



A New Prediction Model for M/H Mobile DTV Service

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Introduction

The Open Mobile Video Coalition (OMVC), an alliance of U.S. commercial and public broadcasters formed to accelerate the development and rollout of mobile DTV products and services, has developed a semi-empirical coverage prediction model for the M/H Mobile DTV service. The OMVC model, currently under evaluation, is designed specifically for the UHF TV band (channels 14 to 51) and intended to predict coverage for three distinct use cases: (1) an automotive service with a fixed antenna mounted on the vehicle, (2) a pedestrian portable device with a built-in attached operating outdoor and (3) a pedestrian portable device with a built-in attached antenna operating indoor. The OMVC model is in the process of being expanded to include the high VHF-TV band (channels 7-13).

A broadcast service using a mobile receiver, such as M/H Mobile DTV, requires a different coverage prediction model than traditionally used by broadcasters providing service to fixed receive locations.¹ This is because the receive antenna height in a mobile service is located low to the ground with an ever-changing and almost infinite number of propagation paths formed between the transmitter and the non-stationary receiver. These varying propagation paths will cause the signal to fade rapidly and deeply, and is more prevalent in highly urbanized areas. A traditional fixed DTV receiver is generally not exposed to as hostile a propagation environment as the mobile receiver, since the fixed receive antenna is usually located at a higher height and the receiver is stationary.

¹ Federal Communications Commission, OET Bulletin No. 69, Longley-Rice Methodology for Evaluating TV Coverage and Interference, February 06, 2004.

Model Development

The goal of a coverage model is to calculate geographic region(s) of service from a set of known transmission system input parameters with reasonable accuracy. A number of techniques may be used to develop coverage models. Some techniques develop coverage models using a purely theoretical basis. Others rely solely on empirical data. Still others use a combination of theory and data, referred to as “semi-empirical,” to achieve the same goal.

Theoretical modeling involves the initial deriving or measuring of the white noise threshold performance of the subject receiving device in a laboratory. The threshold performance is then adjusted to account for the change in the range of received signal levels and signal multipath impairments. After the laboratory threshold characterization, planning factors are calculated for the desired use cases followed by the selection of a theoretically-based propagation model. The propagation model is employed to predict the locations of the threshold conditions.

In contrast, empirically-based modeling involves the determining of the threshold performance of the subject receiving device in the field for the model use cases. The field data is then further used to characterize the propagation environment, by extrapolating a median field loss versus distance chart and/or equation for the measured area.²

The modeling technique employed by the OMVC is the “semi-empirical” methodology. In this situation, field data was analyzed to characterize the threshold performance. The propagation model, which is more theoretically based, was selected upon examination of the data collected and also upon research into what similar types of services employed.

² Examples of pure empirical based models include Bullington (Bullington, K., Radio Propagation at Frequencies Above 30 MHz. Proc. IRE 35) and Egli (Egli, J.J., Radio Propagation Above 40 MHz Over Irregular Terrain, Pro IRE 45).

Initial Investigation

The OMVC model was derived using some of the previous investigations and experiences gained from similar mobile services already deployed in the upper UHF TV band. Research was conducted to determine which services closely resemble the proposed operation of the M/H service, and attempts were made to characterize the type of modeling employed for these services using publically available information. This information included the coverage maps published to advertise these services and the associated transmission parameters reported in the literature and from the appropriate government regulatory agencies.

Using an iterative process, and access to the information above, a number of propagation models were tested to determine the parameters that yielded a “best fit” to those publically available coverage maps. An example of the iterative process is shown in Figure 1. This is a terrain profile from the transmitter site extending radially approximately 20 kilometers with the predicted field strength on the vertical axis and distance away from the transmitter site on the horizontal axis. Particular attention is paid to the field strengths predicted immediately after terrain obstruction in a diffracted path. These highlighted areas as shown by the red vertical lines in Figure 1, are where significant changes to the propagation modes occur. These red lines are used as benchmarks in comparing the radial graph to coverage maps. The depth and span of the field strength nadir, along with the characteristic of the field strength recovery is compared against the known coverage map.

