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A TVWS Quantification Aproach for Mexico.

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Abstract — **In this paper a TVWS available spectrum is calculated, applying some procedures defined for regulatory authorities. The coverage was estimated using the Longley Rice method and the FCC recommendation was applied to delimit geographical zones, defining the occupied and free frequencies.**

Keywords — **TVWS, Longley-Rice.**

I. INTRODUCCTION

Around the world, there is a growing demand for radio spectrum. One alternative to get more spectrum is the Secondary access to the unused spaces in TDT (Terrestrial Digital Television), named as TVWS (Television White Spaces). This alternative represent a promising application and a way to increase the spectrum efficiency. The secondary access implementation could be based on cognitive radio strategies, principally the so-called geo-localized databases; these databases will contain all the information regarding to the licenses frequencies (occupied channels) in the geographical area where the secondary users are situated, therefore they are able to identify the unused spectrum segments, defined as TVWS. When a secondary user wants to transmit, the database assign to the potential secondary user a free TVWS, indicating several technical conditions and monitoring the link performance (duration, interference levels, etc.).

There are several uses and applications cited in the bibliography using the TVWS, by means of the implementation of low power low range wireless networks; some operational and technical characteristics for these networks are defined in the 802.22 IEEE standard.

In this paper is applied a methodology to quantify the radio spectrum available by means of the TVWS.

II. METHODOLOGY

Using the technical data for all the TDT transmitter along the country, the coverage area for each channel was estimated; this evaluation was done applied the Longley-Rice propagation model [9], which is able to estimate the attenuation levels for 20 MHz to 40 GHz frequencies transmissions. In Fig. No. 1 is showed the results obtained for the 41 channel in the Aguascalientes city. Once that the all the coverage area were obtained, a 84 cities distributed along the country was defined as a sample to identify the possible TVWS available in these cities

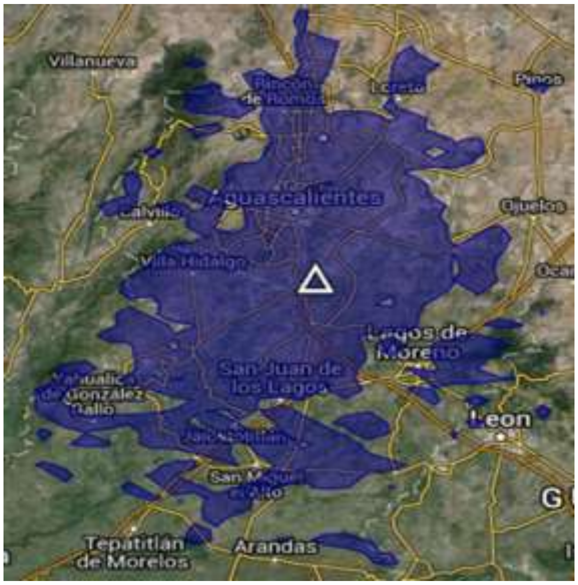

Figure No. 1. Coverage are for the Aguscalientes City..

The procedure to evaluate the potential TVWS is described next.

- The TDT cannel coverage areas were obtained using the Longley-Rice method. In the Table No. is showed the TV transmitters by state.

Estado	No. Canales	Estado	No. Canales
Ags	7	Mor	5
BC	16	NL	21
BCS	12	Nay	11
Campeche	11	Oax	29
Chihua	26	Puebla	7
Chiapas	30	Q. Roo	9
Coah	24	Qro	7
Colima	12	SLP	15
Cd de Méx	14	Sin	14
Dgo	15	Son	39
Gro	17	Tab	12
Gto	26	Tamps	24
Hgo	13	Tlaxc	5
Jal	18	Ver	21
Edo Mex	11	Yuc	9
Mich	27	Zac	16

Table No. 1. TDT channels per state

For each one of the transmitters, the attenuation profile is calculated, according to next expression, defined in the Longley Rice procedure:

$$W(t,\ell,s) = w_0 + y_s(s) + \delta_L(s)y_L(\ell) + \delta_L(s)y_T(t)$$

Where W represent the total attenuation level, w_0 is the free space attenuation and the random variables $y_s(s)$, $y_L(\ell)$ y $y_T(t)$ represent the attenuations due to the site topographic conditions, atmospherics issues and the tx/rx localization [9]. The δ variable represent the level attenuation deviation. In this way, the maximun coverage distance, $d_{maxi}(W)$, is defined as the distance between the cannel transmitter tower , $P_{chi}(lat_{chi}, long_{chi})$, and the point where the signal be received at 48 dBu power.

