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Consultation on Policy for Spectrum Allocation and Efficient Use in Ecuador

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2020

KISDI

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FOREWORD

The adoption of Information and Communication Technology (ICT) has intensified across all sectors of the global economy. The terms such as Industry 4.0, digital transformation, and digital economy have become buzzwords. Among other things, we have witnessed the surge of internet and broadband connections. According to "The State of Broadband: Broadband as a Foundation for Sustainable Development" report published by ITU/UNESCO in September 2019, there are 3.4 billion 4G mobile services subscribers, which is 44% of the total mobile telecommunications services in 2018. 4G services focus mainly on mobile broadband. The number of 4G subscribers exceeds that of 2G mobile services, which deliver mainly voice traffic. The ratio was expected to grow to 50% in 2019 and will peak in 2023 at 62%. Korea, United States, and other countries are leading the development of 5G mobile services.

Many empirical studies show that the increase in access to broadband Internet leads to an increase in GDP. Broadband Internet has contributed to achieving the Sustainable Development Goals (SDGs) that were set by the UN in 2015. The increase in agricultural productivity, income generation and increased community resilience, and improvements in education and health are also positive effects of the wider use of broadband Internet. However, Internet security that cannot keep up with the increase in the number of mobile broadband users has resulted in various cyberattacks, mainly concentrating on women in the form of cyberstalking. The negative impact of the Internet on children, including child abuse, exploitation, and bullying, is also growing.

Despite the negative effects of the Internet, its positive potential is far greater than the negative aspects if we pay attention to its dysfunctions. It can be concluded that bridging the digital divide can contribute to achieving the SDGs, such as gender equality, quality education, and no poverty. However, there are still digital gaps based on gender, urban and rural residency, income level, and age. These digital gaps are wider in developing countries with low-income levels. For example, in 2018, the mobile Internet gap between the urban and rural areas was only 25% in high-income countries but 34.6% in middle- and upper-income countries, 40% in middle- and lower-income countries, and 58% in sub-Saharan Africa. Such broadband gaps among countries are some of the most important factors that widen the digital gap among north and south countries as societies and economies are more digitalized based on Internet connectivity. As new ICTs such as artificial intelligence, IoT, big data, cloud computing, autonomous vehicles, drones, robotics, VR, AR, and block chains are spreading among industries and communities, the ICT gap will deepen the divide between rich and poor within a country and among countries.

The international community, including the United Nations, recognizes the importance of ICT, and it emphasized the worldwide spread of ICT and global connectivity to achieve the SDGs in 2015. ICT is expected to play a key role in promoting inclusive and sustainable economic and social development. Korea is one of the most successful examples of how desirable outcomes can be achieved through the development of the ICT sector. The ICT development experience and achievements of Korea have been highly regarded internationally; in particular, there is increasing interest from developing countries seeking a benchmark.

The Korea Information Society Development Institute (KISDI) has been frequently involved in the ICT policymaking process in Korea and has worked with various stakeholders to check whether the best ICT policy practices of Korea can be emulated in developing countries. KISDI has conducted a total of 90 ICT cooperation projects in 28 countries during 2002~2020. This report is the result of the "Consultation on Policy for Spectrum Allocation and Efficient Use in Ecuador" for 2020. Based on the analysis of the spectrum allocation and ICT status in Ecuador, policy recommendations have been made that reflect both global trends and Korea's experience in the field.

On behalf of KISDI, I would like to extend my deepest gratitude to the Ministerio de Telecomunicacaiones y de la Sociedad de la Informacion (MINTEL) of Ecuador and the KISDI Consulting Group for actively supporting our mission of achieving co-prosperity with partner countries. KISDI looks forward to the results of this consultation contributing to the advancement of spectrum allocation and pricing as well as the socioeconomic development in Ecuador. KISDI also thanks to the Ministry of Science and ICT (MSIT) of Korea for funding the Consultation Program and providing insightful advice leading to the best possible outcomes.

Ho-Yeol Kwon
President
Korea Information Society Development Institute

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Glossary of Terms

3GPP	3rd Generation Partnership Project
AP	Access Point
APT	Asia-Pacific Telecommunity
ARCOTEL	Agency of Regulation and Control of Telecommunications
ARPUs	Average Revenue Per User
ASO	Analogue Switch-Off
AVR	Automatic Voltage Regulator
AWS	Advanced Wireless Services
B2B	Business-to-business
BcN	Broadband Convergence Network
CDMA	Code Division Multiple Access
CNT	Corporación Nacional de Telecomunicaciones Empresa
CONATEL	Consejo Nacional de Telecommunicaciones
DA	Direct Assignment
DAB	Digital Audio Broadcasting
DRM	Digital Right Management
DSL	Digital Subscriber Line
eMBB	Enhanced Mobile Broadband
EPC	Evolved Packet Core
ETSI	European Telecommunication Standards Institute
EWF	Emergency Warning Feature
FBB	Fixed Broadband
FCC	Federal Communications Commission
FDD	Frequency Division Duplex
FODETEL	Fondo para el Desarrollo de las Telecomunicaciones en Areas Rurales y Urbano-marginales
FR	Frequency Range
FTTC	Fiber-to-the-Cabinet
FTTP	Fiber-to-the-Premises

FWB	Fixed Wireless Broadband
GSA	U.S. General Services Administration
GSM	Global System for Mobile Communications
GSMA	Global System for Mobile Communications Association
HcIN	Hyper-connected Intelligent Network
HE-ACC	High Efficiency Advanced Audio Coding
HSPA	High Speed Packet Access
ICT	Information And Communication Technologies
IDB	Inter-American Development Bank
IMT	International Mobile Telecommunications
ISP	Internet Service Provider
ITU	International Telecommunication Union
ITU-R	ITU Radiocommunication Sector
KCA	Korea Communications Agency
KCC	Korea Communications Commission
KII	Korea Information Infrastructure
KISDI	Korea Information Society Development Institute
KT	Korea Telecom
LTE	Long-Term Evolution
MBB	Mobile Broadband
MCPT	Ministry of Communication, Post and Telecommunication of Djibouti
MIC	Ministry of Information and Communication of Korea (former MSIT)
MINTEL	Ministry of Information, Social and Communications
mMTC	Massive Machine Type Communications
MNO	Mobile Network Operator
MPEG	Moving Picture Experts Group
MSMEs	Micro, Small & Medium Enterprises
MVNO	Mobile Virtual Network Operator
NR	New Radio
NSA	Non-Stand Alone
OTL	Organic Telecommunications Law
PPP	Public-Private-Partnership
PSTN	Public Switched Telephone Network
R&D	Research & Development
RDS	Radio Data System

SA	Stand Alone
SBR	Spectral Band Replication
SENATEL	Secretaría Nacional de Telecomunicaciones
SFN	Single Frequency Network
SUPERTEL	Superintendencia de Telecomunicaciones
TDD	Time Division Duplexing
TDMA	Time Division Multiple Access
UBcN	Ubiquitous Broadband Convergence Network
UMTS	Universal Mobile Telecommunications Service
USO	Universal Service Obligation
WRC-19	World Radiocommunication Conference 2019
xHE-ACC	Extended HE-ACC

Executive Summary

Consultation on
Policy for Spectrum Allocation and Efficient Use in Ecuador

1. Introduction

Since the early 2000s, the Korea Information Society Development Institute (KISDI) has provided ICT Policy Consultation to policy-makers from developing countries with best practices and case studies related to the area of consultation.

For the year 2020, ICT Policy Consultation was proposed to Ecuador in the area of spectrum management. KISDI of Korea and the Ministerio de Telecomunicacaiones y de la Sociedad de la Informacion (MINTEL) of Ecuador agreed on the subject for the consultation program. By March 2020, the KISDI Consulting Group was established, headed by Dr. Jong Hwa LEE of KISDI, and consisting of experts and professionals from academia and industry in the field of spectrum management.

As part of the Consultation on Policy for Spectrum Management in Ecuador, a series of meetings, seminars and workshops were held from March to December 2020 through close cooperation between the KISDI Consulting Group and the MINTEL.

2. General Status of Ecuador's ICT

The telecommunications market in Ecuador is still insufficient to meet the needs of the people. The government is responding to this by establishing ICT Plan 2016~2021. This plan not only secures ICT infrastructure, but also promotes economic growth using ICT.

The fixed telecommunications market, where CNT (Corporación Nacional de Telecomunicaciones Empresa) dominates, is gradually being replaced by the mobile market. This is also influenced by Ecuador's mountainous topography. However, the fixed broadband market is constantly growing due to the broadband promotion policy of the government.

In the mobile market, three companies (CNT, Movistar, and Claro) are competing. Recently, with better package services, the ratio of postpaid services over prepaid is increasing slowly in the mobile market. Another important change in mobile market is that 3G technology is replacing 2G technology. Also, LTE is growing rapidly, with fierce competition between the three companies. Investment in 5G is being actively conducted, but it is yet to be commercialized. Internet usage is showing an increasing trend.

Dissolving the monopoly of state-owned enterprises (SOEs) has long been an issue in regulatory environment of Ecuador. In 1992, the Special Telecommunications Law established a state-own company called Emtel. This company was divided into Andinatel and Pacifictel in 1997, with the goal of privatization. For this two companies and the municipal company Epata, the government has signed a five-year exclusive contract for fixed-line services, assigning each company a specific area. The telecommunicaitons market was liberalized in 2002 when this local monopoly contract ended, but privatization of state-owned enterprises failed. The government withdrew its privatization plan and incorporated the two government companies to establish CNT.

MINTEL is the central government agency in Ecuador's information and communication technologies policy. In the past, there were three regulatory authorities related to telecommunication, but the revised Organic Telecommunications Law (OTL) unified the authorities as ARCOTEL (Agency of Regulation and Control of Telecommunications) in 2015.

Under this law, ARCOTEL selects telecommunications operators, and grants the business rights to them. Concession is necessary for telecommunication bussiness in Ecuador. Operators with bussiness rights are subject to restrictions on their revenue contribution, but only CNT is exempt from this fee.

Regulation on the radio spectrum is also being implemented in accordance with OTL. According to Article 52 of OTL, it is possible to allocate radio frequencies through a competitive process such as auction if there is a lack of frequency such as excess demand, but this provision has never been applied. Even in frequency allocation, CNT is given the privilege of providing a service supply.

3. Introduction Plan for IMT Technology

In Ecuador, poor fixed-line infrastructure has stymied the development of Fixed Broadband (FBB) services, and Mobile Broadband (MBB) appears to be the only viable alternative to offer broadband services to the population. Hence, the government should be able to accept MBB as an opportunity for economic growth and regard it as a means to leapfrog over investing its poor fixed-line infrastructure.

Mobile telecommunication has continued to evolve into a new generation every 10 years. The 5G technology was introduced as the succeeding mobile technology after LTE. This new technology makes it possible for us to provide higher performance and capacity for mobile networks. 5G has several remarkable features compared with 3G and 4G. Networks using 5G technology are scalable, programmable, and sliceable. Therefore, 5G will be a significant infrastructure technology to support various types of services.

The rationalization of legacy networks is driven by factors slightly different from the introduction of new technologies and the spread of the next generation. There are several factors, but the main drivers being: more efficient use of spectrum, spectrum harmonization, spectrum license expiry, reducing operational costs, and meeting increasing demand for mobile broadband and data-intensive applications.

4. Spectrum Management

The mobile spectrum of Ecuador amounts to 280 MHz in the bands below 3 GHz. Claro and Movistar renewed their spectrum licenses for USD 700 million in 2008. CNT was able to commence LTE services earlier than its competitors using 30 MHz in the 700 MHz band and 40 MHz in the AWS 1700/2100 band. On the other hand, neither Claro nor Movistar was able to provide LTE services before they purchased additional spectrum in 2015.

Spectrum management is the process of regulating the use of radio frequencies to promote efficient use and gain a net social benefit. As commercial mobile services become more popular, spectrum prices should be set to promote efficient use of the spectrum. In particular, spectrum prices should reflect the opportunity costs of holding spectrum and all administrative costs. It is important that these administrative costs be calculated transparently and reasonably, and they should be recovered from all operators who benefit from spectrum management activities.

The Ecuadorian government has announced a plan to release a bandwidth of 650 MHz

IMT spectrum in addition to the 280 MHz spectrum already assigned. This additional release is expected to be used for expanding MBB network coverage and improving MBB service quality. To increase MBB subscriptions, however, we believe it is more important to make mobile tariffs and handsets affordable than to expand the network coverage. For the affordability of MBB, it is crucial that operators' spectrum costs not be too high. The spectrum costs of private mobile operators consist of the initial license fee for purchasing spectrum and other regulatory fees, including monthly recurring spectrum fees.

Ecuador is preparing to allocate 300 MHz in the C-band for 5G among many options listed by 3GPP (3rd Generation Partnership Project). To fledge the technical performance of 5G fully, it is crucial for the government to allocate a sufficient amount of contiguous spectrum per operator. In addition to exclusively licensed spectrum, the government needs to consider supplying unlicensed Wi-Fi spectrum, as it can still play roles in complementary 5G network. The government should also note that the overall progress toward 5G may be postponed or slowed down due to the global COVID-19 pandemic and that a 5G take-off could be delayed because of the lack of killer applications and the high cost of network equipment.

Auctions have been widely used around the world as a way of allocating spectrum since the mid-1990s. One possible reason is that they have generated substantial revenue for the state, as an auction is designed to award the spectrum to the highest bidder. Therefore, the auction method is likely to direct the spectrum to the more efficient operators. It is important to set the correct reserve prices for the spectrum auction. If the reserve price is set too low, there is a risk that the valuable national spectrum resources would be somewhat wasted. On the other hand, if the reserve price is set too high, there is a risk that the auction will fail and nobody will enter the auction process, which would yield zero revenue for the government. Thus, in this paper, we tried to calculate the reserve prices in two ways: market value pricing and foreign auction unit price application. Market value pricing is the method that estimates the mobile market revenue during the spectrum usage period and calculates the spectrum price using the concept of revenue sharing. A foreign auction unit price application is applied to Ecuador by obtaining the unit price from foreign auction cases. We have calculated the reserve prices in the above two methods, and the use of these methods can be referred to in Ecuador's policy decisions in the future.

5. Universal Service

ITU (2013) explained that the underlying concept of universal service is to ensure that telecommunication services are accessible to the widest number of people (and communities) at affordable prices.

The policy direction of universal service is very appropriate. It is setting policy goals to improve availability, affordability, and accessibility, which are the basic goals of universal services.

In Ecuador, both wired broadband internet and wireless broadband internet are included in the scope of universal service. This is a very positive part as it maintains a technology-neutral view of regulation.

It is appropriate to designate a certain level of speed as a service requirement for Fixed Internet Access Service and not to regulate technology. Among the technologies for providing a certain level of service, allowing the operator to select the most efficient technology can promote technological development and industrial development. The exact service level of the broadband universal service has not been established. It is necessary to set the minimum speed of service.

Regions with high priority should be targeted for universal service policy. In the case of Ecuador, since there is no available budget for universal service, it is practical to impose a universal service obligation as a frequency allocation condition. True access gap area and access gap should be classified. Areas where services are not provided by a market function should be designated as the target of universal service, and financial resources should be aggressively invested in these areas.

Regulation on the radio spectrum is also being implemented in accordance with OTL. The government unilaterally chooses operators, and grants qualifying titles for radio spectrum frequencies.

6. Digital Radio

In this chapter, policy references such as the necessity of digital conversion of the current analogue radio broadcasting and considerations when adopting a digital radio broadcasting method are presented.

In chapter 6.1 The introduction on Digital Radio presented the necessity of digital radio conversion and the expected effects of the conversion to digital radio broadcasting. In chapter 6.2 Features of Digital Radio System, the history of digital radio broadcasting technology has been developed and it includes the technical characteristics of digital radio methods such as DAB/DAB+, HD Radio and DRM/DRM+, available services, terminal market and service introduction status.

In chapter 6.3 The Status of Ecuadorian Radio Broadcast Service includes Ecuador's radio broadcasting service and frequency conditions and digital radio demand. Finally in 6.4. Policy Recommendations policy considerations were presented in consideration of the demand and situation of digital radio broadcasting in Ecuador related to digital radio broadcasting conversion.

7. Policy Recommendation

Clear Spectrum Policy Roadmap

If spectrum resources are to adequately support national goals and objectives, long-term planning is essential. It can provide a basis for effective spectrum management to ensure that spectrum is efficiently allocated and assigned to accommodate constantly evolving spectrum requirements by new systems and their applications. It is also very important to formalize this additional spectrum release plan. The government may consider providing a roadmap for this.

From Effective Competition to Fair Competition in Mobile Market

To increase Internet connection using MBB, the government enabled CNT to compete with Claro and Movistar more effectively by assigning LTE spectrum to CNT ahead of its two private competitors and by exempting CNT from paying spectrum license fees. With the help of this effective competition policy, Ecuador's 4G network coverage reached to about 52% in 2019 and CNT's mobile market share rose sharply from 2014. Yet, it is still too early to conclude that this policy is successful because the cost advantage of CNT is largely from reducing its spectrum costs and because Claro and Movistar could have invested in 4G networks regardless of the competition policy. Reducing CNT's spectrum costs is unfair and induces the social cost of giving up efficient spectrum management. We believe that the policy regime of ‘effective competition’ has to be reconsidered, and the government should consider switching to ‘fair competition’ policy in preparing for 5G era.

Efficient Spectrum Pricing

Spectrum management can be efficient if a regulatory agency sets spectrum prices properly to collect the opportunity costs of holding exclusive licenses and to fully recover the costs of managing and regulating radio frequencies from all operators regardless of private or public.

In Ecuador, it may be difficult to introduce spectrum auction. However, the government can consider using the administrative method which calculates the initial license fee by using AIP (Administrative Incentive Price) to reflect the opportunity cost of holding spectrum and sets the level of spectrum license fees excluding the initial license fee to recover all costs associated with managing and regulating radio frequencies.

