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Subject: Propagation Fundamentals
Recommendation ITU-R P.526-10 – Propagation by Diffraction

05 November 2010
English only

Federative Republic of Brazil

MEASUREMENTS TO STUDY THE DIFFRACTION PHENOMENA ON TROPICAL REGION – VHF BAND

QUESTION ITU-R 202-3/3 - METHODS FOR PREDICTING PROPAGATION OVER THE SURFACE OF THE EARTH

1 Introduction

The study of diffraction propagation prediction is the main topic focused in this paper. The analysis of diffraction was made by means of measurements campaigns developed on May, 2009 (autumn) and August, 2010 (winter), in Brazil, Rio de Janeiro – tropical region.

2 Parameters considered

The main parameters used to set the equipments are listed in the following items:

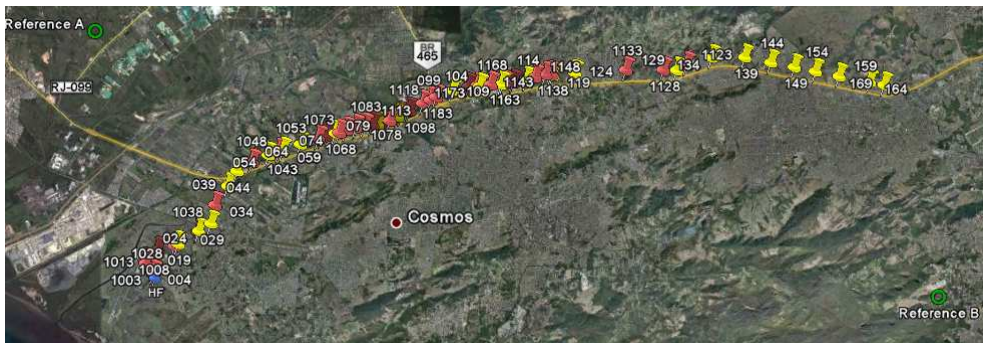
- a) Frequency of study: 150.54 MHz.
- b) Modulation: FM.
- c) Equivalent Earth radius: 8,500 km was taken as a basis.
- d) Measurements were made in suburban area characterized by low buildings up to six meters in most cases. The terrain traversed had mild elevations in the range 001.0 to 183.0 meters. The antennas and the vehicle used to perform the measurements are presented on figure 1.
- e) Transmitter location: 22° 55' 59.30'' South / 43° 42' 36.50'' West (WGS84).
- f) Transmitter output power: 40 Watts (46.02 dBm).
- g) Transmitter cable loss: 2 dB.
- h) Transmitter antenna - Horizontal pattern: omnidirectional / Gain: ≈1 dB / Height: 3 meters.
- i) Receiver antenna - Horizontal pattern: omnidirectional / Gain: ≈1 dB / Height: 2 meters.
- j) Receiver cable loss: 0.5 dB.
- k) Maximum distance from transmitter to the receiver test point: 30,045 meters.
- l) Local time period of measurements (May 2009 - autumn): 10:08 AM to 03:35 PM.
- m) Local time period of measurements (August 2010 - winter): 10:29 AM to 05:05 PM.
- n) Registered levels unit: dBμV.

- o) Explored geographic area: Illustrated on figure 2.
- p) Environment characteristics: One of the typical sites where the data was collected by receiver is showed in figure 3.

Figure 1 – Vehicle used to perform the measurements.



Figure 2 - Aerial view of the terrain where the testes were developed.



Reference points:

Reference A: 22° 50' 33.44'' South / 43° 43' 51.66'' West

Reference B: 22° 56' 14.08'' South / 43° 24' 13.40'' West

Figure 3 – Environment visual details in one of the sites where data was collected.



3 Acquired data

The measurement campaigns collected the data available in the tables 1 and 2. These data allowed to plot the graphics presented on figures 4 (May, 2009 - autumn) and 5 (August, 2010 – winter). Both graphics show the field strength level registered in each test point and the respective distance from transmitter. The distance axis (figures 4 and 5) does not have equal steps because the distances were measured according with the test points coordinates (WGS84), obtained on the locations where the vehicle stopped. Each test point is identified by the **INDEX** number located in the first column of tables 1 and 2.

Figure 4 – Field Strength Level (dB MicroVolts) Campaign – May 2009.

