Comparison of ITM and ITWOM Propagation Models for DVB-T Coverage Prediction

Stylianos Kasampalis, Pavlos I. Lazaridis, Zaharias D. Zaharis, Aristotelis Bizopoulos, Spyridon Zettas, and John Cosmas, Senior Member IEEE

Abstract—Digital broadcasting services require higher prediction accuracy than traditional analogue networks because digital services are planned with tighter margins on the received signal strength and interference. With the rapid deployment of digital TV, there is an increasing need for accurate point-to-area prediction tools. There are several propagation models for coverage prediction of DVB-T. Some of them are purely empirical models, and others are mixed, empirical-analytical models, based on measurements campaigns and electromagnetic theory. The aim of this paper is to compare precision field-strength measurements taken by a Rohde & Schwarz FSH-3 portable spectrum analyzer with simulation results derived from coverage prediction models, like the NTIA-ITS Longley-Rice model, the ITM (Irregular Terrain Model) using the 3-arc-second SRTM (Satellite Radar Topography Mission) data that is available freely, and the newly developed ITWOM (Irregular Terrain with Obstructions Model).

Index Terms—DVB-T, NTIA-ITS, Longley-Rice, ITM, ITWOM, SRTM, ITU-R P.1546

I. INTRODUCTION

THE switch-off of analogue TV channels is now a reality in many European countries. In order to take full advantage of DVB-T services and characteristics, field trials are required, comparing simulation and laboratory results with measurements. The scope of this research is to provide coverage prediction maps for DVB-T services, in the region of Thessaloniki – Greece, and validate the simulation results with field measurements. However, taking on-site measurements is inconvenient, because it costs time and money. Therefore, the use of a prediction model becomes necessary.


In the latest version of SPLAT! the ITM Model have been replaced with ITWOM, [6]. The ITWOM combines empirical data from the ITU-R P.1546 model and other ITU recommendations, with Beer's law and Snell's law, and promises improved accuracy over the older ITM model. In a similar study, path loss was calculated with the use of the Longley-Rice Irregular Terrain Model (ITM), the NASA SRTM terrain data base and the SPLAT! software, [7].

II. MEASUREMENTS AND COMPARISONS

In order to measure the signal strength of DVB-T transmissions, a measurement campaign was carried out around the city of Thessaloniki, located in the north of Greece. Our measurements equipment consists of a Rohde & Schwarz FSH-3 portable spectrum analyzer with tracking generator (100kHz – 3GHz), factory calibrated with ±0.7dB accuracy, two high-precision calibrated biconical antennas by Schwarzbeck, SBA 9113 (500MHz – 3GHz), and BBVU 9135 (30MHz – 1GHz), a log-periodic precision calibrated Schwarzbeck antenna (0.25 GHz – 6GHz), all factory calibrated with ±1.0dB accuracy, and low-loss cable Suhner GX-07272-D, 50 Ohm, 1.8 meters long with N-type connectors. A point-to-point analysis for Greek public TV ERT, Channel 23 (490MHz) is shown in Table I. Errors between measurements (FSH-3 Spectrum Analyzer) and simulations (ITM model from Radio Mobile & SPLAT!), are shown in the bar graph of Fig. 1. Errors between measurements (FSH-3) and the ITM model (Radio Mobile & SPLAT! for Windows), with average error and standard deviation, are shown in Table II. Differences between FSH-3 measurements, the ITM and the ITWOM models, with average error and standard deviation, are shown in Table III. No. 3, 4, 7, 8, 9 and 10 simulation results are better for Radio Mobile than those of SPLAT! for windows, and No. 1, 2, 5, and 6 simulation results are better for SPLAT! (ITM). The main conclusion for the above measurement points is that the Radio Mobile gives overall better simulation results with lower standard deviation (SD = 4.6dB) than SPLAT! for Windows (SD = 6.4 dB), though both programs are based on the same propagation model, i.e., ITM (Longley-Rice model).

| TABLE I |
| A POINT-TO-POINT ANALYSIS FOR GREEK PUBLIC DTV ERT, CH23 |
WITH THE USE OF FSH-3, RADIO MOBILE (ITM) AND SPLAT! (ITM)

TABLE II
ERRORS BETWEEN FSH-3 MEASUREMENTS AND ITM (RADIO MOBILE & SPLAT! FOR WINDOWS)

The sample standard deviation was calculated between measured path loss values and those predicted by Radio Mobile and SPLAT! by the following very commonly used equation with Bessel’s correction:

\[ s = \sqrt{\frac{1}{N-1} \sum_{i=1}^{N} (x_i - \mu)^2} \]

\( N \) is the number of measurement data points (\( N=10 \)), \( x_i \) is the error between the predicted and the measured field-strength (dB) for data point \( i \), and \( \mu \) is the average value of error (dB).