Simplifying Spectrum Price and Set Reservation Price

Ecuadorian pricing system seems to follow global standards in that the government collects the cost of spectrum management via the spectrum fee, and collects the value of spectrum from the auction. In this sense, the overall structure of spectrum pricing appears all right. However, some measures may be considered to encourage spectrum users to utilize the spectrum more efficiently. First, it might be worthwhile to state the principles and objectives of the spectrum pricing policy clearly. Second, the Ecuadorian government may consider introducing the administrative incentive pricing mechanism into the current system. Third, in setting the reserve price for the auction, the Ecuadorian government may refer to the case of Korea and other countries.

Reserve prices play a pivotal role in the auction design. It is a tool to keep the non-serious bidders out and also a means to ensure a certain minimum revenue for the government. Hence, for a smooth auction process, the amount of reserve price must be declared in advance, which can help to promote responsible bidding and ensuring optimal prices. However, to meet these objectives, the reserve prices for spectrum auction must be carefully determined.

It is important to set the correct reserve prices for the spectrum auction. If the reserve price is set too low, there is a risk that the valuable national spectrum resources are somewhat wasted. On the other hand, if the reserve price is set too high, there is a risk that the auction will fail, and nobody enters the auction process, which yields zero revenue for the government.

Also, before the final rule decision, Ecuadorian government must evaluate the extent of the past Ecuadorian spectrum auction reserve price level, and the impact on the future prices of auctions.

Access Technology and Service Requirements

It is appropriate to designate a certain level of speed as a service requirement for Fixed Internet Access Service and not to regulate technology. Among the technologies for providing a certain level of service, allowing the operator to select the most efficient technology can promote technological development and industrial development.

The exact service level of the broadband universal service has not been established yet in Ecuador. It is necessary to set the minimum speed of service. The available speed of LTE service is adequate. If set in this way, operators will provide SMA through LTE, and in the case of wired Internet, it will be possible to provide wired and fixed wireless technology. In the case of the UK, at least 10 Mbps is set as the broadband universal service level.

Financial Support for Parishes in need of Universal Service

Regions with high priority should be targeted for universal service policy. In the case of Ecuador, since there is no available budget for universal service, it is practical to impose a universal service obligation as a frequency allocation condition. True access gap area and access gap should be classified. Areas where services are not provided by a market function should be designated as the target of universal service, and financial resources should be aggressively invested in these areas.

Considerations for Selecting Digital Radio System

The digital conversion of radio broadcasting will require initial system investment, and continuous system operation costs, in addition to selecting the digital radio method. Also, users will be burdened by having to replace the radio receiver.

Therefore, all of these factors should be considered and the most advantageous method should be selected, and after a detailed conversion plan has been established, the conversion should be promoted based on this.

Chapter 1.

Introduction

1.1 Project Overview

Since the early 2000s, the Korea Information Society Development Institute (KISDI) has provided ICT Policy Consultation to policy-makers from developing countries with best practices and case studies related to the area of consultation.

For the year 2020, ICT Policy Consultation was proposed to Ecuador in the area of the spectrum management. KISDI of Korea and the Ministerio de Telecomunicacaiones y de la Sociedad de la Informacion (MINTEL) of Ecuador agreed on the subject for the consultation program. By March 2020, the KISDI Consulting Group was established headed by Dr. Jong Hwa LEE of KISDI and consisting of experts and professionals from academia and industry in the field of spectrum management.

As part of the Consultation on Policy for Spectrum Management in Ecuador, a series of meetings, seminars and workshops were held via online from March to December of 2020 through close cooperation between the KISDI Consulting Group and the MINTEL.

Table 1.

Project Overview

Project Title	Consultation on Policy for Spectrum Allocation and Efficient Use in Ecuador
Agency	KISDI (Korea) and MINTEL (Ecuador)
Period	March 2020 ~ December 2020
Objectives	To provide recommendations on implementing the policy for Spectrum Allocation and Efficient Use in Ecuador by reviewing the current ICT status and spectrum of Ecuador while sharing best practices of spectrum management

1.2 Scope of the Project

As an original process of the ICT Policy Consultation, the KISDI Consulting Group makes a series of on-site visits to conduct meetings, interviews and workshops to identify the ICT status and the spectrum management issues in a partner country. Moreover, KISDI invites partner country's officials to Korea for a one-week program of study visits and seminars. However, for the year 2020, because of the COVID-19 pandemic globally, all the visits were substituted for an online workshop.

As part of the Consultation on Policy for Spectrum Management in Ecuador, the Consulting Group had its first online consultation in June 2020. From the first online consultation, the Consulting Group identified the current ICT status of Ecuador, and discussed spectrum management, universal service and digital radio issues with Ecuadorian government officials and professionals in the field. During the first online workshop, the work scope for the consultation was specified.

In September, the Consulting Group conducted the second online consultation to hold a Workshop on Spectrum Management, Universal Service, and Digital Radio to share information and expertise in spectrum. During the second online consultation, KISDI and MINTEL/ARCOTEL had an in-depth discussion on the issues and how to apply it in Ecuadorian situation.

In November 2020, the final online consultation for the final presentation on the draft of the consultation report was made. The Consulting Group analyzed the current spectrum management, universal service and digital radio policy issues in Ecuador and Korea, and provided policy recommendations on the issues.

Table 2.

Progress of the Project

Schedule	Phase 1 (June)	• First Online Consultation: Specification of Work Scope for the Consultation/Preparatory Work (Data Collection, Interviews, etc.)
	Phase 2 (September)	• Second Online Consultation: Presentation of Midterm Report • Additional Data Collection and Interviews
	Phase 3 (November)	• Final Online Consultation: Drafting the Final Report and Presentation

1.3 Consulting Group

As mentioned in the Project Overview, the KISDI Consulting Group was formed in March 2020. The group was headed by Dr. Jong Hwa LEE of KISDI and consisted of experts and professionals from academia and industry in the field of spectrum management, universal service and digital radio. The list of the KISDI Consulting Group is shown in [Table 3].

Table 3.

KISDI Consulting Group

Organization	Participant	Position	Remarks
Korea Information Society Development Institute (KISDI)	Jong Hwa LEE	Director	Project Manager
	Dong-Min YIM	Associate Fellow	Consultant Spectrum Pricing
	Min SONG	Researcher	Program Officer
Dongguk University	Hyungtaik AHN	Professor	Consultant Spectrum Management
Cheongju University	Hoon JUNG	Professor	Consultant Universal Service
Namseoul University	Prof. Sang Woon LEE	Professor	Consultant Digital Radio
Korea Communications Agency (KCA)	Seunghoon LEE	Director	Consultant Spectrum Management
	Jaekyung PARK	Policy Analyst	Consultant Spectrum Management
Korea Telecom (KT)	Hyunjik KIM	Senior Manager	Consultant Mobile Network

Chapter 2.

General Status of Ecuador's ICT

2.1 Fixed and Mobile Market Status

2.1.1 Overview of Ecuadorian Telecommunications Market

Ecuador's teledensity is insufficient compared to its neighboring countries in South America, and excess demand in telecommunication market is considerable. This is mostly due to topography of Ecuador, especially in rural areas; in rugged terrain, the installation of fiber or copper wire costs a lot. Therefore, wireless networks were mainly used to solve communication problems in remote areas. As a result, this region is focusing on mobile communications rather than fixed lines, like other telecommunication market in South America.

In 2016, MINTEL of Ecuador announced National Telecom and ICT Plan 2016~2021 with the goal of policy development and management in the information and communication field from 2016 to 2021. Improvement of national competitiveness in the field of ICT and strengthening policy linkage between its sub-sectors are the main purpose of this plan. The National Telecom and ICT Plan sets four main goals: first, give an impulse to the establishment of communication infrastructure; second, strengthen the capacity to provide public services using ICT; third, guarantee the use of ICT field for economic and social development; fourth, build a foundation for the long-term development of the ICT industry. All telecommunication operators in Ecuador are participating in this plan with government agency such as the Agency of Regulation and Control of Telecommunications (ARCOTEL).

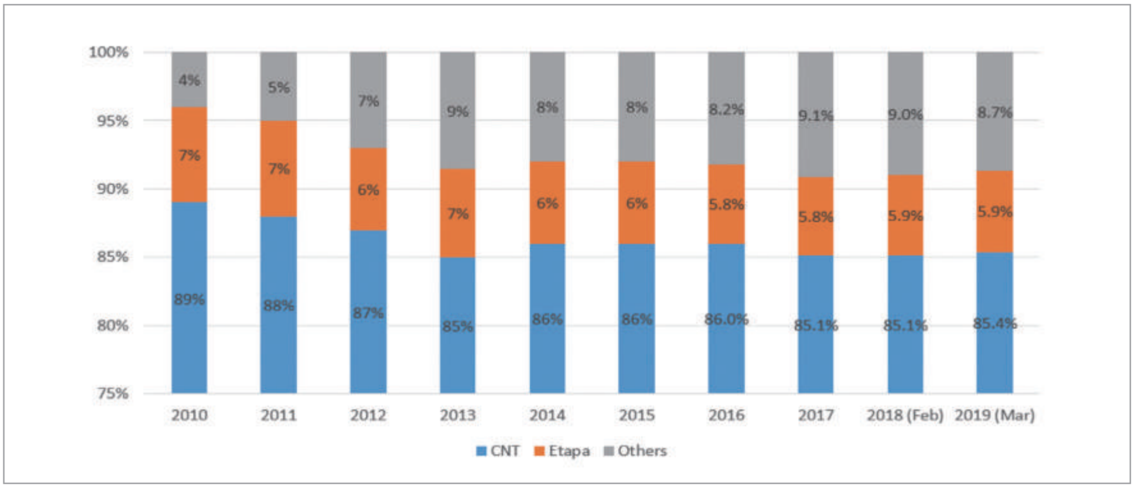
2.1.2 Fixed Market Status

(1) Fixed Market Share

The dominant company in the Ecuadorian fixed market is National Telecommunications Corporation State-Owned Enterprise (SOE)–Corporación Nacional de Telecomunicaciones Empresa Pública (CNT EP). The company with the second largest share is Empresa Pública Municipal de Teléfonos, Agua Potable y Alcantarillado (Etapa). Etapa is public works organization owned by Cuenca, Ecuador's third largest city. Apart from these two companies, there are other participants in the fixed market such as Concel Fixed, Setel, Level 3 and Linkotel.

Figure 1.

Fixed Lines in Service–Operators' Market Share 2010~2019



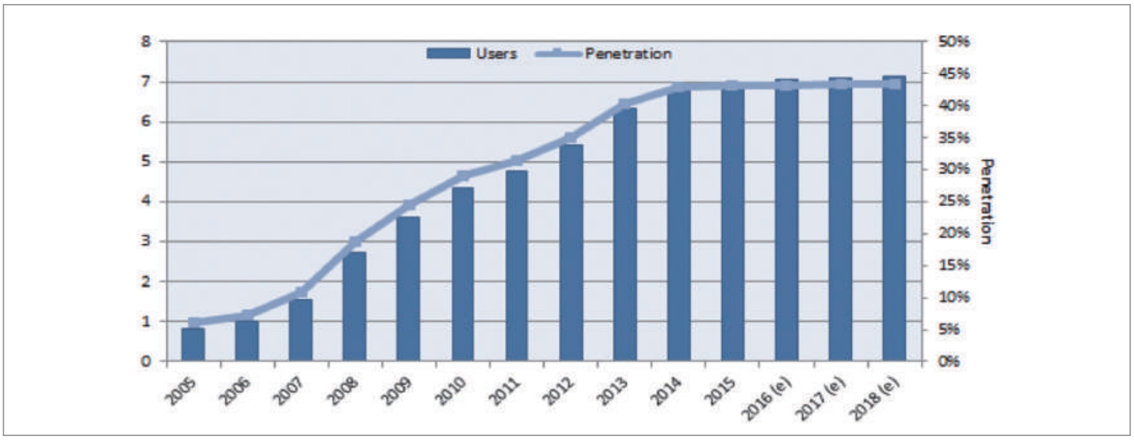
Source: BuddeComm based on Senatel data

(2) Fixed Market Growth

In the latest International Telecommunication Union (ITU) analysis on Ecuador's information technology, the fixed-telephone subscriptions per 100 inhabitants decreased from 15.5 subscribers in 2015 to 12.6 subscribers in 2019. In contrast, fixed-broadband subscriptions per 100 inhabitants increased from 9.18 subscribers in 2015 to 11.44 subscribers in 2018. The government of Ecuador contributed to this growth by launching a project to promote fixed-broadband. The government implemented the 'National Broadband Development Plan' as part of 'Ecuador Digital Strategy 2.0'. The goal of this plan is to increase the penetration rate. In order to provide broadband services to at least 75% of Ecuador's total population by 2017, it focuses on providing high-speed internet services in the area where services are not provided as priority.

Figure 2.

Internet Users and User Penetration Rate 2005~2018



Source: BuddeComm based on Senatel data

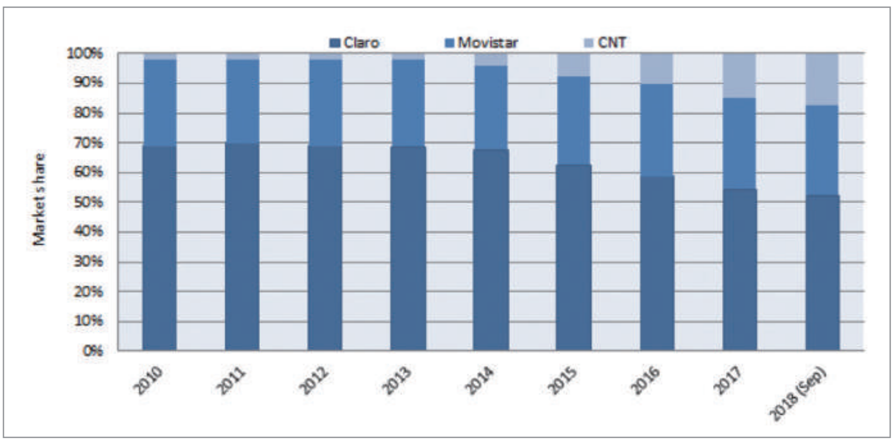
2.1.3 Mobile Market Status

(1) Mobile Market Share

The mobile market leader of Ecuador is Conecel (trading as Claro) with the biggest share; it has a 59% share of the market by subscribers. It is followed by Otecel (trading as Movistar) with about 27% of the market, and CNT (SOE) with a 14% share of the market. The strong triopoly of these three companies (Claro, Movistar and CNT) has made the Mobile Virtual Network Operator (MVNO) field very small in the mobile market up until now.

Figure 3.

Mobile Operators' Market Share 2010~2018



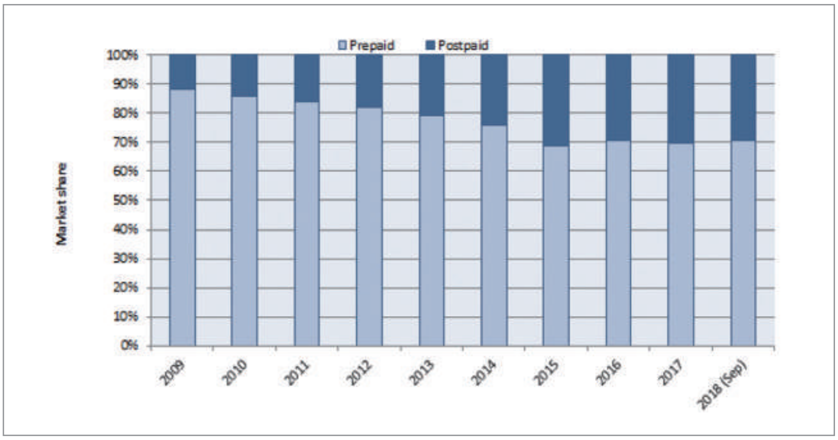
Source: BuddeComm based on Senatel data

(2) Mobile Market Growth

In Ecuador, fixed telecommunications are being replaced by mobile sector. ITU reports that mobile-cellular subscriptions per 100 inhabitants rose from 79.8 subscribers in 2015 to 91.2 subscribers in 2019. Active mobile broadband subscriptions per 100 inhabitants also increased from 35.1 subscribers in 2015 to 53.7 subscribers in 2019.

Like most of the South American mobile market, prepaid subscriptions account for the most of mobile connections in Ecuador. The presence of prepaid services allowed the mobile market to serve a large number of people. However, prepaid subscriptions lead to low ARPUs (Average Revenue Per User). For the advancement of mobile market, payment systems should be diversified and integrated. Fortunately, the proportion of prepaid over postpaid is steadily decreasing since 2009, as postpaid services extend. Since operators are developing more generous mobile data packages, customers are more likely to choose postpaid services. And they are going to use more data for programs presented by Mobile Network Operators (MNOs).

Figure 4.
Mobile Prepaid/Postpaid Ratio 2009~2018



Source: BuddeComm based on regulator data

Despite increasing investment of Claro and Movistar in 5G, it is yet to be commercialized. The key technologies in the Ecuadorian mobile market are Global System for Mobile Communications (GSM), 3G and Long-Term Evolution (LTE). Although the number of subscribers to LTE networks has increased rapidly, companies are reluctant to expand investment to the new technologies in existing infrastructure. Development of LTE technology could be accelerated by the government's support or incentive policy.

In the mid-2000s, Time Division Multiple Access (TDMA) in Ecuador ceased to be used gradually. Code Division Multiple Access (CDMA), which replaced analog services, has also declined rapidly since 2006. From then, the most important technology in the Ecuadorian mobile market was GSM. However, GSM is going downhill today as it is being replaced by 3G technologies.

Table 4.

