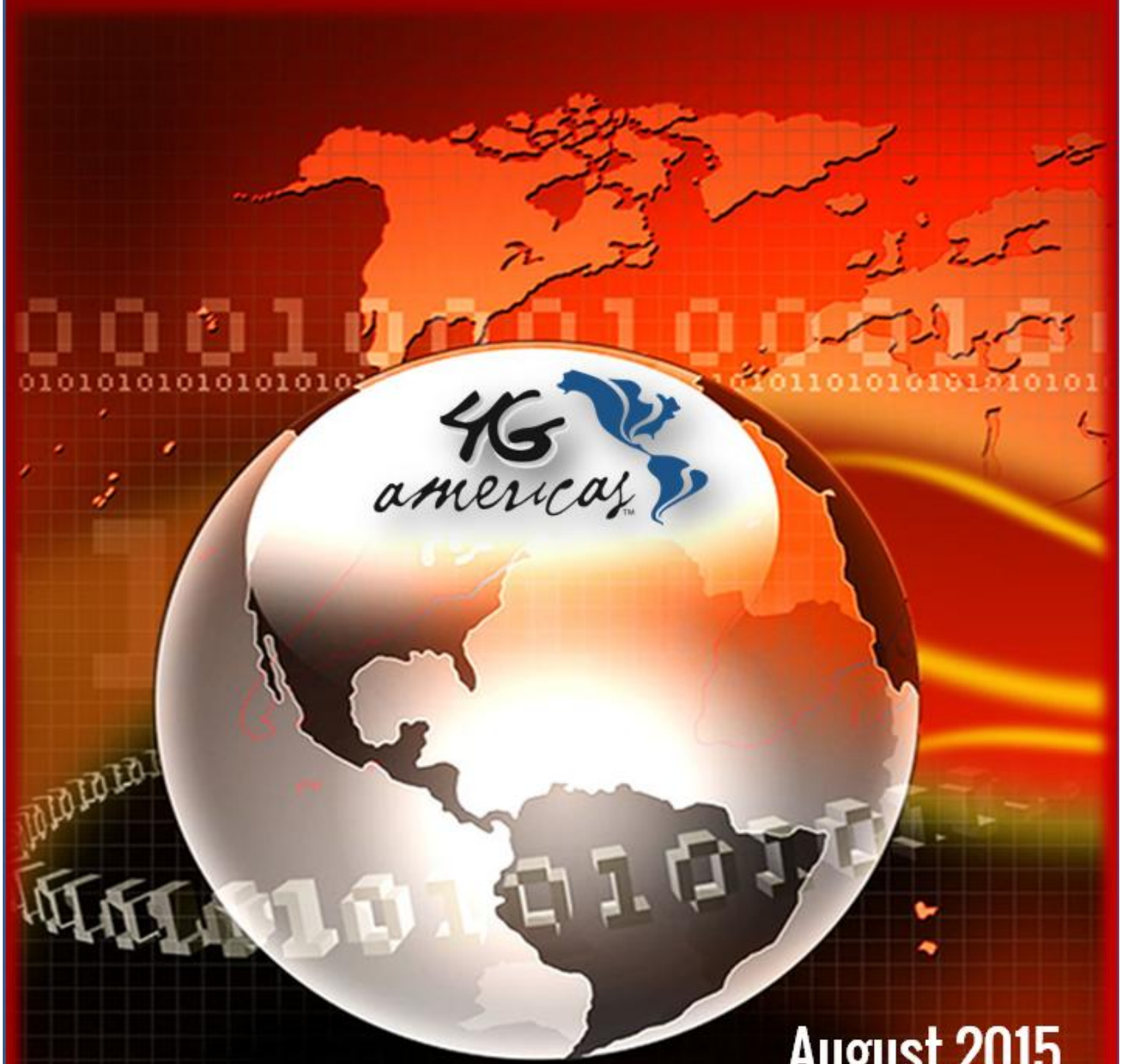
700 MHz Spectrum Processes in Latin America



August 2015

TABLE OF CONTENTS

1 INTRODUCTION: THE IMPORTANCE OF THE 700 MHZ BAND

Radio spectrum holds great importance in the telecommunications industry, particularly in the mobile sector. It is a known fact that today, mobile communications have been responsible for providing connectivity to some of the most remote areas of the world, helping to bridge the gap between people hundreds, sometimes thousands, of miles away. In recent years, improved connectivity has helped to further enable Internet access for millions of people.

Spectrum allocation for the mobile industry is an essential requirement for the Knowledge Society and countries' economic development.

According to a report from the Inter-American Development Bank (IDB), an increase of ten mobile broadband subscribers per 100 inhabitants in Latin American and Caribbean countries results in the following: increases GDP by 3.19 percent, raises productivity by 2.61 percent and creates approximately 67,016 jobs.

In recent years, many Latin American markets have held spectrum auctions although they are still far from meeting the International Telecommunications Union (ITU) recommendations. In the report on Radio Communications for Mobile, Radiodetermination, Amateur and Related Satellite Services 2078 (ITU-R M. 2078), it suggests allocating 1300 MHz for mobile communications by 2015, keeping this suggestion unchanged for 2020.

One of the most appropriate bands to accelerate the adoption of mobile broadband services comes from the so-called digital dividend–the 700MHz band. The digital dividend band is defined as the higher segment of the Ultra High Frequency (UHF) band comprised between 698 MHz and 806 MHz in the Americas.

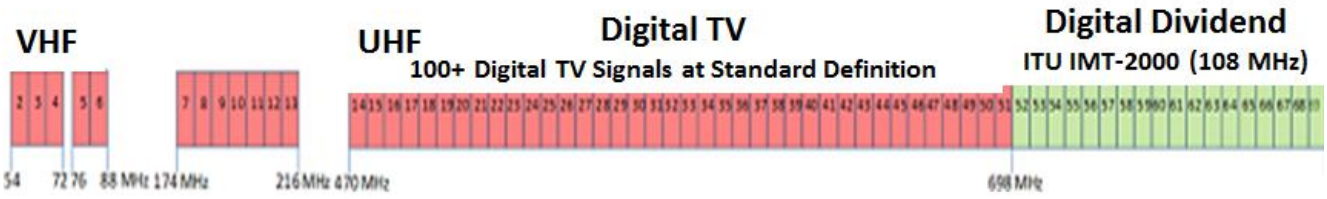


Figure 1. Digital Dividend and UHF Band

In Latin America, this portion of the spectrum is used mostly for Over the Air (OTA) television broadcasting. As broadcasting is enhanced from analog to digital (Digital Terrestrial Television), signals are migrated and spectrum is freed for use with mobile broadband services.

Table 1. Dates of Analog Blackout in Latin America, selected countries.[1]

Market	Analog Blackout	Remarks
Argentina	2019	
Bolivia	2016	
Brazil	2018	Started in 2015- Major cities 2016-Completed by 2018
Chile	2019	Major cities 2017
Colombia	2019	
Costa Rica	2017	Review in mid-2016 to confirm or change date
Ecuador	2018	Starts in 2016 for major cities
El Salvador	2018	
Guatemala	2018	Non-official estimate from SIT to the media
Honduras	2018	Non-official estimate
Nicaragua	n/a	
Mexico	2015	Started in 2014 for some cities
Panama	2020	
Paraguay	2024	
Peru	2024	Starts in 2020 for Lima and Callao. The date matches the third of four blackout stages. There is no specific date for the fourth stage.
Uruguay	2015	Date under review.
Venezuela	2020	

Several countries in Latin America and the Caribbean have decided to allocate the 700 MHz band for mobile services provided by technologies that meet minimum requirements of download and upload speeds such as those commonly known as IMT Advanced, (i.e., for the mobile broadband service commonly known as 4G, especially with LTE technology).