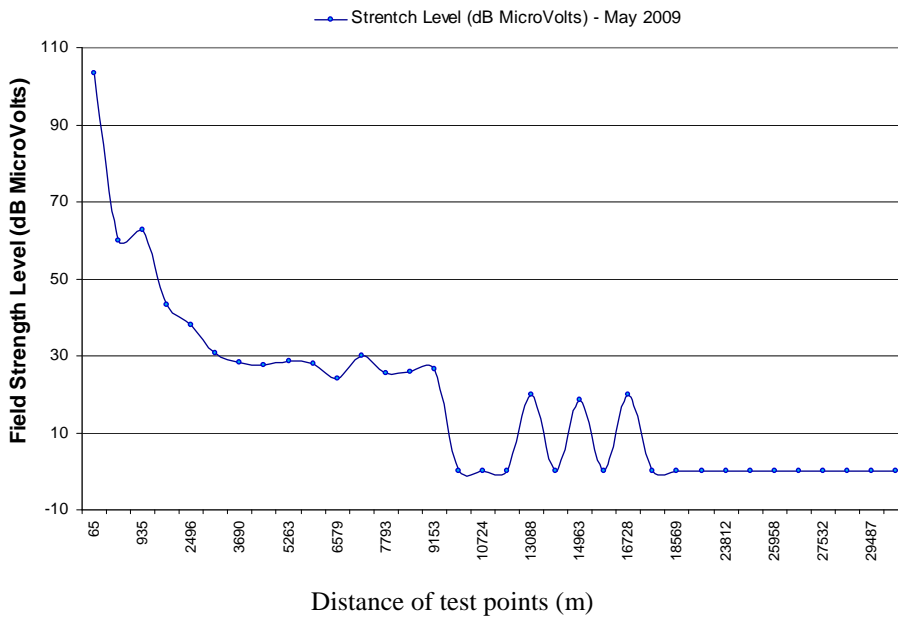


Figure 5 – Field Strength Level (dB MicroVolts) Campaign – August 2010.

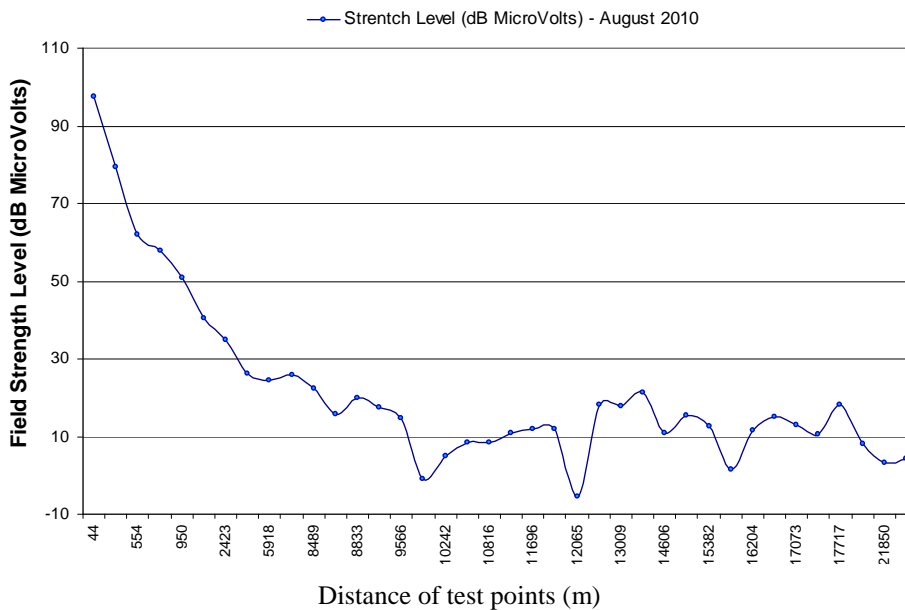


Table 1 - Field Strength Level (dB MicroVolts) Campaign – May 2009.

