The ILLR Computer Program

OET BULLETIN NUMBER 72

July 2, 2002

The ILLR Computer Program

I. Introduction

A. Background

In the Satellite Home Viewer Improvement Act of 1999 (SHVIA),[1] Congress instructed the Commission "to develop and prescribe by rule a point-to-point predictive model for reliably and presumptively determining the ability of individual locations to receive signals in accordance with the signal intensity standard in effect under section 119(d) (10) (A) of Title 17 [United States Code]."[2] Section 339(c)(3) of the Communication Act further provides that "[i]n prescribing such model, the Commission shall rely on the Individual Location Longley-Rice [ILLR] model set forth by the Federal Communications Commission in Docket No. 98-201 and ensure that such model takes into account terrain, building structures, and other land cover variations."[3] Terrain features (such as hills), buildings, and land cover (such as forests) have a major effect on the strength of received signals, and Congress instructed the Commission to make the predictive model as accurate as possible by taking these factors into account. The SHVIA also requires that, in determining household eligibility for reception of satellite retransmission of a TV broadcast network signal, the courts rely on the ILLR model for making a presumptive determination of whether a household is capable of receiving the over-the-air signal of the local station affiliated with that network with at least a certain threshold intensity of signal strength.[4] The threshold signal strength intensity for determining eligibility is the Grade B standard set forth in §73.683(a) of the Commission's rules (47 CFR § 73.683(a)).

This bulletin publishes the detailed definition of the ILLR computer program as established by the Commission in the First Report and Order[5] adopted May 22, 2000. The ILLR Computer Program computes the predicted signal strength of analog television (TV) stations as received over-the-air at individual viewing locations. Individual locations where a network TV signal is below a certain signal strength level are eligible to receive the network broadcast as subscribers of satellite TV services. The program is used by Satellite TV service providers to determine whether particular TV network signals may be included in the package of channels delivered to

---

[1] *Satellite Home Viewer Improvement Act of 1999*, PL 106-113, 113 Stat. 1501, 1501A-526 to 1501A-545 (Nov. 29, 1999), codified in the Communications Act at 47 U.S.C. § 339(c)(3).

[2] 47 U.S.C. § 339(c)(3).

[3] In CS Docket No. 98-201 the Commission endorsed a prediction procedure it referred to as the Individual Location Longley-Rice model. See *Satellite Delivery of Network Signals to Unserved Households for Purposes of the Satellite Home Viewer Act; Part 73 Definition and Measurement of Signals of Grade B Intensity*, adopted February 1, 1999, 14 FCC Rcd 2654 (1999).

[4] 17 U.S.C. § 119(a)(2)(B)(ii)(I).

[5] *First Report and Order In the Matter of Establishment of an Improved Model for Predicting the Broadcast Television Field Strength Received at Individual Locations*, ET Docket No. 00-11, 15 FCC Rcd 12118 (2000).

individual subscribers. To facilitate use of the program by others, this bulletin provides details for combining the program elements on other computers.

As defined by SHVIA, a viewer location is "served," or "unserved," depending on whether the signal strength received at that location is at least, or is less than, a signal strength of Grade B intensity as set forth in FCC Rules.[6] A location found by the ILLR prediction program to be "served" by the signal of a network affiliate station is not entitled to receive satellite transmission of that same network programming. Nevertheless, the SHVIA also establishes a procedure for on-site testing when satellite carriage of network programming is denied to a subscriber as a result of a predictive determination by the ILLR program.[7]

B. Software and Computer Database Requirements to Implement the ILLR Program

Computer program source code to implement the Longley-Rice radio propagation prediction model is available from the Department of Commerce. It must be combined with terrain elevation data and also with a database describing the local environment of building structures and vegetation. Terrain elevation data and the database characterizing the local environment, or Land Use and Land Clutter (LULC), are both available from the U.S. Geological Survey (USGS). To set up a running program, the Department of Commerce Longley-Rice source code must be compiled with specific parameter values and linked with the terrain elevation data. Finally, a computerized lookup table of local environment values must be constructed from the USGS LULC database. A computer program complying with the technical details specified here will qualify as the Individual Location Longley-Rice (ILLR) propagation prediction model per Section 73.683(d) of the FCC rules.

C. Using the ILLR Computer Program

A determination of served/unserved for a particular location is made by finding its latitude and longitude coordinates (using GPS or on-line map services) and technical information about the desired network affiliate broadcasting station. The ILLR computer program is applied using this information.