The above resulted from the ITU's World Radiocommunication Conference held in Geneva, Switzerland in 2012 (WRC 12), which confirmed the allocation of spectrum from 698 MHz to 806 MHz for mobile services in the Americas (Region 2). In this regard, the band will be useful for international roaming.

[1] Regulators, 4G Americas

1.1 WHY 700 MHZ?

One of the main features of the 700 MHz band is its significant capacity to propagate signals, which makes it attractive to broaden the coverage of wireless broadband services in sparsely populated areas with more efficient and timely network deployments.

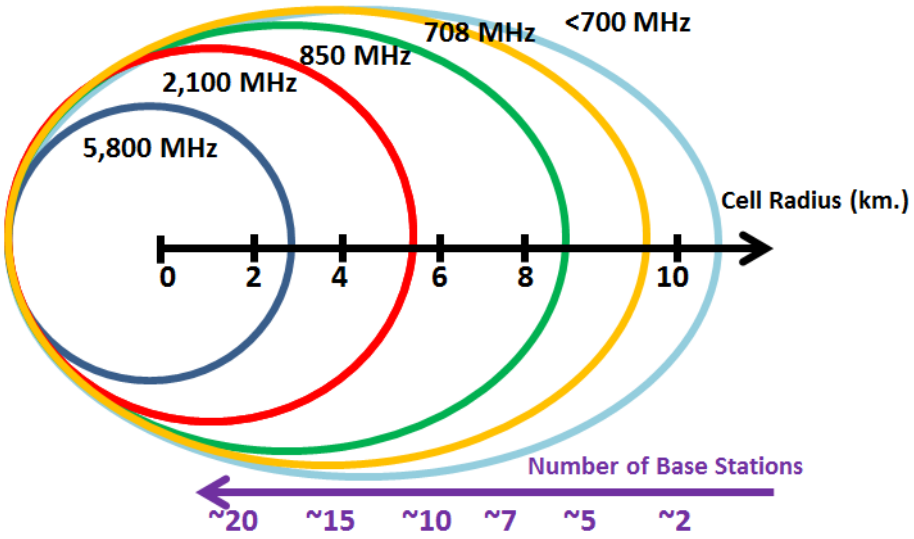


Figure 1.1. Coverage advantages of the 700 MHz band.[2]

As depicted in the graph above by SCF Associates as quoted by the OECD, two base stations in the 700 MHz band could enable coverage for ten kilometers, as opposed to ten base stations providing coverage for four kilometers in Advanced Wireless Spectrum (AWS) (1700/2100 MHz).

The efficient initial investment in network deployment could serve as encouragement to promote the use of mobile broadband services in districts and populations currently lacking this type of access. In other words, introducing the service will not create large volumes of traffic, and thus, the demand can possibly be fully met at a low capital expenditure. In this regard, the digital dividend represents an alternative to wired access in suburban areas where fixed networks in Latin America often lack robust coverage.

Another distinctive feature of the band is that, unlike higher density bands, it has efficient 'indoor' penetration. Studies from the Small Cell Forum indicate that 50 percent of the voice traffic and around 80 percent of the mobile data traffic are routed in closed (indoor) environments. In this regard, the low bands–below 1,000 MHz–have greater penetration in these spaces. In the case of the 700 MHz band, the loss of power (dB) may be 10 dB lower than that in the 2600 MHz band, used for 4G LTE in many Latin American markets.

Although the digital dividend is harmonized in the Americas, the spectrum channeling differs between North and South America, where most markets chose the Asia-Pacific channeling plan (APT 700).

[2] Presentation Broadband and Digital Dividend in Latin America, Fernando Rojas, ECLAC.

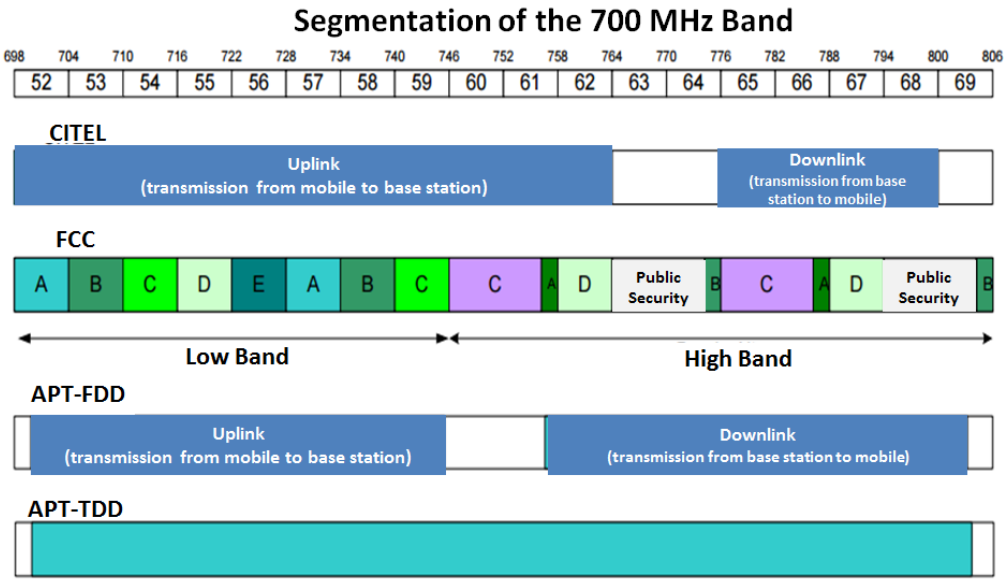


Figure 1.2. Segmentation of the 700 MHz Band.[3]

However, Bolivia and several markets from the Caribbean have chosen the U.S. spectrum channeling plan. The coexistence of different schemes raises harmonization issues due to the channelling differences between the U.S. band and APT 700, thus making them incompatible. 3GPP has designed four operational bands for the United States (Bands 12, 13, 14, 17) and two for APT (Band 28 for Frequency Division Duplex (FDD) and Band 44 for Time Division Duplex (TDD)).

Table 2. 700 MHz Frequency Allocation in Latin America as of July 2015.[4]

	Definition	Allocated / Auction	Currently in service
Argentina	700 MHz APT	Yes	No
Bolivia	700 MHz USA	Yes	Yes
Brazil	700 MHz APT	Yes	No
Chile	700 MHz APT	Yes	No
Colombia	700 MHz APT	No	No
Costa Rica	700 MHz APT	No	No
Ecuador	700 MHz APT	Yes	Yes
El Salvador	No	No	No
Guatemala	700 MHz	No	No
Honduras	No	No	No
Nicaragua	700 MHz APT	Awarded	No
Mexico	700 MHz APT	Wholesale network	No
Panama	700 MHz APT	Yes	Yes
Paraguay	No	No	No
Peru	700 MHz APT	No	No
Uruguay	700 MHz APT	No	No
Venezuela	700 MHz APT	No	No

[3] Telecomunicaciones: Mercados y Tecnología http://telecomunicaciones-peru.blogspot.com.ar/2014/07/peru-tendria-3-redes-4g-en-banda-700.html
[4] 4G Americas.

The differences lie in the operating bands having different spectral locations within the 700 MHz band, in particular, where guard bands are hosted. The U.S. channeling also shows a few inconsistencies, such as the inexistence of in-band interoperability (terminals working on Band 13 are incompatible with those working on other bands).

As depicted in the chart above, very few operators in Latin America were using the digital dividend frequency to provide mobile services as at July 2015. However, several network launches are expected for the next 18 months, as in the case of Chile.