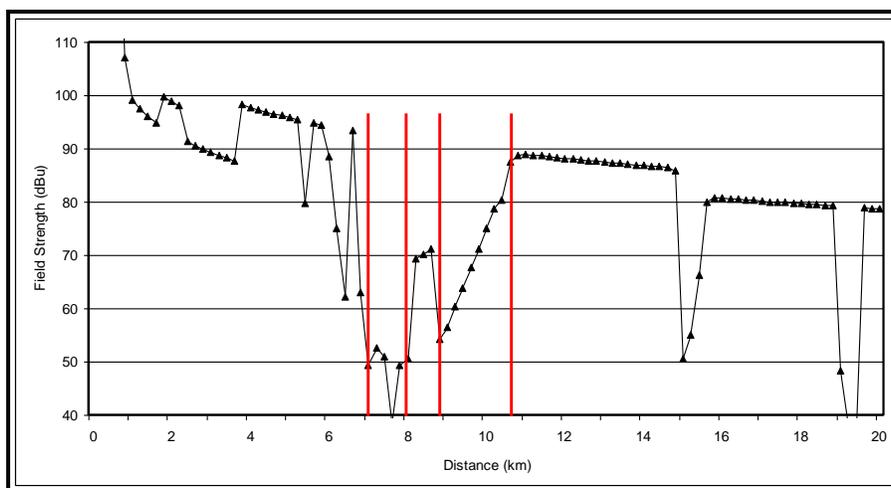


Figure 1. Example of Field Strength Versus Distance of Tested Model on a Specific Radial from 700 MHz Transmission Site

Selection of Model Parameters

Several propagation models were analyzed as part of this process, including the Okumura model as published by Hata, which is generally used by cellular carriers to define mobile coverage, and the point-to-point propagation models of Longley-Rice and TIREM generally used by broadcasters to define fixed receive coverage.^{3 4 5} Our analysis indicates the Okumura model may have some utility, but since it is fundamentally derived from empirically derived field data, the model does not provide detailed predictions over geographic areas with significant and widely varying terrain conditions. The Longley-Rice model tended to over-predict coverage. The TIREM model had the “best-fit” and was selected.

The Terrain-Integrated Rough-Earth Model (TIREM) is designed to calculate the basic median propagation loss over irregular terrain from frequencies from 1 to 20,000 MHz. Using the terrain profile from the transmitter site to the assumed receiver location (as obtained from the appropriate terrain database), the input parameters from the transmitter (antenna height, frequency, and antenna polarization), receiver (antenna height), and atmospheric and ground constants (surface refractivity, humidity, relative permittivity and conductivity), the path loss between the transmitter site and assumed receiver is calculated.⁶ This path loss can then be used to calculate the resulting received signal or field strength level.

The default values for the atmospheric and ground constants were used for the input parameters as it was determined that the employed TIREM model is not sensitive to these specific parameters. This is due to the frequency range of interest (UHF) and that the areas of coverage area are generally close to the transmitter site (within 30 miles).

³ Y. Okumura, E. Ohmori, T. Kawano, and K. Fukuda, Field Strength and Its Variability in VHF and UHF Land-Mobile Radio Service, Review of the Electrical Communication Laboratory, 16, September-October, 1968.

⁴ A. G. Longley and P. L. Rice, Prediction of Tropospheric radio transmission over irregular terrain. A Computer method-1968. ESSA Tech. Rep. ERL 79-ITS 67, U.S. Government Printing Office, Washington, DC, July 1968

⁵ See TIREM/SEM Handbook, Department of Defense, Electromagnetic Compatibility Analysis Center, March 1994.

⁶ The TIREM propagation model computes the median basic transmission loss in two steps. First the terrain profile is examined, and an initial mode of propagation is selected based upon path geometry. The model then branches to the appropriate subroutine that computes the signal propagation loss.