---

[6] *See* 47 C.F.R. § 73.683(a). The signal strength values for Grade B are 47 dBμ for TV channels 2-6; 56 dBμ for channels 7-13; and 64 dBμ for channels 14 and above.

[7] Specifically, the SHVIA prescribes a two-step procedure before a test must be performed. The first step is a waiver request. A subscriber who is denied satellite retransmission of the signal of a specific distant network station or stations based on a predictive determination may request a waiver from the local network affiliate. This request is to be made through the satellite service provider. In the event the local affiliate denies the waiver request, the second step is a request for an on-site test. Once denied a waiver, the subscriber may submit, through the satellite provider, a request for an onsite test to verify the subscriber's inability to receive a signal meeting the signal intensity standard. The satellite carrier and the network station must then select a qualified and independent person to conduct the test, following the procedures set out in the Commission's rules, and the test must be conducted within 30 days of the subscriber's request for a test. If the test verifies the subscriber's inability to receive the locally broadcast signal at the required minimum intensity, the subscriber thereby becomes eligible for satellite retransmission of the distant network station's signal.

II. The Individual Location Longley-Rice (ILLR) Computer Program

A. Computer Source Code

Computer code for the Longley-Rice radio propagation prediction model is published in an appendix to NTIA Report 82-100, *A Guide to the Use of the ITS Irregular Terrain Model in the Area Prediction Mode*, authors G.A. Hufford, A.G. Longley and W.A. Kissick, U.S. Department of Commerce, April 1982. The report may be obtained from the U.S. Department of Commerce, National Technical Information Service, Springfield, Virginia, by requesting Accession No. PB 82-217977. Some modifications to the code were described by G.A. Hufford in a memorandum to users of the model, dated January 30, 1985. With these modifications, the code is referred to as Version 1.2.2 of the Longley-Rice model. It is available for downloading at the U.S. Department of Commerce Web site, http://elbert.its.bldrdoc.gov/itm.html.

The ILLR model was adopted for SHVIA purposes based on the Commission's experience with using the model for predicting service and interference for digital television (DTV). The parameters to be used in a computer implementation of the ILLR model for SHVIA purposes are mostly the same as were used for DTV purposes, with only a few exceptions, stemming from their somewhat different objectives. Specific parameter values are given in Table 1. Following are the unique features of the ILLR prediction procedure for SHVIA (these distinguish the ILLR model from the use of Longley-Rice for digital television coverage and interference calculations as detailed in OET Bulletin No. 69):

- the time variability factor to be used is 50%, based on the fact that the ILLR field strength prediction is to be compared with a required field strength (the Grade B field intensity defined in Section 73.683(d) of the FCC rules) that already includes an allowance for long term (daily and seasonal) time fading;

- the confidence variability factor to be used is 50%, indicating median situations;

- the model is to be run in individual mode;

- terrain elevation is to be considered every 1/10 of a kilometer;

- receiving antenna height is to be assumed to be 6 m (20 feet) above ground for one-story buildings and 9 m (30 feet) above ground for buildings taller than one-story;

- in the rare cases that error code 3 occurs (KWX=3), the predicted field strength is nevertheless to be accepted as indicative of whether a Grade B field strength is available at that location;

- consideration of the land use and land cover (*e.g.,* vegetation and buildings) in the vicinity of the receiving location is to be included through use of a lookup table of clutter losses additional to those inherent in the basic Longley-Rice 1.2.2 model. The lookup table must be constructed from information on the Land Use and Land Cover categories defined by the United States Geological Survey. See Section III below.

HG(1) in Table 1 is the height of the radiation center above ground. It is determined by subtracting the ground elevation above mean sea level (AMSL) at the transmitter location from

the height of the radiation center AMSL. The latter may be found by means of the FCC's TV Query Web site http://www.fcc.gov/mb/video/tvq.html while the former is retrieved from the terrain elevation data base as a function of the transmitter site coordinates also found from the TV Query Web page.

Table 1.

Parameter Values for ILLR Implementation of the Longley-Rice Fortran Code

Parameter	Value	Meaning/Comment
EPS	15.0	Relative permittivity of ground.
SGM	0.005	Ground conductivity, Siemens per meter.
ZSYS	0.0	Coordinated with setting of EN0. See page 72 of NTIA Report.
EN0	301.0	Surface refractivity in N-units (parts per million).
IPOL	0	Denotes horizontal polarization.
MDVAR	1	Code 1 sets individual mode of variability calculations.
KLIM	5	Climate code 5 for continental temperate.
XI	0.1 km	Distance between successive points along the radial from transmitter to individual reception point.
HG(1)	see text	Height of the radiation center above ground.
HG(2)	6 m, or 9 m	Height of TV receiving antenna above ground. Use 6 m for one-story building; otherwise 9 m.
KWX	Numeric error marker	KWX is an output indicating the severity of a possible error due to parameters being out of range. Accept the field strength prediction when KWX is 3.