2 THE NEED TO CLEAR THE BAND

There is an urgent need to have adequate regional planning from policy planners and regulators in Latin America to ensure that the new spectrum allocations are harmonized consistently with the regional commercial benefits offered by the Americas. Latin America has historically lagged behind other world regions when it came to identifying and allocating spectrum for mobile services. Notwithstanding, it is worth clarifying that this situation has started to change over the past three years, although it is still imperative to accelerate the timing of spectrum delivery.

Most Latin American governments have identified bands for IMT-Advanced services as per the recommendations of the World Radiocommunications Conferences, but have been very slow in making spectrum available for this type of service. Moreover, their experience in spectrum allocation without regard for harmonization implies that the mobile industry will have to use significant efforts and investments to address the allocation of harmonized spectrum for 4G services.

It is essential to have new radio spectrum allocated for mobile service provision for immediate use in addition to further spectrum harmonization so that mobile services can continue to expand for the benefit of the citizens in the region and to fully leverage the adoption of mobile technology.

Advocates of spectrum harmonization face a series of economic, technical and political factors that have delayed the allocation of new spectrum, thus weakening the appeal of harmonized spectrum allocations.

In recent spectrum auctions throughout the region, it has been shown that the prices obtained by governments have been lower as measured on the basis on price/MHz/population covered. Nevertheless, operators need new spectrum to enable the growth of mobile penetration as a result of new mobile data and multimedia services based on mobile broadband technologies.

Likewise, there has been a shift in the political philosophy of many of the major countries in the region from a free market approach to the provision of telecommunication services to an approach “based on current needs”. This shift has prioritized the universal service objective as a concession condition and the allocation of spectrum from the government as a requirement for service provision.

Spectrum is the essential input for mobile communications. It can only be used if it meets certain features that make it fit for the fast deployment of operator networks with the purpose of providing service to the population. In essence, spectrum must be available (i.e., it should be fit for use).

In turn, operators can only use radio frequencies if they are clear (i.e., if there are no competing services on the same bands as those of the frequencies awarded). In the case of the 700 MHz band, or digital dividend, the situation is far from ideal.

Only a handful of operators in different countries have launched LTE services on 700 MHz, including Entel and Tigo in Bolivia and Cable & Wireless and Movistar in Panama. Conversely, Argentina, Brazil, Chile and

Nicaragua, for example, have allocated digital dividend spectrum to mobile services but the spectrum is not available for use. Part of this radio electrical resource is taken by other services, mainly television signal broadcast, that will take some time, perhaps years, to migrate spectral position on account of the analog blackout dates. It is worth pointing out that the economic efforts needed for this migration are partly borne by mobile operators who have already paid for the spectrum, as in the case of Brazil.

By virtue of the above, the use of the 700 MHz band in many countries at this time might not be free from interference, damaging the quality of both mobile communication and mobile services.

2.1 THE CASE OF BRAZIL

After a long period of interference testing and reviews of tender models, in September 2014, the National Telecommunications Agency (ANATEL) auctioned the 700 MHz band for mobile 4G LTE services. The government's targets were to develop telecommunications with further coverage and speed for mobile Internet in addition to accelerating the conditions for the digitization of the country's OTA television.

The conditions for the use of the band were established in ANATEL's Resolution 625 from November 11, 2013. The resolution determined mobile services with Asia Pacific Telecommunity (APT) channeling as primary, while the location of the broadcast signals shall be determined in the future. It also pointed out the holding of tests to avoid mutual interference between the IMT and Terrestrial Digital Television (TDT) services, which use Integrated Services Digital Broadcasting (ISDB-T) technology both in Brazil and in most other Latin American markets.

Both field and laboratory testing sought to identify the conditions so that both systems can coexist avoiding critical situations and possibly using interference mitigation techniques.

The testing showed that LTE transmissions between the 698 MHz and 806 MHz bands interfered with TDT signals in several cases: i) with outdoor antenna reception; ii) with indoor antenna reception; iii) with reception of amplified outdoor antennas; iv) in the reception of TV signals on mobile terminals. In turn, TDT signals on channels 14 to 51 interfered in LTE communications.

The interference mitigation techniques tested were: i) distance variation from transmitters to receivers; ii) the use of additional filters, both in the transmitting and receiving end with the purpose of minimizing the emission or reception of unwanted signals; iii) transmit power variation; iv) variation of the features and positioning of emitting and receiving antennas.

Based on these test results, ANATEL published Resolution 640 in July 2014, which approved the "Regulation of conditions for the coexistence of the television broadcast service of the Brazilian Digital Television System (SBTVD) and radio communication services on the 698 MHz - 806 MHz band.

The purpose of the regulation was to establish technical criteria to mitigate unwanted interferences between the two services, considering the interference scenarios and mitigation techniques tested. The regulator proposed a "coexistence matrix" indicating for each scenario which techniques or procedures could reduce possible interference.

ANATEL concluded that the coexistence of LTE transmissions on the 700 MHz band and TDT on channels 14 to 51 is possible, even if in some cases mitigation techniques must be used to eliminate unwanted interference, such as additional filters in TDT receivers or outdoor antennas for digital TV reception.

Based on the data collected during testing, ANATEL and terminal manufacturers may jointly establish the minimum technical features used by receivers and devices to mitigate possible interference, as well as a testing program.

The timing of digital switchover in Brazil is very tight and generates uncertainties about the availability of radio spectrum. Operators can only launch services on this band 12 months after the analog switch off, so in the vast majority of the country the 700 MHz frequency will be available in 2019. The cities of Rio de Janeiro and Sao Paulo will only be allowed to use the 700 MHz frequency to develop 4G only after their entire state has concluded the analog switch off, thus the city of Rio de Janeiro will be able to launched services in 700 MHz in 2018 and the city of São Paulo in 2019.

Table 3. Digital Switchover Schedule in Brazil[5]

Year	Date	State
2015	Nov-29	Piloto - Rio Verde/GO
2016	Apr-03	Brasília
	May-15	São Paulo
	June-26	Belo Horizonte
	Aug-28	Goiânia
	Nov-27	Rio de Janeiro
2017	June-25	Curitiba, Florianópolis, Porto Alegre
	July-30	Salvador, Fortaleza, Recife
	Aug-27	Campinas, Ribeirão Preto
	Sep-24	Vale do Paraíba, Santos
	Oct-29	Interior do RJ, Vitória
	Nov-26	São José do Rio Preto, Bauru, Presidente Prudente
2018	July-01	Manaus, Belém, São Luís
	July-29	Natal, João Pessoa, Maceió, Aracaju, Teresina
	Aug-26	Campo Grande, Cuiabá, Palmas
	Nov-25	Porto Velho, Macapá, Rio Branco, Boa Vista, Demais Cidades

[5] Diario Oficial de la Unión http://pesquisa.in.gov.br/imprensa/jsp/visualiza/index.jsp?jornal=1&pagina=42&data=23/06/2014.

2.2 COORDINATION ALONG BORDERS

Either the APT or U.S. channeling plans for the 700 MHz band may possibly cause interference issues along the borders of neighboring countries that have opted for one or the other. The most severe case in the Americas is that of the United States and Mexico because of their extensive and heavily travelled land border and the economic integration between the two countries. Another interference issue may also arise between Bolivia (U.S. channeling) and Argentina, Brazil, Chile and Peru, which have chosen the APT channeling arrangement.

The chart below depicts the difficulties on the US plan for 3GPP bands 12, 13, 14 and 17 at the top and Band 28 (APT700, FDD) at the bottom.

