Pedagogical Methogolgies For Teaching of Signal Path-Loss Models Applied to Power Intensity Analysis Through the Usage of Google-SketchUp

Huber Nieto-Chaupis
Universidad de Ciencias y Humanidades
Center or Research eHealth Lima39
Av. Universitaria 5175 Los Olivos Lima39 Peru
huber.nieto@gmail.com

David Llulluy
Universidad de Ciencias y Humanidades
The Electrical Engineer Program
Av. Universitaria 5175 Los Olivos Lima39 Peru

***Abstract*—A study of the applicability of the well-known Google SketchUp as to model the signal path-loss in mid-sized urban areas is presented. From the fundamental power equation and the usage of Dirac distributions arriving to nonlinear input/output (I/O) integrals with unknown parameters applied. We use this scheme to optimize antenna deployment in an urban zone containing buildings and delimited areas. The modeling assumes that the Delta function contains a polynomial argument and unknown parameters. The extracted parameters through Monte Carlo steps, would serve to measure the signal intensity degradation over the mid-sized urban areas assisted with the Google-SketchUp version 8.**

***Index Terms*—Power intensity, Dirac-Delta Functions, Path Loss Modeling**

I. INTRODUCTION

A. Motivation of This Paper

Nowadays, most of the well-known geo reference softwares are consisting in well designed tools that combine geographic location and other tools in according to the requirement of the designer [1]. A good example of application of these softwares falls down inside the territory of the telecommunications engineering since we are experienced epochs of massive networking due to the rapid arrival of the sophisticated technologies such as Internet. Thus radio propagation techniques are to be extended in a sustainable manner in according to the end-user necessities[1][2][3]. Therefore it seems to be suitable to introduce novel and powerful softwares aiming a better understanding of the problem that commonly appears in antenna deployment: to find the more optimal location for the best signal reception[4][5][6][7]. Specially in those students pursuing a first degree in electrical and telecommunications engineer one needs to known which kind of software might be profitable inside the territory of interest of the student by keeping the academic level and covering the expectations of the faculty charged to provide academic sessions that combine the theory and applications in a sustainable manner.

Digital Object Identifier (DOI): http://dx.doi.org/10.18687/LACCEI2018.1.1.387
ISBN: 978-0-9993443-1-6
ISSN: 2414-6390

B. Contribution of This Paper

Experiences dictates that a possible logical pathway to acquire a sustainable domain in advanced software such Google SketchUp [8] really needs of a well-dedicated sequence of toipics during the first years of the program. For example concretely in our case we listed that route: (i) Set up the mathematical foundations [9], (ii) The physics processes, (iii) Computing[10], (iii) Numerical Approaches[11], (iv) The Antenna problem [12][13][14][15], (v) Google SketchUp. In addition in Table I and Table II are listed the theoretical and computing background respectively previous for an extensive course based in antenna deployment with SketchUp.

TABLE I
THEORETICAL BACKGROUND SUGGESTED BY THE AUTHORS TO START AN ADEQUATE USAGE OF SKETCHUP

Topic	Hours/Week	Semester
Waves Electr	5 - 10	V-VI random
Equations Maths	4-8	II-V
Antenna	4-8	VII-VIII
Examples	5-10	V-VI
Miscel	5-15	VI-X
Wireless	3-6	IX-X
WiFi Tech	2-4	X
Models	2-4	XIII-X
RFID	4-8	X
Radio Propag	2-4	IX-X
MicroWave	3-6	VIII-X
Proj	2-4	IX-X

II. SETUP OF THE THEORY

Power intensity for example can be derived from the following relation:

$$\mathrm{P}(r)=\int_{0}^{\infty}\mathcal{G}(r,x)P_{D}(x)dx \tag{1}$$

where $P_D(x)$ is seen as the initial power. The r variable denoting the distance. Thus Eq. 1 For instance, if a P(r)

TABLE II
COMPUTING BACKGROUND COMMONLY USED IN THE PROGRAM

Topic	Hours/Week	Semester
Basics	2-4	II-V random
Wolfram	5-10	II-III
C++	3-6	II-III
Labs	5-10	V-VI
Proj	5-15	V-VII
Design	3-6	V-VIII
Google SketchUp	3-6	VIII-X
Examp	4-8	IX-X
Apps	4-8	IX-X

is perceived as output, then would have to have its input associated function in the following way,

$$\mathrm{P}^J(r) = \int_0^\infty \sum_{JK} \mathcal{G}_{JK}(\lambda, x) P_D^K(x) dx. \tag{2}$$

The function $\mathcal{G}_{JK}$ denotes the functions that convolute together to the initial power that is supposed to be decreased by terrain morphology, obstacles, etc [9].

