Analysis and Evaluation of Radio Mobile program on Line of Sight paths, with SRTM and ASTER DTEDs and its v11.6.6 / v9.1.6 versions

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Abstract **— This paper is submitted as a continuation of a paper presented by the authors in IEEE-ACCA.- Concepción 2018, addresses an unexpected outcome on the propagation simulations on 24 Line of Sight TV links in Santiago, performed with last version of the freeware Radio Mobile and SRTM1 elevation data. Most of those links behave as having a high reflection level not consistent with the characteristic of the profiles involved.**

On a search for an answer, links and terrain parameters were deeply analyzed but still not explaining the discrepancies. Further analysis and simulations were performed involving ASTER, another compatible digital elevation data and later with a previous propagation model of Radio Mobile. Partial answers were obtained which are duly explained but still further work is required, including the author of Radio Mobile program.

Keywords **— Irregular Terrain Model (ITM), Two Ray Model (TR), Clutter, Rayleigh roughness criterion, reflection coefficient (ρ), SRTM and ASTER, Digital Terrain Elevation Data (DTED), Radio Mobile v11.6.6 and V9.1.6**

I. INTRODUCTION

During the process of a M.Sc. thesis, presently under construction and related to TV propagation in Santiago and Valparaiso areas, it was noticed that Line of Sight *(LOS)* paths exhibited an abnormal amount of links with an equivalent reflection coefficient equal or very near to one, not nearly consistent with the surrounding land environment and link profiles. That phenomena did not exist in Valparaiso region where most links where diffracted; but Santiago city is located on an essentially flat valley with a gentle East – West slope, a condition which could explain the abundance of links with high reflection coefficients. But on the other side, one hundred percent of the area under study is covered by dwellings, high-rise buildings, factories, strip centers, malls,etc. which gives the profile a roughness consistent with much lower 2-R reflections. In order to find an explanation of the mismatch between simulations and land environment, it was decided to conduct a study with two sources of elevation data: First, SRTM1 and later on with ASTER V2 and. driven by the outcome of those simulations, performing it with two versions of Radio Mobile with different approaches to LOS propagation: ITM *(Irregular Terrain Model – aka Longley-Rice)* which was implemented in Radio Mobile (*RM)* since the introduction of the program, and a 2-Ray version introduced by the author of RM on V10.1.0 *(October 2009)* in substitution of ITM's LOS section.

Besides the introductory Section I, this document is organized as follows: Section II. Radio Mobile and ITM, Section III. Roughness Criterion and Reflection Coefficients, Section IV. Link simulations with DTEDs and Model Versions, and Section V, conclusions and future lines of investigation to develop.

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II. RADIO MOBILE AND ITM

A. ITM v1.2.2 and Radio Mobile before Version 10.1.0.

Radio Mobile is probably the most used freeware all over the world by consultants, academia, small telecon enterprises, researchers, etc. It's a Windows program developed by Roger Coudé - Canada, based on the Irregular Terrain Model ITM, which is a deterministic model based on the electromagnetic theory [1], [2]. RM *(Radio Mobile)* solves the reference attenuation Acr *(the difference between received values and FSL)* by a continuous line which goes from: LOS *(Line of Sight),* diffraction and tropo-scatter zones described each one by the following equations:

$$A_{ref} = \begin{cases} \max\left(0,\ A_{el} + K_1 d + K_2 \ln\left(\dfrac{d}{d_{LS}}\right)\right), & d \le d_{LS} \qquad (2) \\ A_{ed} + m_d d, & d_{LS} \le d \le d_x \qquad (3) \\ A_{es} + m_s d, & d_x \le d \qquad (4) \end{cases}$$

The four zones reference attenuation. Figure 1 [3,4].

