Where are the TV White Space pilots? Are they still a solution for the mobile broadband market?¹

Miquel Oliver  
Universitat Pompeu Fabra  
miquel.oliver@upf.edu

Francisco Salas  
Universitat Pompeu Fabra  
francisco.salasch@gmail.com

BIOGRAPHIES
Miquel Oliver is Associate Professor and Director of the ICT Department at the UPF. He is leading the multidisciplinary Networking and Strategies Research Group (NeTS) since its foundation. His research is on wireless communications, with a multidisciplinary view including regulation, telecom policies and economic impact.

Francisco Salas is Master student at the Master in Wireless Communications, a joint program between the Universitat Pompeu Fabra and the Universitat Politècnica de Catalunya.

ABSTRACT
TV White Spaces is a cost-effective solution to provide broadband Internet in rural and remote areas. Several TVWS pilots and testbeds are now being deployed to explore the limitations of such technology. Some Latin American countries already started benchmarking and analysing TVWS and the spectrum occupancy to support future digital services. The results evidence that even when the region has a significant amount of spectrum with all the needed characteristics, the majority of the countries do not use it, mostly as a consequence of the lack of frequency regulations and coordinations within the Latin American region.

Keywords
Spectrum, TV White Spaces, Digital Dividend, Latam.

INTRODUCTION
In the last years the consumption of mobile data services has greatly increased, as more users consume everyday through their smartphones, tablets, laptops, and other devices to browse the web. Plus the significant increase of video represents a challenge, as increased usage strains the capacity of the airwaves. Many experts agree that, despite the continuous investment in networks and advances in wireless efficiency, the increment demand for mobile broadband service is likely to surpass the available spectrum capacity in the short term.

This has led to the mobile operators to compete in order to gain access to a share of the available spectrum commonly referred as “TV White Spaces” (TWS), which can be defined as the VHF (Very High Frequency)/UHF (Ultra High Frequency) frequencies left in idle by the Television broadcasting. [1] These bands have excellent characteristics as propagation and low level of noise, which allows large macro-cell sizes and low density of subscribers. These idle frequencies also offer an exceptional opportunity to connect sparse communities found on the extensive rural areas, especially because there is a lack of plans to extend fiber to these communities and they provide a really cost-effective solution compared to fiber. [2]

The new opportunities for efficient use of the spectrum in community networks, particularly taking advantage of the cognitive radio technology, are significantly enhanced with the availability of channels from white spaces and gains from the digital dividend. [3] The carriers are going to be able to reach a large market; thanks to the economies of

¹ This work has been partially supported by the Spanish Government under projects TEC2016-79510-P (Proyectos Excelencia 2016).
scale could even prevent the high prices in the upcoming equipments. Moreover, not only telecommunications companies can benefit from a TV White Space auction. Cable companies or small Internet providers can purchase unlicensed broadband spectrum and use it to enlarge their market share promoting both, Internet service in remote and rural areas to reduce the digital breach, and an increase of the competition lowering prices for the final users.

There is a strong reason that focuses the spectrum debate on the TV spectrum. The relatively long wavelengths of the TV bands are able to cover larger areas and penetrate buildings, vegetation and terrains with good signal quality. These characteristics make this technology ideal for long-range backhaul scenarios where other technologies at higher frequencies such as 3G and 4G have a higher cost per user. More precisely, the VHF/UHF TV spectrum enables Non-Line-of-Sight (NLOS) wireless communication that can reach up to 30 km with current technology. [5] Several reports and analysis have studied the use of TV white spaces for other applications [6-7], which will be discussed in further detail in the following chapters.

Starting in 2011 [8], several pilots and experiences around the globe were launched. Most of them were endorsed by glocal Internet organizations such as Microsoft or Google from slightly different angles and perspectives. Uruguay, Colombia, Ecuador, Argentina as well as Ghana, Malawi [9]. Kenya and many other countries participated in proofs of concept, analysis, sensing trials, pilots or initial developments to benchmark TVWS as a cost-effective mobile broadband solution for several scenarios (rural and urban).