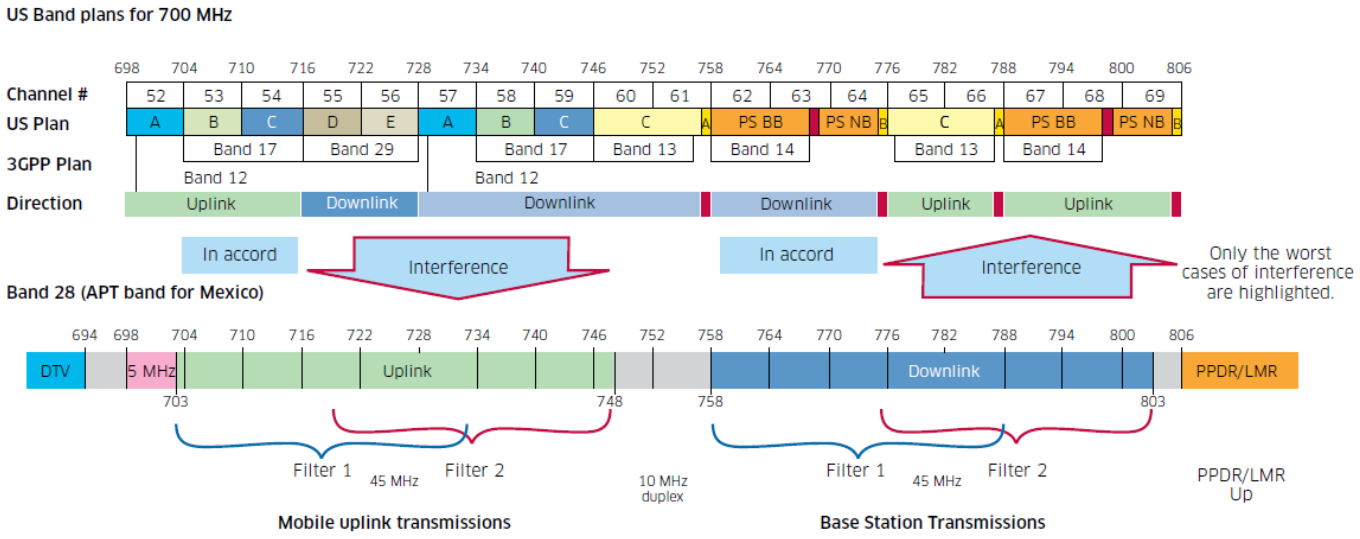


Figure 2.1. Difficulties on the U.S. plan for 3GPP bands 12, 13, 14 and 17 at the top and Band 28 (APT700, FDD) at the bottom.[6]

The spectrum from 776 MHz to 803 MHz has base stations in Mexico which could potentially cause interference on base station receivers on the U.S. side of the border, as well as a number of public security receiver systems. The same situation may occurs from U.S. base stations creating interference to Mexico-based wireless networks. These spectrum regions require close coordination of the placement of the base station as well as antenna orientation to reduce interference. A buffer zone is required to mitigate interference.

Negotiations between each countries' operators should be mutually beneficial, for the damage is mutual. Changing antenna angles or placing antennas close to the border facing the service areas may be helpful. Operators can further place smaller cells close to the border, while using indoor cells to complement their coverage on this region. In this case, the signal loss inside buildings may contribute to the necessary antenna insulation to obtain an agreed mitigation level.

Although technical solutions to avoid cross-border interference are available, there should be a negotiation framework between operators and the regulatory authorities of the countries involved.

[6] Alcatel-Lucent.

3 SPECTRUM ALLOCATION MECHANISM

The allocation of sufficient spectrum by governments in Latin America for mobile telecommunication services is key to the industry's development, the connectivity of inhabitants and the bridging of the digital divide. As indicated by the Organization for Economic Cooperation and Development (OECD), spectrum is currently identified by policymakers as a key asset in supporting growth in the digital economy.

The different governments in Latin America take a wide variety of approaches to the allocation of radio spectrum for mobile services. Differences are not limited to the variety of regulations among the 20 countries in the region, for it is often the case that regulations of a single country are amended before each new concession process. In this regard, the allocation of new spectrum is leveraged by the authorities to impose new rules on interested operators as a condition to participate in the process, affecting both the new frequencies and those acquired previously.

Latin America has a very large number of spectrum allocations which have been awarded by auction instead of through beauty contests. If the latter option is chosen, as was the case in Chile, the government determines who will be awarded the spectrum concession based on investment plans and coverage footprint. In addition, concessions awarded through a beauty contest typically go hand in hand with a strict coverage schedule determined either as percentages of the national geography, population or both.

It is worth noting that spectrum allocation through beauty contest processes cannot be considered necessarily "free of charge." There are different costs to the operators which materialize in the coverage requirements that were absent in most of the spectrum allocations made in Latin America over the past 25 years.

Notwithstanding, the fact that auction processes prevail over beauty contests helps to stress that the region's governments seem to focus more on raising revenue than other priorities.

It should be further noted that the benefits obtained by the government from radio spectrum concessions for mobile services are many. Revenues continue to be raised during the life of the concession both directly and indirectly by means of either tax payments, technology investments or direct and indirect job creation.

Over the past few years, Latin America has witnessed a shift in the governments' approach when it comes to allocating spectrum concessions. The line between auctions and beauty contests becomes blurred as an increasing number of markets are including as a requirement for new licenses (or the renewal of existing ones) the acceptance of duties of coverage and specification of theoretical data upload / download speeds offered by the technology to be deployed, among other aspects.

3.1 CHILE: BEAUTY CONTEST FOR 4G LTE

For its latest spectrum allocations (2600 MHz and 700 MHz), Chile has chosen the 'classic' beauty contest process. To award the 700 MHz band, the Under secretariat of Telecommunications (SUBTEL) offered operators 70 MHz out of a total of 90 MHz of available spectrum. This spectrum complements the 2.6 GHz band and allows a better deployment of 4G services in the country. The regulator divided the spectrum into seven 5+5 MHz blocks.

Table 4. 700 MHz Spectrum Blocks.[7]

Blocks	Frequency bands Mobile transmission (MHz) Sub blocks	Frequency bands Base station transmission (MHz) Sub blocks	Total
A	713-718 718-723	768-733 733-778	10 + 10 MHz
B	723-728 728-733 733-738	778-783 783-788 788-793	15 + 15 MHz
C	738-743 743-748	793-798 798-803	10 + 10 MHz

The results were publicized in March 2014. In view of the equal scoring obtained at the beauty contest (technical tie), the operators had to make a payment to obtain the spectrum they sought. Entel obtained the B band at a Price of CLP 6880 million (US$ 12.3 million, at the time of the contest), Movistar was awarded block A at a Price of CLP 4249 million (US$ 7.6 million) and Claro paid CLP 404.2 million (US$ 723,000) for the C block.

As part of the conditions to be met by operators in exchange for the spectrum on 700 MHz, SUBTEL included the duty to provide mobile voice connectivity as well as data transmission with Internet access for remote areas (1281 districts in all) and 500 municipal schools subsidized by the government. Establishing these services will bring savings to the Government in the order of U$200 to U$250 million.

In addition to connectivity for rural areas, the terms and conditions of the competition further required that the award winners offer an array of facilities and resale plans for virtual mobile operators and a basic supply of interconnection for automatic national roaming, in addition to the wholesale supply of data transmission with high speed Internet access at the national and international level. The carriers shall offer a unique discount percentage on these services.

3.2 BRAZIL: REVENUE TARGETS AND COVERAGE COMMITMENTS

The Brazilian government determined a revenue raising model with successive auctions in ascending rounds to which it added coverage targets.

Six operators bid at the 450 MHz – 2500 MHz tender –: the four largest mobile operators, namely Vivo, Claro, TIM and Oi, in addition to SKY (a DTH service provider) and Sunrise (currently On Telecom). Although ANATEL's intention was to secure the entry of new operators into the market, all tender participants were already incumbents in the country either as mobile operators or through other services, as in the case of Sky and Sunrise, which offered pay-TV.