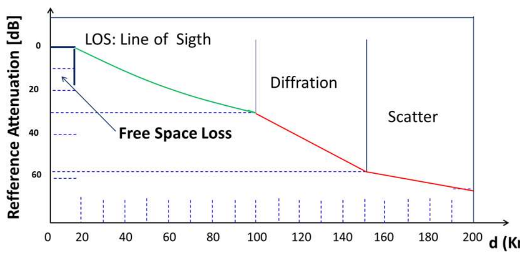

Fig. 1. ITM model Zones and additional attenuation to FSL [10].

The continuous line from d_0 *(A_0)* to d_6 *(A6),* as shown in Figure 2. is built by solving above equations. Those zones are calculated by ITM algorithms and associated reference losses [11]. This is known as the averaging system of ITM which saves quite a lot of memory and computer processing capabilities, critical at the time the program was created [9].

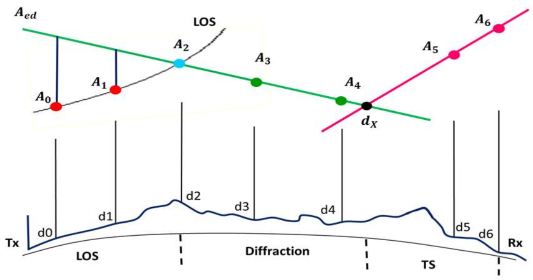

Fig. 2. Seven points for a reference profile [5].

Above picture shows the classical structure of ITM and it was fully described on a paper of the authors, accepted by the IEEE-ACA Congress. Concepción – Chile October 2018 and published by IEEE Explore [2]. It's important to highlight for our purposes the structure of ITM' LOS Zone, where the reference attenuation is calculated by two 2-R values: A_0 and A_1 plus a value A_2, as an extrapolation from the diffraction zone. On that zone, the continuous diffraction line is converted from a straight to a logarithmic one.

B. ITM v1.2.2 and Radio Mobile after V10.1.6 -October 2009. Now V11.6.6.

On 2007 a well-known US Consultant, Mr. Sydney Shumate, wrote a series of articles on the IEEE Broadcast Technology Society, devoted to an analysis of ITM and its alleged inaccuracies due to errors on the transcription of the program from Fortran 66 to Fortran 77 [5].

On those articles, Mr. Shumate addressed the opinion of some propagation experts that LOS zone of ITM was overly optimistic, besides not recognizing obstructions affecting a receiver being displaced along the radial, something basic for a point to area calculation. That led him to propose an alternate model for the LOS zone propagation called "Energy Transfer Machine" giving birth to a new program called ITWOM *(for ITM With Obstructions)*, which he proposed in several seminars. As far as we know that program has been implemented only in SPLAT 1.4.1 in Linux [5,13].

On October 2009, Mr. Roger Coudé, the author of RM, at that time based on the complete ITM 1.2.2 [11], was in accordance with Mr. Shumate's opinions so he decided to modify the LOS zone of RM with a 2-R model which is still running on the last versions. Later, on September 2011, he introduced on version 11.0.4 a transition between that 2-Ray model and the diffraction zone of ITM.

C. Digital elevation data SRTM and ASTER.

SRTM is a well-known DETD, which covers the whole world from 60 degrees North to 56 degrees South. It was surveyed by the NASA Space Shuttle Endeavour on year 2000 with a granularity of elevation samples every 1 arcsec. [14,16]. It is based on the HGT geographical format and its free of charge and easy to download from the Radio Mobile web site [7]. From the beginning, the 1" data was available only for the United States, being an extrapolated 3" version available or the rest of the world. On 2014, the 1" data was made available for the rest of the world with some restrictions. At the present, a 0.3" arcsec data is available for the US and other countries.

SRTM, being obtained by Synthetic Aperture Radar reflects the elevation of the bare land **not considering the clutter**. Even in those cases where the radar is properly reflected by hard clutter such as buildings, it interpolates the bare land elevations to reflect only the elevations of the soil. That characteristic of SRTM led us to consider the cause of the high 2-R reflections on LOS paths and look for an alternative.

ASTER is another source of elevation data, far more complete than SRTM [15]. It is photographic on several wavelengths, so besides clutter elevations it can recognize the composition of what is over the land and it has less voids than SRTM. The Format is TIFF, which is a photographic format preferred by graphics production as it has lossless compression.