Terrain elevation data at uniformly spaced points between the transmitter and receiver must be provided. The ILLR computer program must be linked to a terrain elevation data base that provides elevation data values for locations separated by greater than 3 arc-seconds of latitude and longitude. The program should retrieve elevations from this data base at regular intervals with a spacing increment of 0.1 kilometer (parameter XI in Table 1). The elevation of a point of interest is determined by linear interpolation of the values retrieved for the corners of the coordinate rectangle in which the point of interest lies.

B. Acquiring Terrain Elevation Data

Terrain elevation data for the United States is available from the United States Geological Survey (USGS) in the form of elevations relative to mean sea level at grid points separated by 3 arc-seconds (roughly every 100 feet at mid-latitudes of the U.S.). The Web site for obtaining these data directly from the USGS is http://edc.usgs.gov/geodata/. The data are also available from several commercial sources. Installation of the ILLR program necessarily entails a computer coding task to link the terrain elevation data to the propagation prediction code. Computer program code must be developed to retrieve data representing the elevation of points along the path from the network affiliate's transmitter to the individual reception point of

interest. From the geographic coordinates of a point along the path, the elevation of points at each corner of the 3-arc-second grid should be retrieved. The elevation of the point along the path should then be calculated by 4-point linear interpolation.

III. Land Use and Land Cover (LULC) Clutter Losses

A. Clutter Losses

The presence of foliage and man-made structures in the radio path tends to reduce the strength of received signals. These effects are included to some extent in the basic Department of Commerce propagation prediction code (Longley-Rice Version 1.2.2). However, the Department of Commerce code was developed from field strength measurements in areas selected for the purpose of investigating effects of terrain elevation profiles. The ILLR computer program defined in this bulletin takes account of additional factors, especially buildings and vegetation, as clutter losses. The clutter loss at an individual reception location 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. Finally, the clutter loss is subtracted from the signal strength predicted by the basic propagation prediction code to determine whether the location is served or unserved.

B. Source of LULC Classification Data

The LULC database is available for downloading at the USGS Web site http://edcwww.cr.usgs.gov/glis/hyper/guide/1_250_lulc. In the FCC's implementation of the ILLR program, the LULC classifications are stored in a rasterized fashion like that used for terrain elevations. That is, the classifications are stored as functions of the latitude and longitude coordinates of points of the Universal Transverse Mercator (UTM) system with 200 meters between grid points. The classification of the nearest grid point is then used as the classification of any particular latitude-longitude point.

C. LULC Categories of the ILLR Program

Since the LULC classifications of the USGS have a broader purpose, and are not targeted for application to radio propagation analyses, we have regrouped these classifications into more appropriate categories for use in the ILLR program. Table 2 defines this regrouping. For each computer run of the program, the appropriate ILLR clutter category number should be selected from Table 2 according to environmental conditions in the vicinity of the individual reception point. The clutter loss value is then determined as a function of the ILLR clutter category number and the channel number of the desired network television affiliate, by referring to Table 3.

Table 2.

Regrouping of LULC Categories for ILLR Applications*

The United States Geological Survey (USGS) maintains a database on land use and land cover indicating features such as vegetation and man-made structures. It is often called the LULC database and is available from the USGS web page at http://edcwww.cr.usgs.gov/glis/hyper/guide/1_250_lulc.

LULC Classification Number	LULC Classification Description	ILLR Clutter Category Number	ILLR Clutter Category Description
11	Residential	7	Residential
12	Commercial and services	9	Commercial/industrial
13	Industrial	9	Commercial/industrial
14	Transportation, communications, & utilities	1	Open land
15	Industrial and commercial complexes	9	Commercial/industrial
16	Mixed urban and built-up lands	8	Mixed urban/buildings
17	Other urban and built-up land	8	Mixed urban/buildings
21	Cropland and pasture	2	Agricultural
22	Orchards, groves, vineyards, nurseries, and horticultural	2	Agricultural
23	Confined feeding operations	2	Agricultural
24	Other agricultural land	2	Agricultural
31	Herbaceous rangeland	3	Rangeland
32	Shrub and brush rangeland	3	Rangeland
33	Mixed rangeland	3	Rangeland
41	Deciduous forest land	5	Forest land
42	Evergreen forest land	5	Forest land
43	Mixed forest land	5	Forest land
51	Streams and canals	4	Water
52	Lakes	4	Water
53	Reservoirs	4	Water
54	Bays and estuaries	4	Water
61	Forested wetland	5	Forest land