Index	Local Time	Frequency (MHz)	Field Strength Level (dB μ V*)	Latitude South			Longitude West			Distance to Transmitter (m)	Environment features
				Grade	Minutes	Seconds	Grade	Minutes	Seconds		
4	10:08	150,54	103,55	22	55	57,20	43	42	36,10	66	Suburb
9	10:14	150,54	60,04	22	55	45,10	43	42	43,10	476	Suburb
14	10:21	150,54	62,76	22	55	29,30	43	42	30,90	937	Suburb
19	10:27	150,54	43,18	22	55	20,50	43	42	1,20	1561	Suburb
24	10:43	150,54	37,91	22	55	4,10	43	41	32,10	2500	Suburb
29	10:48	150,54	30,74	22	54	54,40	43	41	15,20	3058	Suburb
34	10:57	150,54	28,37	22	54	30,30	43	41	9,10	3701	Suburb
39	11:03	150,54	27,54	22	54	6,40	43	40	51,40	4586	Suburb
44	11:13	150,54	28,52	22	53	47,40	43	40	38,50	5270	Suburb
49	11:22	150,54	27,87	22	53	34,40	43	40	17,60	5961	Suburb
54	11:29	150,54	23,97	22	53	26,80	43	39	54,70	6578	Suburb
59	11:34	150,54	29,85	22	53	20,60	43	39	34,60	7121	Suburb
64	11:40	150,54	25,4	22	53	12,90	43	39	9,90	7802	Suburb
69	11:44	150,54	25,8	22	53	5,50	43	38	45,20	8487	Suburb
74	11:51	150,54	26,53	22	52	58,80	43	38	21,30	9150	Suburb
79	11:56	150,54	No field strength detected	22	52	51,20	43	37	51,10	9982	Suburb
84	12:03	150,54	No field strength detected	22	52	47,10	43	37	22,00	10737	Suburb
89	12:10	150,54	No field strength detected	22	52	37,70	43	36	53,60	11574	Suburb
94	12:20	150,54	19,85	22	52	20,60	43	36	19,30	12681	Suburb
99	12:27	150,54	No field strength detected	22	52	4,20	43	35	37,40	13963	Suburb
104	12:33	150,54	18,49	22	51	58,60	43	34	59,30	14987	Suburb
109	12:39	150,54	No field strength detected	22	51	56,00	43	34	29,30	15774	Suburb
114	12:45	150,54	19,95	22	51	50,20	43	33	54,00	16747	Suburb
119	12:51	150,54	No field strength detected	22	51	44,70	43	33	17,80	17745	Suburb
124	12:56	150,54	No field strength detected	22	51	41,70	43	32	46,80	18581	Suburb
129	14:53	150,54	No field strength detected	22	51	38,10	43	30	24,60	22353	Suburb
134	15:02	150,54	No field strength detected	22	51	21,90	43	29	35,70	23833	Suburb
139	15:08	150,54	No field strength detected	22	51	21,40	43	28	49,60	25070	Suburb
144	15:14	150,54	No field strength detected	22	51	28,10	43	28	13,30	25978	Suburb
149	15:18	150,54	No field strength detected	22	51	33,80	43	27	40,40	26813	Suburb
154	15:22	150,54	No field strength detected	22	51	39,40	43	27	11,00	27562	Suburb
159	15:25	150,54	No field strength detected	22	51	45,60	43	26	38,10	28407	Suburb
164	15:30	150,54	No field strength detected	22	51	52,70	43	25	55,60	29517	Suburb
169	15:35	150,54	No field strength detected	22	51	56,80	43	25	35,30	30045	Suburb