The cons: it's quite complicated to download from the NASA repositories, involving registration and exchange of mails for downloads. As being a tiff format not supported by RM, requires a conversion to hgt, so a program for batch conversion was on record time developed Ing. Marcelo Pandolfo, Gerente de Ingeniería of La Red TV Network.

The feature of recognizing clutter elevations is a bonus for a more accurate calculations of 2-R reflections. That's the reason why it was included in our simulations and comparisons with those with SRTM.

D. The network of radials and sites in Santiago. Ch. 24.

The thesis mentioned before involves in Santiago 48 links distributed on eight radials: 24 on TV channel 33 and 24 on channel 24 as in Fig. 3 Each radial has three receiving sites located at nominal 5, 10 and 15 km from the TV.

All those links have the structure of a high to low path, the transmitter is located on a high hill and the test receivers by an antenna over a 10 m pole as per ITU Recommendations for field strength measurements.

Fig. 3, shows the RM map of the network analyzed in the previous work mentioned on the abstract, which was used by authors as a source to conduct this work [8].

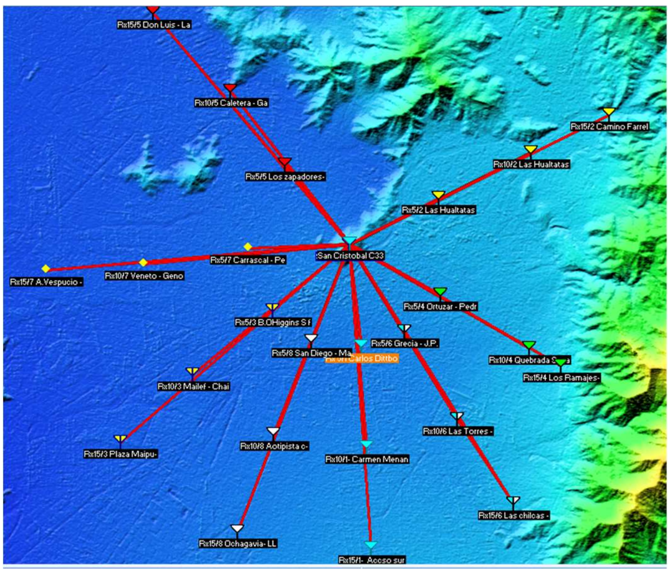

Fig. 3. The network.

An overview of the land environment can be obtained from the profiles, approximately over the four 4 cardinal directions. As shown in Fig.4.

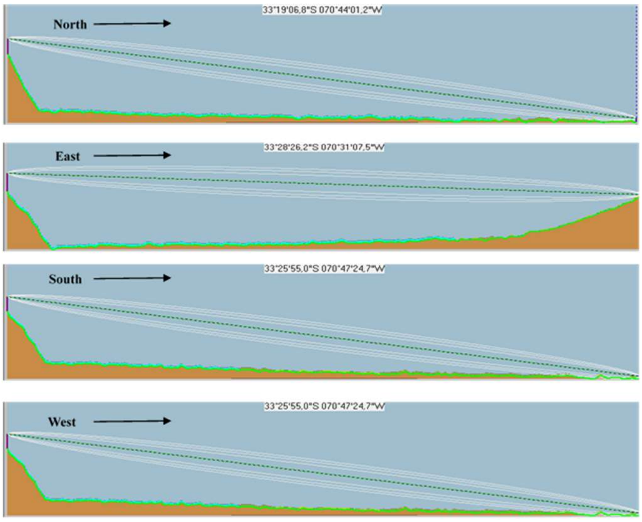

Fig. 4. Profiles in 4 cardinal directions.

From the preceding pictures, the profiles seem run over the bare land.