A. A Simple Example

The most simple case which would be used to extract an approximate Powerc Intensity curve would have to be the replacement of the transfer function by a delta function,

$$\mathrm{P}(r) = \int_0^\infty \delta(x - r) P_D(x) dx = P_D(r) \tag{3}$$

returning a shape exactly like the $P_D(x)$ because the effect in using a Delta function does not change the initial form on it. In reality for this simple case, one can test a Delta function with different argument which would make the departure from an ordinary one to one much more phenomenological,

$$\mathrm{P}(r) = \int_0^\infty \delta(xr - \eta) P_D(x) dx \tag{4}$$

$$= \int_0^\infty \frac{1}{r}\delta(x - \frac{\eta}{r}) P_D(x) dx = P_D(r) \tag{5}$$

$$= \frac{1}{r} P_D(\frac{\eta}{r}) \tag{6}$$

resulting in a distribution that does not coincides with that of the P_D necessarily. Contrarily to the trivial example as given in (3), to note now appears a quantity η in (5). The resulting shape obtained in (5) is plotted in Fig. 1 together to its input as well. In blue one the theoretical curve is plotted against R expressed in Km. Whereas in red the P_D one as a simple exponential that would denote the one in praxis.

III. COMPUTING

A. Input Selection

For the present analysis, we invoke to a simulation in order to built the corresponding input function namely a simple function. We have appealed to an algorithm Monte-Carlo-like

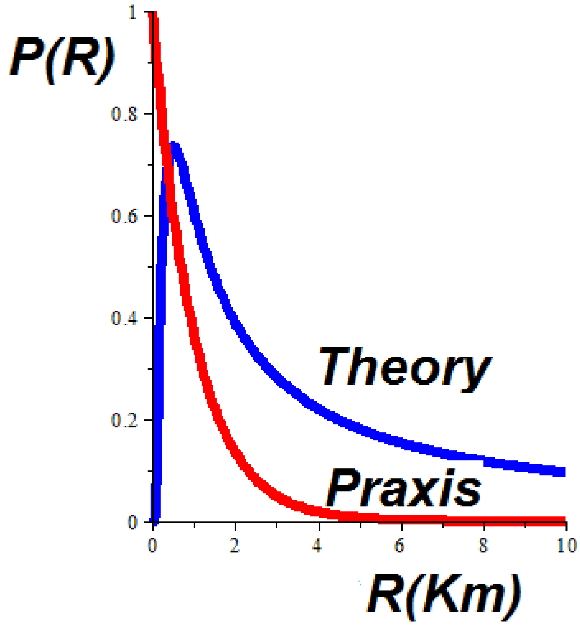

Fig. 1. Normalized power versus R expressed in Km. Curves with η=0.5, from the usage of Eq. 6. In red is plotted [10] the expected P_D intensity function following the shape of a simple exponential function whereas the blue one displays the purely theoretical result from the usage of Eq. 6.

in order to generate the input curves. Instead of exponential profiles as commonly is derived from statistical foundations [3], a function conserving a Gaussian-like shape is considered. In essence, the algorithm can be resumed as indicated below,

```
> ! start loop
> do q=1,1000 ! distance
> call random x1 ! first aleatory number
> call random x2 ! secondary aleatory number
> f(q) = N exp(-(q-h(x2)/g(x2))**2) ! define Gaussian parameters
> if(f(q).lt.x1) then ! Monte-Carlo-like step
> accept q, h(x2), g(x2) endif ! acceptance
> enddo ! end loop
```