- To declare if a some city is located inside the coverage area for any of the cannel, the distance between the *ith* channel tower transmission, $P_{chi}(lat_{chi}, long_{chi})$, and the city geographical coordinates $P_c(lat_c, long_c)$. To get these distance, teh Haversine function was used. This function is defined as

$$haversin\left(\frac{d_{ic}}{R}\right) = haversin(lat_{chi} - lat_c) + \cos(lat_{chi})\cos(lat_c)\,haversin(\Delta\lambda)$$

where

$$haversin(\theta) = \left(\sin\left(\frac{\theta}{2}\right)\right)^2$$

d_{ic}=i transmitter and c city distance.
R= Earth radium.
Δλ= longitude diference.

IV. RESULTS.

For all the cities in the simple, was identified the principal and adjacent channels. Using this information, the TVWS was obtained for each city; a sample of this results is showed in Fig. No.2

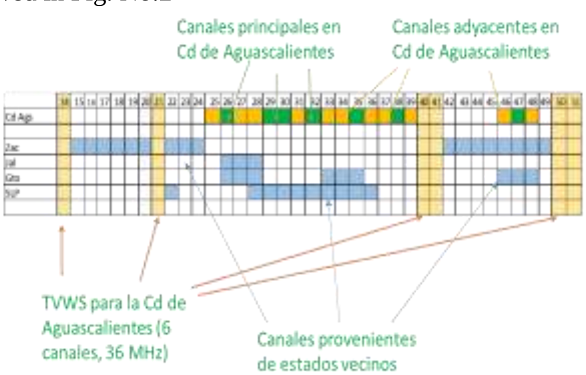

Figure No. 2. TVWS identification procedure.

Using the data obtained, a estimation for the TVWS number available for state was done. Fig. No. 3. A TVWS distribution map was elaborated using this information. Fig. No. 4

Figure No. 3. Available spectrum by state.

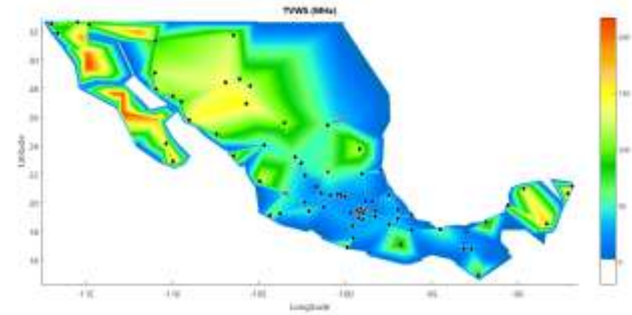

Figure No. 4. TVWS distribution.

Comparing the total radio spectrum available by the TVWS alternative, we compare it with the total spectrum dedicated in Mexico for IMT services. The data was exposed in Table No.2 Fig. No. 5.

Region	TVWS (MHz)	BW IMT (MHZ)
1	109.20	302.95
2	106.00	312.45
3	96.86	316.87
4	76.50	313.87
5	48.00	313.45
6	43.20	318.95
7	39.43	313.70
8	100.00	315.45
9	25.09	321.87
Average	71.59	314.40

Table No. 2. Spectrum for IMT and TVWS for cellular zone.

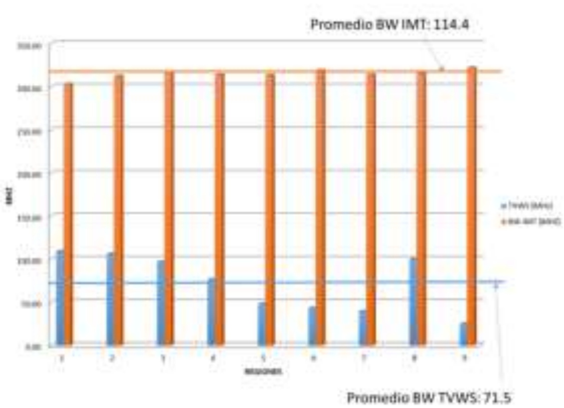

Figure No. 5. Spectrum for IMT and TVWS for cellular zone.