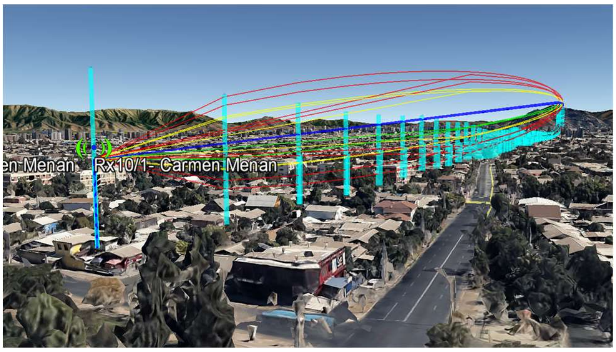

Fig. 5. Land cover marks on the map.

However, all of them run over a variety of houses, buildings, etc. which produces a roughness of the profile with a standard deviation of a couple of meters or more, as can be seen on Fig 5 and 6 [8].

Fig. 6. Land cover marks on the map.

The following table, calculated from the Rayleigh roughness criterion shows the relationships between wavelength, standard deviation, reflection coefficient and the values range the received signal may take due to direct- reflected rays change of phase.

TABLE I
RELATION BETWEEN λ, $\boldsymbol{\sigma}$, $\boldsymbol{\rho}$ AND THE RANGE VALUES OF THE RECEIVED SIGNAL

ψ°	2,4		**Variation Range**	
σ/λ	g	ρ	Obst Loss max	Obst. Loss min.
0,5	0,26	0,97	-5,87	29,36
1	0,53	0,87	-5,44	19,48
1,5	0,79	0,73	-4,77	13,03
2	1,05	0,57	-3,94	8,83
3	1,58	0,29	-2,19	3,93
4	2,11	0,11	-0,90	1,58
6	3,16	0,01	-0,06	0,15
8	4,21	0,00	0,00	0,01
10	5,26	0,00	0,00	0,00

Where:

ψ: Reflected ray angle to the horizontal plane.

g: Ryleigh criterion of roughness = 4π (σ/λ) sin ψ

ρ: Reflection coefficient = $\rho = e^{\left(-\frac{1}{2}g^2\right)}$

σ: Terrain standard deviation.

As the wavelength λ of Ch 24 is 0.56m, it can be seen that a standard deviation σ of the terrain plus 2m average clutter, will reduce obstruction loss variations from -6 to +30 dB for a totally reflective terrain, to -0.9 to 1.58 dB, more in accordance to real experiences for a LOS area.

During the process of LOS links calculations on Ch24 or Ch33 with RM/SRTM1 in Santiago city for the previously mentioned TV survey, calculated data frequently differed significantly between links of similar characteristics *(length and terrain),* and actual Field Strengths measurements [6].

Sometimes the calculated value was over the FSL by a few dB *(4-6, and not more than that)*, but on others it was under by 10-20 dB or more, fluctuating between those extreme values by small variations of antenna height, even by tens of centimeters. That is a textbook behavior of a 2-ray model over a perfect reflecting terrain with a reflection coefficient = 1. verified in the program modifying the path geometry by raising or lowering the receiving antenna by a few meters, obtaining variations from up to +6 dB and down to -30 dB from the expected value. In practice that is seldom experienced unless the path goes over a calm lake or a marsh.

To determine the source of those discrepancies, it is necessary to evaluate the equivalent reflection coefficients of RM to perform those LOS calculations and compare them with calculated coefficients from the path profiles and visual evaluations As RM program gives full details of the attenuation contributions to the path loss and a complete record of path parameters for each register, even every 30 m, it will be relatively easy to calculate the reflection coefficients and perform the comparisons.

On this work, the authors started calculating and analyzing with the current version of RM V11.6.6 and SRTM1, 24 links in 8 radials on TV channel 24 *(ITU Region 2 channeling)* on Santiago City.

It must be highlighted that antenna heights in RM can be continuously modified even by cm steps, allowing to modify the path geometry, consequently varying the relative phase of direct and reflected rays. Not every freeware, and even expensive commercial SW have that feature.