B. Models of Signal Path-Loss Model and Power Intensity

Starting form the fact that the Dirac-Delta argument presents various types of nonlinear definitions, the subsequent step is the incorporation of these functions inside the scheme I/O formulation for the Power Intensity measurement. Thus $I(t) = \int \delta\left[G(t,\tau)\right] \mathcal{I}(\tau) d\tau$ where the Dirac-Delta functions acquires the role of kernels, and their free parameters can be interpreted as the system parameters. Also, the $\mathcal{I}(\tau)$ functions are the input functions. In this way, the generalization of the I/O scheme can be written as the infinite sum of contributions of N-order. Under this view the master integral that models

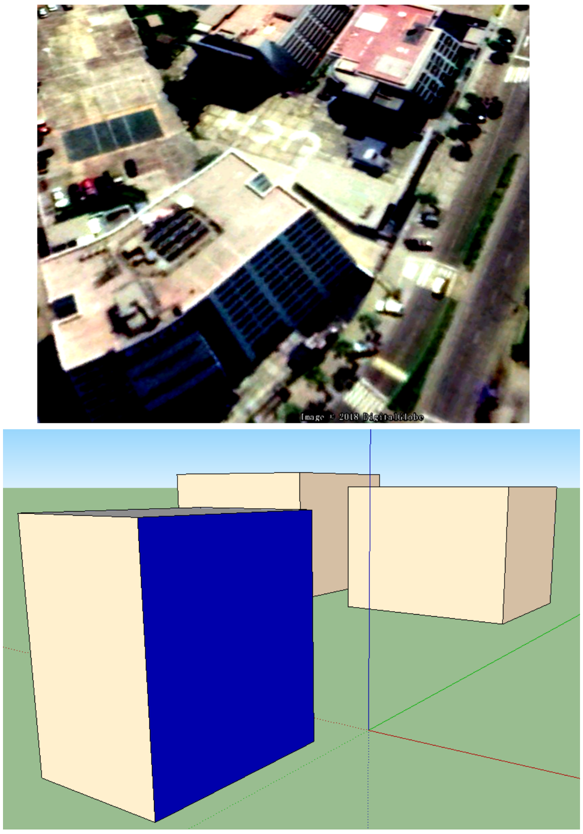

Fig. 2. Top: aerial view of the UCH in Lima. Bottom: A first step by using the Google SketchUp for modeling the buildings of the view.

any signal intensity [9] modeled by Delta function reads

$$O(t) = \sum_{M=1}^{N} \int_{-\infty}^{\infty} \delta \left[\prod_{j=1}^{Q_2} (\gamma_j t - \rho_j \tau - a_j) \right] \mathcal{N}_\ell(\tau_\ell) d\tau_j. \quad (7)$$

and the intensity or emitted power can be written as

$$I(t) = \left| \sum_{M=1}^{N} \int_{-\infty}^{\infty} \delta \left[\prod_{j=1}^{Q_2} (\gamma_j t - \rho_j \tau - a_j) \right] \mathcal{N}_\ell(\tau_\ell) d\tau_j \right|^2 \quad (8)$$

Inspired in logarithm-like models like Okumura,Okumura-Hata models (and others) which are known by having in their equations the form $P_L = A + \text{Log} B$, where parameters A and B depends on frequency and antenna height, respectively, is possible to define the signal path-loss equation but with the Dirac-Delta formulation,

$$P_L = \text{Log} \left[\sum_{M=1}^{N} \int_{-\infty}^{\infty} \delta \left[\prod_{j=1}^{Q_2} (\gamma_j t - \rho_j \tau - a_j) \right] \mathcal{N}_\ell(\tau_\ell) d\tau_\ell \right]. \quad (9)$$

where one can see that the model equation is the logarithm of the $I(t)$, simply. The model can be adjusted with the insertion of more constant in order to be similar to the known model.

IV. Introducing Google Sketch-Up

A. Combined Computational Algorithm

In order to apply the mathematical methodology for this concrete case, a computational scheme is used. The idea behind of this, is that the signal path-loss equation should be estimated together to one computational scheme that contemplates the extraction of the Delta parameters. We propose a pedagogical path to accomplish the introduction of a first course of propagation with the Google SketchUp.