In this paper we browse all the information available from TVWS experiences in Latin American countries and Jamaica, to provide an updated picture with all the information publicly available to analyze the barriers and benefits derived from each experience. We have reported some TVWS facts from seven countries (Argentina, Brazil, Colombia, Ecuador, Jamaica, Uruguay and Venezuela) that we summarize below. Before, we briefly describe the TVWS technology to understand the basics assumptions even for readers with non-technological background. Finally we conclude the paper by answering the research questions stated.

In an upcoming section, the main issue will be to query for those TVWS pilots and infer which is the current status of them, with special focus in the LATAM region. The first TVWS pilots will provide suitable experience to define the road map and future applications in the development and uptake of the mobile broadband market. [10]

**TV WHITE SPACES: THE BASICS**

**Technology**

TV White Spaces (TVWS) access can be easily deployed and takes advantage of otherwise unused spectrum. Because enabling spectrum access to white space devices does not require relocating incumbents and because the rules protect those incumbents, a license–exempt framework for access to TV white spaces can be adopted and put into use without disruption to incumbent operations. [11]

Two different techniques have been developed to check spectrum availability. These techniques use the information of the network previously delivered by the operators. The first model is proposed by the Federal Communication Commission (FCC) [12], which regulates interstate and international communications in the United States, while the other is proposed by the European Conference of Postal and Telecommunications Administrations (CEPT). [13]

Both techniques show similar characteristics, summarized in a geo-referenced database with information of the location of the frequencies occupied; recommendations on some spectrum detection techniques in secondary use devices to confirm channel availability before use; and a classification of the secondary devices according to their mobility, sensibility and use. However, FCC either CEPT do not take into account the current coverage of the TV channels, so they do not allow the identification of TVWS available in areas where there are coverage problems due to geographic and propagation conditions. By adding a computer-simulated coverage maps allows the identification of potentially allocated but unused channels available, increasing the number of detected white spaces compared to the detection techniques used in traditional models. [14]

**Digital Divend and analog TV switch-off to allow more free spectrum**

The process of digitalization (and compression) of the TV signal allows a multiplication of the capacity of every single analog channel. The release of electromagnetic spectrum in the traditional TV bands of VHF and UHF for other digital services is known as digital dividend. A better frequency shaping of the digitalized TV signals allows the use of adjacent (or neighboring) channels releasing even more capacity for other services.
In most countries the digital dividend usually locates at frequency bands VHF (174-230 MHz) and UHF (470-862 MHz). The coexistence of other wireless services such as satellite, emergency or cable services in these bands makes the digital dividend very country-dependent in shape, size and location. Most of the countries, LATAM countries included, are planning the allocation of their digital dividends in the next years, allowing more less-interfered white spaces.

Most of the Latin American countries planned the switch-off of the analog TV as the last milestone of the digital dividend process between 2019 and 2025, depending on the area and the deployment of infrastructures to support the distribution of the digital TV along the country [15].

In summary, the digital dividend allows a more compacted spectrum in UHF and VHF TV bands increasing the feasibility of TVWS technologies as a solution to provide broadband in rural and remote areas to avoid digital inclusion. Some Latin American countries targeted in this paper plan to finish the digital dividend in 2019 (Argentina and Colombia [16]), Brazil first decided in 2016 but finally moved to late 2018 [17], Ecuador approved to switch-off the TV services in June 2017 [18]. Venezuela switch-off will be in 2020.

As presented before, the amount of white spaces greatly differ among regions. An analysis done in [19] indicates the availability of TV white space in some European countries, and when compared with the US, they found that their results show that at an average location in a representative European region, about 56% of the spectrum is unused by TV networks, compared to the 79% in the USA. They concluded that their results confirm quantitatively the often-stated expectation that there are fewer white spaces available in Europe compared to the United States of America. In general, developed regions have less white spaces than developing regions largely due to the differences in the number of TV broadcasting stations. Even in Urban areas, the average amount of TVWS spectrum in developing countries is about 200 MHz [20].