With this tender, ANATEL expected to provide LTE coverage for the six venues of the soccer Confederations Cup by April 30, 2013, expand it to the twelve cities that hosted the FIFA Brazil 2014 World Cup, and to all municipalities with populations in excess of 100,000 by year-end 2016.

[7] SUBTEL.

The target for the 450 MHz band was to cover rural areas located in a radius of up to 30 kilometers from the venue of all Brazilian municipalities by December 31, 2015.

The economic bids under this auction ultimately raised US$ 1.32 billion for ANATEL, with an average price premium of 34.37 percent as compared to the base price.

Table 5. Outcome from the Spectrum Auction of 2,500 MHz in Brazil.[8]

Operator	Band	MHz	Scope	Coverage 450 MHz	Price (U$ million)	Price x MHz (U$ million)
Claro	2.500 MHz	40	National	9 states	410.6	10.26
Oi	2.500 MHz	20	National	4 states	164.7	8.2
TIM	2.500 MHz	20	National	4 states	164.3	8.3
Vivo	2.500 MHz	40	National	9 states	510.45	12.76

The tender of the 700 MHz band for 4G LTE raised BRL 5.85 billion (U$ 2.4 billion at the exchange rate of the time), barely above the base price set by the authorities. Claro, TIM and Vivo were awarded 20 MHz each for national coverage, while Algar Telecom obtained the same spectral bandwidth for 87 municipalities in the country. Two of the lots offered by regulator ANATEL were declared vacant.

Table 6. Outcome from the Spectrum Auction of 700 MHz in Brazil.[9]

Operator	Lot	MHz	Coverage	BRL	U$	Base Price Premium
Algar	5	10 x 10	87 municipalities in GO, MG, MS and SP	29.567.738,00	12,129,277	0.02%
Claro	1	10 x 10	National	1.947.244.417,70	798,798,605	1%
TIM	2	10 x 10	National	1.947.000.000,00	798,698,340	0.99%
Vivo	3	10 x 10	National	1.927.964.770,00	790,889,708	0%

The main absence in the tender was Oi, the fourth largest mobile operator with national coverage. Nextel also failed to participate. Overall, the revenue raised from aucions amounted to 75 percent of the figure the government had initially expected.

Given that not all the available spectrum was auctioned, excess frequencies imply that there are 10 MHz of additional spectrum to separate mobile operations from broadcasting, which may help mitigate interference and reduce migration costs.

The auction obligations to winner operators included covering the cost of cleaning the 700 MHz spectrum band acquired during the process (aggregated estimated cost US$ 1,100 million).

[8] ANATEL.
[9] *Ibid.*

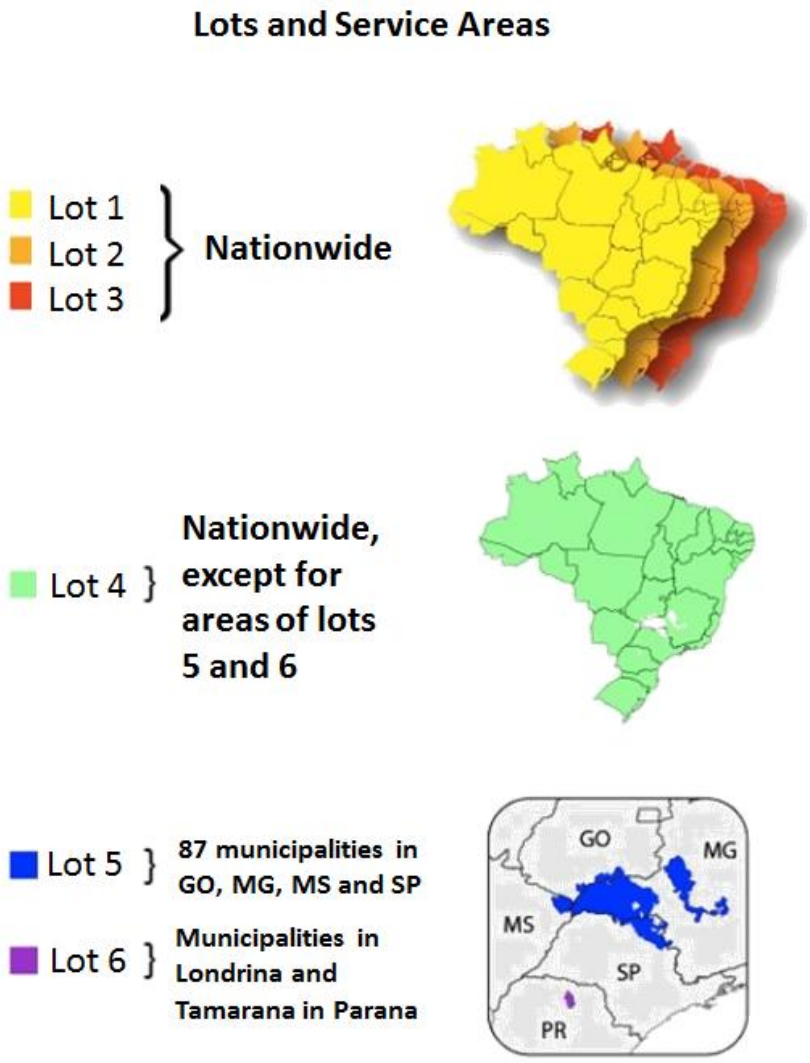


Figure 2.2. Lots and Service Areas.[10]

In Brazil, the 700 MHz band may be used from the date of the analog blackout, whose completion is scheduled for late 2018. To that end, it will be necessary to migrate the TV signals currently providing service on that band. Operators have started making payments for the migration to Exposure at Default (EAD), an entity created by the companies to support the analog blackout. During the second quarter of 2015, the awardees outlaid a total of BRL 1.44 billion (US$ 467 million), representing 40 percent of the total amount needed for the technology migration from analog to digital TV. The remaining amount shall be deposited at two instances over the next two years.

Claro, Vivo and TIM shall contribute BRL 1.19 billion (US$ 396 million) each, while Algar Telecom, which was awarded spectrum on 700 MHz for Goiás, Minas Gerais, Mato Grosso do Sul and Sao Paulo, shall contribute BRL 18 million (US$ 5.8 million).

The government put forth stringent coverage targets in the 2012 tender of 2.5 GHz. Government estimations indicate that the operators that were awarded frequencies in the 2.5 GHz band shall invest from US$ 5.5 billion to US$ 7 billion in 4G infrastructure by 2018. Also noteworthy are the amount of resources that operators are required to use in migrating the TV signals that occupy the spectrum.

[10] *Ibid.*

The choice between designing radio spectrum allocations based on beauty contests or revenue raising has analysts throughout the world arguing about their advantages and disadvantages for both the government, operators and mobile ecosystem at large. One should not overlook the fact that regulatory decisions and every public policy element considered at the time of designing a radio spectrum competition or auction have an impact on investor behavior, the competitive dynamics, the degree of service adoption and affordability, among other factors. It should be kept in mind that the spectrum allocated to mobile services is the facilitator of the development of network and broadband service, a key service to economic development, welfare and the reduction of the digital divide in Latin American countries.

4 SPECTRUM CONSIDERATIONS AND REGULATIONS

In the late 90's and the first decade of the 21st century, operator purchases had the main purpose of expanding to new geographical markets. Through its purchases in Colombia, Brazil, Argentina, Peru, Chile, the Dominican Republic and Central America, América Móvil became one of the major telecommunications groups in Latin America. Telefónica also expanded its international scope in the region through the purchase of BellSouth in 2004 to become another large operator in the region.

