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Subject: Propagation Fundamental  
Recommendation ITU-R P.526-12 – Propagation by  
Diffraction

## **Federative Republic of Brazil**

### **MEASUREMENTS OVER THE SEA TO STUDY THE DIFFRACTION PHENOMENA ON TROPICAL REGION - UHF BAND**

QUESTION ITU-R 202-3/3

#### **Methods for predicting propagation over the surface of the Earth**

## **1 Introduction**

This document shows propagation measurements performed in the UHF band over the sea in the Guanabara Bay, located in Rio de Janeiro, Brazil. Specific routes were chosen to capture the transmitted wave samples, surrounding natural obstacles, in order to evaluate the diffraction mechanism and provide the results to the ITU-R database.

During the measurements were recorded the spectrum analyzer screens, according with the index point identification. In each point, photos were taken to the direction of the transmitter to identify the main obstacles in the line of sight from the receiver to the transmitter.

## **2 Parameters considered**

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

- a) Frequency of study: 563.143MHz.
- b) Modulation: 64QAM.
- c) Equivalent Earth radius: 8,500 km was taken as a basis.
- d) The 96 measurements presented were made over the sea, in the Guanabara Bay, surrounding natural obstacles like mountains.
- e) Transmitter location: 22° 57' 6.15" South / 43° 14' 14.10" West (WGS84).
- f) Transmitter output power: 6,000 Watts.
- g) Transmitter cable loss: 1.1 dB.
- h) Transmitter antenna – Horizontal pattern: omnidirectional / Maximum Gain: 9.7 dBd = 11.85 dBi / Height: 97 meters.

- i) Receiver antenna – Horizontal pattern: **omnidirectional** / Gain: 11 dBi / Height: 2.5 meters.
- j) Receiver cable loss: 0.5 dB.
- k) Maximum distance from transmitter to the receiver test point is about 9,200 meters.
- l) Local time period of measurements (November, 2008 – Spring).
- n) Registered levels unit: dB $\mu$ V.
- o) Explored geographic area – Guanabara Bay: Illustrated on Figure 4.
- p) Environment characteristics: Sea.

### 3 Resources and available data

The source of the irradiated signal is a television broadcast station, operating in the frequency of 563.143MHz, 64QAM modulation, located in the following coordinates: latitude 22° 57' 6.15" South & longitude 43° 14' 14.10" West. The other important characteristics of measurements set were described in the previous section “2 Parameters considered”, in this document.

The boat used to the measurements campaign is the one showed in figure 1. The antenna is in the figure 2, where we can also see the team of technicians mounting it on a mast in the boat, with the possibility of targeting the foot dynamically toward to the transmitter.



FIGURE 1

**Boat used to perform the measurements**



FIGURE 2

**Team of technicians mounting the antenna**

A graphic representing the measurement levels [dB $\mu$ V x Index] is displayed in the figure 3, where it is noted a variation of the signal from 20 dB $\mu$ V up to 57 dB $\mu$ V depending on the location and the kind of obstacle identified in each radio link.

This paper shows the total of 96 measurement results. The table 1 presents the first 55 points acquired along the sea, in the Guanabara Bay. The columns of each line have available information according to the following sequence: index of the measurement, frequency [MHz], latitude and longitude (degrees - minutes - seconds - WGS84) where the signal was registered, reference of a spectrum analyzer measurement screen, reference of the photo taken right to the transmitter location direction, sample level in [dBμV] unit and the environment features. In order to complete the 96 mentioned points, the table 2 shows the other 41 points of the study. The explored region is available in figure 4, with some point's location plotted.

