements for each one of the 5 sites, regarding 3 propagation models and 3 diffraction method are presented.

			Site 1	Site 2	Site 3	Site 4	Site 5	
	Modelo	Difracción	Δ dB	Δ dB	Δ dB	Δ dB	Δ dB	Mean
ITU-R P.525	Subpath attenuations - ITU.R P.526	Bullington	54,37	46,96	51,19	67,61	51,97	54,42
		Deygout	46,37	51,96	51,19	67,61	59,97	55,42
		526 Round Mask	55,37	49,96	51,19	67,61	29,97	50,82
	Subpath attenuations - No subpath loss	Bullington	8,37	1,04	11,19	28,61	7,97	11,436
		Deygout	11,37	5,96	16,19	37,61	15,97	17,42
		526 Round Mask	46,37	33,96	51,19	67,61	34,97	46,82
Okumura/Hata/Davidson	Subpath attenuations ITU R-526	Bullington	37,63	29,04	51,19	67,61	38,97	44,888
		Deygout	37,63	29,04	51,19	67,61	64,97	50,088
		526 Round Mask	37,63	29,04	51,19	67,61	64,97	50,088
	Subpath attenuations - No subpath loss	Bullington	37,63	29,04	18,19	14,61	0,03	19,9
		Deygout	37,63	29,04	19,19	19,61	9,97	23,088
		526 Round Mask	37,63	29,04	51,19	67,61	14,97	40,088
ITU-R P.1546	Subpath attenuations ITU R-526	Bullington	6,37	4,96	51,19	67,61	40,97	34,22
		Deygout	4,37	6,96	51,19	67,61	39,97	34,02
		526 Round Mask	4,37	6,96	51,19	67,61	43,97	34,82
	Subpath attenuations - No subpath loss	Bullington	22,63	11,04	51,19	67,61	23,97	35,288
		Deygout	22,63	11,04	51,19	67,61	23,97	35,288
		526 Round Mask	22,63	11,04	51,19	67,61	23,97	35,288

5. Conclusions and future work

A propagation model was found for broadcast TV services in the 470MHz to 698 MHz band and for Mobile services in the 806 MHz to 898 MHz band, on the interest area. The propagation models presents the best fitting values required for the field prediction.

The prediction for mobile services result in a lower quality due to the characteristics of the different types of signals that appear in the spectrum and area of work.

The evidence suggests that the deterministic models considered represent more adequately the measured phenomena, in comparison with deterministic models.

We expect to integrate the selected propagation and loss model into the web tool developed by the ANE

6. Acknowledgments

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7. References

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