- `Inputs:` m
- `Distances, Intensities`
- `Define the polynomials`
- `Define values for` γ_j, ρ_j `and` a_j
- `Provide random values for` M, N, Q_1
- `Define input functions` $\mathcal{N}(\tau)$ `(Eq.2)`
- `Compute master integral Eq.7, Eq.8 and Eq.9`
- **Building urban zone with Google SketchUp**
- `Call Random locations`
- `Call Random Intensities in Urban area`
- `Calculate Dips of Delta Functions`
- `Save set of locations of dips` $\mathcal{S}_m$
- `Performing matching`
- `If dips inside random location` $\mathcal{S}_m$ `then`
- `If` $\mathcal{S}_m \subset \mathcal{C}_m$ `then`
- `Save` $\mathcal{S}_m$
- `Evaluate Log` $< P_L >$.
- `Calculate Error`
- `redraw best scenario urban area`

The algorithm can be explained as follow: For a m given, the definitions of intensities and free parameters are given. We estimate the parameters polynomials. With this, the adjudicated values for M,N and Q, as well as we gives by hand an analytical function $\mathcal{N}(\tau)$. Therefore we proceed to calculate the integrations Eq.8 and Eq.9. All this is needed to build an urban zone with Google SketchUp. Once it is done we proceed to assign random locations. It is compared with all dips calculated from the Dirac functions. Thus we make a matching if these dips belong to the zone where is selected spatial point inside of the urban area. If is true then we evaluate the path loss and their errors. With this output we pas to redraw again the best locations of signal reception.

B. The Usage of Google Sketch-Up

Eq.8 and 9 are the main equations of the proposed formalism was tested in a mid-sized urban with their free parameters extracted from the previous algorithm. We assumed that the student has knowledges of algorithms and programming. In Fig. 3 (from top to bottoms) aerial view of zone under study built with Google SketchUp with their respective distances and perimeters. The first one starting from the top indicating not any color denotes the first scenario without received intensities. We have worked out with this first scenario and therefore the morphology of the locations of buildings and others terrain morphologies are imposed afterwards the resulting