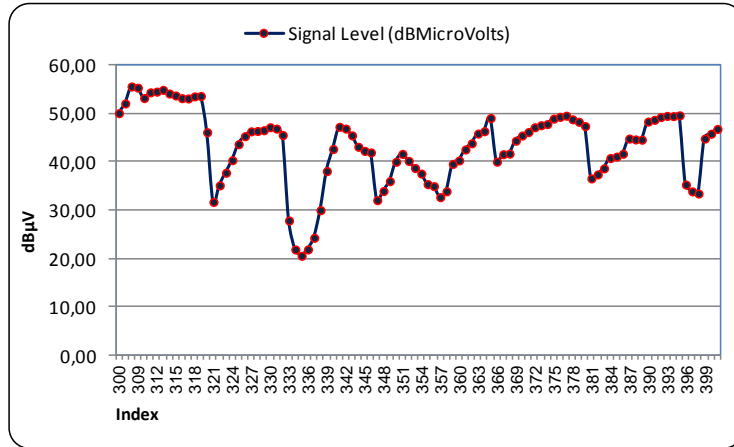


FIGURE 3  
Graphic of measurements results (dBμV) – Campaign – November 2008

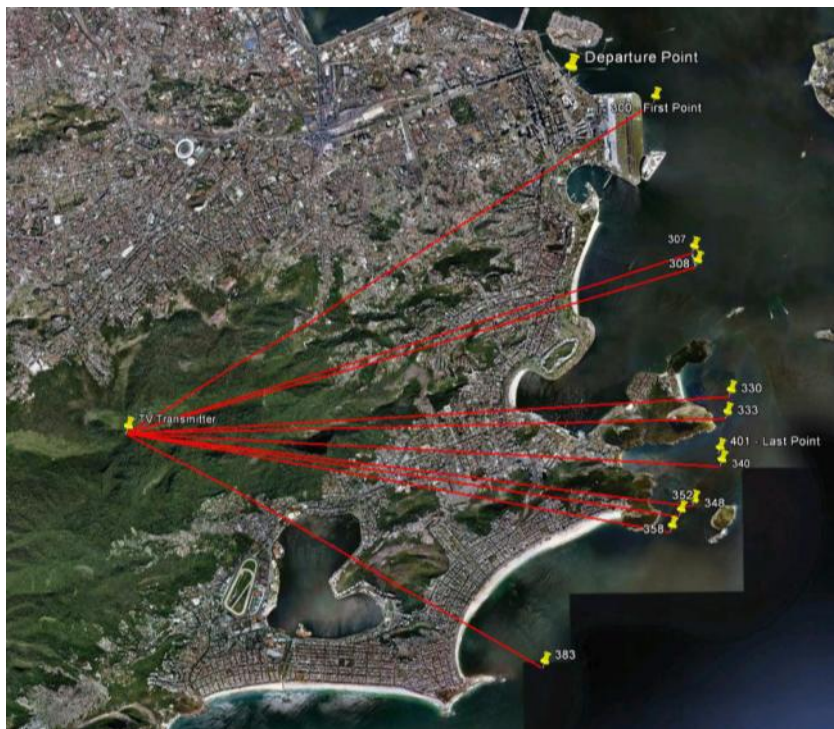


FIGURE 4  
Explored geographical area [Guanabara Bay] with 11 of the 96 measurement points

TABLE 1

**Index 361 to 360, Frequency, Coordinates, References (Spectrum Analyzer screen / Photo), TX-RX Obstruction, Field strength level (dBµV) - Campaign - November 2008**