Number of Subscribers by Technologies in 2019

<table>
<tr><th rowspan="2">Operator</th><th rowspan="2" colspan="2">Technology or Type of use</th><th rowspan="2">Year service started</th><th colspan="2">2019</th></tr>
<tr><th>Subscribers</th><th>Annual revenue, (USD million)</th></tr>
<tr><td rowspan="4">Claro</td><td>2G</td><td>GSM</td><td>2008</td><td>1,452,334</td><td rowspan="4">932,808,399</td></tr>
<tr><td rowspan="2">3G</td><td>UMTS</td><td>2008</td><td>1,970,422</td></tr>
<tr><td>HSPA+</td><td>2012</td><td>1,937,931</td></tr>
<tr><td>4G</td><td>LTE</td><td>2015</td><td>3,132,367</td></tr>
<tr><td rowspan="3">Movistar</td><td>2G</td><td>GSM</td><td>2008</td><td>525,012</td><td rowspan="3">367,973,486</td></tr>
<tr><td>3G</td><td>UMTS</td><td>2009</td><td>1,498,098</td></tr>
<tr><td>4G</td><td>LTE</td><td>2015</td><td>2,433,247</td></tr>
<tr><td rowspan="3">CNT</td><td>2G</td><td>GSM</td><td>2008</td><td>90,785</td><td rowspan="3">182,337,751</td></tr>
<tr><td>3G</td><td>HSPA+</td><td>2014</td><td>57,576</td></tr>
<tr><td>4G</td><td>LTE</td><td>2014</td><td>2,755,329</td></tr>
<tr><td colspan="4"></td><td>Subscribers</td><td>Annual Revenue (USD million)</td></tr>
<tr><td colspan="4">Total</td><td>15,853,100</td><td>1,483,119,636</td></tr>
</table>

Source: MINTEL (2020)

When it comes to 3G technology, Claro and Movistar launched Universal Mobile Telecommunications Service (UMTS) in 2007 and 2009 respectively. And they are now providing nationwide services. Claro is providing both UMTS and Evolved High Speed Packet Access (HSPA+) technology for 3G currently. However, CNT is providing nationwide services using only HSPA+ technology.

In October 2012, regulation authorities adopted Asia-Pacific Telecommunity (APT) to effectively utilize LTE technology. APT is a division standard that covers the use of 700 MHz. CNT, which started its business in 2013, was the only LTE license holder until 2015. The Ecuadorian government implemented this support to CNT in order to actively enhance competition in the LTE mobile market. However, authorities negotiated with Claro and Movistar to allocate spectrum for LTE in early 2014 to break the CNT's monopoly and foster a healthy competition. Currently, this three companies are competing fiercely in the LTE market.

Table 5.

LTE Subscribers by Operator 2014~2018

Year	Claro	Movistar	CNT
2014 (Jan.)	-	-	310
2014	-	-	28,170
2015	195,630	189,990	564,100
2016	623,180	656,770	996,860
2017	1,433,060	876,770	1,873,100
2018 (Sep.)	2,048,650	2,219,180	2,381,330

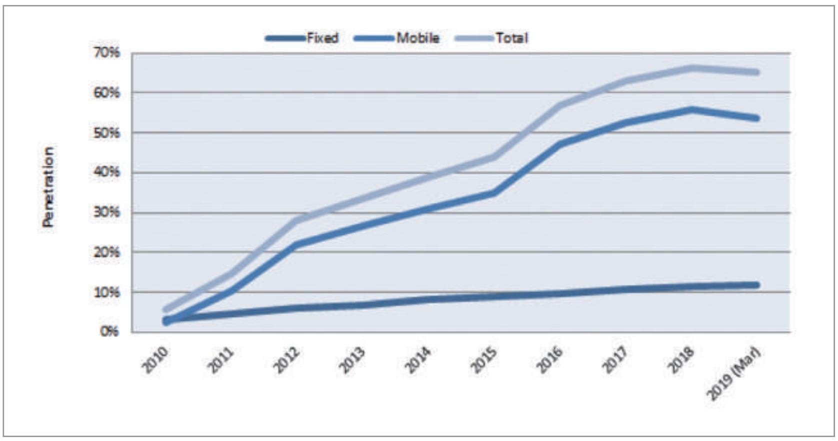
Source: BuddeComm based on Senatel data

2.1.4 Internet Uses

According to ITU and BuddeComm, percentage of internet users in Ecuador had increased from 48.9% in 2015 to 66.3% in 2018. However, a slight decrease is predicted in 2019 compared to 2018; the internet usage rate in March 2019 will be 65.2%.

Figure 5.

Fixed and Mobile Internet Subscriber Penetration 2010~2019



Source: BuddeComm based on Senatel and Supertel data

2.2 Regulatory Framework

2.2.1 Regulatory Environments

The current system of the regulatory framework goes back to 1992 when the Special Telecommunications Law (Ley Especial de Telecomunicaciones) was enacted. The Special Telecommunications Law created the Emetel (Empresa Estatal de Telecomunicaciones, State Telecommunications Company) owned by the State. Emetel was divided into Andinatel and Pacifictel with a view to privatization in 1997. Andinatel and Pacifictel signed five-year contracts that granted them regional monopoly in fixed-line and other telecommunications services in the north and in the south of Ecuador, respectively. Besides these two state-owned companies, Epata, a third municipally owned operator, held an exclusive contract to offer fixed-line service in the Cuenca Municipality.

Repeated privatization efforts during 1997 and 2006 had been unsuccessful. The government dropped the privatization plans of Andinatel and Pacifictel, reuniting and merging them into CNT in 2008. Eventually, Ecuador's telecommunications market was liberalized in January 2002.

2.2.2 Regulatory Authority

Currently, MINTEL is the governing body for the development of information and communication technologies in Ecuador, which include telecommunications and the radio spectrum. MINTEL issues policies, general plans, and monitors and evaluates their implementation, coordinating actions with the stakeholders of the strategic sectors to guarantee equal access to services and promote their efficient and effective use, ensuring progress towards the information society for the good living of the Ecuadorian population.[1] MINTEL was set up by a presidential decree in August 2009. MINTEL acts as the governing body for ICT development in Ecuador and oversees the operations of state-owned CNT.

There had been three telecommunications regulators in Ecuador until April 2015 when legislation was passed which amended the regulatory landscape. Firstly, CONATEL (Consejo Nacional de Telecommunicaciones, The National Telecommunications Council) was the principal telecom regulatory authority. Its main functions included the technical management of radio spectrum and approval of frequency plans, defining the terms of concessions; approving tariffs and interconnection charges, and promoting fair competition among operators. Secondly, SENATEL (Secretaría Nacional

1 https://www.telecomunicaciones.gob.ec/valores-mision-vision/

de Telecomunicaciones, The National Telecommunications Secretariat) implemented telecom policies and provides administrative support to CONATEL. Finally, SUPERTEL (Superintendencia de Telecomunicaciones, The Telecommunications Superintendence) functioned as a supervisory entity. It monitored the use of radio spectrum, supervised telecom operators, and superintended the correct application of tariffs approved by CONATEL. In August 2009, the National Radio and Television Council were merged with CONATEL while CONATEL's administrative functions were taken over by SENATEL.

In April 2015, the National Assembly passed the revised Telecommunications Act, which created the ARCOTEL. ARCOTEL now integrates the functions of management, regulation and control of telecoms and radio spectrum, and combines the functions of SUPERTEL, SENATEL and CONATEL. ARCOTEL regulates the sector in conjunction with the MINTEL.

FODETEL (Fondo para el Desarrollo de las Telecomunicaciones en Areas Rurales y Urbano-marginales, the Fund for the Development of Telecommunications in Rural and Marginalized Urban Areas) was found in 2010 via new regulations. MINTEL took over from SENATEL the management of the fund, which is financed with 1% of operators' revenues. Some of FODETEL's resources have been invested in community telecentres and other public facilities offering ICT access.

In June 2013, the Organic Telecommunications Law (OTL) was passed after 4 years of discussions and postponements since a bill was drafted in 2009 by the order of the Constitution of 2008. In November 2013, MINTEL approved amendments to the Rules of Provision of Value-Added Service (Internet Access). The rules are aimed at ensuring universal access to ICT by increasing the penetration of fixed broadband access and reducing tariffs. The reforms allow access to the internet via an ISP's own infrastructure rather than having to go through a third-party to serve end-users.

MINTEL also approved a resolution aimed at encouraging competitive access to fixed infrastructure in 2013. A survey of underground networks was completed in mid-2014 to facilitate the replacement of copper and coaxial lines with fibre optic cables. The rules make it mandatory for operators to share network infrastructure, including equipment and related civil works such as cable ducts, surveys and cabinets.

The OTL was amended in 2015 to include provisions to ensure universal service, as well as a revised revenue contribution based on a percentage of telcos' subscriber market share. Companies with a market share of between 35% and 75% pay between 1% and 9% of revenue: this excludes CNT.

The central government was granted authority to administer, regulate, manage and control telecom services and radio spectrum, with MINTEL becoming the principal agency under the OTL. The OTL also created ARCOTEL, which works alongside the SUPERTEL to provide control and management functions. This set-up replaced the previous system under which the telecom sector was administered by CONATEL, SUPERTEL and SENATEL.

Table 6.

The Organic Telecommunications Law

TITLE I GENERAL DISPOSITION		
CHAPTER I Preliminary Considerations		
	Art. 1	Object
	Art. 2	Scope
	Art. 3	Objectives
	Art. 4	Principles
	Art. 5	Definition of telecommunications
	Art. 6	Other Definition
CHAPTER II Competences		
	Art. 7	Powers of the Central Government
	Art. 8	Provision of services in a State of Exception
TITLE II NETWORKS AND PROVISION OF TELECOMMUNICATION SERVICES		
CHAPTER I Establishment and exploitation of networks		
	Art. 9	Telecommunications networks
	Art. 10	Public telecommunications networks
	Art. 11	Establishment and exploitation of public telecommunications networks
	Art. 12	Convergence
	Art. 13	Private telecommunications networks
CHAPTER II Provision of telecommunication services		
	Art. 14	Forms of Management
	Art. 15	Delegation
	Art. 16	Telecommunications Reserved to National Security
	Art. 17	Internal communications
	Art. 18	Use and Exploitation of the Radioelectric Spectrum
	Art. 19	Domiciliation
	Art. 20	Obligations and Limitations
TITLE III RIGHTS AND OBLIGATIONS		
CHAPTER I Subscribers, customers and users		
	Art. 21	Definition and type of users

	Art. 22	Rights of subscribers, clients and users
	Art. 23	Obligations of the subscribers, clients and users
CHAPTER II Telecommunication Service Providers		
	Art. 24	Obligations of telecommunication service providers
	Art. 25	Rights of telecommunication service providers
TITLE IV EX-SECTORAL REGULATION FOR THE PROMOTION, PROMOTION AND PRESERVATION OF THE CONDITIONS OF COMPETITION		
CHAPTER I Regulation Types		
	Art. 26	Sector regulation
	Art. 27	Scope of regulation
	Art. 28	Economic regulation
	Art. 29	Technical regulation
	Art. 30	Regulation of access
CHAPTER II Market regulation		
	Art. 31	Determination of relevant markets
	Art. 32	Imposition of obligations
	Art. 33	Operator with market power and preponderance
	Art. 34	Payment for market concentration to promote competition
	Art. 35	Telecommunications Services
	Art. 36	Types of Services
	Art. 37	Enabling Titles
	Art. 38	General Authorization
	Art. 39	General Conditions of public companies for the provision of services
	Art. 40	Award and Renewal Criteria
	Art. 41	Registry of Services
	Art. 42	Public Telecommunications Registry
	Art. 43	Duration
	Art. 44	Transfer or Assignment
	Art. 45	Content of the Enabling Titles
	Art. 46	Extinction of the Qualifying Titles
	Art. 47	Extinction of the qualifying titles of broadcasting services
	Art. 48	Rights for the Granting of Qualifying Titles
	Art. 49	Changes of Control
CHAPTER II Use and Exploitation of the Radio Spectrum		
	Art. 50	Granting

	Art. 51	Direct Award
	Art. 52	Competitive Public Process
	Art. 53	Frequencies for private use
	Art. 54	Rights and Rates for Spectrum Use
	Art. 55	Preferential Law of Public Companies
	Art. 56	Duration
	Art. 57	Reassignment
	Art. 58	Compensation
	Art. 59	Use and Exploitation of the radio spectrum for radio broadcasting services
	Art. 60	Rates for Adjudication and Use of Frequencies for Broadcasting Services Holders
	Art. 61	Approval of Rates for Adjudication and Use of Frequencies for Services of Broadcasting
SOLE CHAPTER Regime and Regulation		
	Art. 62	Rate regime
	Art. 63	Rate regulation
	Art. 64	Applicable rules
TITLE VII INTERCONNECTION AND ACCES		
CHAPTER I Common provisions		
	Art. 66	Principles
	Art. 67	Interconnection
	Art. 68	Access
	Art. 69	Obligation
	Art. 70	Faculty of intervention
	Art. 71	Economic regulation of interconnection and access
	Art. 72	Negotiation and agreement
	Art. 73	Interconnection or access provisions
	Art. 74	Approval and modification
	Art. 75	Prohibition
TITLE VIII SECRET OF COMMUNICATIONS AND PROTECTION OF PERSONAL DATA		
CHAPTER I Communications secret		
	Art. 76	Technical security and invulnerability measures
	Art. 77	Interceptions
CHAPTER II Protection of personal data		
	Art. 78	Right to privacy

	Art. 79	Information duty
	Art. 80	Disclosure procedures
	Art. 81	Telephone or subscriber guides in general
	Art. 82	Commercial use of personal data
	Art. 83	Technical control
	Art. 84	Delivery of information
	Art. 85	Additional obligations
TITLE IX TELECOMMUNICATIONS EQUIPMENT		
SOLE CHAPTER Homologation and Certification		
	Art. 86	Obligation
	Art. 87	Prohibitions
TITLE X SOCIETY OF INFORMATION AND KNOWLEDGE AND UNIVERSAL SERVICE		
SOLE CHAPTER Promotion of the Information Society and Provision of Universal Service		
	Art. 88	Promotion of the Information and Knowledge Society
	Art. 89	Universal service
	Art. 90	Universal Service Plan
	Art. 91	Execution of universal service projects and programs
	Art. 92	Contribution
TITLE XI SCARCE RESOURCES AND OCCUPATION OF ASSETS		
CHAPTER I Radio spectrum allocation		
	Art. 93	Management
	Art. 94	Objectives
	Art. 95	Planning
	Art. 96	Use
CHAPTER II Numbering Resource		
	Art. 97	Administration and management of the resource
	Art. 98	Assignment
	Art. 99	Prohibition of assignment or transfer
	Art. 100	Conservation of the number
CHAPTER III Property occupation		
	Art. 101	Right of occupation
	Art. 102	Expropriation power
	Art. 103	Procedure
	Art. 104	Use and Occupation of Public Domain Assets
	Art. 105	Easement of Passage or Occupation

	Art. 106	Infrastructure Sharing
CHAPTER IV Orbital resources and satellite services		
	Art. 107	Management before the International Telecommunication Union
	Art. 108	Regulation and control
	Art. 109	System of use and services
TITLE XII BROADCASTING SERVICES		
SOLE CHAPTER Installation of Infrastructure and Technical Characteristics		
	Art. 110	Term to Install
	Art. 111	Compliance with Regulations
	Art. 112	Modification of the Enabling Title
	Art. 113	Infrastructure Sharing
	Art. 114	Technical Characteristics
	Art. 115	Classification
TITLE XIII SANCTIONARY REGIME		
CHAPTER I Offenses		
	Art. 116	Subjective scope and definition of responsibility
	Art. 117	First class offenses
	Art. 118	Second class offenses
	Art. 119	Third Class Offenses
	Art. 120	Fourth class infractions
CHAPTER II Sanctions		
	Art. 121	Classes
	Art. 122	Reference amount
	Art. 123	Destination of the fines
	Art. 124	Closure of radio broadcasting stations
	Art. 125	Sanctioning power
	Art. 126	Opening
	Art. 127	Evidence
	Art. 128	Powers of investigation
	Art. 129	Resolution
	Art. 130	Extenuating
	Art. 131	Aggravating conditions
	Art. 132	Legitimacy, enforcement and corrective measures
	Art. 133	Preventive measures
	Art. 134	Appeal

	Art. 135	Prescription
CHAPTER IV Intervention and Reversal of Assets by Revocation		
	Art. 136	Intervention
	Art. 137	Procedure of intervention
	Art. 138	Reversal of assets due to revocation of the enabling title
	Art. 139	Disqualification
TITLE XIV INSTITUTIONALITY FOR REGULATION AND CONTROL		
CHAPTER I Ministry of Telecommunications and the Information Society		
	Art. 140	Stewardship of the sector
	Art. 141	Powers of the Governing Body
CHAPTER II Telecommunications Regulation and Control Agency		
	Art. 142	Creation and nature
	Art. 143	Domicile and deconcentration
	Art. 144	Powers of the Agency
	Art. 145	Directory
	Art. 146	Powers of the Board of Directors
	Art. 147	Executive Director
	Art. 148	Powers of the Executive Director
GENERAL DISPOSITION		
TRANSITORY DISPOSITIONS		
DEROGATORY PROVISIONS		
FINAL PROVISIONS		

2.2.3 Licensing System of Telecommunications Services

Article 36 of OTL defines telecommunications services as those services that are supported on networks of telecommunications in order to allow and facilitate the transmission and reception of signs, signals, texts, video, images, sounds or information of any nature, to satisfy the telecommunications needs of subscribers, customers, and users. Examples of the telecommunications services are the fixed and mobile telephony, carriers and value-added. Fixed or mobile telephone service providers may provide other services such as carriers and value-added that can be supported on your network and platforms, in accordance with the regulation that is issued for the effect.

Article 37 says that ARCOTEL may grant enabling titles such as concession, authorizations and registry of services. Concession is required for services such as fixed telephony and advanced mobile service as well as for use and exploitation of the spectrum, by mixed economy companies, by private initiative, and by the popular and solidarity economy. Authorization is required for the use and exploitation of the spectrum, by public companies and State institutions. The registry is required for the provision of carrier services, submarine cable operators, radio amateurs, value aggregate, radio communication, networks and private use and resale activities. ARCOTEL will determine the values for the payment of concession and registration rights as well as the values for the payment of authorizations. If the services which require registration want to use frequencies, they must previously request and obtain the concession or authorization, as appropriate.