It is worth noting that in Latin America the quantity of White Spaces corresponds to a region in which the TV service is still analog, and so we can expect an increase of spectrum availability after the transition to digital TV broadcasting. [21]

**Opportunities and TVWS services**

Thanks to the penetration benefits plus the potential large spectrum available, a broad set of applications for the TVWS are possible [10]. Here we list some of those applications to be offered on top of a TVWS network:

Machine-to-machine communications (M2M): Traditionally, M2M faced problem of range from the current ISM unlicensed band solutions or cost from public network solution. TVWS is positioned uniquely between these two where it is license–exempt as well as have good range. One of the earliest M2M applications is smart grid.

Super Wi-Fi: Instead of using the 2.4 GHz radio frequency of Wi-Fi, the "Super Wi-Fi" proposal takes advantages of the lower-frequency of the TVWS. Various standards had been proposed for this concept. The IEEE developed a standard to make use of the white spaces, the 802.11af (Super Wi-Fi) white space spectrum in the VHF and UHF bands between 54 and 790 MHz. The standard was approved in 2014. [22]

Video Surveillance: Most of the video surveillance communications are wired, incurring in a greater cost, due to the lack of bandwidth of the actual wireless connections. Some solutions employ 3G data connection, even though the difference of bandwidth between the down-link and uplink hadn't let this approach to grow. TVWS provides the necessary data rates to support high-quality video surveillance with a sufficient bandwidth and giving the video operators freedom to deploy surveillance cameras at their preferred locations.

Disaster planning: In 2015, Gigabit Libraries Network and State Library Agencies in the United States started to explore the possibility of using the portable TVWS broadband equipment in community disaster planning. A TVWS network can help fill the communications gap through deploying temporary Internet hotspots around the community in much greater distances compared with that the traditional Wi-Fi can reach. [23] During Typhoon Haiyan disaster in the Philippines, the Department of Science & Technology’s (DOST) ICT Office sent in a TV White Spaces (TVWS)-based network to provide an immediate on-the-ground communications network for disaster relief respondents and victims of the disaster. The resulting network provided immediate two-way voice and data wireless communications for anyone with a functioning device (handsets, laptops, tablets, etc.) that came within range of the network. [24]

**STATE OF LATAM AND CARIBBEAN TVWS**

CPRLATAM Conference, Cartagena, Colombia, June 22-23rd, 2017 in coordination with CLT2017, June 20-23rd, 2017
In this section we introduce a panel of seven countries reporting the status of the TVWS plans or actions deployed in each. We have included in this panel any Latin American or Caribbean country with some declared activity to deploy or analyze the feasibility of TVWS. All details related to each country are relevant to cope the intentions of the governments or national regulators towards TVWS.

**Argentina, controversy in the agreement with Microsoft for TVWS**

The Argentinean regulator authority ENACOM (“Ente Nacional de Comunicaciones”), similarly to Uruguay, has recently signed an agreement with Microsoft to sense TVWS technologies to deploy a broadband infrastructure to provide Internet in remote areas. The agreement, signed in August 2016, targets unspecified rural zones where the main goal is to reduce the digital divide in Argentina. The tests and pilots will run along 2017 with a multidisciplinary board of experts to assess the evolution and achievements of the project.

The agreement between the public authority and Microsoft created some political controversy due to the lack of details included in the agreement. This has caused a dispute in senate, causing the members to demand ENACOM the release of the details of the contract signed with Microsoft [25].

In parallel, Argentina is currently in process to start the transition to the digital television and closing all the emissions of analog TV in the following years. A first trial will be done in the “Tierra del Fuego” province, located on the remote south of the country. Two main stations in Ushuaia and Rio Grande will cover all the population in the area broadcasting a dozen of TV channels including local ones. The telecommunications company Arsat is deploying new infrastructures for TDT migration in central Argentina including Cordoba and Buenos Aires as crowded areas to free part of the UHF spectrum [26].

**Brazil, pioneering the digital TV standards**

Brazil is the largest country in the area so far, with a noticeable fraction of its population in remote areas with no Internet service. There is a global lack of 3G and 4G infrastructures in many areas and the coverage of mobile broadband is in the range of 75-95% according to AHCIET [27].