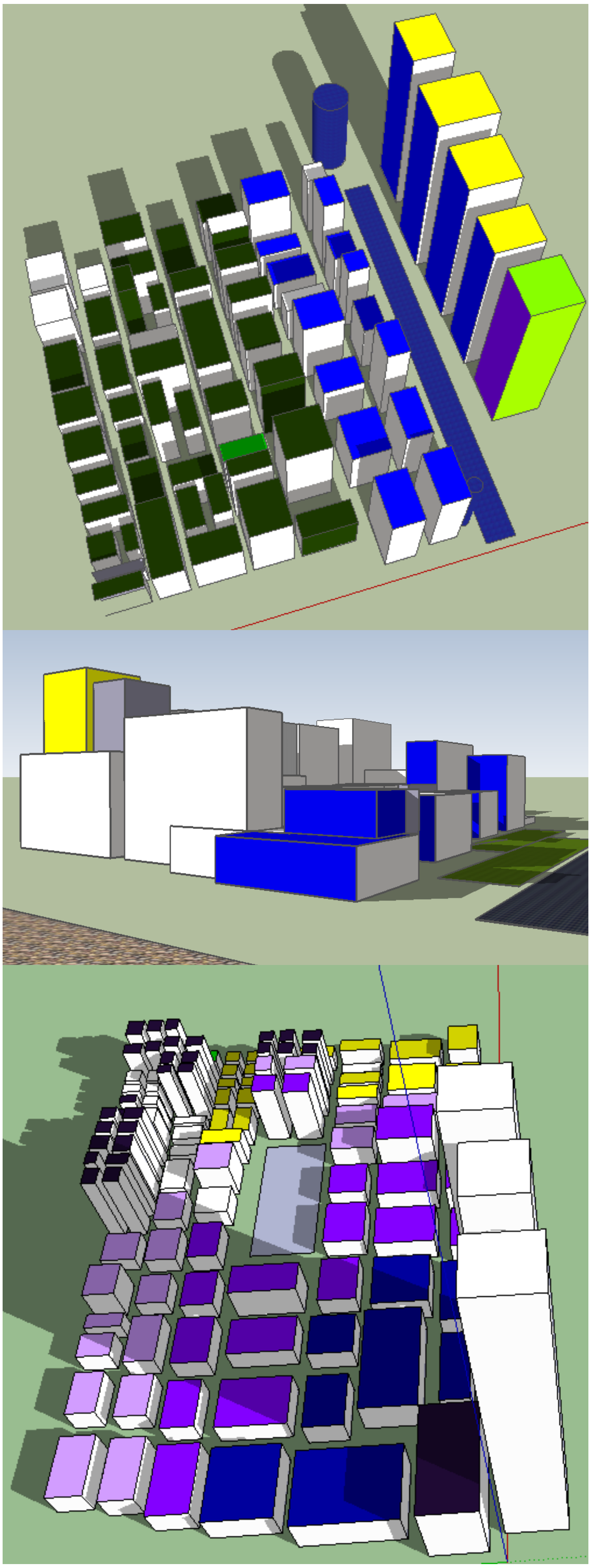

Fig. 3. From top to bottom all scenarios of signal reception simulated with the software Google SketchUp. In all scenarios is contemplated the position of a base station. Colors denote the places of best intensity reception.

outputs of the previous applied algorithm. Colors indicates the regions where the intensities have been calculated. They are also indicating us a possible location of base station. The respective geometry and terrain morphologies are considered for urban simulation with the assistance of Google-SketchUp. The suburb under study contains rectangular dimensions of 400 m$\times$ 200 m. Indeed, the base station is expected to be in 50 m. in front. The urban simulation contemplates up to 103 blocks and heights ranging between 2.5 m and 25 m. For simulation base station, length is ranging between 20 and 40 m. In addition, the signal strength received at end users is simulated through the Monte Carlo step as detailed in algorithm previously. It is because the stochastic character of the spatial propagation inside the suburb that justifies the usage of this method. Consequently, for simulation criterion 80 Km^2 area is thus divided in 20$\times$10 portions which does not necessarily fits with the blocks location. In this way, 200 blocks and their location are spatially allocated in simulation, as well as individual strength signals are assigned to them, in according to the far-field antenna case. For this exercise is assumed that the base station gain is of order of -50 dB. With this in hands, up to 200 values of signal strength were generated. In order to operate the Metropolis step (acceptance or rejection), a Gaussian probability distribution function g(d_q) =R exp(-$(d_q - \Delta d_q)^2/\Delta d_q^2$) with R normalization constant, is established. The obtained errors satisfy the relation $\bar{d} < \Delta d_q$, where $\bar{d}$ the statistical error. As consequence up to 15 possible scenarios have been selected because their highest probabilities. Fig (3) display three of them. The average base station height becomes a variable into the simulation. The resulting scenario is depicted in Fig 4 (a). Now we transcribed this result into an integral containing a Delta function with a polynomial argument by which would resemble the full mechanism among the transmitter, communication medium and receiver:

$$P_L = \mathcal{A}\text{Log}\left\{ \int_{-\infty}^{\infty} \delta \left[\prod_{j=1}^{3} (\gamma_j t - \rho_j \tau - a_j) \right] \mathcal{N}(\tau) d\tau \right\} \tag{10}$$

where $\mathcal{A}$=45. It was assumed up to N=40 obstacles but 3 of them locate at 21, 55, and 137 m., have presented influence on the signal degradation. It might be an interesting advantage of model, since we can predict path-loss with algorithm of Eq. 8 and 9.