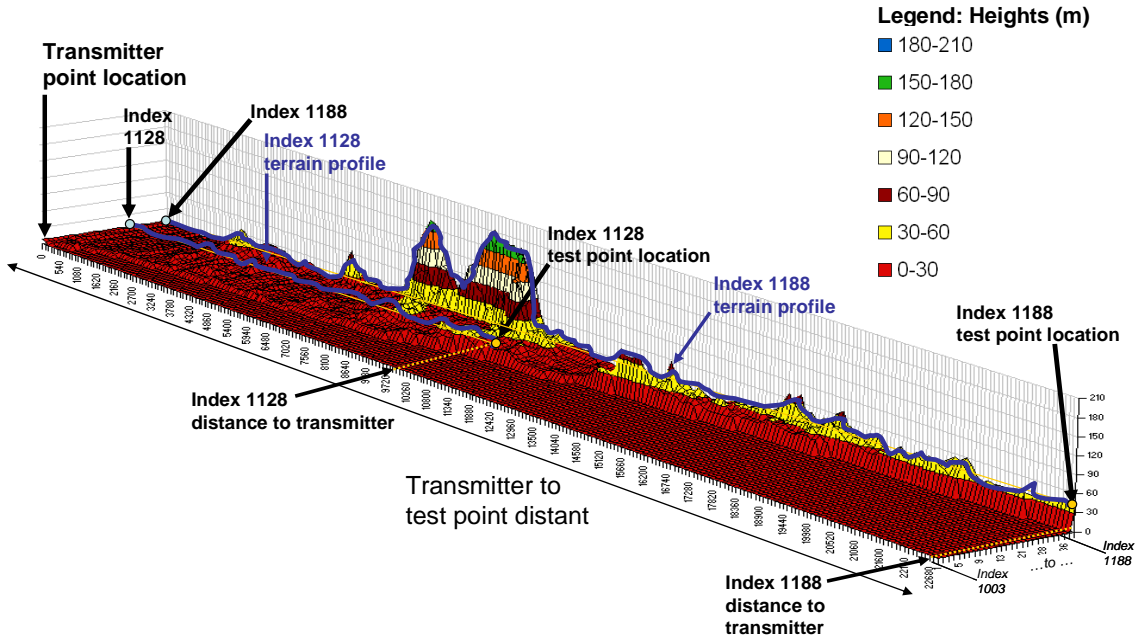
Table 2 - Field Strength Level (dB MicroVolts) Campaign – August 2010.

Index	Local Time	Frequency (MHz)	Measured Field Strength Level (dBµV*)	Latitude South			Longitude West			Distance to Transmitter (m)	Environment features
				Grade	Minutes	Seconds	Grade	Minutes	Seconds		
1003	10:29	150,54	97,63	22	55	57,90	43	42	36,00	45	Suburb
1008	10:39	150,54	79,54	22	55	55,70	43	42	36,70	111	Suburb
1013	10:48	150,54	62,03	22	55	44,40	43	42	47,40	554	Suburb
1018	10:58	150,54	57,82	22	55	42,20	43	42	47,60	614	Suburb
1023	11:08	150,54	50,71	22	55	28,70	43	42	29,60	962	Suburb
1028	11:16	150,54	40,57	22	55	23,50	43	42	6,00	1403	Suburb
1033	11:22	150,54	34,85	22	55	5,20	43	41	33,90	2440	Suburb
1038	11:39	150,54	26,29	22	54	30,60	43	41	9,10	3694	Suburb
1043	11:49	150,54	24,33	22	53	35,80	43	40	17,30	5935	Suburb
1048	12:06	150,54	25,93	22	53	22,20	43	39	39,90	6977	Suburb
1053	12:15	150,54	22,33	22	53	5,10	43	38	44,70	8506	Suburb
1058	12:26	150,54	15,89	22	53	4,00	43	38	40,20	8627	Suburb
1063	12:30	150,54	19,74	22	53	1,70	43	38	32,20	8850	Suburb
1068	12:42	150,54	17,34	22	52	58,10	43	38	15,50	9295	Suburb
1073	12:48	150,54	14,8	22	52	54,60	43	38	5,70	9583	Suburb
1078	12:55	150,54	-0,85	22	52	51,50	43	37	52,70	9939	Suburb
1083	13:08	150,54	5,12	22	52	49,50	43	37	40,50	10259	Suburb
1088	13:16	150,54	8,36	22	52	47,80	43	37	29,40	10533	Suburb
1093	13:21	150,54	8,45	22	52	45,80	43	37	18,90	10816	Suburb
1098	13:27	150,54	11,04	22	52	42,70	43	37	5,00	11200	Suburb
1103	13:32	150,54	11,77	22	52	35,80	43	36	49,10	11696	Suburb
1108	17:05	150,54	11,75	22	52	29,40	43	36	40,00	12021	Suburb
1113	13:39	150,54	-5,5	22	52	30,10	43	36	37,70	12065	Suburb
1118	13:48	150,54	18,06	22	52	20,50	43	36	19,00	12673	Suburb
1123	13:55	150,54	17,69	22	52	16,20	43	36	8,00	13009	Suburb
1128	17:01	150,54	21,21	22	52	12,40	43	36	0,50	13253	Suburb
1133	16:57	150,54	10,92	22	51	58,70	43	35	14,60	14606	Suburb
1138	16:53	150,54	15,37	22	51	57,80	43	35	3,30	14883	Suburb
1143	16:49	150,54	12,54	22	51	56,30	43	34	44,10	15382	Suburb
1148	16:48	150,54	1,52	22	51	55,20	43	34	31,00	15726	Suburb
1153	16:42	150,54	11,72	22	51	53,80	43	34	12,80	16204	Suburb
1158	16:39	150,54	15,17	22	51	50,10	43	33	55,10	16704	Suburb
1163	16:35	150,54	13,01	22	51	46,90	43	33	42,30	17073	Suburb
1168	16:33	150,54	10,37	22	51	43,80	43	33	27,70	17488	Suburb
1173	16:26	150,54	18,08	22	51	43,10	43	33	19,10	17717	Suburb
1178	16:22	150,54	8,02	22	51	37,70	43	31	35,40	20471	Suburb
1183	16:15	150,54	3,28	22	51	37,70	43	30	43,10	21850	Suburb
1188	15:50	150,54	4,2	22	51	31,20	43	30	10,90	22777	Suburb