However, in the process of digitalization of TV Brazil has lead a modification of the Japanese version for DTV, the ISDB-Tb that has been also spread to neighboring countries such as Argentina, Chile, Peru, Venezuela, Ecuador, Paraguay, Costa Rica as well as other African countries. The effort of defining the Brazilian system has not come along with the regulatory changes needed to close the analog emissions, and the full transition towards DTV in the country is not expected to be finished before 2018.

Local governments are not pushing for a more favorable regulation to the use of cognitive radios and get advantages of the unused (white) TV channels in rural areas because they are more concentrated in responding the pressure from large telecommunications corporations. The use of the UHF spectrum in Brazil is in hands of the current holders of the TV broadcasters where they plan to use for future digital services including the white spaces. At the same time, the mobile operators claim an urgent application of the digital dividend with the threat of the spectrum crunch.

From a public perspective, the digital inclusion has set as a national priority although the governmental efforts on that area are still shy. A sundry of non-governmental organizations [28] have proliferated to provide broadband and Internet coverage in remote zones to promote the digital inclusion with some impact.

**Colombia, testing TVWS to provide service to remote schools**

Only 9.4% of the rural homes have Internet access (2012) in Colombia and the government is looking for affordable and more cost-effective alternatives to traditional mediums such as fiber, mobile or satellite communications. This is how TVWS starts in Colombia, in May 2016, with a strong push from the central government and following an agreement with Microsoft. The targeted areas to deploy TVWS technologies were mainly rural to provide broadband access to remote communities. Schools in those areas will be the connecting points of the network. But not only education was set as a priority: health, social prosperity, cloud services and entrepreneurship were also included in the program.

A key driver to choose TVWS is the availability of spectrum and the non-licensing which lowers the barriers in such deployments. Spectrum availability in rural Colombia is assured; only ten of the 48 available channels are used for TV services.

Three pilots deployed by ANE (Agencia Nacional del Espectro) in La Guajira (Dibulla), Norte de Santander (Pamplonita) and Caldas (Aguadas). A joint effort with involvement from both public and private parties such as Ministry of Education, National Authority of TV, Mintic and corporations Microsoft and Azteca. The first pilot deployed in Aguadas, department of Caldas, a remote area in inner Colombia.
As a main result, a public consultation regarding an incoming act has been set to achieve a higher adoption.

**Ecuador, sensing Quito and surroundings for TVWS availability**

The public entity that regulates the spectrum in Ecuador is the Agency for Control and Regulation of Telecommunications (ARCOTEL). As usually, Arcotel splits the spectrum bands into groups of channels that are assigned to specific geographical areas, the VHF band is divided into A1, A2, B1 and B2, while UHF G1 and G2 groups. A specific analysis of the spectrum bands available in Azuay province, more specifically in the city of Cuenca has been done in [29]. Although the TV analogic switchover has not yet done in Ecuador (planned for 2018), the analysis shows the availability of up to 20 UHF+VHF 6MHz channels as white spaces over a total amount of 50 existing channels. So that, these white space channels represents a free bandwidth of 120 MHz available for applications such as data and video services, security services, internet-of-things and smart city applications, data meters, etc.

The province of Pichincha has been sensed to explore the availability of white spaces [30]. Pichincha has six different cantons including dense urban areas such as Quito as well as more rural and remote ones. The measurements were taken in 2014 and the availability of white spaces ranges from 85% in Mejía and San Miguel de los Bancos cantons, to a 29% in central Quito (see Table 5 in [31]) with more than 70% of availability in most areas.

**Jamaica, TVWS as part of the 2030 development plan**

In 2015, Jamaica announced the development of broadband access in Jamaica utilizing TV Whitespace technology. The project was proposed by the United States Agency for International Development (USAID) and launched by NetHope. Microsoft is also providing technical support for network deployment including software and services a TVWS database, and technical and regulatory support. This project builds upon the Vision 2030 Jamaica National Development Plan (www.vision2030.gov.jm/National-Development-Plan), which focuses on expanding affordable broadband into rural communities.

The TVWS pilot is working to leverage other education and community-focused technology grants and projects for the newly connected locations, to 31 schools, libraries, and other community locations in rural areas around Jamaica.