V. Main Result and Conclusion

The extracted parameters average values $\mathcal{Q}$=3, γ_1=20.9, γ_2=-2.3, γ_3=28.6, ρ_1=-3.2, ρ_2=35.1, ρ_3=20.1, a_1=-1.2, a_2=20.4, a_3=39, that constitutes a 9-parameters system. All of them enter in Eq. 8 for integral evaluation and logarithm operation. The coverage distance is of 500$\pm$ 10 m.Threshold values are inside the valid range of models [2]. It is interesting that the proposed model fits well the mean values of the Dirac model with a coverage distance of 0.5 Km, height receiver of 20 m, and received signal of -76 dB. Errors beyond 5% appears to be consistent with the known models [4]. In addition, the Usage of Google SketchUp helps substantially to model a

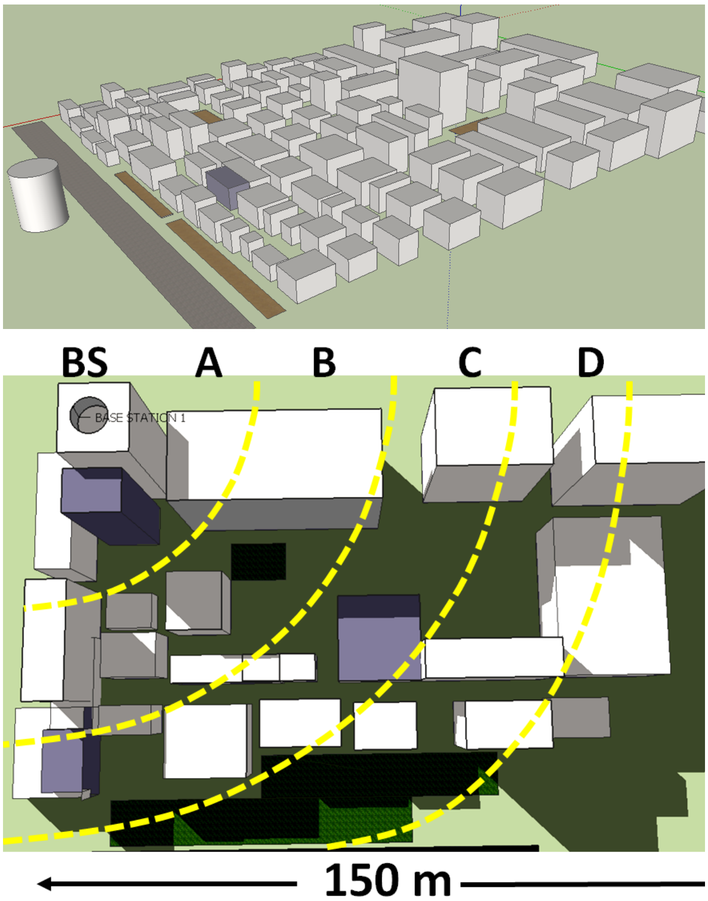

Fig. 4. Top: urban area previous to the full arrival of intensity of signal emitted by the base station. The urban area is assumed to be homogeneous to some extent in order to avoid complications with the simulations and numerical calculations. Bottom: possible signal arrival (isotropic) inside the urban area by assuming the one built by Google SketchUp indicating the best coverage radius A, B, C and D.

scenario of best antenna location [13][14] for a best reception as part of a first course of antenna in electrical engineering students with the application of well-known mathematical schemes such as the Dirac-Delta functions [15]. For the whole methodology an error of the algorithm of order 10% in average is obtained.

References

[1] Won Mee Jang, Communications Letters IEEE, Vol 15, pp.266-268 (2011).

[2] Erceg, V., et.al., IEEE Journal on, Vol. 17, No 7, 1999. pp. 1205 - 1211.

[3] Hoskins R. F., Delta Funtions: Introduction to Generalized Functions 2nd Edition, Int. Specialized Book Service.

[4] Morten Jacobsen, Msc thesis, Aalborg University Denmark, Modeling and Estimation of wireless multi-path channels, 2009.

[5] Sarkar, T.K., Ji, Z., Kim, K., Medouri, A., Salazar-Palma, M.: A Survey of Various Propagation Models for Mobile Communication. IEEE Antennas and Propagation Magazine 45(3), 5182 (2003).

[6] Yixi, X., Lavergnat, J., Mon, J.P.S., et al.: Microwave and Millimeter Wave Propagation. International Academic Publishers, New York (1995).