Index	Frequency (MHz)	Latitude			Longitude			Spectrum Analyser	Transmitter Direction Photo	Signal Level (dBµV)	Environment
		Grades	Minutes	Seconds	Grades	Minutes	Seconds				
300	563,143	22	54	21	43	9	35	<a href="#">Image 100</a>	5169	38,39	Sea
307	563,143	22	55	36	43	9	14	<a href="#">Image 107</a>	5179	57,09	Sea
308	563,143	22	55	43	43	9	12	<a href="#">Image 108</a>	5184	55,64	Sea
309	563,143	22	55	47	43	9	12	<a href="#">Image 109</a>	5186	55,35	Sea
310	563,143	22	55	59	43	9	9	<a href="#">Image 110</a>	5191	53,20	Sea
311	563,143	22	56	1	43	9	9	<a href="#">Image 111</a>	5192	54,39	Sea
312	563,143	22	56	3	43	9	8	<a href="#">Image 112</a>	5193	54,53	Sea
313	563,143	22	56	5	43	9	7	<a href="#">Image 113</a>		54,90	Sea
314	563,143	22	56	8	43	9	6	<a href="#">Image 114</a>		54,14	Sea
315	563,143	22	56	10	43	9	5	<a href="#">Image 115</a>	5194	53,73	Sea
316	563,143	22	56	12	43	9	4	<a href="#">Image 116</a>	5195	53,18	Sea
317	563,143	22	56	14	43	9	3	<a href="#">Image 117</a>	5197	53,12	Sea
318	563,143	22	56	15	43	9	2	<a href="#">Image 118</a>	5198	53,55	Sea
319	563,143	22	56	18	43	9	1	<a href="#">Image 119</a>	5200	53,63	Sea
320	563,143	22	56	20	43	9	0	<a href="#">Image 120</a>	5201	46,13	Sea
321	563,143	22	56	29	43	8	57	<a href="#">Image 121</a>	5202	31,72	Sea
322	563,143	22	56	31	43	8	57	<a href="#">Image 122</a>	5203	35,14	Sea
323	563,143	22	56	34	43	8	56	<a href="#">Image 123</a>	5205	37,76	Sea
324	563,143	22	56	37	43	8	56	<a href="#">Image 124</a>	5206	40,35	Sea
325	563,143	22	56	39	43	8	55	<a href="#">Image 125</a>	5207	43,66	Sea
326	563,143	22	56	42	43	8	55	<a href="#">Image 126</a>		45,31	Sea
327	563,143	22	56	43	43	8	54	<a href="#">Image 127</a>		46,32	Sea
328	563,143	22	56	44	43	8	54	<a href="#">Image 128</a>		46,39	Sea
329	563,143	22	56	46	43	8	54	<a href="#">Image 129</a>	5208	46,55	Sea
330	563,143	22	56	48	43	8	54	<a href="#">Image 130</a>	5209	47,17	Sea
331	563,143	22	56	49	43	8	54	<a href="#">Image 131</a>	5210	46,88	Sea
332	563,143	22	56	50	43	8	54	<a href="#">Image 132</a>	5213	45,55	Sea
333	563,143	22	56	59	43	8	53	<a href="#">Image 133</a>	5214	27,87	Sea
334	563,143	22	57	3	43	8	53	<a href="#">Image 134</a>	5215	21,88	Sea
335	563,143	22	57	5	43	8	54	<a href="#">Image 135</a>	5216	20,58	Sea
336	563,143	22	57	9	43	8	55	<a href="#">Image 136</a>	5217	21,89	Sea
337	563,143	22	57	11	43	8	55	<a href="#">Image 137</a>	5218	24,30	Sea
338	563,143	22	57	16	43	8	56	<a href="#">Image 138</a>		30,01	Sea
339	563,143	22	57	21	43	8	57	<a href="#">Image 139</a>	5221	38,09	Sea
340	563,143	22	57	23	43	8	59	<a href="#">Image 140</a>	5222	42,66	Sea
341	563,143	22	57	28	43	9	1	<a href="#">Image 141</a>	5223	47,25	Sea
342	563,143	22	57	29	43	9	2	<a href="#">Image 142</a>	5224	46,88	Sea
343	563,143	22	57	31	43	9	3	<a href="#">Image 143</a>	5225	45,48	Sea
344	563,143	22	57	33	43	9	5	<a href="#">Image 144</a>	5226	43,12	Sea
345	563,143	22	57	34	43	9	6	<a href="#">Image 145</a>	5227	42,27	Sea
346	563,143	22	57	35	43	9	7	<a href="#">Image 146</a>	5228	41,96	Sea
347	563,143	22	57	41	43	9	12	<a href="#">Image 147</a>	5229	32,08	Sea
348	563,143	22	57	43	43	9	14	<a href="#">Image 148</a>	5230	33,97	Sea
349	563,143	22	57	43	43	9	15	<a href="#">Image 149</a>	5232	36,01	Sea
350	563,143	22	57	45	43	9	17	<a href="#">Image 150</a>	5233	40,03	Sea
351	563,143	22	57	47	43	9	18	<a href="#">Image 151</a>	5234	41,65	Sea
352	563,143	22	57	48	43	9	19	<a href="#">Image 152</a>	5235	40,19	Sea
353	563,143	22	57	49	43	9	21	<a href="#">Image 153</a>	5236	38,73	Sea
354	563,143	22	57	50	43	9	21	<a href="#">Image 154</a>	5239	37,57	Sea
355	563,143	22	57	51	43	9	22	<a href="#">Image 155</a>	5240	35,40	Sea
356	563,143	22	57	53	43	9	23	<a href="#">Image 156</a>	5241	34,98	Sea
357	563,143	22	57	55	43	9	25	<a href="#">Image 157</a>	5242	32,70	Sea
358	563,143	22	57	56	43	9	26	<a href="#">Image 158</a>	5243	33,91	Sea
359	563,143	22	57	59	43	9	29	<a href="#">Image 159</a>	5244	39,58	Sea
360	563,143	22	58	0	43	9	29	<a href="#">Image 160</a>		40,30	Sea