In recent months, AT&T returned to the Mexican mobile market with the acquisition of Iusacell for US$ 2.5 billion in November 2014, and in January of this year it purchased the assets of Nextel for US$ 1.87 billion in the same market.

Nextel's operation in Peru also changed hands: it went to Entel (Chile) for US$ 400 million in April 2013.

The pay-TV market also witnessed AT&T's purchase of DirecTV in the United States for US$ 48.5 billion. This transaction has had wide repercussions in Latin America.

Several regulators in Latin America have attempted to promote the entry of new players in their specific countries based on spectrum auctions by setting aside frequency blocks for new operators. In general, in the latest tenders held in the region, the bidders have been incumbent operators and other players which provided services different from mobile and wanted to enter the mobile broadband market as a way of complementing their service offering. Examples of this are DirecTV/SKY in Brazil, Colombia and Venezuela, and On Telecom in Brazil.

Some Latin American regulators have set aside spectrum for new entrants with minimal results of their expectations. One of the emblematic cases of the boost toward new operators was the tender held in Chile in July 2009. The Under secretariat of Telecommunications (SUBTEL) awarded spectrum in the AWS (1700/2100 MHz) bands. The spectrum was divided into three blocks of 30 MHz each. Nextel was awarded blocks B and C with a total bid of approximately US$14.7 million, while VTR secured block A with a total bid of US$3.02 million.

The tender was characterized by the fact that three incumbent mobile operators (Claro, Entel and Movistar) were excluded because they reached the spectrum cap of 60 MHz set by the Supreme Court for this process.

Nextel and VTR took a similar path. Both operators started deploying network infrastructure for 3G services, albeit with different strategies. With the spectrum it obtained, Nextel took a technology leap to exit its digital trunking operation with iDEN technology and become a 'typical' mobile operator, as it did in Mexico, Brazil and Peru. VTR's plans included the launch of an operation focused on mobile Internet to broaden its fixed service offering. To advance the launch of their mobile services, Nextel and VTR entered into national roaming agreements with Entel and Movistar, respectively. However, five years after the tender, neither operator has fulfilled their initial plans in a highly competitive market.

In January 2014, VTR reported that it had ceased to use its mobile telephony network commercially and became a virtual mobile operator on Movistar's network. The agreement with Movistar helps VTR Móvil to reduce the costs associated with the mobile business since it has national coverage from Telefónica's operator; in turn, it allows it to remain flexible and independent to design its own rates and business plans.

In a similar situation to VTR's, Nextel submitted an MVNO concession request to SUBTEL in May 2014, the goal being to offer pre-paid services by a virtual operation. Finally, in August 2014 NII Holdings agreed to sell Nextel Chile to an international consortium composed of companies from Argentina, the United Kingdom and the United States.

Another example of spectrum reservation took place in Argentina. In July 2014, the Communications Secretariat called for bids for the tender of radio spectrum. The frequencies to be tendered comprise the 1850-1910 MHz and 1930-1990 MHz (PCS) and 824-849 and 869-894 MHz (SRMC) bands. This spectrum was segmented in the following manner:

- 30 MHz in PCS for management areas I and II
- 7.5 MHz in SRMC for management area II
- 35 MHz in PCS for management area III

Furthermore, the band called AWS (1710-1770 MHz and 2110-2170) for Advanced Mobile Communications Service (SCMA) sold 90 MHz, grouped into four licenses

- 20 MHz set aside for new entrants.
- 30 MHz will not be auctioned but remain outstanding for a future tender.

On the other hand, 90 MHz were auctioned for the band between 698-806 MHz for the provision of SCMA. The 90 MHz will be grouped into four licenses, with 20 MHz set aside for new entrants.

Unlike previous tenders, the new call for auction included duties of coverage in five stages, distinguishing between incumbent and new operators.

The four awardees were the incumbent mobile operators, namely Movistar, Claro and Personal, which were joined by Arlink. Movistar and Personal started providing 4G LTE service with specific coverage in a few Argentine cities in December 2014.

In June 2015, the Communications Secretariat allocated 700 MHz spectrum nationwide licences to Movistar (703-713 MHz and 758-768 MHz), Personal (713-723 MHz and 768-778 MHz) and Claro (723-738 MHz and 778-793 MHz).

Finally, on June 2015 the government awarded Airlink the spectrum that it obtained during the 700 MHz mobile auction:

- 1895-1905 MHz & 1975-1985 MHz (Area I, North).
- 1890-1900 MHz & 1970-1980 MHz (Area II, Greater Buenos Aires)
- 1880-1890 MHz & 1960-1970 MHz para el Área III (Area III, South)
- 1745-1755 MHz & 2145-2155 MHz, Nationwide
- 738-748 MHz & 793-803 MHz, Nationwide

5 ECONOMIES OF SCALE

The band of the digital dividend is widely accepted by the industry for the provision of mobile, especially broadband mobile services. It is estimated that by 2020, approximately six billion inhabitants worldwide will be covered by mobile technologies on the digital dividend spectrum.

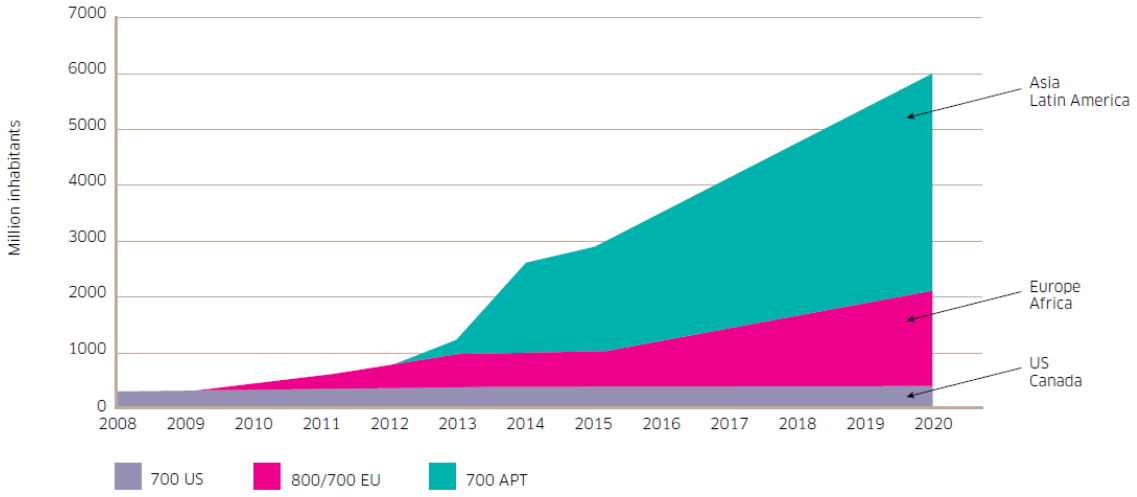


Figure 5.1. Population covered by digital dividend spectrum in mobiles.[11]

Of the different channelings of the 700 MHz band, the one with the higher scale is APT, especially for its FDD version, which has obtained global support from the industry and regulators. The FDD configuration is standardized by the 3GPP (Band 28) with two blocks of 45 MHz each (703-748 MHz for the 'uplink' and 758-803 MHz for the "downlink"), with a guard band of 10 MHz.

Major mobile broadband infrastructure providers offer equipment for APT 700 MHz.

The adoption of the APT 700 MHz band in FDD mode by several countries has created a significant opportunity for the harmonization of LTE spectrum globally, providing significant economies of scale for user terminals as well as for network equipment.