As Version 3.19 of TIREM does not consider long-term power fading statistics for coverage radii of less than 50 kilometers, and most M/H coverage areas meet that criterion, the default value of 50% was selected for the long-term power fading. For field strengths greater than 50 kilometers from the transmitter site, the calculated field strengths were further attenuated by 5 dB to account for the longer propagation path and therefore the greater probability of field strength deviations.

Therefore, after significant analysis, the “best-fit” modeling parameters were selected and are tabulated below in Figure 2.

Propagation Model:	Terrain Integrated Rough-Earth Model (TIREM) Version 3.19	
Terrain Database:	1 second	
Terrain Increment:	0.2 km	
Long-Term Power Fading (time-variability):	50%	
Transmit Polarization:	Horizontal	
Transmit Frequency:	Center Frequency of Subject UHF DTV Channel	
Assumed Receiver Height:	1 m above ground level	
LULC Clutter Category ⁷ Clutter Attenuation (dB) ⁸	Open Land:	5
	Agricultural:	5
	Rangeland:	5
	Ocean:	0
	Forest Land:	15
	Wetland:	3
	Residential:	16
	Mixed Urban/Buildings:	17
	Commercial/Industrial:	15
	Snow & Ice:	0
Fresh Water:	0	

Figure 2. OMVC Initial Propagation Model Parameters.

⁷ The clutter loss is determined by reference to the Land Use and Land Cover (LULC) database of the USGS. This database is entered with the geographic coordinates of the reception point to find the point's LULC classification and, subsequently, to determine a clutter loss value. The clutter loss is then subtracted from the signal strength predicted by propagation model.

⁸ The clutter attenuation specified herein has a basis from the Commission's First Report and Order in ET Docket 00-11, *Establishment of an Improved Model for Predicting the Broadcast Television Field Strength Received at Individual Locations*, May 22, 2000. The clutter attenuation values were modified to fit the coverage areas.

Simultaneous with the model development, an extensive field test program was undertaken to determine the threshold field strength for reception, and the other factors for predicting the M/H service. Figure 3 sets forth the field strengths for the tested use cases. In addition, the data collected in the field was used to validate the model. To date, the field strength threshold is the only metric to define the extent of M/H Mobile DTV service.

Use Case	Field Strength Threshold
Automotive Mode	55 dBu
Pedestrian Mode – Outside	72 dBu
Pedestrian Mode - Inside	82 dBu

Figure 3. UHF M/H Signal Threshold Values

Model Results

The model was built using software developed by du Treil, Lundin & Rackley, Inc. The software combines the TIREM propagation model engine, the 1 second terrain database, and the land-use land-clutter database. After the software calculations, the software output is provided as a grid of points containing the predicted field strength at each point location. This grid is then displaced by a GIS platform, such as MapInfo[®], where the traditional coverage contours can be calculated.

The following is an example of the predicted M/H coverage from a station using the OMVC model. The station is WPXN in New York, NY which transmits from atop the Empire State Building on physical DTV channel 31. Figure 4 identifies the WPXN transmission parameters used for the coverage analysis.

Station	RF Transmission Parameters
WPXN – RF Channel 31	FCC File Number: BDSTA-20090922ABY Empire Transmitter Site Effective Radiated Power: 180 kW Horizontal-Only Polarization Azimuth Pattern: Cardioid Toward NW Radiation Center: 1175 feet AGL

Figure 4. WPXN Mobile DTV Modeling Input Parameters



Figure 6. WPXN Pedestrian Outside Environment Predicted Coverage



Figure 7. WPXN Pedestrian Inside Environment Predicted Coverage

Conclusion

Additional field testing has been completed to determine if the initial OMVC model yields satisfactory predictions. The automobile use-case has shown excellent correlation between the model predictions and collected field data. The pedestrian use-case field data is more limited, as it is not collected in an automated format, and therefore is inconclusive on how it corresponds to the model prediction.

Future development of the model will consider the impact of elliptical or circular polarized transmission antennas and additional effect due to tall buildings close by the receiver. Also, a VHF model is presently under development.