TABLE 2

**Index 361 to 401, Frequency, Coordinates, References (Spectrum Analyzer screen / Photo), TX-RX Obstruction, Field strength level (dB $\mu$ V) - Campaign - November 2008**

Index	Frequency (MHz)	Latitude			Longitude			Spectrum Analyser	Transmitter Direction Photo	Signal Level (dB $\mu$ V)	Environment
		Grades	Minutes	Seconds	Grades	Minutes	Seconds				
361	563,143	22	58	2	43	9	31	<a href="#">Image 161</a>		42,57	Sea
362	563,143	22	58	2	43	9	32	<a href="#">Image 162</a>		43,85	Sea
363	563,143	22	58	4	43	9	34	<a href="#">Image 163</a>		45,85	Sea
364	563,143	22	58	5	43	9	35	<a href="#">Image 164</a>		46,35	Sea
365	563,143	22	58	10	43	9	39	<a href="#">Image 165</a>		49,07	Sea
366	563,143	22	58	27	43	9	55	<a href="#">Image 166</a>		40,04	Sea
367	563,143	22	58	28	43	9	56	<a href="#">Image 167</a>		41,59	Sea
368	563,143	22	58	29	43	9	57	<a href="#">Image 168</a>		41,71	Sea
369	563,143	22	58	31	43	9	59	<a href="#">Image 169</a>		44,37	Sea
370	563,143	22	58	32	43	10	0	<a href="#">Image 170</a>		45,45	Sea
371	563,143	22	58	33	43	10	1	<a href="#">Image 171</a>		46,17	Sea
372	563,143	22	58	34	43	10	2	<a href="#">Image 172</a>		47,16	Sea
373	563,143	22	58	35	43	10	3	<a href="#">Image 173</a>		47,58	Sea
374	563,143	22	58	36	43	10	4	<a href="#">Image 174</a>		47,82	Sea
375	563,143	22	58	38	43	10	6	<a href="#">Image 175</a>	5248	48,94	Sea
376	563,143	22	58	39	43	10	7	<a href="#">Image 176</a>	5249	49,31	Sea
377	563,143	22	58	39	43	10	8	<a href="#">Image 177</a>	5250	49,55	Sea
378	563,143	22	58	41	43	10	10	<a href="#">Image 178</a>	5251	48,80	Sea
379	563,143	22	58	42	43	10	11	<a href="#">Image 179</a>	5252	48,29	Sea
380	563,143	22	58	43	43	10	12	<a href="#">Image 180</a>	5253	47,40	Sea
381	563,143	22	59	2	43	10	32	<a href="#">Image 181</a>	5254	36,58	Sea
382	563,143	22	59	3	43	10	33	<a href="#">Image 182</a>	5255	37,41	Sea
383	563,143	22	59	4	43	10	35	<a href="#">Image 183</a>	5256	38,66	Sea
384	563,143	22	58	35	43	10	4	<a href="#">Image 184</a>		40,79	Sea
385	563,143	22	58	33	43	10	2	<a href="#">Image 185</a>		41,09	Sea
386	563,143	22	58	32	43	10	1	<a href="#">Image 186</a>		41,68	Sea
387	563,143	22	58	27	43	9	55	<a href="#">Image 187</a>		44,82	Sea
388	563,143	22	58	25	43	9	54	<a href="#">Image 188</a>		44,64	Sea
389	563,143	22	58	23	43	9	52	<a href="#">Image 189</a>		44,59	Sea
390	563,143	22	58	16	43	9	44	<a href="#">Image 190</a>		48,34	Sea
391	563,143	22	58	15	43	9	43	<a href="#">Image 191</a>		48,70	Sea
392	563,143	22	58	13	43	9	42	<a href="#">Image 192</a>		49,27	Sea
393	563,143	22	58	1	43	9	32	<a href="#">Image 193</a>		49,51	Sea
394	563,143	22	58	0	43	9	31	<a href="#">Image 194</a>		49,47	Sea
395	563,143	22	57	59	43	9	30	<a href="#">Image 195</a>	5241	49,63	Sea
396	563,143	22	57	47	43	9	24	<a href="#">Image 196</a>		35,30	Sea
397	563,143	22	57	46	43	9	22	<a href="#">Image 197</a>	5258	33,90	Sea
398	563,143	22	57	44	43	9	21	<a href="#">Image 198</a>		33,45	Sea
399	563,143	22	57	20	43	9	3	<a href="#">Image 199</a>		44,82	Sea
400	563,143	22	57	19	43	9	2	<a href="#">Image 200</a>		45,82	Sea
401	563,143	22	57	17	43	9	0	<a href="#">Image 201</a>	5259	46,81	Sea