**Uruguay, pioneering the use of TVWS in Latam**

Uruguay was one of the first Latin American countries that evaluated TVWS technologies as a broadband solution linked to a general public educational plan. The evaluation was done under the Plan Ceibal (http://www.ceibal.edu.uy/), a government effort to push for inclusion and equality in opportunities with the main goal to provide technology solutions for Uruguayan educational policies. Plan Ceibal that started in 2007, extending the global objectives defined in the One-Lap-Top-per-Child (OLTC) ONG, a Nicholas Negroponte initiative, in Uruguay [32]. So that, every child gets a computer lap-top with free Internet connection from each school and educational resources as soon as he or she lands on the education system.

The TVWS piloting in Uruguay was agreed with Microsoft in 2014, and technically included ten rural schools with a full penetration of computers among the primary school children. The tests used 6 different harmonic-UHF channels in the lower part of the spectrum to get more advantage in terms of distances covered for each radio link, with the approval of URSEC (www.ursec.gub.uy) the Uruguayan National Regulator. The selected areas were Juan Lacaze, in the department of Colonia, and Florida capital, building radio links among several schools in the area using a start topology with ten remote nodes linked using three main base stations. The channels used were 5 MHz from 20 to 24 UHF, between 513.25MHz and 532.25MHz, with directive antennas from 7 to 11dB of gain [33].

Testing compatibility with the legacy TV service was also one of the objectives of the pilots first designed in 2013. However, the technology was not considered adequate. The advantage it offers are debatable and requires a great breakthrough in regulatory matters, which doesn’t seems to be happening in the near future. Nevertheless, the country recognizes that given the weight of the companies interested in this type of technology, the picture may be different in some years [33].

**Venezuela**
A first analysis of the TV spectrum in Venezuela has been done in the city of Merida [34]. An exhaustive measurement in the 700 and 800 MHz bands, including four runs with more than 10,000 measurements each in the city center of Merida, concluded that the TV space is highly sub used.

A similar measurement campaign carried out in urban and suburban areas of Barquisimeto, a big city in Venezuela, in 2013. The amount of white spaces in urban and suburban areas goes between 66%-75% and in suburban and rural areas is of 86%-96%. It is worth noting that one can expect an increase of spectrum availability after the transition to digital TV broadcasting [21].

CONCLUSIONS
The reported cases from seven different countries clearly show that the TV White Spaces in Latin America and Caribbean countries are still in the early stages. There is some activity around TVWS technology, mainly based on measurements and estimations of white spaces in urban and rural areas. A first conclusion is that most measurement studies report a great availability of spectrum to run TVWS applications and services although the digital dividend is no fully deployed in that region.

Where are the TV White Space pilots?
The most advanced countries in terms of piloting are Uruguay and Colombia, both under signed agreements with Microsoft to develop trials in remote areas. Digital inclusion, targeting schools in remote areas is one of the common denominators of the TVWS pilots in both countries. Argentina has also signed an agreement with Microsoft but no pilot has been identified yet. The need for specific frequencies to run the pilots require the direct involvement of the governments and the frequency regulation authorities which makes difficult to massively extend the trials to more zones and countries.

Are they still a solution for the mobile broadband market?
All seven countries show spectrum availability and a great potential for the use of TVWS in rural areas. However, the lack of common agreements in the region, similarly to the selection of the Brazilian system as the common standard for digital TV in most LATAM countries, shows that there is still a long path to run before looking at TVWS as a current solution for broadband services in those countries.

REFERENCES


19. Van de Beek, J., Riihi arvi, J., Achtzehn, A., Member, S., Onen, P., & Member, S. (2011) TV white space in Europe. https://doi.org/10.1109/TMC.2011.203


23. Microsoft. TVWS in Disaster Response: A Breakthrough Technology for Rapid Communications after Typhoon.


34. Hernández, M., Pérez, M., Pérez, J., Ramírez, F. Monitoreo de espacios en blanco de televisión en Mérida. http://www.academia.edu/10933571/Monitoreo_de_espacios_en_blanco_de_televisi%C3%B3n_en_M%C3%A9rida