In Latin America and the Caribbean, this band was chosen by Argentina, Brazil, Chile, Colombia, Costa Rica, Curacao, the Dominican Republic, Ecuador, Mexico, Panama, Peru and Venezuela. In Asia Pacific, it was chosen by Afghanistan, Australia, Bangladesh, Bhutan, Brunei, Cambodia, Fiji, India, Indonesia, Japan, Laos, Malaysia, Myanmar, Nepal, New Zealand, Pakistan, Papua New Guinea, Singapore, South Korea, Taiwan, Thailand, Tonga Vanuatu and Vietnam.

As at April 2015, APT 700 MHz spectrum was allocated to mobile operators on 13 markets worldwide, and it is being used in ten countries.

In turn, 13 manufacturers now offer smartphones, tablets and customer premises equipment (CPE) in the marketplace. These are: Acer, Apple, Asus, Foxconn/InFocus, Fujitsu, HTC, Huawei, LG, Motorola, Samsung, Sony Mobile, TCL/Alcatel and ZTE.

[11] Alcatel-Lucent.

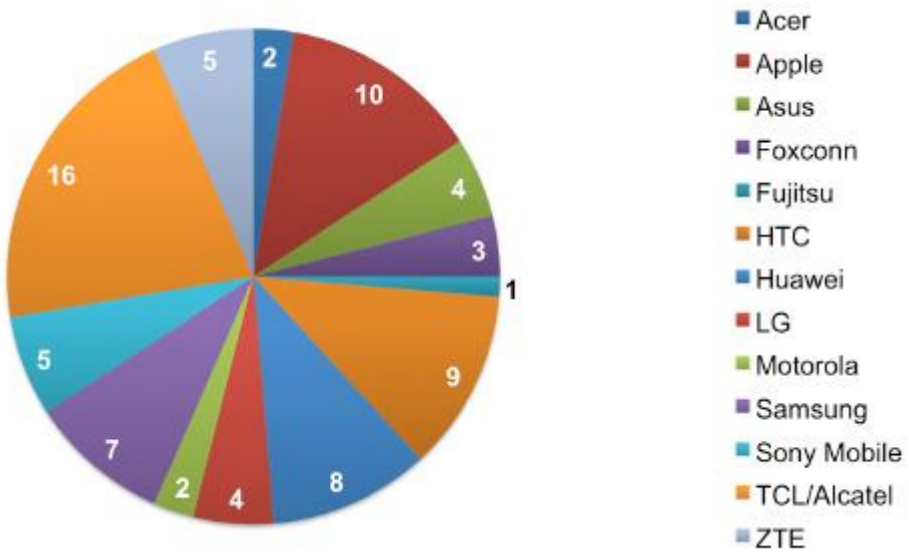


Figure 5.2. Number of smartphones, tablets and customer premises equipment (CPE) in the marketplace.[12]

The issue of terminal availability for users is key for the telecommunications industry and its impact on the economic development of countries and bridging the digital divide. Devices typically need to be available at reasonable prices to allow operators to increase the number of users adopting new technology. In other words, the size of a new network in terms of geographical coverage and available tariff offers is irrelevant – unless devices are capable of connecting to the new technology, their adoption will not be possible.

The situation described above holds true for the world at large, but is particularly relevant in Latin America. Unlike former technologies, such as GSM or UMTS, 4G LTE is being deployed in the region almost simultaneously with developed markets.

However, the availability of terminals is not the same. The launches of new telephone form factors are made in mature markets (mid-high/high end) or very large mass markets such as India and China (mid/low end). The newest form factors usually land months later in Latin America. In the case of the 700 MHz band, this situation might repeat itself. In addition, and despite its tremendous growth, economies of scale are not mature enough to leverage the digital dividend.

In addition, some Latin American markets such as Argentina, Ecuador and Venezuela have restrictive policies on the entry of terminals. This type of policy is often promoted internally as an industrialization process by import substitution. In other words, the objective is to manufacture locally instead of importing.

Nevertheless, the local manufacturing of high-tech devices such as smartphones usually lacks technology transfer or know-how and is limited to the assembly of imported components. It is possible that this type of policy responds to cyclical macro-economic and tax account issues, basically an imbalance in the payments account of the trade balance checking account.

Ultimately, this type of policy delays the adoption of technology by the population in the local mobile telecommunications market or, in the best-case scenario; it results in lack of competition in the market for terminals, which makes the purchase of technology (smartphones, in the case at hand) more costly.

[12] GSA.

Another factor affecting technology adoption in Latin America is the tax burden imposed on telecommunications services and devices by different tax collection means, such as taxes on imports or excise taxes on services.

Imported equipment for the mobile sector in Latin America pays a significant amount of taxes to the government in the way of import tariffs and sales tax. External tariffs and excise taxes impose a substantial burden on mobile users and put up a barrier to adoption from the lower income segments of the population in Latin America.

High taxes on imports of mobile terminals and mobile service provision could possibly prevent the adoption of mobile services by the lower income segments of society. Taxes represent a high percentage of the mobile ownership cost and potentially a barrier to the adoption of mobile services. In Latin American countries, taxes on the sale of imported terminals exceed 40%.

The historically used tax philosophy reflects the old perception that mobile services are a luxury item, although this is no longer the case in most countries. While fixed lines have an average penetration of around 20 percent, mobile services have an average penetration of around 100 percent or higher and thus represent the lifeblood of communications for Latin American countries. High taxes on mobile services could delay mobile deployments and deprive these countries from the higher efficiencies derived from widespread connectivity.

The total cost of ownership of mobile telecommunications, which comprises acquisition and recurring charges, is impacted by numerous taxes. A previous study from 4G Americas distinguishes different types of taxes which are imposed on mobile telephony. There are three recurring taxes on services:

- Value added tax. Most countries levy some sort of value added tax, a general sales tax or similar excise tax as a percentage of billing.
- Telecommunication-specific taxes. Some countries levy an additional excise tax on telecommunications as a percentage of billing.
- Flat taxes. In addition to the tax as a percentage of use, some countries levy a flat tax that may be determined by the use of communications in general or by the use of the mobile service.

In addition to taxes based on service, other taxes can be levied on mobile terminals:

- Value added tax. These represent the taxes paid directly by the consumer at the time of purchasing the mobile terminal as well as at the time of replacing one terminal by a new one.
- Customs tax. This tax is included in the retail price of the telephone.
- Other taxes. Telecommunication-specific taxes on the cell phone (such as royalties calculated on the cost of the earphone).
- Flat taxes. Fixed excise taxes on the handset, such as ownership quotas.

Although there is no uniform approach to the taxation of mobile services, all countries levy taxes on services and cellular telephones using different types of taxes and rates. While taxes on cell phones increase the acquisition cost, taxes on service increase recurring expenses to users.

Taxes should be as low as reasonably possible in order to reduce the digital divide, since the on-going technology evolution of mobile telecommunication services enables mobile services as the gateway to the digital world in remote populations.

6 BACKHAUL

The expansion of 4G LTE networks and the continuous development of 3G boost the use of mobile data. Moreover, the shift worldwide from phones with basic features to smartphones, on-going expansion of the use of tablets, reemergence of portable computers with compressed features and expansion of Machine-to-Machine (M2M) connections are all key factors boosting traffic growth. From a perspective of mobile networks, it is expected that by 2017, 3G will surpass 2G as a superior mobile technology based on share of connections. In 2019, 3G networks will support 44 percent of all mobile devices and connections worldwide and 4G networks will support 26 percent, according to data from Cisco's Visual Networking Index published in February 2015.