* This regrouping into 10 categories for use with the ILLR model was designed by EDX Engineering, Inc., now the EDX Division of Comarco Wireless Technologies, P.O. Box 1547, Eugene, OR 97440-1547, U.S.A.

Table 2.

Regrouping of LULC Categories for ILLR Applications (continued)

LULC Classification Number	LULC Classification Description	ILLR Clutter Category Number	ILLR Clutter Category Description
62	Non-forest wetland	6	Wetland
71	Dry salt flats	1	Open land
72	Beaches	1	Open land
73	Sandy areas other than beaches	1	Open land
74	Bare exposed rock	1	Open land
75	Strip mines, quarries, and gravel pits	1	Open land
76	Transitional areas	1	Open land
77	Mixed barren land	1	Open land
81	Shrub and brush tundra	1	Open land
82	Herbaceous tundra	1	Open land
83	Bare ground	1	Open land
84	Wet tundra	1	Open land
85	Mixed tundra	1	Open land
91	Perennial snowfields	10	Snow & ice
92	Glaciers	10	Snow & ice

Table 3.

Clutter Loss as a Function of ILLR LULC Clutter Category and TV Channel

ILLR Clutter Category Number	ILLR Clutter Category Description	**Clutter Loss** Additional path loss, dB, to be subtracted from the signal strength predicted by Longley-Rice Version 1.2.2			
				UHF Band	
		Low Band VHF, Channels 2-5	High Band VHF, Channels 7-13	Channels 14-36	Channels 38-69
1	Open Land	0	0	4	5
2	Agricultural	0	0	5	6
3	Rangeland	0	0	3	6
4	Water	0	0	0	0
5	Forest Land	0	0	5	8

Table 3.

Clutter Loss as a Function of ILLR LULC Clutter Category and TV Channel (continued)

ILLR Clutter Category Number	ILLR Clutter Category Description	Clutter Loss Additional path loss, dB, to be subtracted from the signal strength predicted by Longley-Rice Version 1.2.2			
				UHF Band	
		Low Band VHF, Channels 2-5	High Band VHF, Channels 7-13	Channels 14-36	Channels 38-69
6	Wetland	0	0	0	0
7	Residential	0	0	5	7
8	Mixed Urban/Buildings	0	0	6	6
9	Commercial/Industrial	0	0	5	6
10	Snow and Ice	0	0	0	0

IV. Field Strength Calculation

The field strength of a network TV station at an individual location is predicted as follows:

1) Find the engineering facilities data for the network affiliate station of interest by, for example, consulting the TV Query FCC Web site at http://www.fcc.gov/mb/video/tvq.html. Necessary data are station latitude and longitude, height above mean sea level of the radiation center, and the effective radiated power (ERP) in the direction of the individual location under study.

2) Run Longley-Rice 1.2.2 in the point-to-point mode with the parameters specified in Table 1 to find the propagation path loss relative to free space propagation.

3) Find the USGS Land Use and Land Cover classification of the individual location under study by consulting the LULC database, available from the USGS web page at http://edcwww.cr.usgs.gov/glis/hyper/guide/1_250_lulc.

4) Convert the USGS Land Use and Land Cover classification to the corresponding ILLR clutter category using Table 2, and find the associated clutter loss from Table 3.

5) Finally, calculate the ILLR field strength prediction from the formula

   Field = (Free Space Field) – (Longley-Rice 1.2.2 Path Loss) – (ILLR Clutter Loss)

   where the Free Space Field in dB: $= 106.92 + 10\log_{10}(\text{ERP}) - 20\log_{10}(\text{distance})$, and distance is the path length in kilometers from transmitter to the individual location under study.

The field strength calculated in the last step determines whether the individual location is served or unserved. For local network affiliate stations transmitting on one of TV channels 2 through 6, the individual location is served if the calculated field equals or exceeds 47 dB : ; for channels 7 through 13, the field must equal or exceed 56 dB : ; and for channels 14 and above the field must equal or exceed 64 dB : .