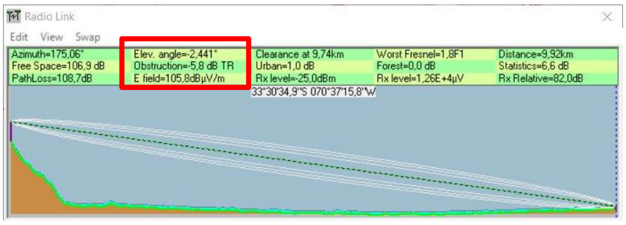

Fig. 7. Obstruction label TR (2-Ray) on Radio link panel.

By performing link calculations, it has been verified that other attenuations to the received signal on the Radio link panel "Urban" and "Forest": are not related to the 2R model, as shown in Fig.7. The same applies to "Statistics" which reflects the random variabilities of the signal.

The analysis of the magnitude and phase of the 2R model vectors, are shown in Figure 8.

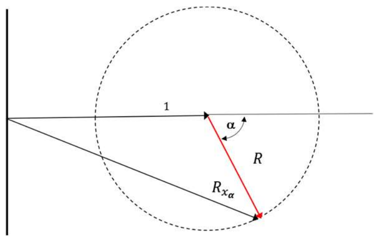

Fig. 8. General scheme of a 2 Ray path model.

Where:

R_{x_α} = Obst. Loss dB
D = 1, Direct ray
R = Reflected ray

Received signal level with original antenna height. Eq (4)

$$R_{x\alpha} = \left[10^{\frac{Obst.Loss\ (dB)}{20}}\right] \tag{4}$$

To simplify the analysis the direct ray is given the value of 1, therefore the obstruction loss dimensionless magnitude becomes the value of the total received signal. But that alone cannot calculate the value of R_1, as $\propto$ is not known.

However, by making a few assumptions and using the feature of RM of raising or lowering the Rx antenna in small steps, it´s possible to determine the magnitude of R. That modifies the lengths of the direct and reflected rays but not at the same rate, resulting in a variation of the angle $\propto$. When $\propto = 0$ or 180° both, direct and reflected rays are in phase or in counterphase, so $\cos \propto = 1$ *or* -1, and they can be added algebraically. Figure 9.

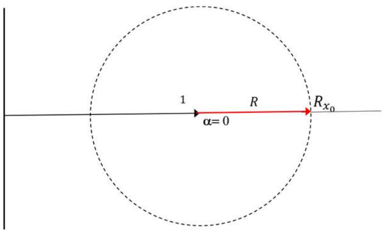

Fig 9. Vectors by raising Rx antenna until $\boldsymbol{\alpha}$=0.

Where:

R_{x_0}= *Obst. Loss 0 (dB)*

$R_{x_0} = 1 + R$

Received signal level at max. obstruction antenna heigh.t α=0. Ec (5)

$$R_{x_0} = \left[10^{\frac{Obst.Loss\ 0\ (dB)}{20}}\right] \tag{5}$$

Equivalent RM reflection coefficient. Ec (6)

$$\rho_{rm} = R = \left[10^{\frac{Obst.Loss\ 0(dB)}{20}}\right] \tag{6}$$

Under above condition, Rx_0 = 1+R or 1-R, then the value of R becomes the value of the dimensionless obstruction loss and consequently the value of the reflection coefficient.

It should be mentioned at this point, that all calculations have been performed with the present version 11.6.6 of RM which has Roger's last version of the 2 Ray model implemented [7] which is different from previous versions before October 2009, when LOS was implemented with 1.2.2 version of ITM Longley- Rice.

At this point the equivalent 2-R reflection coefficient of the link is known, but not the value of α , which may be needed if the link must be evaluated with a reflection coefficient extracted from path roughness.