VI. CONCLUSIONES

A TVWS average spectrum was obtained, which value is around 71.5 MHz. Several uses and application could be developed using this result. A TVWS spectrum per city is showed in the Appendix I.

REFERENCES

[1] Federal Communications Commision (FCC), “Second report and Order and Memorandum Opinion and Order in ET Docket Nos. 02-380 (Additional Spectrum for Unlicensed Devices Below 900MHz and in the 3 GHz Band) and o4-186 (Unlicensed Operation in the TV Broadcast Bands),” FCC08-260 November 14, 2008.

[2] Office of Communications (Ofcom), “Implementing Geolocation Summary of consulation responses and next steps”. Ofcom statement, September 23, 2011.

[3] M.Nekovee, “Cognitive Radio Access to TV White Spaces: spectrum Opportunities, Commercial Applications and Remaining Technology Challenges,”. 2010 IEEE Symposium on New Frontiers in Dynamic Spectrum Access Networks, Singapore, April 2010.

[4] S. M. Mishra and A. Sahai, “How much white space has the fcc opened up?” IEEE Communication Letters, 2010.

[5] K. Patil, K. E. Skouby and R. Prasad, "Cognitive access to TVWS in India: TV spectrum occupancy and wireless broadband for rural areas," Wireless Personal Multimedia Communications (WPMC), 2013 16th International Symposium on, Atlantic City, NJ, 2013, pp. 1-5.

[6] http://www.ift.org.mx/sites/default/files/comunicacion-y-medios/comunicados-ift//comunicado125ift2.pdf

[7] http://www.ift.org.mx/industria/infraestructura

[8] POLÍTICA PARA LA TRANSICIÓN A LA TELEVISIÓN DIGITAL TERRESTRE. Capítulo I. Disposiciones Generales. http://www.dof.gob.mx/nota_detalle.php?codigo=5359731&fecha=11/09/2014.

[9] Longley-Rice model prediction inaccuracies in the UHF and VHF TV bands in mountainous terrain. Stylianos Kasampalis; Pavlos I. Lazaridis; Zaharias D. Zaharis; Aristotelis Bizopoulos; Lidija Paunovska; Spiridon Zettas; Ian A. Glover; Dimitrios Drogoudis; John Cosmas. 2015 IEEE International Symposium on Broadband Multimedia Systems and Broadcasting.

[10] http://www.awe.communications.com/Propagation/Rural/ITM/index.htm

[11] B. Scott and M. Calabrese, “Measuring the TV ’White Space’ Available for Unlicensed Wireless Broadband,” New America Foundation, Tech.Rep., Jan. 2006.

[12] R. Kennedy, K. George, O. Vitalice and W. Okello-Odongo, "TV white spaces in Africa: Trials and role in improving broadband access in Africa," AFRICON, 2015, Addis Ababa, 2015, pp. 1-5.

[13] S. Kawade and M. Nekovee, "Is wireless broadband provision to rural communities in TV whitespaces viable? A UK case study and analysis," Dynamic Spectrum Access Networks (DYSPAN), 2012 IEEE International Symposium on, Bellevue, WA, 2012, pp. 461-466.