Article 38 defines general authorization as the instrument issued through resolution by the Agency for the Regulation and Control of Telecommunications. Once the requirements established in the law have been met current legal, which will establish the approved terms, conditions and deadlines, and will incorporate, if applicable, the use and exploitation of the respective essential frequency bands of the spectrum, necessary for the provision of the service. The general authorization will be granted for the provision of telecommunications services such as fixed telephony and advanced mobile service, and will be implemented through concessions or authorizations, as applicable. Fixed or mobile service providers who have a general rating may also provide other services, such as carrier and value-added services, for example but not limited, for whose provision only registration of services is required.

Article 39 describes general conditions of public companies for the provision of services. Public companies are granted by authorization and instrument of accession, in favor of public companies constituted for the provision of telecommunications services that meet the requirements established by the ARCOTEL. The public companies will enjoy the exemptions, exceptions, exonerations and prerogatives established in the laws without prejudice. Public companies and public entities for the provision of telecommunications services, on the one hand, will be obliged to pay the rights, fees, contributions and other obligations established in this law, except for: 1) by granting or renewing qualifying titles, and 2) for granting or renewal of authorization of frequencies for its use and exploitation. On the other hand, public telecommunications companies must comply with public policy issued by the governing body of telecommunications and with the obligations of a social nature, universal service or the execution of public policies that provide the ARCOTEL to accrue the radio spectrum allocation made by the State. These obligations are independent of those related to the contribution to the Telecommunication Development Fund.

Article 40 explains the procedure for award and renewal criteria. For the granting and renewal of qualifying titles for the provision of services to joint ventures, popular and solidarity economy organizations and private companies, the ARCOTEL will consider the need to attend to: technological development, the evolution of markets, the National Telecommunications Plan, the needs for the sustained development of the sector and the State and universal access to ICT, as well as the effective satisfaction of the public interest or general. The government may deny the granting or renewal of such titles considering the regulations, provisions or policies that are issued for this purpose, before the application process for granting the enabling title or its renewal. Given the nature of the granting of qualifying titles for the provision of telecommunications and use of the radio spectrum, as well as its renewal, the institution of positive administrative silence. Before issuing the renewal decision, compliance with the terms and conditions of the enabling title that is about to expire, for which the ARCOTEL will issue the respective report. The renewal of the qualifying titles will be for a period equal to that originally granted and may be carried out in an updated legal regime in accordance with the technological evolution of the service and Market situation.

In the case of applications for the granting of new qualifying titles, it must be evaluated whether some company or group of companies related to the applicant for the title provides the same service or similar services and the effects that the granting of the new title may have on the market enabling agent; For this purpose, an affidavit must be presented on bonding.

Article 43 says that the duration of the concessions and authorizations for the provision of Telecommunications Services is up to 15 years. The duration of the other qualifying titles will be established in the regulations issued by the ARCOTEL. However, the term of duration may not exceed 15 years, except for submarine cable operators and public companies of telecommunications.

Article 44 says that the qualifying titles may not be alienated, assigned, transferred, leased or taxed by any means without authorization from the ARCOTEL.

2.2.4 Regulation on Radio Spectrum

Article 50 says that for the purposes of granting qualifying titles for radio spectrum frequencies, the State will attend to the public interest, promote the rational and efficient use of said limited resource, it will guarantee equal, equitable access and allocation in conditions of transparency. The granting of qualifying titles of radio spectrum frequencies, observing the guiding principle of technical, social and economic efficiency, may be carried out through direct award or competitive public bidding process, in accordance with the provisions of the Regulation to Grant Qualifying Titles issued by the ARCOTEL.

Article 51 describes conditions for direct award of radio spectrum frequency such as: 1) non-essential frequencies, 2) essential frequencies required for the introduction of new technologies or improvements in the service, when the holder of the enabling title is providing the service or to be granted to a new provider of services that are not of a massive nature, 3) frequencies for public companies and public entities, 4) shared use bands, 5) reassignment of frequencies, 6) registration of services, 7) renewal of qualifying titles, in the cases established in the Regulations for Granting Qualifying Titles or resolutions of the Agency for the Regulation and Control of Telecommunications, and 8) private networks.

Article 52 says that concessions for use and exploitation will be granted through a competitive public bidding process when: 1) the number of applicants exceeds the number of frequencies available for granting, 2) the number of service or use and exploitation concessions of spectrum frequencies that is planned to be granted is limited, for reasons of public interest, of development technological or market evolution, 3) the frequencies or frequency bands to be granted to a new service provider have a high economic valuation, in accordance with the evaluations made by the Agency of Telecommunications Regulation, or 4) frequencies or frequency bands are intended for the provision of character services massive by a new provider.

Article 54 describes rights and rates for spectrum use. The ARCOTEL will set the value of the rights for the granting of qualifying titles, as well as fees for the use and exploitation of the radio spectrum. The setting of the parameters and the establishment of models for the determination of the referred amounts must attend to the public interest; the evaluation of the radio spectrum; income estimates for dealers; investments made, or to be made, by the concessionaires; coverage rates; contractual stipulations; compliance with social obligations or Universal Service; type of services and the massive nature that these may have, as well as the contribution of the concessionaire for the development of projects that promote the society of the information and knowledge, among others.

Article 55 describes preferential treatment of public companies, saying that public companies that provide telecommunications services will have a preferential right for the use and exploitation of the radio spectrum, in accordance with the existing availability.

Article 56 says that the qualifying titles for the use and exploitation of the radio spectrum will have the same duration of the title enabling the service or services to which they are associated and are they will find integrated in a single instrument. If their duration is not associated with any service, it will be five years. In the event that concessionaires for the exploitation of telecommunications services request and be granted additional essential frequencies, the ARCOTEL may provide for the readjustment of the terms, conditions and deadlines of the qualifying title for the operation of the service, as long as the following are met terms: 1) that the granted frequencies or essential frequency bands have a high economic valuation, 2) that it is a massive service, and 3) that the need for an extension of the term of the concession contract for the operation of the service, so that there is sufficient time for the amortization of the investment to be made by the operator. The concessionaire must pay the concession rights and payment for the use of respective frequencies that implies the extension of the term. In the event of termination of the title enabling the service for the established reasons, it will be understood that the authorization for the use of radio spectrum associated with said title also expired.

Article 57 describes the conditions for reassignment of radio spectrum and Article 58 deals with compensation related with reassignment.

Chapter 3.

Introduction Plan for IMT Technology

3.1 IMT Technology Roadmap

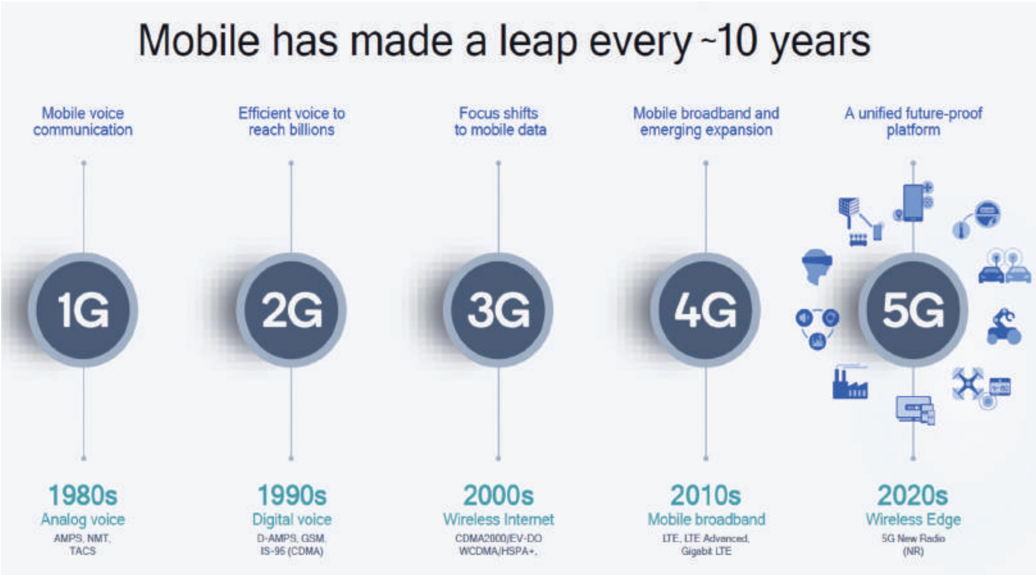
3.1.1 History of IMT Technology

Mobile telecommunication has continued to evolve into a new generation every 10 years. 2G has spread due to standardization, market competition, and service effects. And 3G has been delayed due to a combination of economic slowdown, lack of performance and service differentiation compared to 2G, lack of market competition, and stagnant application ecosystem. In 4G, the full-fledged distribution of smartphones, the activation of the application ecosystem around the mobile OS platform, and the significant improvement in mobile communication performance has greatly affected the spread.

5G is characterized by its consideration of various aspects such as latency, spectrum efficiency, connection density, and reliability, which is different from the existing mobile telecommunication that has evolved around transmission speed.

Figure 6.

Evolutionary Process of Mobile Communication Generation

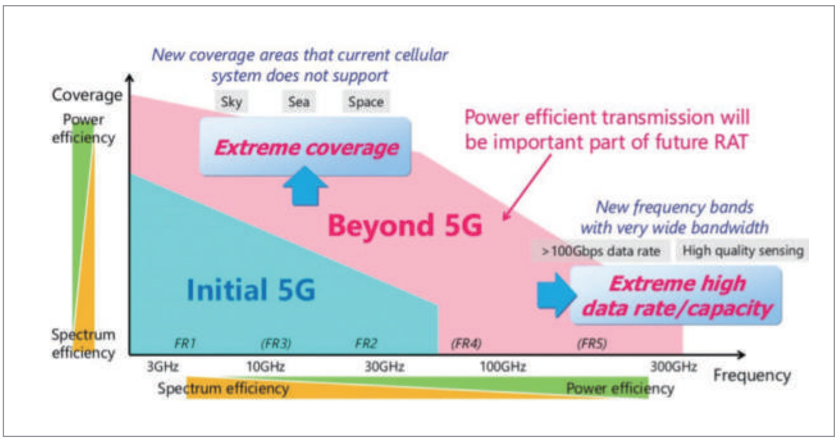


Source: Qualcomm (2020b)

Even though the 5G market is not yet on full track, discussions and research on 6G technology have already begun. For the reason, it usually takes about 10 years to develop, standardize, and discuss global harmonic frequencies, when a new generation enters commercialization, technology research for the next generation will be launched. South Korea has also established a strategy to promote 6G mobile telecommunication R&D and plans to provide about USD 170 million over the next five years.

Figure 7.

Deployment of 5G and the Roadmap to 6G



Source: Aljumaily, Mustafa (2020)

3.1.2 Technological Progression of Mobile Communications in Korea

Since Korea first introduced 1G in 1984—two to three years later than advanced countries—it introduced 2G in 1996, 3G in 2002, and 4G (LTE) in 2011, and succeeded in commercializing 5G for the first time in the world in 2019, rising from a latecomer in mobile communication technology to a starter.

Prior to promoting commercialization of 4G, Korea conducted standardization by considering international standards, and domestic technologies such as WiBro-Evolution being applied to 4G standardization, and standardization being completed in cooperation with international organizations centered on private standardization agencies.

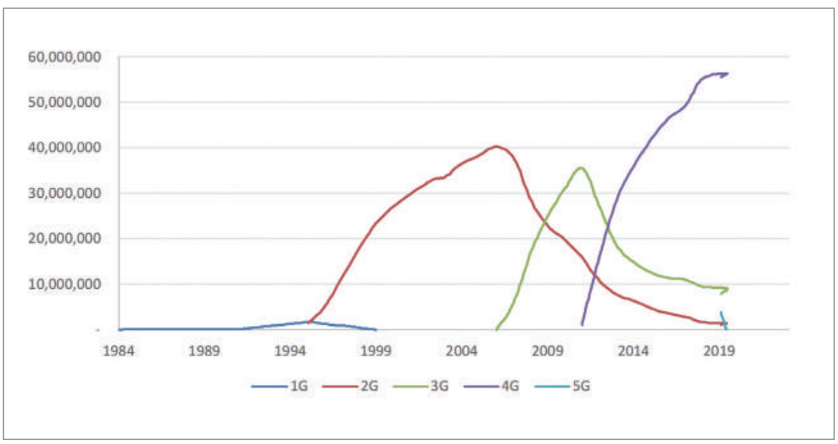
Furthermore, the world's first commercialization of 5G in Korea was supported by active participation in international discussions such as 5G service vision and spectrum, domestic prior research, pilot service promotion, and active service provision by major mobile carriers.

1G (telephone), 2G (text), 3G (low-capacity video), and LTE (real-time video) had no choice but to provide B2C (Business to Consumer) services limited to mobile phones due to their performance. On the other hand, 5G has the potential to provide B2B (Business to Business) convergence services to various industries by being applied to various high-tech terminals as well as mobile phones.

[Figure 8] is the result of analyzing the life cycle of each generation of mobile telecommunication in Korea. The number of 3G subscribers began to increase gradually in 2006, and has been decreasing continuously since the peak was reached in 2011. Based on the decreasing pattern of 2G services, 3G subscribers are also expected to remain at the 1 million levels over the next 10 years.

Figure 8.

Lifecycle of Mobile Generations in Korea



Source: KCA

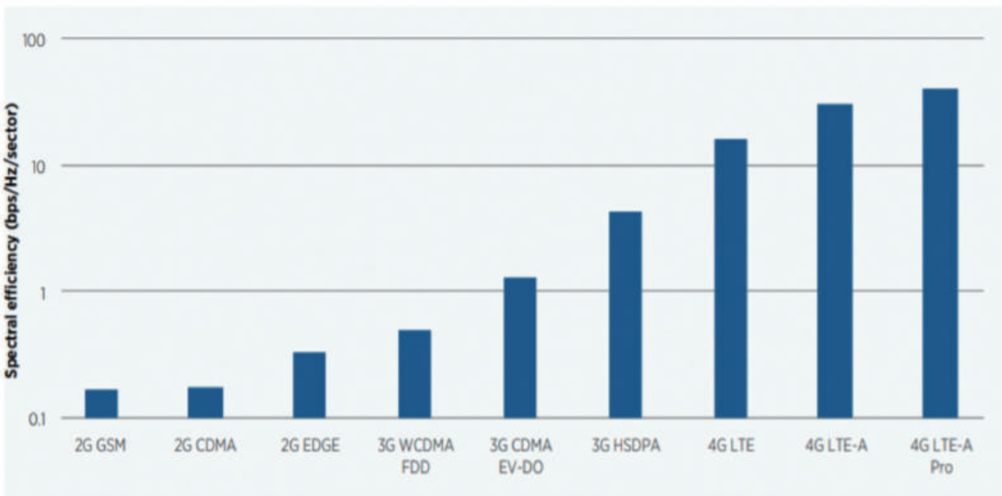
3.1.3 Driving Factors for Next Technology

The rationalization of legacy networks is driven by factors slightly different from the introduction of new technologies and the spread of the next generation. There are several factors, but the main drivers being:

- More efficient use of spectrum;
  - The increased efficiency offered by newer technologies can then be translated into significant cost savings and increased coverage for subscribers.

Figure 9.

The Evolution of Maximum Achievable Spectral Efficiency of Mobile Technologies from GSM to 4G LTE-A PRO



Source: Network Strategies

- Spectrum harmonization;
  - It refers to the consistent allocation of frequency bands across countries. Harmonizing spectrum enables economies of scale and facilitates cross-border coordination and roaming for end users.
- Spectrum license expiry;
  - The expiry of spectrum rights can be an important factor in triggering the decommissioning of a legacy network, if other market conditions are met. Also, the expiration of the license is an opportunity to streamline the use of spectrum.
- Reducing operational costs; and
  - As running multiple generations of mobile networks simultaneously is economically inefficient, operators tend to decommission the redundant legacy networks to

reduce operational costs.

- In Korea, the desire to switch off 2G was based on the obsoleteness of 2G (CDMA) networks where key components can be no longer be procured. In addition, since handset manufacturers such as Samsung and LG have not provided 2G handsets since 2014, any technical problems arising from out-of-date 2G handsets cannot be easily rectified.

- Meeting increasing demand for mobile broadband and data intensive applications.

Table 7.

Key Switch-off Drivers in Case Study Markets

Market	Spectrum reuse for 3G/4G	Spectrum harmonisation	Spectrum license expiry	Cost optimisation	Declining 2G demand
Australia	■			■	■
Japan		■		■	
Macao, SAR	■				■
New Zealand	■			■	■
Singapore	■		■		■
South Korea	■			■	■

Source: Network Strategies

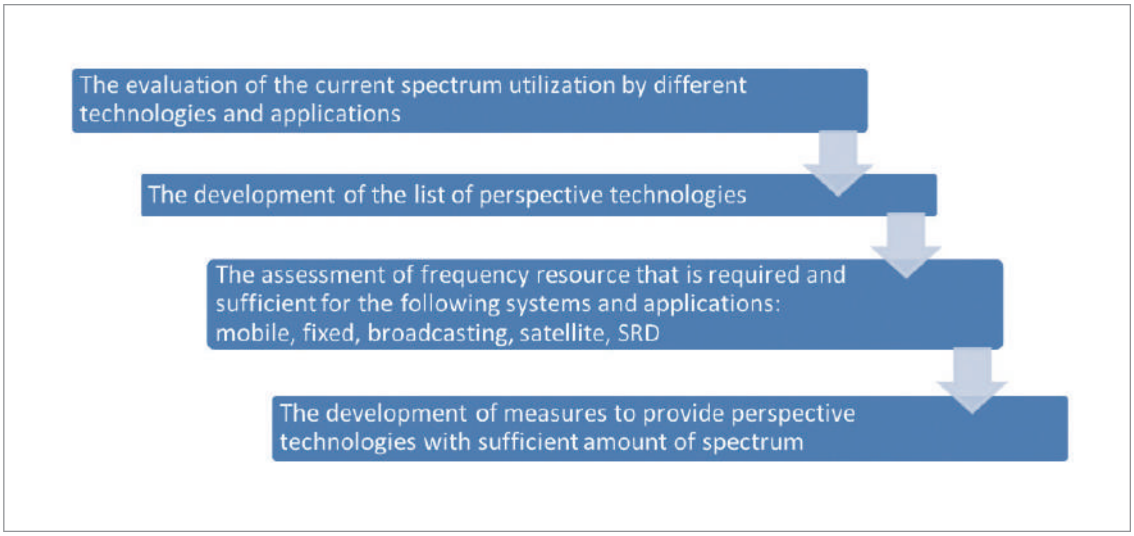
3.1.4 Spectrum Strategy for Introducing New Technologies

Although many countries have researched and analyzed the current status of spectrum utilization periodically, it is difficult to produce an appropriate policy that takes into account future demand and supply comprehensively because of the limitations from fragmentary and qualitative analyses. As a result, some countries have recently applied a method of discovering candidate bands and evaluating their priority in order to reserve spectrum systematically in the long-term planning process.