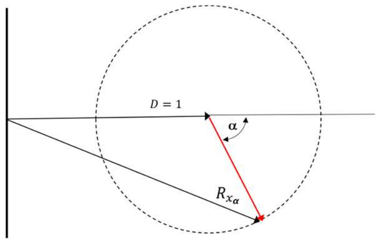

Fig. 10. Terrain w/o Clutter $\boldsymbol{\alpha} \neq 0$.

$$\cos \alpha = \frac{R_{x_\alpha}^2 - R^2 - 1}{2\,R} \tag{7}$$

With above theoretical information, it was decided to further investigate the 24 links mentioned before. First, they will be analyzed searching the existence of a 2R links showing -6dB or +30 dB obstruction loss, a clear sign that such links were calculated with a coefficient equal to an **equivalen**t reflection coefficient = 1.

Each of the 24 links was deployed on RM Radio link panel, and every Rx antenna was displaced up and down until reaching the minimum or maximum obstruction level. Per 2-R theory, there are several maximum and minimum values so the closest to the nominal antenna height of 10m was selected. Sixteen out of 24 links showed values of -6 or +30 dB reflecting a probable ρ =1.

Eight links did not show that behavior as follows:

On 6 links: the path had a significant slope in the area close to the Rx, not allowing the geometry of incident and reflected ray equal grazing angles.

One 1 link there was a 2R situation, but not close to -6 or +30-dB obstruction.

On 1 l ink, the reflected ray was grazing.

On the 16 links candidates to ρ =1, a complete analysis was conducted. For that purpose, two more equations are required.

III. ROUGHNESS CRITERION AND REFLECTION COEFFICIENT

A. *Profile Roughness*

The roughness calculation of the reflection zone was evaluated by the well-known Rayleigh's Roughness Criterion [12]. Ec.8

$$g = 4\pi\ (\sigma_h/\lambda)\ \text{sen}\ \varphi \tag{8}$$

A surface with g< 0.1 is assumed totally reflecting, whilst g>10 means total opacity.

B. Reflection coefficient

There are several methods to evaluate the reflection coefficient. but equation 9 is simple and with enough precision for our purposes [12].

$$\rho = e^{\left(-\frac{1}{2}g^2\right)} \tag{9}$$

Every profile was exported to individual Excel pages and elevations versus distance were modified to compensate earth curvature with K=4/3, to be able to apply simple trigonometry over flat land. The reflection point was calculated by searching equal incident/reflected grazing angles. By those angles ψ and the intercept range of F1 over the terrain; standard deviation σ_h. of elevations, the Rayleigh Criterion g and its associated reflection coefficient ρ for each link were calculated. Those parameters were transferred to Table II, profile section, to be compared with the **equivalent** reflections of the link by coefficients obtained from RM data.

TABLE II
CALCULATIONS

Radio Mobile V11.6.6 SRTM1						**Profile**		
Link. km/Radial nbr.	2 Ray Obst. Loss dB at h10m	Modified hrm antenna	Obst. Loss dB at hrm TR	Worst F1	RM Equiv. ρ of 2-R	σ (m)	g	Profile Ref Coef. ***ρ***
5/1	-5,9	9,9	-6	2,30	0,995	1,49	2,723	0,025
10/1	0,1	10,9	30	1,90	0.965	2,980	3	0,024
15/1	6,7	13,3	-4,2	1,70	0,662	1,590	0,874	0,682
5/2	-1,9	11,2	-5,9	2,10	0,972	3,330	4,562	0,000
10/2	0,9	14,5	0,8	1,40	0,088	3,84	7,882	0,000
15/2	23,4	N. A	N. A	0,60	Diff.	N. A	N. A	N. A
5/3	-5,0	10,5	-6	2,20	0,995	1,58	2,337	0,042
10/3	3,1	11	30	1,30	0,968	1,70	1,831	0,187
15/3	-6,0	10	-6	1,00	0,995	2,21	2,380	0,059
5/4	-5,1	10,6	-6	2,20	0,995	0,84	1,367	0,393
10/4	-0,5	11	3,5	0,90	0,332	3,63	3,159	0,007
15/4	-0,4	15	-0,6	1,2	0,072	3,50	3,906	0,000
5/5	-5,0	9,5	-6	2,3	0,995	1,14	2,347	0,064
10/5	-6,0	10	-6	1,7	0,995	2,12	2,406	0,055
15/5	-5,7	10,5	-6	0,9	0,995	2,21	1,675	0,246
5/6	-3,6	11	-6	2,1	0,995	0,98	2,021	0,130
10/6	-3,3	8,5	-5,2	1,80	0,822	3,25	2,665	0,029
15/6	-0,4	11,5	-0,8	1,60	0,096	12,30	8,260	0,000
5/7	-5,9	9,6	-6	2,70	0,995	1,22	2,500	0,044
10/7	-5,3	11	-6	1,70	0,995	0,76	0,776	0,740
15/7	-0,8	14,5	-6	0,60	0,995	3,83	2,668	0,028
5/8	-6,0	10	-6	2,20	0,995	1,09	2,249	0,080
10/8	-3,5	11,5	-6	1,60	0,998	1,16	1,122	0,582
15/8	-1,9	7,5	-6	1,30	0,995	1,99	1,041	0,582
				$\bar{X}$	0,662			0,024