#### 4 Information about annexed files

All of the 96 sample levels were recorded, by the screen capture of the spectrum analyzer and in most of the points it was possible to take a picture, focused in the transmitter location. Thus, this study allows a more detailed investigation on the prediction models, by the use of information about the obstacles kind and shape seen by the receiver antenna. In the figure 5 there are three points selected from the files (Index 330, 333 and 340) in order to show these facilities. For each one there is a correspondent photo, indicated by the same index number, as presented in table 3, and in the figures 5, 6 and 7.

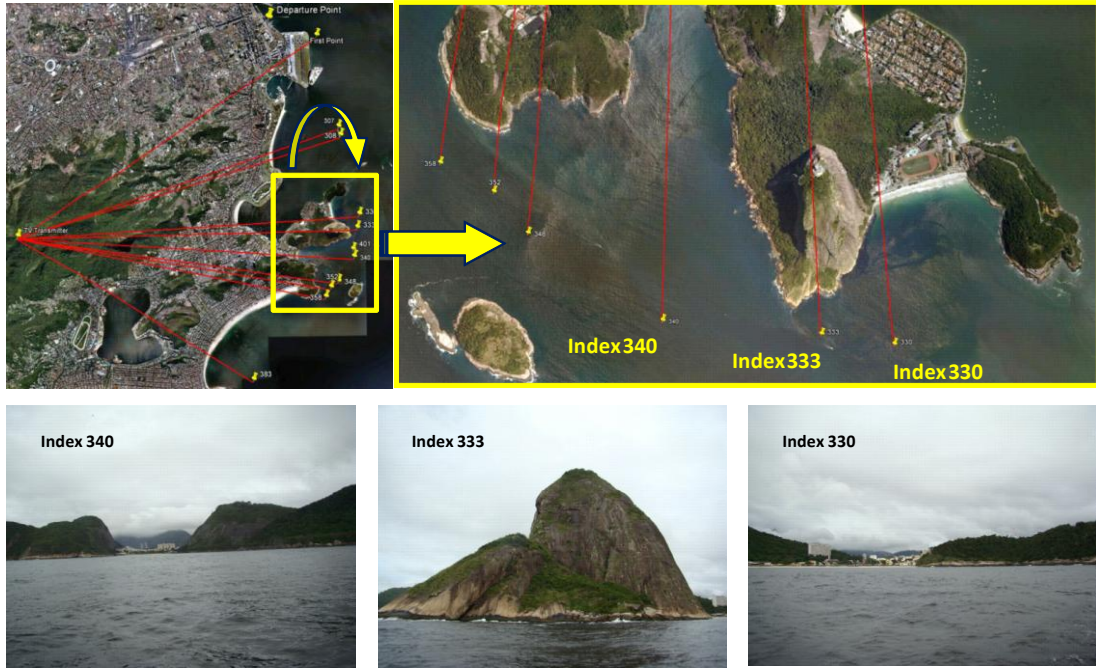


FIGURE 5

Explored geographical area [Guanabara Bay] with 11 of the 96 measurement points

TABLE 3

Index number, Spectrum analyzer screen and photo reference relational to figure 5

Index	Spectrum Analyzer Screen	Photo
330	Image 130	5209
333	Image 133	5214
340	Image 140	5222