If spectrum resources are to adequately support national goals and objectives, long-term planning is essential. It can provide a basis for effective spectrum management to ensure that spectrum is efficiently allocated and assigned to accommodate constantly evolving spectrum requirements by new systems and their applications.

Figure 10.

Process of Development of a Long-term Spectrum Planning



Source: ITU-R (1998)

[Table 8] shows the amount of spectrum (total MHz) currently assigned for mobile use in major countries or under investigation for potential future allocation. Data such as assigned bandwidth and future plans of leading mobile communication countries will be a reference to Ecuador's long-term spectrum strategy.

Table 8.

Comparison of Total Mobile Spectrum in Different Markets

Low band: current + potential future assignments (total MHz)[2]

	450	EU 700	800	900	EU 1500	1800	1900 and 2000[1]	2100	2300	2400 unlicensed	2600	Total licensed	Total unlicensed
France		85	60	70	90	150		120		84	180[2]	755	84
Germany		75	60	70	40	150		120		84	190	705	84
Italy		60	60	70	40	140		120		84	150	640	84
Qatar		60	40	44		80		60		84	80	364	84
Spain		60	60	70	40	150		120		84	180	680	84
Sweden	10	60	60	70	90	140		120	80	84	190	820	84
UK		80	60	70	40	150[3]		120	40	84	175[4]	735	84
	600	NAM 700	850	900	ATC spectrum[5]	PCS	AWS-1/ AWS-2	AWS-3/ AWS-4	2300 (WCS)	2400 unlicensed	2600		
US	70	70	64[6]	6	30	130	100	105	20	84	180[7]	775	84
Canada	70	68	50			130	90	90	30	84	190	718	84
	600	APT 700	850	900	Japan 1500	1800	1900 and 2000[1]	2100	2300	2400 unlicensed	2600		
Australia		90	70	50		150		120	100	84	140	720	84
China		80	20	52		140	50	90	70	84	160	662	84
Hong Kong	70**	90**	25	60		150		118	90	84	140	743	84
Japan		60	60	30	70	150	31[8]	120		84	80[9]	601	84
S. Korea		40	60	20		120		120	80	84	160	600	84

Mid band: current + potential future assignments (total MHz)[4]

	3.3–3.4GHz	3.4–3.6GHz	3.6–3.8GHz	3.8–4.2GHz	4.2–4.5GHz	4.5–5GHz	5.15–5.895GHz unlicensed	5.925–6.425GHz unlicensed	6.425–7.125GHz	Total licensed	Total unlicensed
France		110	200				455	500		310	955
Germany		200	100+100*				455	500		400	955
Italy		126	200				455	500		326	955
Qatar		200	200				580			400	580
Spain		160	200				455	500		360	955
Sweden		190	120+80*				455	500		390	955
UK		190	200	400*			580	500		790	1080
US	100[1]	200[1,2]	200[2]	180			625	500	700[3]	600	1905
Canada		150[4]	150[4,5]	180[5]			530			480	530
Australia		200	200	400[6]			430			700	430
China	100**	200				160	260			460	260
Hong Kong	100**	200				160	580			460	580
Japan		200	200	300		100+200*	560[7]			1000	560
S. Korea		200	200	200			440			600	440

High band: current + potential future assignments (total MHz)[6]

	24.25–27.5GHz	27.5–29.5GHz	37–43.5GHz	45.5–47GHz	47.2–48.2GHz	57–66GHz unlicensed	66–71GHz unlicensed	71–76GHz	81–86GHz	Total licensed	Total unlicensed
France	3250[1,‖]					9000	5000			3250	14 000
Germany	3250*					9000	5000			3250	14 000
Italy	1000					9000	5000			1000	14 000
Qatar	800[‖]					4700				800	4700
Spain	1400[‖]					9000	5000			1400	14 000
Sweden	3250*					9000	5000			3250	14 000
UK	3250[2]*[‖]					9000	5000			3250	14 000
US	2950	850	3500[3]		1000	9000	5000			8300	14 000
Canada	1000	850	3000			9000	5000			4850	14 000
Australia	2400					9000	5000			2400	14 000
China	2750[‖]		5500[‖]			5000				8250	5000
Hong Kong	3250	850*				9000				4100	9000
Japan	500	2000*				9000				2500	9000
S. Korea	3000	1400				7000				4400	7000

Currently assigned spectrum | Spectrum being investigated for potential future use

Sources: Analysys Mason (2020)

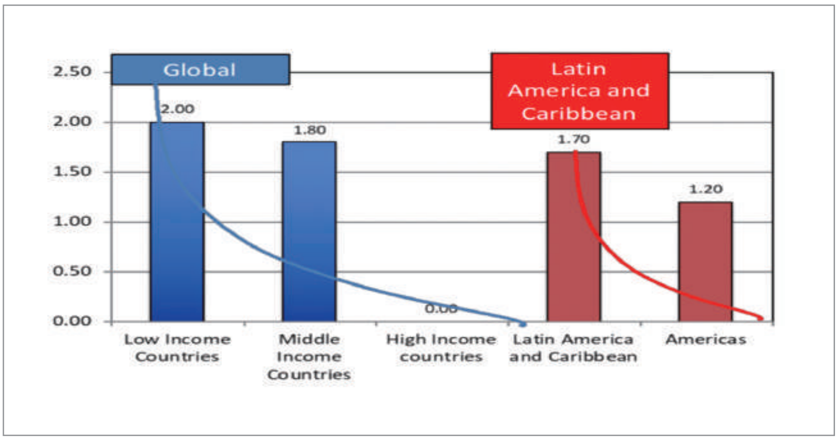
3.2 Evolution of Mobile Broadband

Broadband access refers to technologies that provide access to the Internet at download speeds of 256 kbit/s or greater. Broadband can further be divided into fixed broadband (FBB) and mobile broadband (MBB). FBB includes DSL (Digital Subscriber Line), cable modem, fibre-to-the-home and other fixed technologies (such as broadband over power lines and leased lines). MBB includes 3G with HSPA and other recently developed high-speed mobile connection such as 4G LTE or 5G. GSMA (2018a) reports that MBB technology has spread very rapidly, with global connections increasing from approximately 27,000 in 2001 to 5.5 billion in 2018.

The expansion of MBB can have positive effects on economic development. First, MBB usage can enable a fast distribution of information and new ideas, which should give rise to large productivity increases. Second, MBB can enhance competition in many product markets. For instance, it enables consumers to compare prices and conduct market transactions. As displayed in [Figure 11], the empirical study by ITU (2019b) has estimated that the economic impact of MBB is higher in lower income countries, and reported that an increase of 10% in MBB penetration yielded an increase in 1.7% in GDP of Latin Americas and Caribbean nations, which is slightly higher than the global average 1.5%.[2]

Figure 11.

Economic Impact of MBB



Source: ITU (2019b)

Moreover, the literature shows that MBB has a higher impact of on the world economy than FBB has, and suggests that countries with scarce fixed deployment can benefit more from MBB.[3] In Ecuador, poor fixed-line infrastructure has stymied

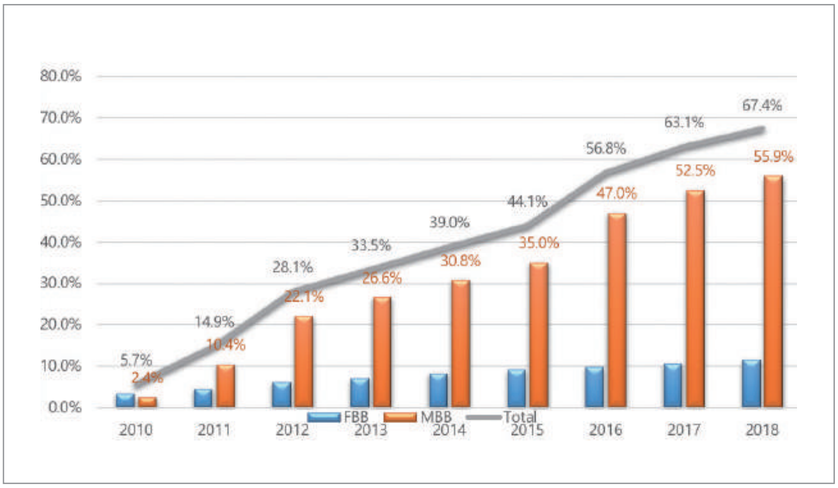
2 Similarly, Edquist et al. (2018) and by Bahia et al. (2019) conclude that the impact of MBB is higher in lower income countries.

3 Refer to Lee et al. (2012), ITU (2018), and Bahia et al. (2019).

the development of FBB services and MBB appears to be the only viable alternative to offer broadband services to the population. Hence, the government should be able to accept MBB as an opportunity of economic growth and regard it as a means to leapfrog over investing its poor fixed-line infrastructure. For reference, National Broadband Plan (2016~2021) of Ecuador has been implemented to expand and improve Internet access for all Ecuadorians. This plan aims at arming its public institutions with digital technologies and providing citizens with easy access to high speed Internet. More specifically, the plan targets at increasing 4G LTE coverage to 80% of population and MBB penetration to 64% by 2021.[4]

Figure 12.

Ecuador's Broadband (MBB & FBB)



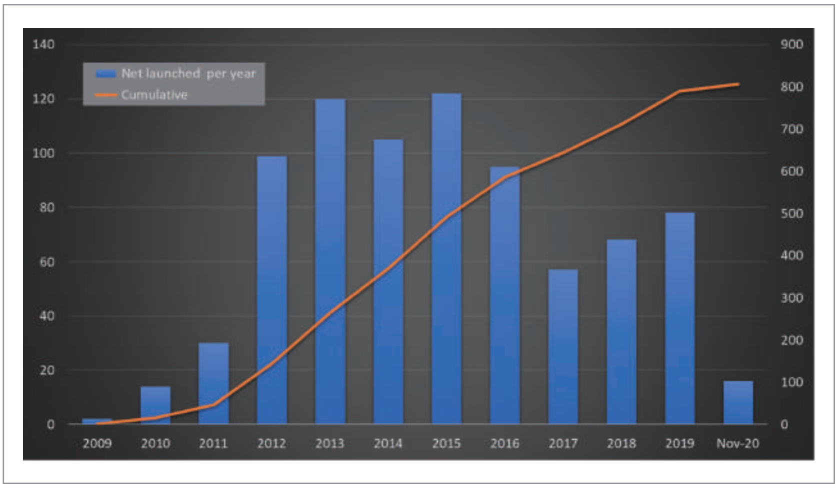
Source: Lancaster, Henry (2020)

3.3 5G Technology

These days, LTE is the mainstream of mobile communication technology. By November 2020, LTE subscriptions became more than 5.4 billion worldwide. More than 900 operators have plans to invest in LTE or are aggressively investing in LTE networks. The mobile communication services and Fixed Wireless Access services with LTE networks already are being provided in 237 countries or territories worldwide.

4 The plan also targets at smartphone penetration to 42% and mobile phone penetration in households to 91%.

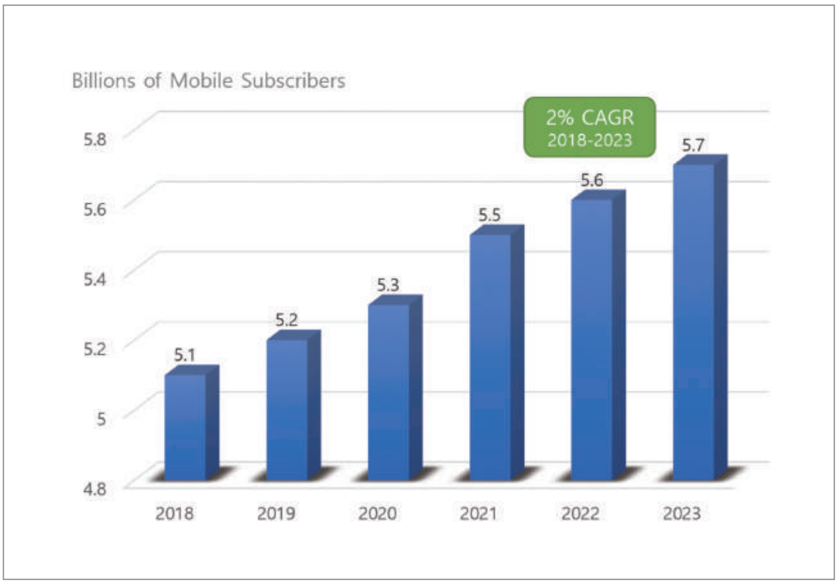
Figure 13.
Growth of LTE



Source: GSA (2017)

As mobile network coverage expands, mobile subscriptions are also increasing every year. Owing to the development of mobile technologies and the explosion of media content usage by smartphone or other mobile devices, mobile subscriptions and mobile traffic have been increased dramatically. Over 70 percent of the global population will have mobile connectivity by 2023. The total number of global mobile subscribers will increase from 5.1 billion (66 percent of the population) in 2018 to 5.7 billion (71 percent of the population) by 2023.

Figure 14.
Global Mobile Subscriber Growth

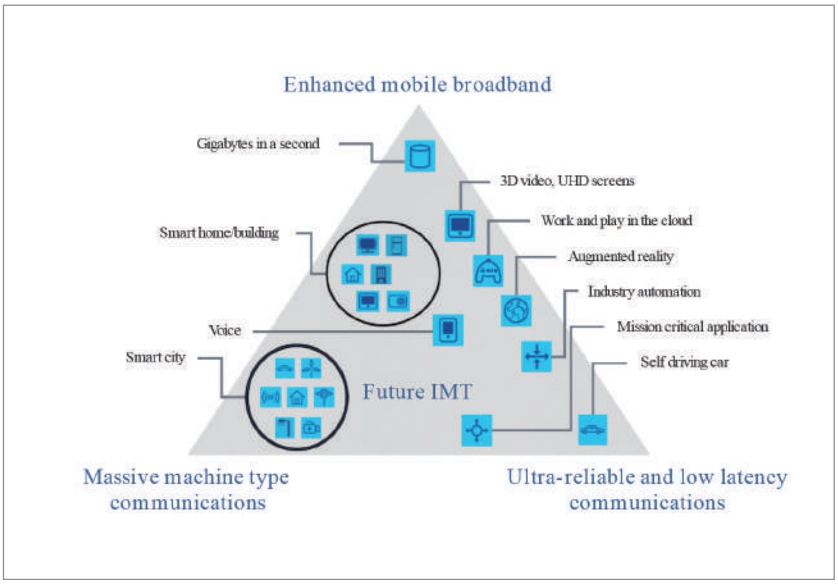


Source: Cisco (2018)

Consequently, the insatiable demands for the faster or higher quality of services are rising and always require the higher performance and capacity of mobile technology. So, the 5G technology was introduced as the succeeding mobile technology after LTE. This new technology makes it possible for us to provide higher performance and capacity for mobile networks. 5G has several remarkable features compared with 3G and 4G. Networks using 5G technology are scalable, programmable and sliceable. Therefore, 5G will be a significant infrastructure technology to support various types of services.

The ITU Radiocommunication Sector (ITU-R) specified three main usage scenarios for 5G, Enhanced Mobile Broadband (eMBB), Ultra-reliable and low latency communications, and Massive Machine Type Communications (mMTC). The eMBB feature is the typical key factor of mobile communications related to legacy systems. This feature can be obtained by using a wider spectrum bandwidth. Meanwhile, Low latency for real-time service can be improved by enhanced network and protocol architecture rather than wider spectrum bandwidth. The representative use case of mMTC is IoT (Internet of Things), such as massive sensors. IoT devices use relatively narrow spectrum bandwidth. In case of 5G, the specific spectrum with just enough bandwidth will be preferred. From these usage scenarios, a broad variety of capabilities were derived, and the current and future trends will be considered as well. As a result, under the key design principles, flexibility and diversity, 8 parameters are considered as key capabilities of IMT-2020.

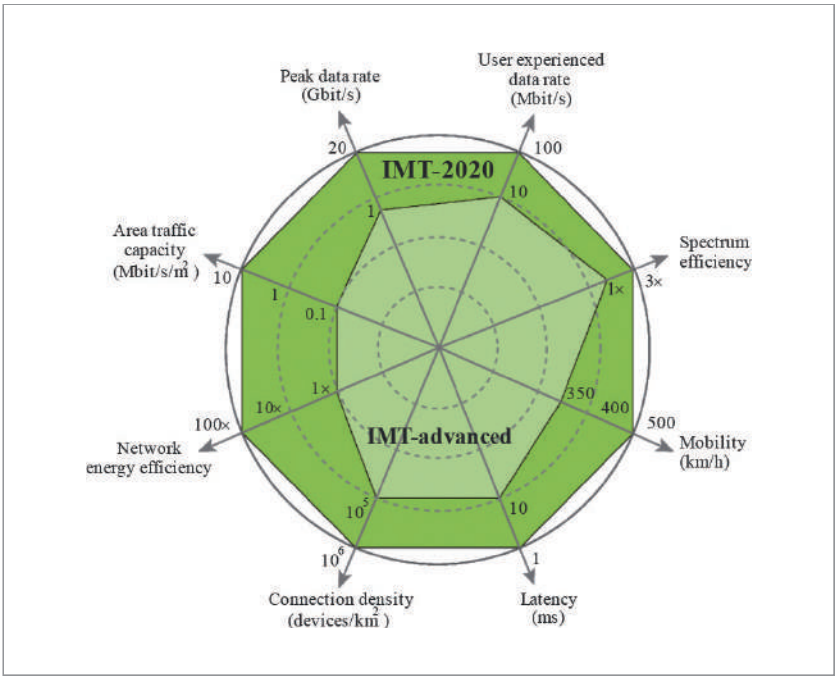
Figure 15.
Usage Scenarios of IMT for 2020 and Beyond



Source: ITU-R (2015a)

Figure 16.