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Appendix I.
TVWS per city

Ciudad	Latitud	Longitud	TVWS(MHz)	Ch Disp	Ciudad	Latitud	Longitud	TVWS(MHz)	Ch Disp
La Paz	24.142427	-110.315559	144	24	Ags	21.887806	-102.283918	36	6
Los Cabos	22.891044	-109.916262	192	32	SLP	22.151982	-100.980778	60	10
Tijuana	32.503998	-116.954327	102	17	Soledad	22.186319	-100.938206	60	10
Mexicali	32.624892	-115.453209	102	17	Cd. Valles	21.996744	-99.006658	42	7
Ensenada	31.866095	-116.594977	66	11	Leon	21.119192	-101.665153	18	3
Hermosillo	29.074504	-110.964439	120	20	Irapuato	20.674687	-101.345494	30	5
Cd Obregón	27.481743	-109.93453	108	18	Celaya	20.52646	-100.812895	30	5
Nogales	31.299965	-110.940529	90	15	Salamanca	20.572523	-100.191987	24	4
Guaymas	27.916997	-110.911264	120	20	Acapulco	16.857506	-99.842015	84	14
Navojoa	27.073045	-109.44313	96	16	Chilpancingo	17.540427	-99.502994	30	5
Sn Luis Río C	32.452548	-114.773999	102	17	Iguala	18.346277	-99.532349	30	5
Mazatlán	23.249155	-106.415122	126	21	Veracruz	19.182901	-96.151873	42	7
Los Mochis	25.789211	-108.991384	144	24	Xalapa	19.538329	-96.896409	30	5
Culiacán	24.806008	-107.4022	102	17	Coatzacoalcos	18.133568	-94.459943	60	10
Durango	24.025991	-104.658539	42	7	Poza Rica	20.529735	-97.448029	42	7
Gómez Palacio	25.588717	-103.488705	108	18	Córdoba	18.890255	-96.939147	36	6
Chihuahua	28.635079	-106.055349	114	19	Puebla	19.041531	-98.20687	30	5
Cd Juárez	31.691003	-106.42044	120	20	Tehuacán	18.466509	-97.400388	36	6
Delicias	28.187211	-105.458104	120	20	Oaxaca	17.072519	-96.729809	96	16
Cuahutémoc	28.406263	-106.865762	138	23	Tuxtepec	18.087005	-96.130663	30	5
Hidalgo del Parral	26.931326	-105.671836	150	25	Tlaxcala	19.412808	-98.176532	18	3
Mty	25.684381	-100.320606	36	6	Villahermosa	17.988359	-92.942993	18	3
Apodaca	25.762836	-100.195809	36	6	Tuxtla	16.74945	-93.112919	24	4
General Escobedo	25.795719	-100.316328	36	6	Tapachula	14.907128	-92.2638	84	14
Santa Catarina	25.677115	-100.451066	36	6	San Cristóbal	16.734256	-92.641799	30	5
Tampico	22.262728	-97.890334	54	9	Campeche	19.827826	-90.527136	114	19
Cd Victoria	23.733533	-99.143081	120	20	Cd del Carmen	18.654271	-91.797636	108	18
Saltillo	25.426203	-100.985976	54	9	Cancún	21.155767	-86.850985	156	26
Tepic	21.497951	-104.886689	126	21	Chetumal	18.511697	-88.299886	174	29
Colima	19.242722	-103.718737	42	7	Playa del Carmen	20.646402	-87.069808	186	31
Manzanillo	19.10511	-104.324268	72	12	Mérida	20.979745	-89.618155	138	23
Guadalajara	20.661356	-103.349974	48	8	DF	19.315961	-99.135447	24	4
Zapopán	20.672815	-103.429902	48	8	Ecatepec	19.573658	-99.04069	30	5
Tlaquepaque	20.594538	-103.322587	48	8	Toluca	19.283558	-99.655925	24	4
Morelia	19.701554	-101.195996	30	5	Chalco	19.26541	-98.895121	30	5
Uruapán	19.407222	-102.043986	48	8	Texcoco	19.503771	-98.884135	30	5
Zamora	19.989889	-102.282477	30	5	Naucalpan	19.462342	-99.246684	24	4
Zacatecas	22.76575	-102.582868	42	7	Cuernavaca	18.925406	-99.221965	24	4
Guadalupe	22.7508	-102.513483	48	8	Cuautla	18.81495	-98.955546	30	5
Fresnillo	23.180326	-102.867998	54	9	Jiutepec	18.892927	-99.1739	30	5
Qro	20.606835	-100.403179	30	5	Pachuca	20.098802	-98.764846	18	3
Sn Juan del Río	20.393818	-99.980253	24	4	Tulancingo	20.090384	-98.369313	18	3