![Error (dB) Chart](chart.png)

1 PROFITIS ELIAS (7Km/313degs) 40.640411 23.039927 101.9 95.3 100.1
2 THESSALONIKI (12Km/279degs) 40.615822 22.955735 94.7 98.2 95.0
3 LAKE VOLVI (14Km/31degs) 40.513489 22.937471 98.2 94.8 92.4
4 PEREA (16Km/236degs) 40.469402 22.574711 89.1 82.4 82.8
5 METHONI (47Km/252degs) 40.307130 22.618620 83.5 80.4 81.6
6 KORINOS (52Km/232degs) 40.307130 22.588160 64.1 72.3 78.4
7 BORDER EVZONI (68.8Km/321degs) 41.081410 22.588360 71.9 72.4 78.4
8 SOUMELA (86Km/256degs) 40.410086 22.116606 77.3 77.9 77.0
9 LOUTRAKI (107Km/293degs) 41.081190 22.588360 71.9 72.4 78.4
10 POLIKASTRO (69Km/320degs) 41.081190 22.588360 71.9 72.4 78.4

![Error (dB) Chart](chart.png)

1 PROFITIS ELIAS 101.9 100.1 94.7 -1.8 -7.2
2 THESSALONIKI 94.7 95.0 93.8 0.3 -0.9
3 LAKE VOLVI 98.2 93.7 90.7 -4.5 -7.5
4 PEREA 98.2 92.4 89.4 -5.8 -8.8
5 METHONI 89.1 82.8 65.0 -6.3 -24.1
6 KORINOS 83.5 81.6 57.4 -0.9 -20.5
7 BORDER EVZONI 77.3 73.7 54.2 -3.6 -23.1
8 SOUMELA 77.9 77.0 57.4 -0.9 -20.5
9 LOUTRAKI 77.3 73.7 54.2 -3.6 -23.1
10 POLIKASTRO 71.9 78.4 59.0 6.5 -12.9

Average -0.6 0.5
Standard Deviation 4.6 6.4

TABLE III
ERRORS BETWEEN FSH-3, ITM SPLAT! FOR WINDOWS AND ITWOM SPLAT! V1.4.0 FOR LINUX

It can be noticed from the above measurements and simulation results, that SPLAT! v1.4.0 with ITWOM gives worse simulation results than SPLAT! for Windows and Radio Mobile. Additionally, for distances larger than around 40km...
the simulation results are much worse. Most probably, SPLAT! with ITWOM overestimates the attenuation by obstacles. Errors between measurements (FSH-3) and simulations (SPLAT!-ITM & SPLAT!-ITWOM) are shown in the bar graph of Fig. 2.

![Fig. 1. Errors between measurements (FSH-3) and simulations with ITM model, SPLAT! for Windows and ITWOM model SPLAT! v.1.4.0 Linux.](image1)

A coverage map produced by Radio Mobile with ITM for Greek Public TV ERT, Channel 23 (490MHz), is shown in Fig. 3. The broadcasting station coordinates are N 40.5976648 - E 23.099793, the transmit power is 1600 Watts, the transmit channel is UHF 23 (490 MHz), the antenna type is a 4 bay - 3 directions UHF panel array, the antenna height is 70m, and the central lobe azimuth is 285degs. A coverage map produced by SPLAT! for the Greek Public TV, ERT Channel 23 (490MHz), is shown in Fig. 4.

![Fig. 4. Coverage map produced by SPLAT! with ITM for ERT CH-23, SPLAT! for windows. Omni antenna has been used.](image2)

A coverage map produced by SPLAT! v.1.4.0 with ITWOM model is shown in Fig. 5. Because SPLAT! v.1.4.0 works only with Linux, we used Ubuntu 12.10 to produce the coverage map. For simulation results an omni antenna has been used in this case.

All measurements were made with the reception antenna at an altitude from 0.5 meters to 2.5 metres above ground. The simulation results produced by ITM & ITWOM model with
Radio Mobile and SPLAT! used the same antenna height range, from 0.5 to 2.5 meters, for more accurate comparisons.

III. CONCLUSION

The Longley-Rice (ITM) model, that Radio Mobile and SPLAT! use in conjunction with worldwide Shuttle Mission Satellite Radar 3-arc-second data (SRTM), produce in some cases big errors compared to the measurement results. The ITM model does not work quite well in the line-of-sight mode and in the early diffraction range. The recently proposed ITWOM model is supposed to be more accurate than the older ITM model at least for shorter distance. However, this is not verified by our comparison results.

REFERENCES