As Radio Mobile doesn't give information of a reflection coefficient –if there is one – an **equivalent** reflection coefficient can be determined from the procedures of Fig. 8 to 10 and equations 4 to 7.

IV. LINK SIMULATIONS WITH DTEDS AND MODEL VERSIONS

The results on the comparisons of reflection coefficients on Table II are amazing. Out of 24 links, 16 show a ρ≥0,97 which from table I means equal or near equal perfect reflection. Counting the links non applicable to 2-R (5) being LOS but with blocked reflections, steep terrain at reflection or diffracted/grazing; that is 16 out of 19. Also, the fact that 18 out of the 24 show reflection coefficients ≤ 0.3 which means a contribution only of 1-1.5 dB of the reflected ray.

SRTM and its inability to include clutter may be the explanation. The solution could be another free DETD RM compatible and substitute SRTM. ASTER was investigated being the best solution, downloading the data and converting the TIFF to HGT. That was realized with the collaboration of our colleague: Ing. Marcelo Pandolfo.

ASTER.hgt worked ok and its capability of including the clutter was demonstrated, both on profile and standard deviation increase, which exponentially reduces ρ. But also test the influence of the propagation models: V9.1.6 / ITM and V11.6.6 based on 2-R models.

In order to speed up the process and space capacity, 5 links out of 24 were selected as representative for; 5,10 and 15 km. plus Obstruction Loss values. Eeach of the 5 links will be simulated with SRTM1, ASTER, V11.6.6 and V9.1.6.

The results and comments are displayed on Table III.

TABLE III
SUMMARIZES ALL CALCULATIONS

Sumary of all relevant calculations						**Profile**		
Link. km/Radial nbr.	2 Ray Obst Loss dB at hrx	Modified hrm antenna	Obst. Loss dB at hrm TR	Worst F1	Coef. Ref. ρ Radio Mobile ρ	σ (m)	g	***ρ***
5/2 S V11	-1,9	11,2	-5,9	2,10	0,972	3,330	4,562	0,000
5/2 A V11	-4,3	9,0	-4,8	1,80	0,738	4,630	6,403	0,000
5/2 S V9	-0,9	11,4	-4,6	2,10	0,698	3,410	5,014	0,000
5/2 A V9	-4,0	9,0	-4,5	1,80	0,679	4,724	6,768	0,000
15/3 S V11	-6,0	10,0	-6,0	1,00	0,995	2,210	2,380	0,059
15/3 A V11	14,2	14,5	-6,0	1,40	0,995	2,510	1,871	0,174
15/3 S V9	-5,5	10,5	-5,5	1,00	0,884	2,380	1,713	0,231
15/3 A V9	12,8	14,3	-5,3	1,90	0,841	2,420	1,728	0,225
10/5 S V11	-6,0	10	-6,0	1,70	0,995	2,120	2,406	0,055
10/5 A V11	-4,8	11,5	-6,0	1,00	0,995	3,430	3,783	0,001
10/5 S V9	-5,4	10,0	-5,4	1,70	0,862	2,130	2,403	0,056
10/5 A V9	-3,5	11,7	-5,2	0,80	0,862	3,209	3,756	0,000
5/6 S V11	-3,6	11,0	-6,0	2,10	0.995	0,98	2,021	0,130
5/6 A V11	-5,1	9,0	-6,0	1,80	0,995	4,530	8,090	0,000
5/6 S V9	-2,4	10,8	-4,9	2,20	0,758	1,010	1,662	0,251
5/6 A V9	-3,8	9,4	-4,6	1,70	0,698	4,766	7,789	0,000
10/7 S V11	-5,3	11	-6,0	1,70	0.995	0,760	0,776	0,740
10/7 A V11	5,9	10,1	-6,0	1,00	0,995	3,290	3,649	0,001
10/7 S V9	-4,7	11	-5,4	1,70	0,862	0,690	0,766	0,746
10/7 A V9	-5,1	9,97	-5,1	0,90	0,799	3,372	3,760	0,000