Enhancement of Key Capabilities of IMT-Advanced to IMT-2020

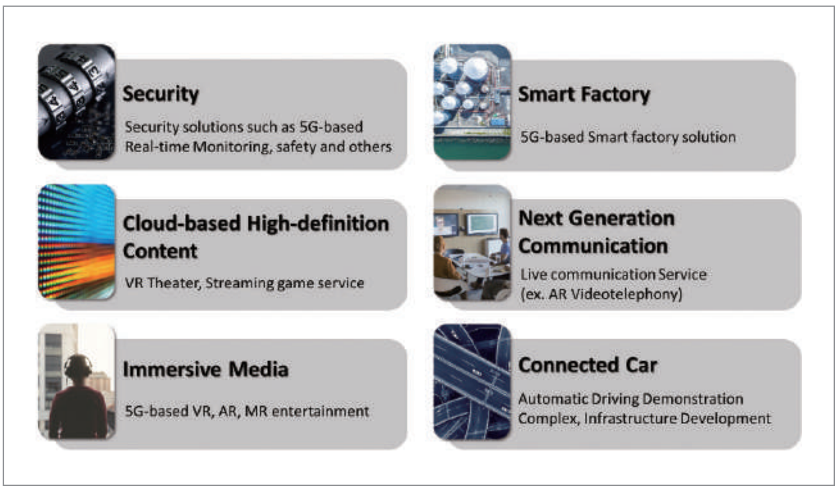


Source: ITU-R (2015a)

[Figure 17] shows the advanced key capabilities of 5G compared with those of 4G. Based on these key capabilities, 5G represents the next major phase of mobile technology beyond the current 4G LTE technology and it is transforming the role of mobile in society. These features of 5G networks make it possible to provide faster data speeds, lower latency, larger network capacity, mobile edge computing, etc. The representative 5G services with the remarkable 5G features are as follows.

Figure 17.

Examples of 5G services



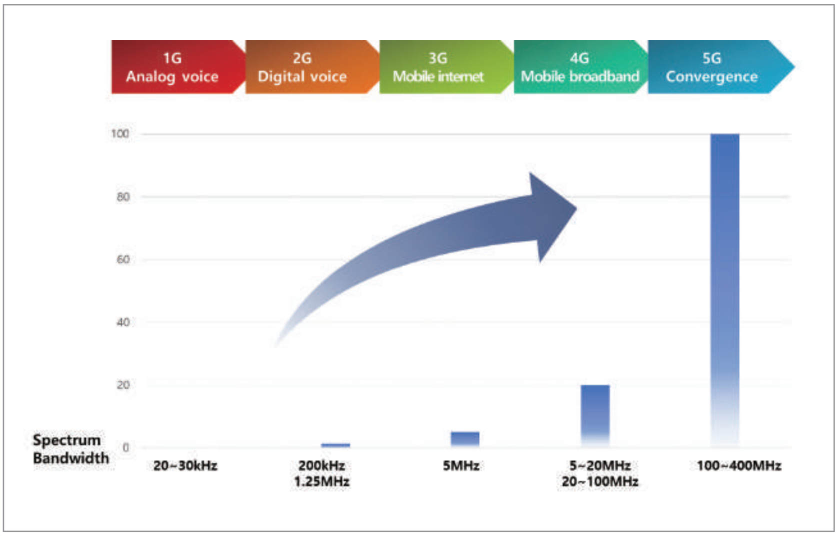
Source: ITU-R (2015a)

The role of spectrum is critical for 5G's success. In contrast to previous technologies, 5G can use all kinds of spectrum bands. It can be applied with variable spectrum bandwidth per service type. The main service of 5G is still a personal communication service that requires higher capacity and faster data rate. Recently, the demand for no-contact services, such as video conferences, is increased due to COVID-19. Such services require wider spectrum bandwidth to communicate with video and voice simultaneously without delay.

Certainly, as the mobile service area in real life will continue to expand, the demand for the spectrum of mobile service will be stronger. The necessary spectrum bandwidth will be increased for the guarantee of service quality and capacity when the new mobile service is introduced. [Figure 18] shows the required spectrum bandwidth by the evolution of mobile technology.

Figure 18.

Required Spectrum Bandwidth by Mobile Technology



Source: ITU-R (2015a)

Typically, the lower frequency was preferred because of coverage. Wider coverage of lower frequency enables fewer network requirements and lower rollout costs. It is valid in the case of 2G and 3G voice services and some limited services of lower data rates. However, capacity and data rates are more significant key factors of mobile data services rather than coverage in terms of 4G LTE or 5G. A higher frequency spectrum is suitable for high data rates and high capacity because it is available in larger spectrum blocks capable of higher capacity and data rates.

Most frequency spectrum bands under 2GHz are already used by the legacy system. To support the future mobile technology or to migrate to the advanced mobile systems, defining the usage of the spectrum is important. If the defined spectrum is used by the legacy system, it is needed to implement frequency refarming gradually by considering the market environment, new mobile service, and so on.

Spectrum bands for 5G are divided into 2 types: Frequency Range (FR) 1 and FR2 defined in standards. FR1 band of frequencies is used for carrying most of the traditional cellular communications, while the FR2 band is focused on short-range, high data rate capabilities.

Table 9.

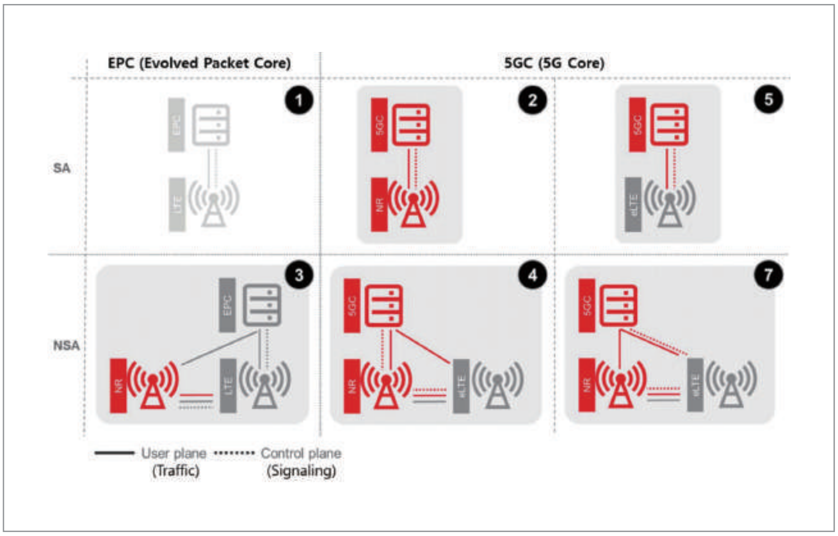
Frequency Ranges for 5G New Radio (NR) in 3GPP Standard

Frequency Range Designation	Frequency Range (MHz)
FR1	410~7,125
FR2	24,250~52,600

Since 5G was introduced, the frequency spectrum over 3 GHz is using for mobile communications. Even the mmWave spectrum is already used or will be used in many countries for 5G mobile services. As the 5G mobile market grows, various services will be introduced, and the customized services will require the diverse type and bandwidths of the spectrum. Now, of the leading 5G spectrum bands, Band n77 or Band n78 is most widely supported in 5G ecosystems. According to a General Services Administration (GSA) report on October 2020, 188 operators were investing or actively deploying networks in the C-band spectrum at 3300~4200 MHz. and the mmWave spectrum bands n257, n258, n261, which is from 24250 MHz to 29500 MHz, have also been considered with 130 operators.

From the beginning of 5G, implementation of full coverage will put a strain on operators. They already have intact mobile networks and want to make full use of their legacy networks as well as 5G. Furthermore, the 5G market is still immature, so the adoption of 5G has to be done gradually. There are several deployment options or configurations defined by 3rd Generation Partnership Project (3GPP) for connecting to a 4G Evolved Packet Core (EPC) or new 5G core network. Each option is distinguished by some features, such as the use of dual connectivity, radio access technology acting as a master node, and core systems used. [Figure 19] shows the major options for 5G deployment.

Figure 19.
3GPP Defined Options for 5G Deployment

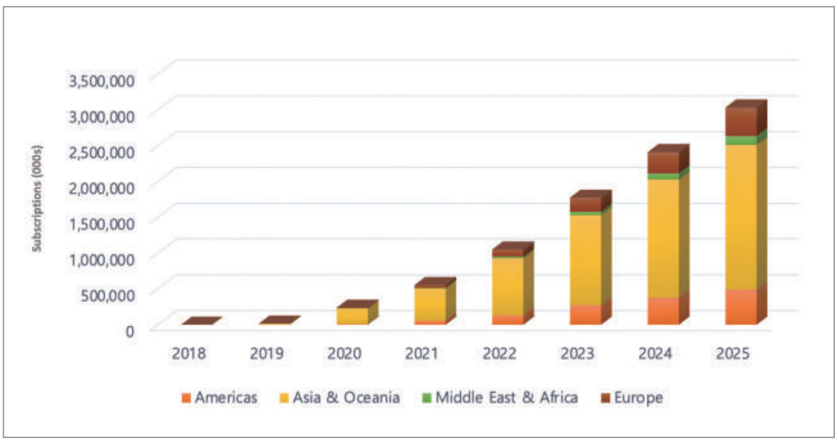


Source : GSMA (2019a)

The mainstream of mobile technology is LTE nowadays. So many operators consider the Non-Stand Alone (NSA) configuration when they want first to introduce the 5G service. NSA network architecture can be implemented with the existing LTE network. Operators who manage the NSA network can provide enhanced mobile broadband services, supplementing 4G LTE capacity. On the contrary, the Stand Alone (SA) configuration consists of a completely new 5G core network. In Korea, option 3 was selected to deploy the initial 5G network.

Although the SA network configuration can fully support new features of 5G services, the investment cost is relatively high and the immature 5G ecosystem is another issue. As 5G continues its global proliferation, 5G subscriptions are also expected to rise.

Figure 20.
5G Mobile Subscriptions Forecast by Omdia



Source: Omdia (2020)

To anticipate and respond to changes of the future mobile society, it is needed to introduce the new mobile services and to implement the advanced mobile infrastructure for supporting the future mobile services.

3.4 Economic Impact of 5G

As a result of TMG Research, the economic growth effect of 5G was calculated from the additional production of USD 20.8 billion 1.2% increase in GDP, and USD 6.8 billion in additional tax revenues for Latin America and Caribbean regions.

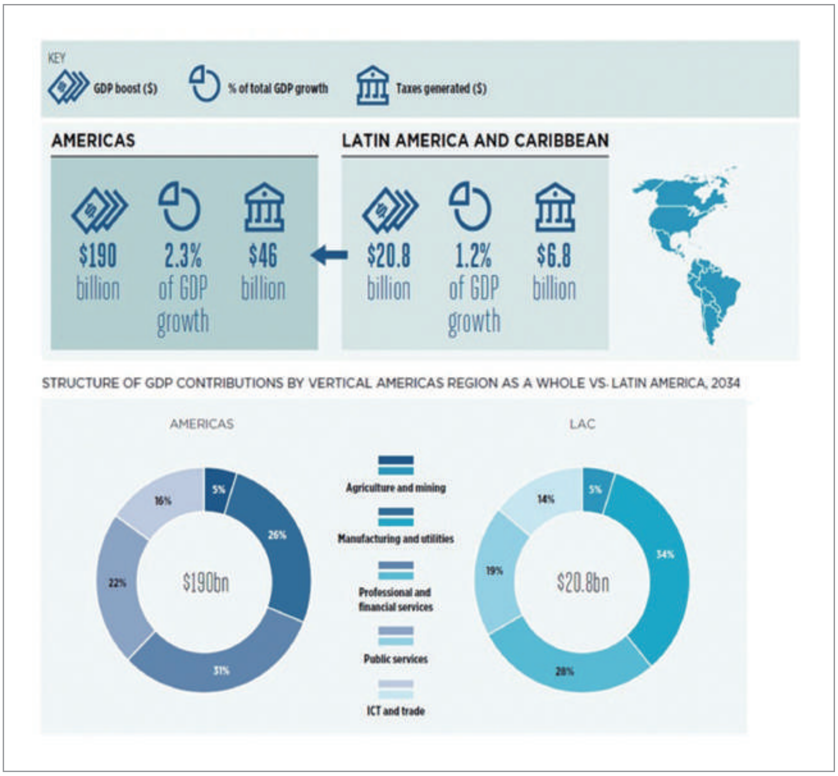


Figure 21. **Economic Results for the Americas and LAC, 2034**

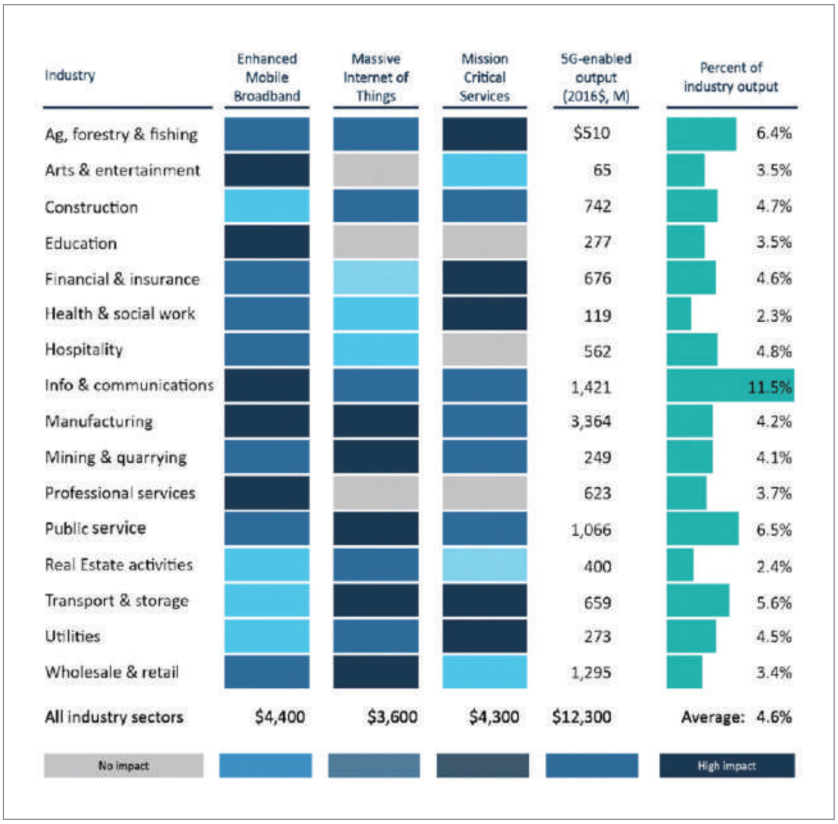
Source: TMG

3.5 Global Impact of 5G on Various Industries

According to the analysis of global impact on other industries through 5G, the impact on industries such as manufacturing, information and communication, public services, wholesale and retail is significant. If Ecuador commercializes 5G, the impact on the main industry can be roughly predicted through these results.

Figure 22.

Global Impact of 5G on Various Industries



Source: IHS (2017)

3.6 Policy Recommendation

The longer the spectrum usage period is, the more exclusive the use is, the more likely that large-scale capital investments such as the establishment of infrastructure will expand. However, from the government's point of view, various reviews such as scarcity of radio resources, efficiency in use, validity of utilization decisions, and equity among multiple users are indispensable, which can also conflict with user requirements.

It is recommended to establish a national spectrum long-term strategy to encourage the mobile communications market and long-term large-scale investment. Moreover, regulators must consult stakeholders in advance to ensure spectrum awards and licensing approaches consider technical and commercial deployment plans.

Chapter 4.

Spectrum Management

4.1 Ecuador's Spectrum Management

4.1.1 Status

As of now, Ecuador has allocated a total of 280 (2×140) MHz of mobile spectrum below 3 GHz.[5]

Table 10.

Mobile Spectrum of Ecuador

Band	CONECEL	OTECEL	CNT
700 MHz			30 MHz (4G)
850 MHz	25 MHz (2G, 3G)	25 MHz (2G, 3G)	
1900 MHz	30 MHz (2G, 3G)	60 MHz (2G–4G)	30 MHz (3G)
AWS 1700/2100	40 MHz (4G)		40 MHz (4G)

The frequency bands below 1 GHz are optimum for the needs of developing countries due to the ability to serve larger rural areas from a single cell site. CNT uses 30 MHz in the APT700 for 4G LTE, and Claro and Movistar each use the 25 MHz spectrum in the 850 MHz band for 2G GSM and 3G UMTS/HSPA+.[6]

- CNT: 30 MHz (uplink 733~748 and downlink 788~803)[7]
- Claro: 25 MHz (uplink 824~835, 845~846.5 and downlink 869~880, 890~891.5)
- Movistar: 25 MHz (uplink 835~845, 846.5~849 and downlink 880~890, 891.5~894)

Traditionally, the frequency bands between 1 and 3 GHz were for capacity purposes. However, as it becomes more difficult to secure mobile spectrum below 1 GHz, the bands above 1 GHz are more frequently used for coverage purposes in wider areas. So far, Ecuador has allocated 80 MHz in the Advanced Wireless Services (AWS) 1700/2100 and 120 MHz in the 1.9 GHz bands. In the AWS band, CNT and Claro each use 40 MHz for 4G LTE.