4 Terrain profile

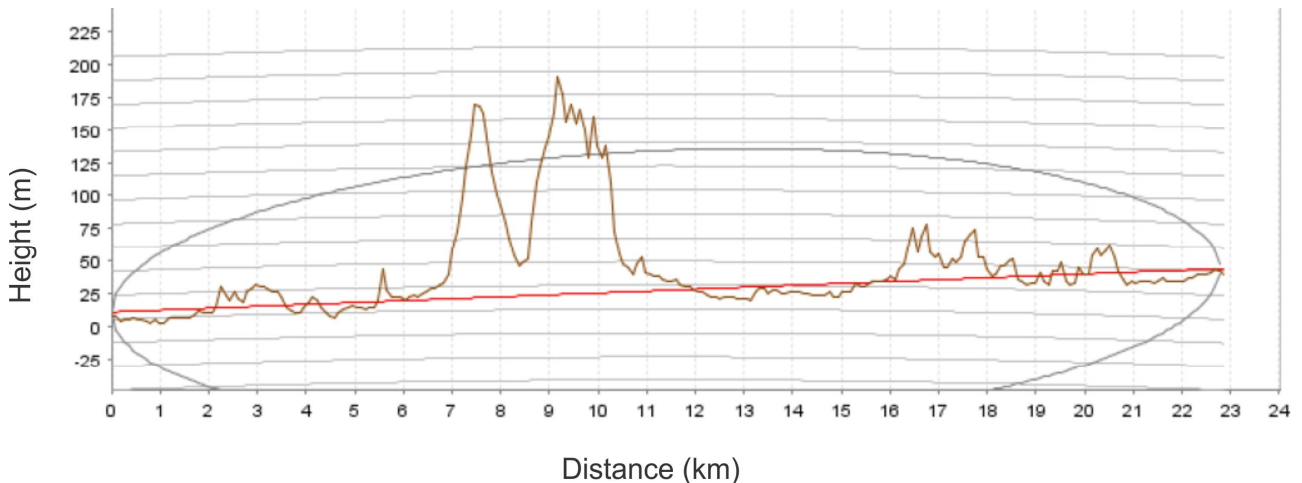
The terrain profiles were digitalized with 90 meters resolution and are available in the files “PROFILES MAY 2009” and “PROFILES AUGUST 2010” annexed to this Contribution. The profiles pages have the correspondent index numbers to facilitate the link identification as showed on tables 3 and 4. Figure 6 shows a tridimensional plot of profiles side by side and figure 7 presented an example of terrain profile of link registered by INDEX 1188, on page 38. All these files were send to ITU – Study Group 3, together with the Contribution to be downloaded from the website.

Figure 6 – Terrain profile data (Campaign – August 2010).



Example of available data (August, 2010).

Figure 7 – Terrain profile Index 1188 - (Campaign – August 2010).



It is necessary to take into account that the geometries of each link are different, because the test track along the road is not exactly a radial, than the study and comparisons need to be done carefully.

Table 3 – Profile page number & INDEX number - Campaign – May 2009.

Profile page	INDEX number	Profile page	INDEX number	Profile page	INDEX number	Profile page	INDEX number
1	4	11	54	21	104	31	154
2	9	12	59	22	109	32	159
3	14	13	64	23	114	33	164
4	19	14	69	24	119	34	169
5	24	15	74	25	124		
6	29	16	79	26	129		
7	34	17	84	27	134		
8	39	18	89	28	139		
9	44	19	94	29	144		
10	49	20	99	30	149		

Legend No field strength detected. (very low intensity)

Table 4 – Profile page number & INDEX number - Campaign – August 2010.