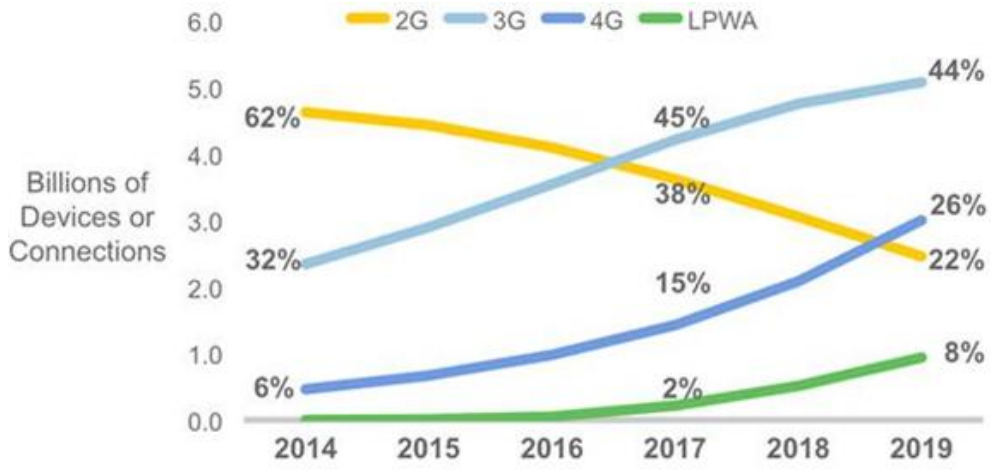


Figure 6.1. Evolution of mobile connections.[13]

In addition, the constant adoption of smart mobile devices and more powerful M2M connections, combined with greater access to the fastest cellular networks, are key factors in the growth of mobile traffic. In 2014, 88 percent of the world's mobile data traffic was 'smart' traffic, with advanced computing/multimedia capabilities with mínimum use of 3G connectivity; however, this figure is expected to climb to 97 percent by 2019.

[13] Cisco.

Figure 6.2. Mobile data traffic per region.[14]

In terms of data traffic growth, Cisco projects that the world's mobile data traffic will reach an annual growth rate of 292 exabytes by 2019, compared to 30 exabytes in 2014 (one exabyte is a unit of data or information storage equal to one billion gigabytes).

This forecast of 292 exabytes of mobile data traffic would represent:

- 292 times more than all the Internet Protocol (IP) traffic, both fixed and mobile, created in 2000; or
- 65 billion pictures (for example, multimedia messaging service or Instagram) – or 23 pictures per day per person on Earth for one year; or
- 6 billion video clips (as in YouTube) – more than two video clips per day per person on Earth for one year

The growth in data consumption can only be absorbed by robust mobile networks on air LTE and HSPA interfaces, although it is essential to deploy the fiber optics that will connect the cell sites. We cannot discuss mobile broadband without bearing in mind the availability of optical transport networks and other high speed backhaul networks to process the traffic received by the antennas. In this regard, there is an imperative need for fiber networks and other high speed backhaul technologies to support traffic growth, for each antenna has a link connecting it to the fiber optics backbone in its market, thus allowing traffic to reach the end user's mobile at the speeds promised.

Latin America has made a note of the need for broadband and different countries have undertaken connectivity plans, such as Argentina Conectada (Connected Argentina), Plan Nacional de Banda Larga (National Broadband Plan or PNBL, Brazil), Vive Digital (Live Digital) in Colombia and the Red Dorsal de Fibra Óptica (Fiber Optics Backbone, Peru), among others. In principle, these plans which are the result of public-private initiatives seek to take fixed connectivity from North to South and from East to West in the respective countries with the purpose of reducing the digital divide.

The ways of selling this transport capacity vary with each project. In Argentina, it is the Federal state and the authorities of the provinces who are mainly responsible for the initiative. In Brazil, state operator Telebras is in charge of the expansion of the PNBL. In Colombia and Peru, fiber deployments are undertaken by private

[14] Cisco.

operators to which the state has granted specific subsidies; they are further responsible for selling the installed capacity.

Faced with this scenario, mobile operators can choose these networks traffic transport. However, in the countries mentioned, the speed of expansion of the LTE wireless networks may be higher than in land deployments. On the other hand, some of the markets either lack national connectivity plans or they have fell behind in their implementation. These situations force mobile operators to enhance their land deployments with higher capacity and the deployment of new fiber.

For as long as mobile communications stayed on 2G, the backhaul called for an E1/T1 connection, for each voice channel only consumed 8 Kbps. With the arrival of 4G however, fiber or VDSL2 connections are required. If a mobile operator deploys LTE in the air interface but the backhaul connections do not support the high speeds that this technology enables, the result is a similar connection to that obtained from former technologies such as 3G.

LTE is an 'all IP' technology which implies the transition from 3G backhauls through TDM or ATM technology to IP links for data traffic transport. The new terminology for transport networks includes acronyms like FTTT (Fiber-To-The-Tower) or FTTCS (Fiber-To-The-Cell-Site) by analogy to FTTH (Fiber-To-The-Home), FFTB (Fiber-To-The-Building) or FFTC (Fiber-To-The-Curb) in the home and corporate markets.

The need for fiber deployments means that Latin American governments should facilitate and encourage the granting of permits for mobile network deployment. Keeping in mind that in most markets in the region these authorizations are granted at municipal level, there is the risk for mobile broadband deployments to be delayed artificially because of bureaucracy or lack of information, mostly in rural or remote areas which, ironically, are the ones in great need of technologies like LTE for connectivity.

7 CONCLUSIONS AND RECOMMENDATIONS

- The allocation of enough spectrum by the governments in Latin America for mobile telecommunications services is key to the industry's development, connectivity of the populations and bridging the digital divide.
- One of the best-suited bands to accelerate the adoption of mobile broadband services is the one emerging from the so-called digital dividend, or the 700 MHz band, contained from 698 MHz to 806 MHz in the Americas.
- It is estimated that by 2020, some six billion inhabitants worldwide will be covered by mobile technologies on spectrum in the digital divide.
- Of the different channeling plans of the 700 MHz band, the one with the largest scale will be APT, especially in its FDD version, which has garnered global support from the industry and regulators.
- One of the main features of the 700 MHz band is its significant capacity to propagate signals, which makes it attractive to broaden the coverage of wireless broadband services in sparsely populated areas with efficient deployments
- One should not overlook the fact that regulatory decisions and every public policy element considered at the time of designing a radio spectrum auctions have an impact on investor behavior, the competitive dynamics and technology deployments among other factors.
- It is essential to have new radio spectrum allocated for mobile service provision to be used immediately in addition to further spectrum harmonization so that mobile services can continue to expand for the benefit of the citizens in the region and to fully leverage the adoption of mobile technology.
- Operators can only use radio frequencies if they are clear (i.e., if there are no competing services on the same bands as those of the frequencies awarded). In the case of the 700 MHz band, or digital dividend, the situation is far from ideal.

- The growth in data consumption can only be absorbed by robust mobile networks on air LTE and HSPA interfaces, although it is essential to deploy high speed backhaul that will connect the cell sites.

ACKNOWLEDGEMENTS

The mission of 4G Americas is to advocate for and foster the advancement and full capabilities of the LTE mobile broadband technology and its evolution beyond to 5G, throughout the ecosystem's networks, services, applications and wirelessly connected devices in the Americas. 4G Americas, the voice of 5G for the Americas, is invested in leading 5G development for the Americas and maintaining the current global innovation lead in North America with LTE technology. 4G Americas' Board of Governors members include Alcatel-Lucent, América Móvil, AT&T, Cable & Wireless, Cisco, CommScope, Entel, Ericsson, HP, Intel, Mitel, Nokia, Qualcomm, Sprint, T-Mobile US, Inc. and Telefónica.

4G Americas would like to recognize the significant project leadership and important contributions of Alcatel-Lucent, América Móvil and Telefónica as well as representatives from the other member companies on 4G Americas' Board of Governors who participated in the development of this white paper.