- CNT: 40 MHz (uplink 1710~1730 and downlink 2110~2130) assigned in 2013
- Claro: 40 MHz (uplink 1730~1750 and downlink 2130~2150) assigned in 2015

Spectrum allocation in the 1.9 GHz band is a bit more complicated. Claro uses the 30 MHz spectrum for 2G and 3G services. It used to hold 10 MHz before 2011 and added 20 MHz in 2015.

- 10 MHz (uplink 1885~1890 and downlink 1965~1970)
- 20 MHz (uplink 1880~1885, 1890~1895 and downlink 1960~1965, 1970~1975)

Movistar currently holds 60 MHz in the 1.9 GHz band for 2G, 3G, and 4G. It used to hold 10 MHz and added 50 MHz in 2015.

- 10 MHz (uplink 1865~1870 and downlink 1945~1950)
- 50 MHz (uplink 1850~1865, 1870~1880 and downlink 1930~1945, 1950~1960)

Besides Claro and Movistar, CNT was granted 30 MHz in this band in 2011, and provides 3G services.

- 30 MHz (uplink 1895~1910 and downlink 1975~1990) was granted in 2011

4.1.2 License Renewal

Both Claro and Movistar renewed their spectrum licenses in the 850 MHz and 1.9 GHz bands in 2008. Movistar's offer of USD 220 million was accepted in April 2008, and Claro's offer of USD 480 million was accepted in May 2008. The new licenses will be good until 2023.

5 This does not include 9.95 MHz for CDMA450 in the 450 MHz band and 50 MHz for WiMAX in the 3.5 GHz band.

6 Claro's 1.5×2 MHz and Movistar's 2.5×2 MHz are discontiguous.

7 In addition, CNT has used 9.95 MHz (uplink 452.500~457.475 and downlink 462.500~467.475) in the 450 MHz band for CDMA450 since 2011. CDMA450 is used for advanced telecommunication services over wide areas. A number of countries are known to deploy CDMA450 networks both commercially and as part of their universal access and service programs. In LATAM countries, CDMA450 technologies are commercially available in Argentina, Mexico, Peru, Suriname, and Venezuela in addition to Ecuador.

Table 11.

License Renewal

	Price	Bands	Usage duration
Claro	USD 480 million	25 MHz in the 850 MHz band and 10 MHz in the 1.9 GHz band	2008~2023
Movistar	USD 220 million	25 MHz in the 850 MHz band and 10 MHz in the 1.9 GHz band	2008~2023

4.1.3 Spectrum Assignment in the 4G Era

CNT was able to commence LTE services earlier than its competitors using 30 MHz in the 700 MHz band and 40 MHz in the AWS 1700/2100 band. The spectrum in these bands was granted in 2013. On the other hand, neither Claro nor Movistar was able to provide LTE services until additional spectrum was purchased in 2015. Claro purchased 40 MHz in the AWS 1700/2100 band and 20 MHz in the 1900 MHz band for USD 180 million, and Movistar purchased 50 MHz in the 1900 MHz band for USD 150 million. Both companies use only part of the newly purchased spectrum for LTE.

Table 12.

Spectrum Allocation in the 4G Era

	Frequency band	Bandwidth (MHz)	Price	Usage duration
CNT	700 MHz	2×15	-	2013~2031
	AWS 1700/2100	2×20		
Claro	AWS 1700/2100	2×20	USD 180 million	2015~2023
	1.9 GHz	2×10		
Movistar	1.9 GHz	2×25	USD 150 million	2015~2023

4.2 Efficient Spectrum Pricing and Management

4.2.1 Principles

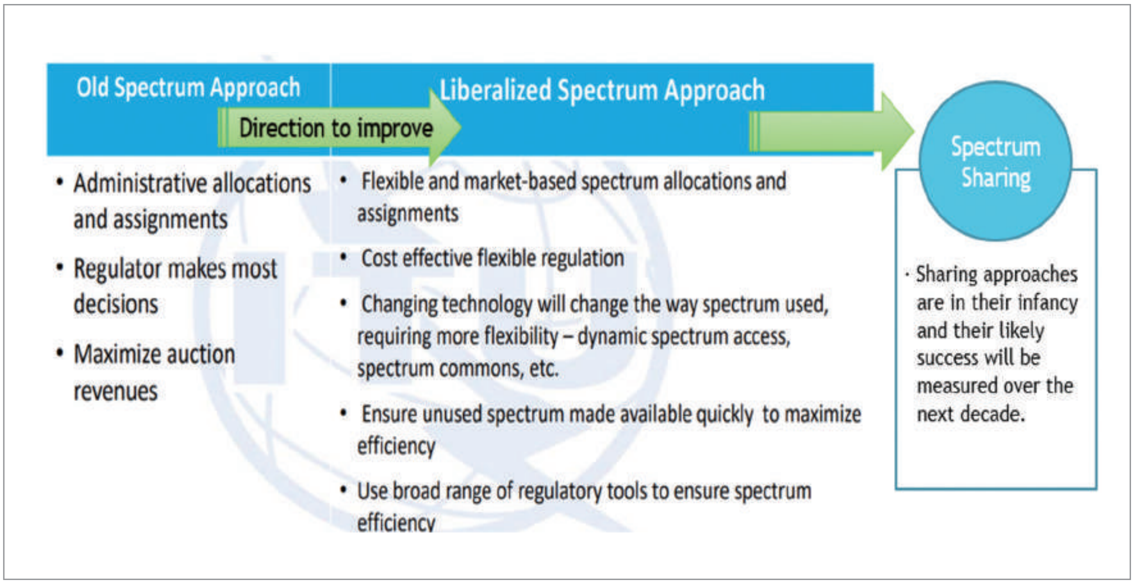
Spectrum Management System

Spectrum management is the process of regulating the use of radio frequencies to promote efficient use and gain a net social benefit. Historically, access to and use of radio spectrum has been highly regulated in order to prevent interference among users of adjacent frequencies or from neighboring geographic areas, particularly for reasons of defense and security. Avoiding harmful interference has, therefore, been the fundamental reason for managing spectrum, and command-and-control management has been very effective. This method dominated until the 1990s; however, as commercial mobile services become more popular, the demand for spectrum has grown significantly, highlighting the need for efficient use of all available spectrum in order to avoid scarcity. Spectrum is viewed as a finite resource in the sense that in a given frequency band within a specific location, there will be a physical limit to the amount of use possible, and market-based management has emerged as a way to allocate this scarce resource more efficiently. Spectrum auction is an example of this market-based method. In addition, the spectrum commons method also rolled out for flexibility in regulation around 2015, focusing on harnessing the potential benefits of spectrum sharing. However, it seems a bit early to conclude whether this spectrum sharing approach would manage scarce spectrum resources successfully.

As described in [Figure 23], the paradigm of spectrum management has shifted toward emphasizing more flexible and market-based spectrum allocations. Nevertheless, the command-and-control method may still be the most popular approach employed by regulators around the globe. The government of Ecuador also relies heavily on this method.

Figure 23.

Paradigm of Spectrum Policy

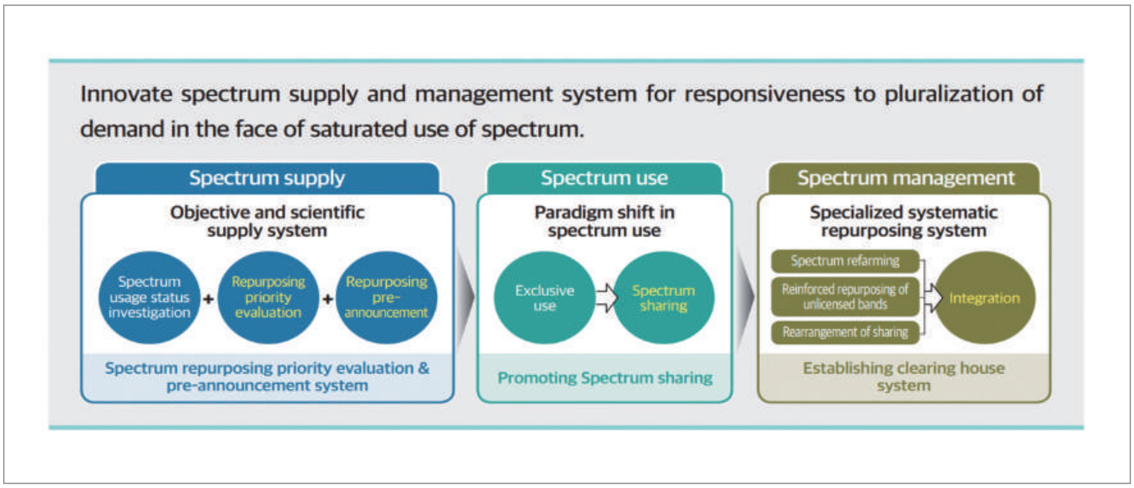


Source: ITU

In Korea, the government first introduced the spectrum auction in 2011 for the allocation of new spectrum for 4G LTE, and continues using this auction system in allocating more spectrum for mobile services. It has also established spectrum sharing and a new spectrum management system with the introduction of 5G.

Figure 24.

Spectrum Management System in Korea



Source: Ministry of Science and ICT (2019)

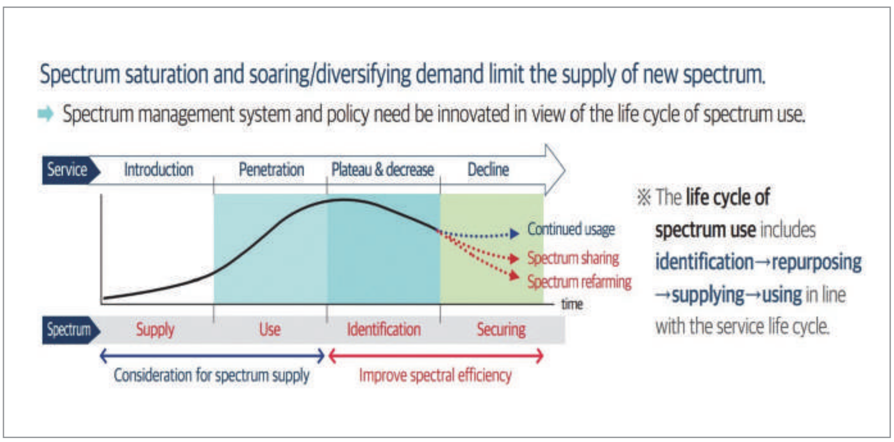
Spectrum Prices

Spectrum prices should be set to promote efficient use of the spectrum (ITU, 2016). In particular, the spectrum should be assigned to the operator who values it most highly. In Ecuador, mobile spectrum has been assigned by the Direct Assignment (DA) method. It should be noted that this DA method cannot promote efficient distribution of the spectrum unless the opportunity cost of holding the spectrum is reflected in the initial mobile license fee. In addition, spectrum prices should be set at a level to recover all administrative costs. The costs may occur from all activities of managing and regulating the spectrum, such as planning spectrum use, allocating and assigning spectrum licenses, coordinating shared spectrum use, harmonizing regional and global spectrum standards, and monitoring and controlling its actual use. For efficient spectrum management, it is important that these administrative costs be calculated transparently and reasonably, and they should be recovered from all operators who benefit from spectrum management activities—both private and public.

Creating a Virtuous Circle of Spectrum Resources

Like all other resources, the use of spectrum resources is based on the phases of introduction, penetration, stagnation, and decline. The government can use this life cycle of spectrum resources to implement more efficient and innovative spectrum policies. For example, using the life cycle of each generation of mobile telecommunication, it is possible to prepare a plan in advance for changing the supply status, such as allowing the current usage status, or refarming or sharing with other services before the license expires.

Figure 25.
The Life Cycle of Spectrum Use



Source: Ministry of Science and ICT (2019)

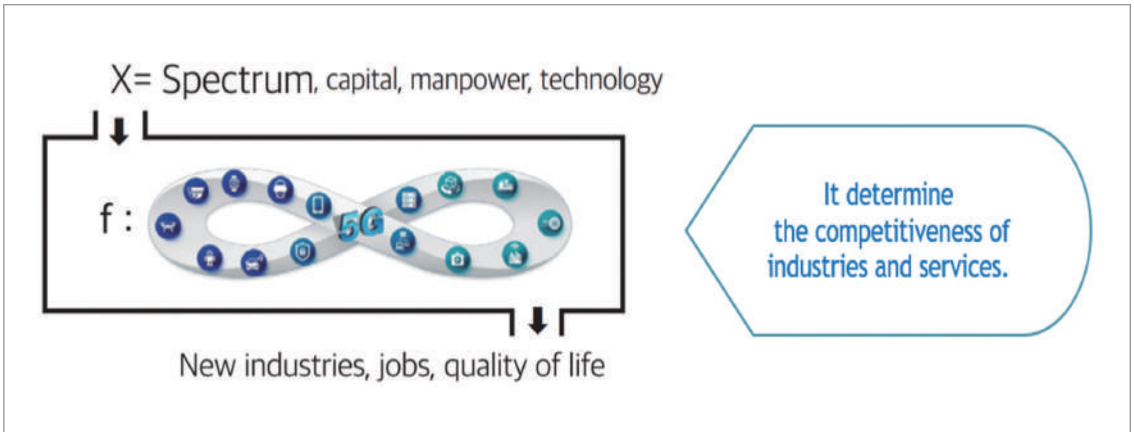
Quality and Quantity of Spectrum Supply

Korea has set up a system to evaluate bands that need maintenance by priority in the saturation of spectrum use. This system can improve the predictability of spectrum supply and demand policies by predicting targets for maintenance in advance and minimizes social costs by preventing unnecessary investment.

From our analysis and experience, for the introduction of new technologies including 5G, providing a series of broadband spectrum by supplying the adjacent bands of the previously supplied bands is effective in improving the quality of service and reducing investment costs.

Figure 26.

Spectrum Supply System



Source: Ministry of Science and ICT (2019)

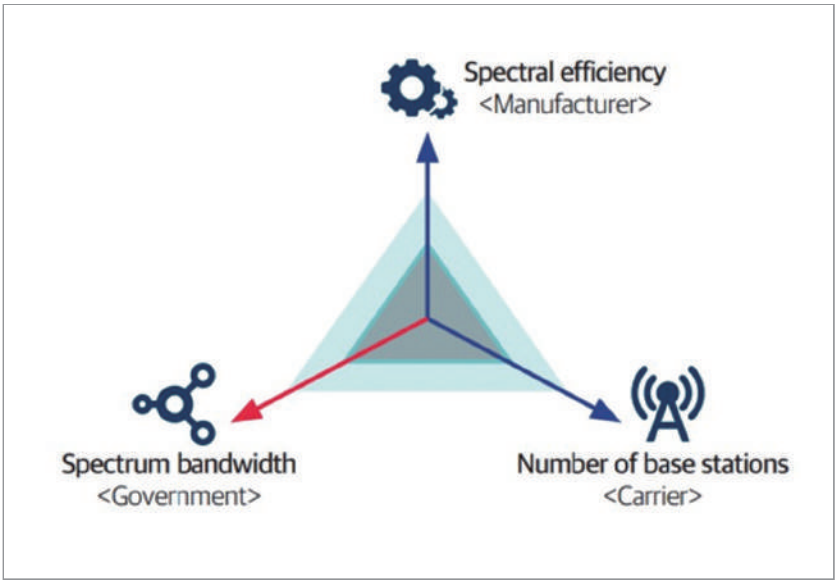
Changes in spectrum demand and supply have a considerable impact on consumers and citizens; there is a role for regulation in addressing such impacts. By changing spectrum supply and demand policy, the Korean government aims to develop a proactive spectrum supply system. The adoption of the spectrum repurposing priority evaluation and pre-announcement system systematically identifies the bands requiring urgent repurposing and develop measures for efficient use by enforcing the repurposing priority evaluation system, improve the predictability of spectrum supply policy via the pre-announcement of repurposing, and minimize the social cost including prevention of unnecessary investment. Ecuador also needs to improve its frequency supply and demand system innovatively by benchmarking cases such as Korea in preparation for the expansion of spectrum use and growing demand.

Trends in Supply for Emerging Services

The most important factor in securing a competitive edge in services and industry is to supply the contiguous broadband spectrum by increasing transmission speed while decreasing investment cost, and the government is responsible for securing and supplying the contiguous broadband spectrum in a timely manner.

Figure 27.

Considering Factors



Source: Ministry of Science and ICT (2019)

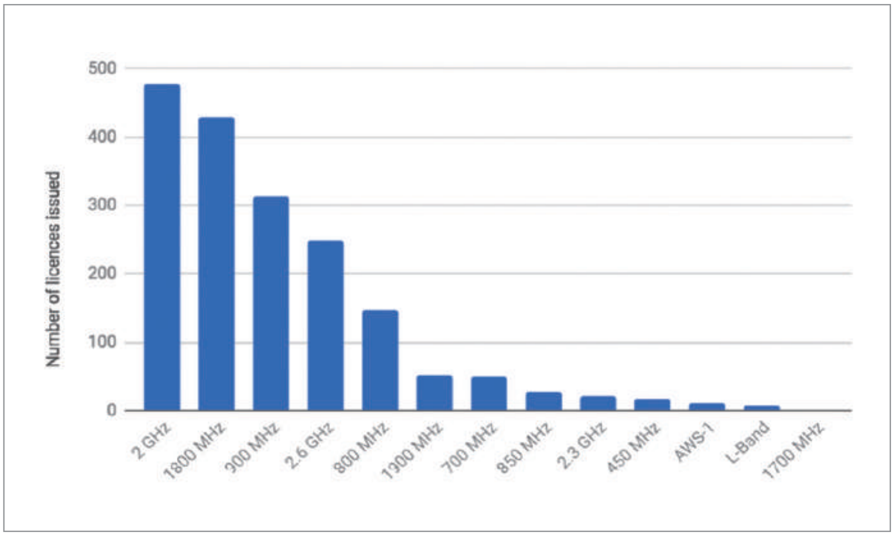
Spectrum Preference for Mobile Communications

Spectrum can become usable for mobile service when it is supported in international regulations, available in mass-produced equipment, and licensed to mobile operators. Regulators, manufacturers, and mobile operators have created the above conditions for an ever-growing list of frequencies. The spectrum policy of Ecuador also needs to proceed with future spectrum allocation in mind such as global harmonization and most-used bands.