[7] Uchida, K., et.al., Interpolation of communication distance in urban and suburban areas, Antennas and Propagation (ISAP), 2013 Proceedings of the International Symposium on, Vol 2, 23-25 Oct. 2013, pp. 873 - 876.

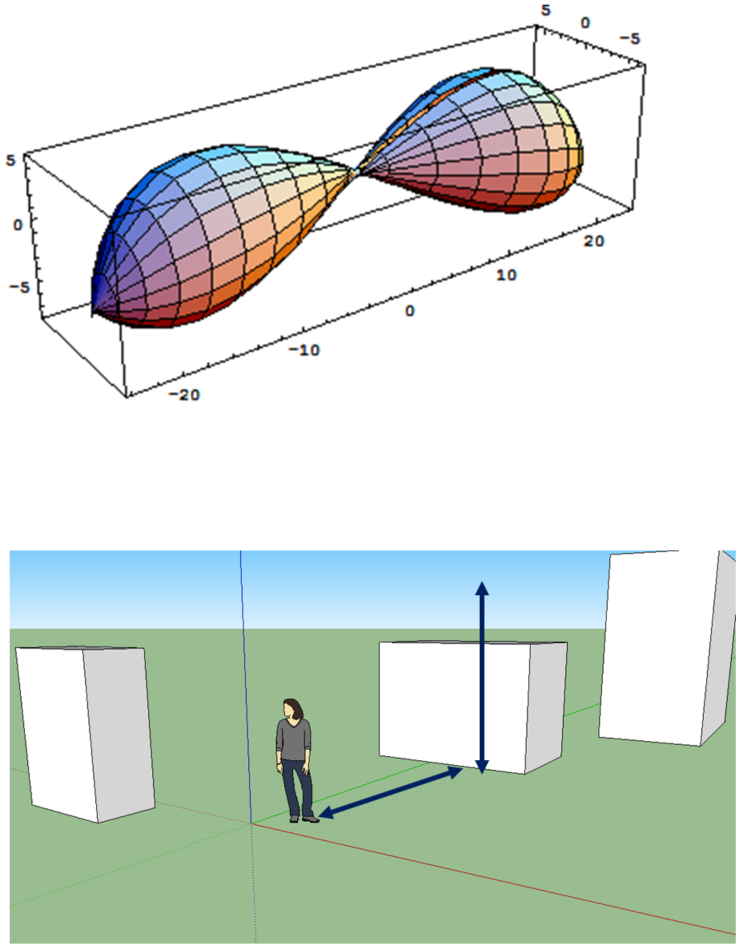

Fig. 5. Top: a possible pattern of radiation made with [10]. Bottom: the adjustment of the best antenna location with the Google SketchUp. The deployment therefore uses the information of the radiation shape [12].

[8] Google SketchUp, https://www.sketchup.com/es.

[9] Kepler, J.F., Krauss, T.P., and Mukthavaram, S., Delay spread measurements on a wideband MIMO channel at 3.7 GHz, in Proceedings of the 56th IEEE Vehicular Technology Conference, 2002 Fall, p. 2498.

[10] Mathematica Wolfram: http://www.wolfram.com.

[11] Numerical Recipes in C++. Addison-Wesley, Massachussets, (1992). Second version (1994).

[12] H. Nieto-Chaupis, Radiation intensity of base station antenna from Ad Hoc complex bessel functions series, 2017 IEEE XXIV International Conference on Electronics, Electrical Engineering and Computing (INTERCON) Year: 2017 Pages: 1 - 4.

[13] H. Nieto-Chaupis, Measurement of the probability of call completion with the Dirac-Delta convolution, Huber Nieto-Chaupis 2016 IEEE International Conference on Automatica (ICA-ACCA) Year: 2016 Pages: 1 - 4.

[14] H. Nieto-Chaupis, Measurement of the probability of call completion with the Dirac-Delta convolution, 2016 IEEE International Conference on Automatica (ICA-ACCA) Year: 2016 Pages: 1 - 4.

[15] H. Nieto-Chaupis, A closed-form expression for the received power through the usage of the Dirac-Delta functions with nonlinear argument, 2015 International Workshop on Telecommunications (IWT) Year: 2015 Pages: 1 - 5.