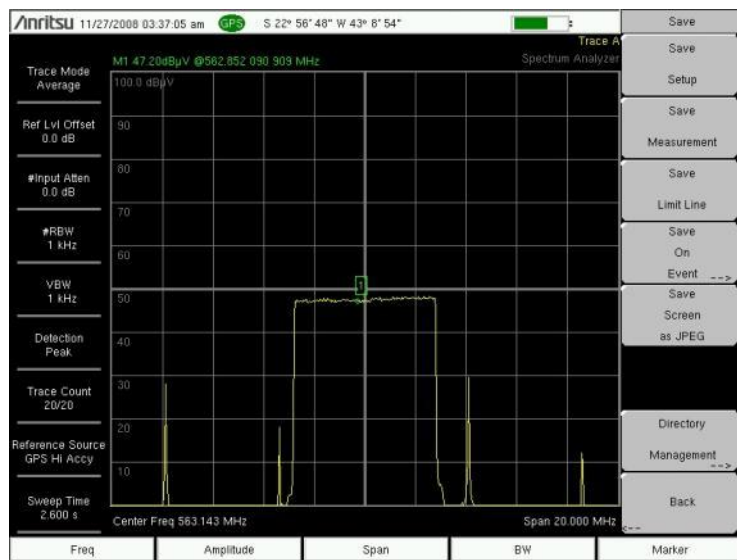


FIGURE 5

Spectrum analyzer screen of measurement index 330 – Image 130

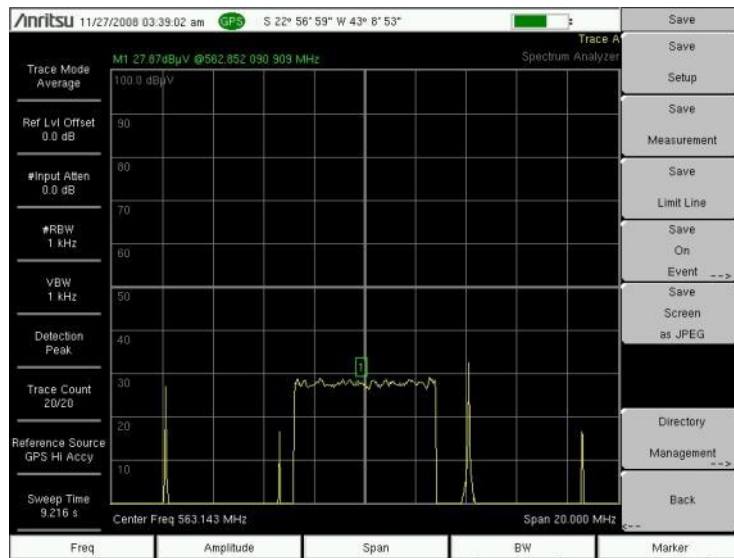


FIGURE 6

Spectrum analyzer screen of measurement index 333 – Image 133

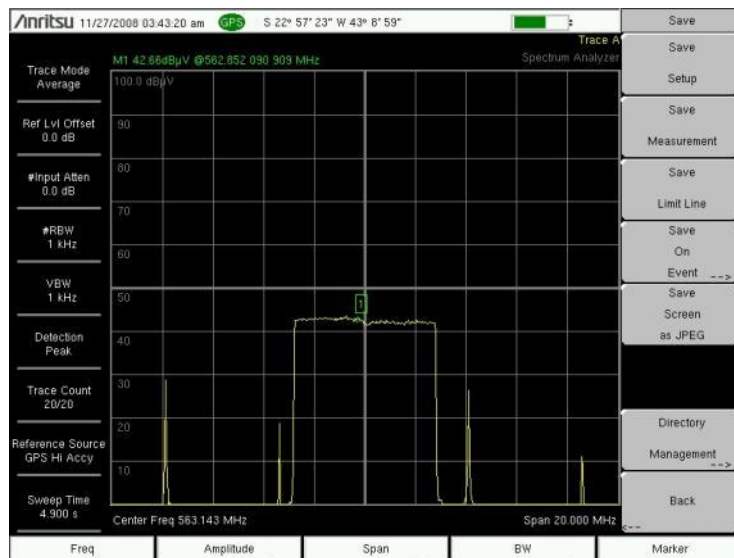


FIGURE 7

Spectrum analyzer screen of measurement index 340 – Image 140

The two files annexed are:

- Zip file “*Photos Receiver - Transmitter direction*” - This file contains the photos.
- Zip File “*Spectrum Analyzer Screens*” - This file contains the spectrum analyzer screens.

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## **5 Future work**

In order to improve this study it will be attempted to obtain all the terrain profiles of the measured links, to facilitate automated processing of the collected data and perform tests on the new model of ITU-R P. 526 Propagation by Diffraction.

## **5 Conclusion**

The intention of this study is to provide detailed data for testing, analysis and improvement of Recommendation ITU-R P. 526 Propagation by Diffraction. The available data provide useful information for assessment of the obstacles, making it possible to investigate the effects of its forms and composition in the propagation mechanism. The absence of the terrain profile is due to the unavailability of accurate data at this time, which should be available in a near future to complete this work.