Note. - S = SRTM
A=ASTER
N/A= NO APLICA
Diff= Diffraction

V. CONCLUSIONS

First. - The difference between the equivalent reflection coefficients calculated by RM and those of the profile calculated from the same profile data, by means of the Rayleigh's Criterion, are surprisingly different, as shown on Table III. All those calculated by RM are close to full reflection whilst those calculated from the profile are close to low or zero reflection.

Much to the surprise of the authors, the inclusion of ASTER, which was supposed to solve the 2-R problem due a significant increase on the profile standard deviation and consequent reflection coefficients, was not reflected at all on RM. This contradicts the basic principles of the 2-Ray model widely used on LOS propagation.

Second. - When the present version 11.6.6, based on the proprietary 2- Ray model implemented on October 2009 is substituted by the previous version 9.1.6, RM starts to reflect the substitution but in a very moderate way, not even close to the Reflexion Coefficients calculated by Rayleigh Criterion. It seems to point the discrepancies to an error or missing algorithms produced on the program when it was converted from V.9.1.6.to the present series of versions.

The author of the RM, Mr. Coudé is aware of our work and in principle is willing to introduce modifications, providing they are not intensive, due his present obligations.

Third. - As the explained before, the problems of ITM on the LOS area are not new, that was one of the reasons of Mr. Shumate's modifications precisely on LOS. However, some administrations including USA FCC, continue to use ITM based programs on TV interferences.

Fourth. - On spite of the fact that ASTER does not improve the results of 2-R model, it's advisable to load it in the PC due to the inclusion of clutter, because it has less voids than SRTM and better map image resolution. Therefore, in every case by just a click the most convenient DTED can be selected.

Fifth. - Future works will be performed by the authors, on a research for modifications improving Radio Mobile performance. The program is a very useful tool for radio propagation and so has been for over 20 years, widely used by thousands of professionals, professors and amateurs devoted to the subject, so it deserves to be as accurate as possible.

Final

Radio Mobile is very useful free program for simulations of radio propagation.

Extensive simulations and analysis prove that RM has accuracy problems on the Line of Sight area not solved so far by a more precise source of elevation data as ASTER is.

Going back with the program to the previous model is not a definitive solution but it's recommended to do it, as the errors with the present model are not acceptable.

It is expected that the program's author will introduce modifications to improve it in the LOS environment involved.

STATEMENT

Under no circumstances this work should be interpreted as a criticism or derogative opinion on the Radio Mobile program and/or its author. Radio Mobile is an excellent freeware having made valuable contributions to radio propagation knowledge and continue to do so. The problem here addressed applies to specific cases, easy to detect and easy to manually correct until a fix is obtained. The authors intent has only been to promote a solution which will improve, even more Radio Mobile. The authors of this work extend their deepest appreciation to Mr. Roger Coudé for his valuable contributions to the Radio Community.

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