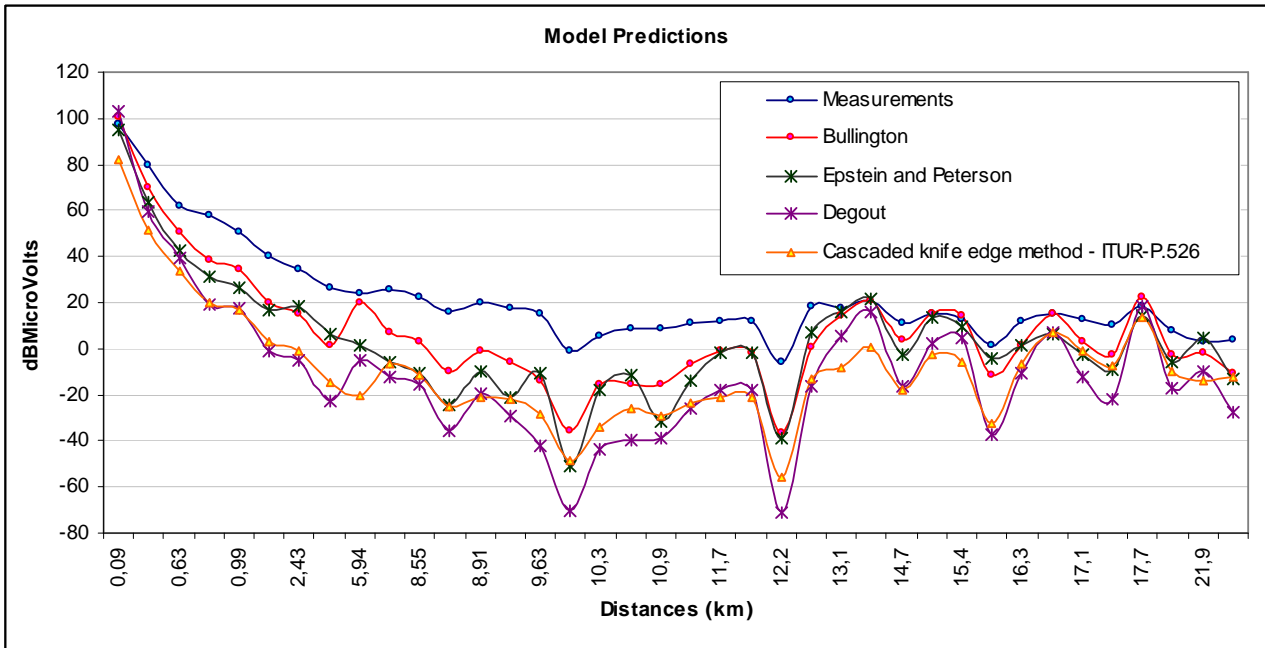
Profile page	INDEX number	Profile page	INDEX number	Profile page	INDEX number	Profile page	INDEX number
1	1003	11	1053	21	1103	31	1153
2	1008	12	1058	22	1108	32	1158
3	1013	13	1063	23	1113	33	1163
4	1018	14	1068	24	1118	34	1168
5	1023	15	1073	25	1123	35	1173
6	1028	16	1078	26	1128	36	1178
7	1033	17	1083	27	1133	37	1183
8	1038	18	1088	28	1138	38	1188
9	1043	19	1093	29	1143		
10	1048	20	1098	30	1148		

Besides the mentioned information and data, it is available two zipped files (“*TERRAIN DATA MAY 2009*” and “*TERRAIN DATA AUGUST 2010*”) with the terrain data, including distances and heights of each test link profile.

5 Comparisons among models

The preliminary results of this study permit to plot the graphic presented on figure 8, where it is possible to compare some models with the practical results (Campaign – August 2010).

Figure 8 – Comparisons among models - (Campaign – August 2010).



6 Conclusion

The available data permit to reproduce the diffraction propagation prediction using the ITU methods and compare it with practical results, verifying the points where the divergences are more significant in order to propose the future improvements or remarks to the existing Recommendation.