[Figure 28] shows the 12 mobile bands that are most used globally. The most important LTE band in most countries remains the 1800 MHz band. This role is taken by the AWS bands in the Americas, which also has extensive use of the 1900 MHz band for 4G. The rest of the world has widespread 4G use of the 800 MHz and 2.6 GHz bands, which have been cleared and auctioned by regulators in recent years. As these bands become saturated, operators and regulators are turning toward other bands for 4G capacity.

Figure 28.

The 12 Mobile Bands Most Used Globally



Source: PolicyTracker (2018)

Some 4G bands have emerged from operators' reuse of bands that they already used for legacy 2G or 3G services. The most important of these are the 450 MHz, 850 MHz, 900 MHz, and 2.1 GHz bands. These bands' use is generally dependent on the demand for the incumbent services in relation to 4G services in a given market. Other bands, specifically the L band and 2.3 GHz band, have been—or are being—cleared by regulators specifically for the purpose of providing 4G services.

Table 13.

The Progression from 2G to 5G

	Incumbent 2G/3G usage	Post 2010 cleared spectrum
Current extensive 4G usage	1800 MHz (Regions 1+3) AWS Bands (Region 2) 1900 MHz (Region 2)	800 MHz (Regions 1+3) 2.6 GHz (Global)
Increasing 4G usage	450 MHz (Global) 850 MHz (Region 2) 900 MHz (Regions 1+3) 2.1 GHz (Regions 1+3)	L-Band (Region 1) 2.3 GHz (Global)
Future 5G with interim 4G usage		600 MHz (Regions 2+3) 700 MHz (Global) 3.3~3.8 GHz (Global) 3.7~4.2 GHz (USA and Japan)

The majority of current 4G networks use a handful of frequency bands, but the standard supports a long tail of other bands that might serve the needs of particular operators. 5G networks will likely have a similar pattern: there is clear support for one or two bands in the low, mid-, and high band, but the standard is designed to offer a larger number of bands beyond this. Specifically, 5G is set to support at least a portion of almost every 4G band that we have identified.

Almost all 4G bands could theoretically be used for 5G in the future. [Table 14] shows the family of technologies that will be supported in each of the spectrum bands. The bold ticks indicate a focus band for a given technology, and comparing the preferred frequency bands with Ecuador's spectrum supply for mobile communications, it was found that additional supply reviews are needed in such bands as 900 MHz, 2.6 GHz, and 3.6 GHz.

Table 14.

Comparison of Spectrum Supply for Mobile Communication

Technological progression for current mobile bands

	2G	3G	4G	5G
450 MHz		✓	✓	
600 MHz			✓	**✓**
700 MHz			✓	**✓**
800 MHz		✓	**✓**	✓
850 MHz		✓	✓	✓
900 MHz	**✓**		✓	✓
L-Band		✓	✓	✓
1800 MHz	**✓**	✓	**✓**	✓
1900 MHz	✓	✓	**✓**	✓
AWS Band		**✓**	**✓**	✓
2.1 GHz	✓	**✓**	✓	✓
2.3 GHz			✓	
2.6 GHz		✓	**✓**	**✓**
3.3 – 3.8 GHz			✓	**✓**
3.7 – 4.2 GHz				**✓**

These bands needs to be reviewed for additional supply.

< Spectrum Holding of Mobile Operators in Ecuador (2020) >

(unit : ㎒)

band	CONECEL		OTECEL		CNT		Total
	width	usage duration	width	usage duration	width	usage duration	
450㎒	-	2023	-	2023	(9.95)	2031	(9.95)
700㎒	-		-		30		30
800㎒	25		25		-		50
900㎒	-		-		-		-
1900㎒	30		60		30		120
1700/2100㎒	40		-		40		80
2600㎒	-		-		-		-
3500㎒	-		-		(50)		(50)
Total	95 (34%)		85 (30%)		100 (36%) (159.95)		280 (100%) (339.95)

Source: PolicyTracker (2018)

Source: MINTEL (Ansewrs to Checklist, June 2020)

4.2.2 Strategies for Enhancing Mobile Broadband in Ecuador

Affordability

In Ecuador, MBB appears to be the only viable alternative to offer broadband services to the population. Even though Ecuador's mobile Internet penetration is higher than fixed Internet, a significant proportion of mobile subscribers is not yet connected to MBB.[8] Obviously, the coverage provided by the mobile service networks is a substantial barrier to MBB connection.

The Ecuadorian government has naturally enforced policies aiming to expand the network coverage. In particular, CNT has taken the role of catalyzing 4G network investment.[9] With the help of such network expansion policies, Ecuador's 4G network coverage reached about 52% in 2019 and continues to improve, and 4G LTE services are available in most urban areas. In order to increase MBB subscriptions further, however, we believe that making mobile tariffs and handset prices more affordable is more effective than expanding network coverage. GSMA (2019b) also supports the idea of improving affordability of MBB subscriptions:

- "In 2018, for the first time, among the population living in the footprint of a mobile broadband network, there were more mobile internet users (3.5 billion) than nonusers (3.3 billion). However, the fact that the usage gap is more than four times larger than the coverage gap (750 million) highlights the importance of factors other than coverage that are stopping people from adopting mobile internet, particularly on the demand side" (GSMA, 2019b).
- This report also shows that the percentage of covered but not connected to MBB was 39%, while the percentage of uncovered was only 7% in Latin America and Caribbean countries in 2018.

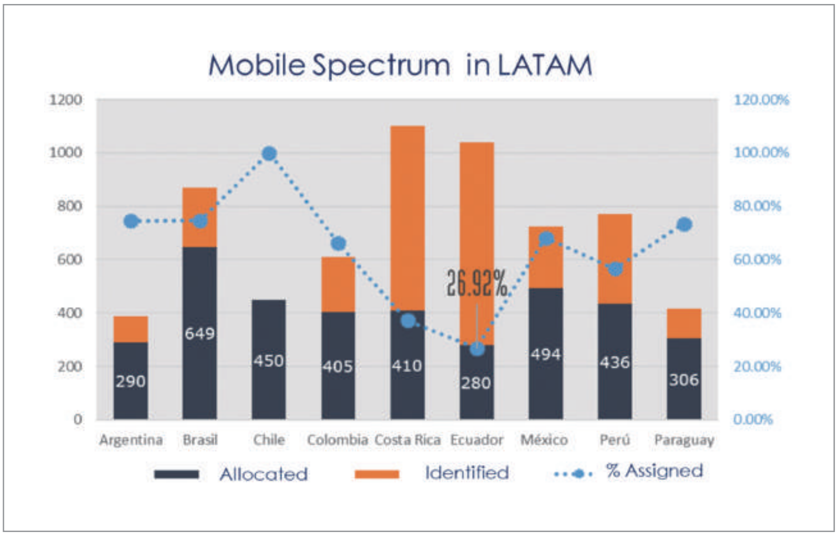
Additional Spectrum Allocation and Spectrum Pricing

As shown in [Table 14], Ecuador has allocated 280 (2×140) MHz of paired spectrum for mobile services. This IMT spectrum amounts to only 26.9% of the ITU recommendation, and it is the least among LATAM countries.[10]

8 In 2018, non-MBB mobile users were more than 56.3%.
9 We discuss more about the government's competition policy using CNT in Chap. 7.
10 5G Americas' white paper (2018a) shows that only four LATAM countries have allocated more than 30% of the ITU's suggestion for 2015: Argentina (31%), Brazil (41.7%), Chile (35.8%), and Nicaragua (32.3%).
11 For reference, it is estimated that the average spectrum awarded per country for broadband in LATAM is 363.8 MHz as of December 2018.

Figure 29.

Mobile Spectrum in LATAM



Source: MINTEL (2020)

The MBB spectrum is even less than 280 MHz because some of the spectrum in the 850 MHz and 1900 MHz bands are used for non-MBB (2G and 3G without HSPA) services.[11] It would be possible for Ecuador's mobile operators to upgrade their networks to provide MBB services; however, there may exist many non-MBB subscribers who do not want to upgrade their networks.

As discussed earlier, the lack of sufficient spectrum has negative consequences for consumers and can limit the growth potential of the mobile industry. With this background, Ecuador's government has announced a plan to allocate 650 MHz of additional IMT spectrum as shown in [Table 15]. The key driver behind the government initiatives to allocate this additional spectrum would probably be the necessity to promote technological innovation by the development of new technologies like 4G and 5G. We expect that most, if not all, spectrum will be used for MBB.

Table 15.

Ecuador's Additional Mobile Spectrum Allocation Plan

Band	Bandwidth (MHz)
APT 700 MHz (703~733 and 758~788)	2×30
900 MHz (895~915 and 940~960)	2×20
AWS (1750~1780 and 2150~2180)	2×30
2.5 GHz (2500~2570 and 2620~2690 for FDD, 2570~2620 for TDD)	2×70+50
3.5 GHz (C-band) 3300~3600	300

It is worth noting that the APT 700 MHz band is a "digital dividend" in most LATAM countries and commonly harmonized spectrum in the region. In 2013, CNT was given 30 MHz (733~748 and 788~803) in this band. The AWS 1700/2100 spectrum is the capacity of choice for 4G in urban areas in the Americas; hence, economies of scale may be possible in the region. CNT and Claro are known to provide LTE services using the AWS band spectrum. CNT was given 2×20 MHz (1710~1730 and 2110~2130) in 2013 and Claro purchased 2×20 MHz (1730~1750 and 2130~2150) in 2015. The common worldwide band for commercial MBB services is 2.5 GHz. Several regulators in the world already allocated spectrum in the band as Frequency Division Duplex (FDD) and separately the center gap as Time Division Duplex (TDD) (b7 and b38, Recommendation ITU-R M. 1036-3), but more regulators are now looking at licensing the band as TDD (b41/n41, 3GPP Release 16). Finally, 300 MHz of the C-band spectrum is in preparation for the launch of 5G services scheduled between 2021 and 2022.

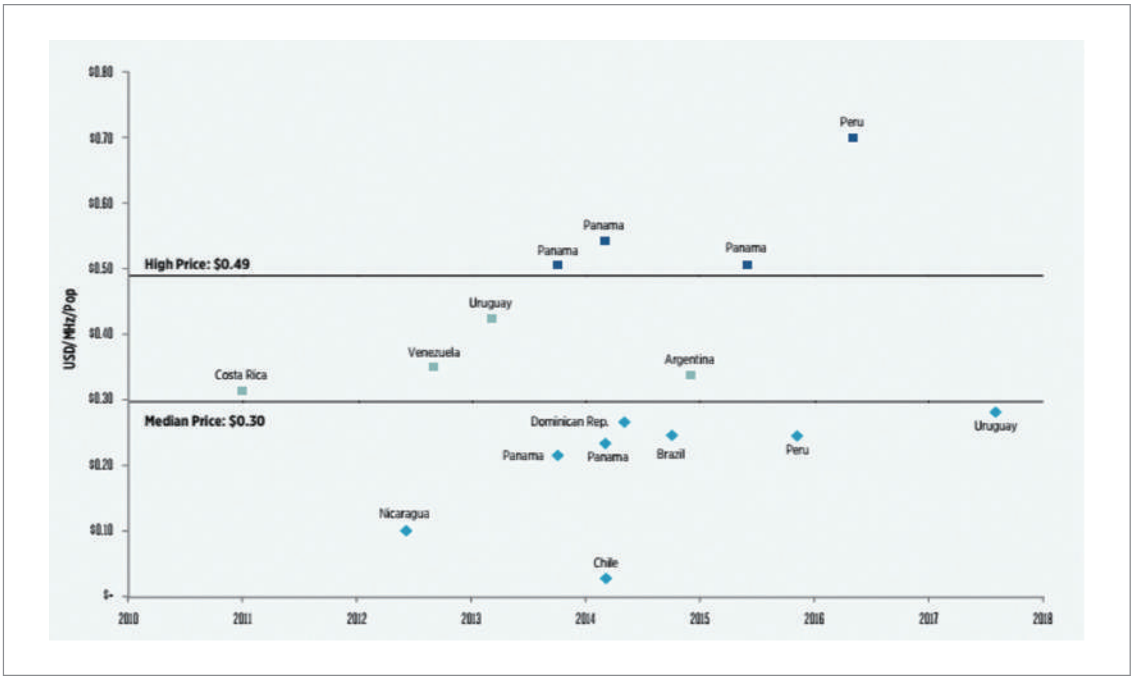
It should be noted that this additional spectrum allocation plan can only contribute to Ecuador's economic growth when three mobile operators invest in their MBB networks and when more Ecuadorian consumers subscribe to MBB services. Hence, the government should pay attention to whether the spectrum costs faced by the three operators are too high. Observe that higher spectrum reserve prices and license fees are associated with more expensive and lower-quality MBB services, reducing the incentives of network investment and price competition, and irrecoverable losses in consumer welfare.

Unfortunately, spectrum prices are often set too high in most LATAM countries.[12] Indeed, GSMA (2018b) reports that median prices for capacity spectrum in LATAM are about 60% higher than in Europe (see Figs. 30 and 31). Moreover, it is shown in [Figure 32] that the percentage of spectrum cost out of sales revenue is even higher in Ecuador compared with most other LATAM countries.

12 GSMA (2018b) reports that spectrum prices in this region are not determined by market forces but are more linked to decisions by local policymakers.

Figure 30.

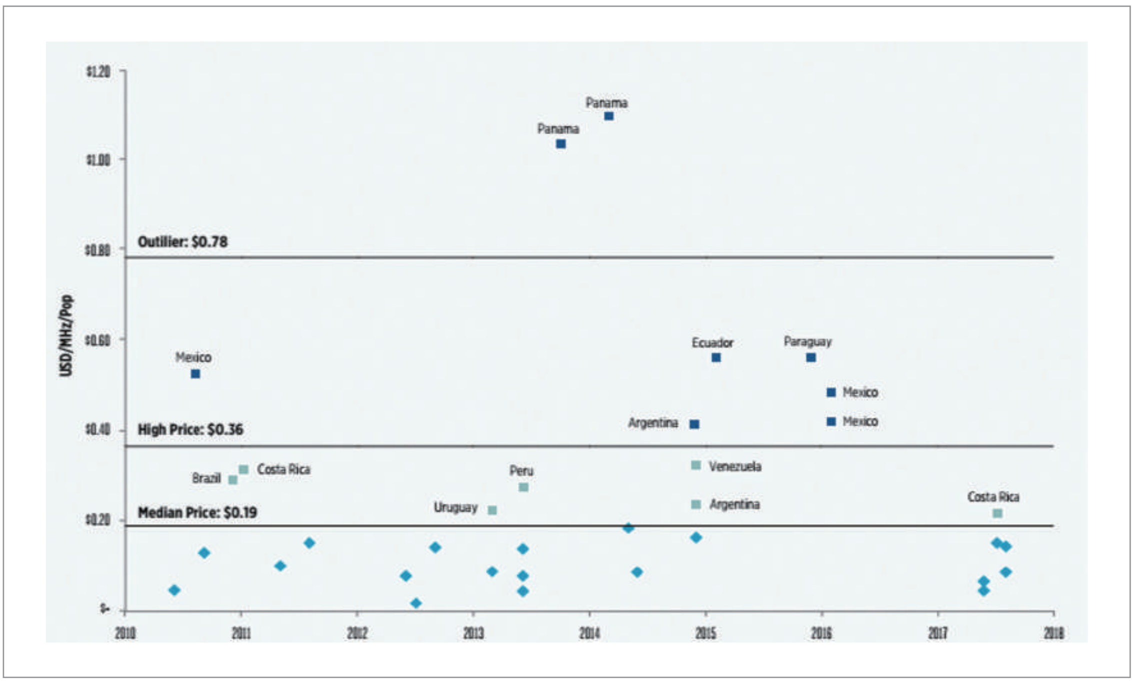
Coverage Spectrum Prices



Source: GSMA (2018b)

Figure 31.

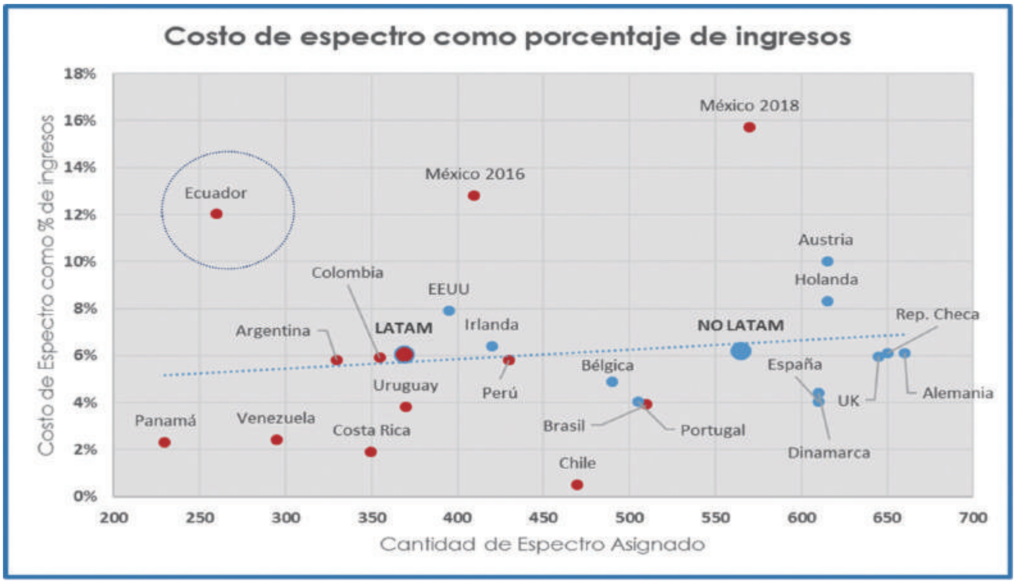
Capacity Spectrum Prices



Source: GSMA (2018b)

Figure 32.

Percentage of Spectrum Cost



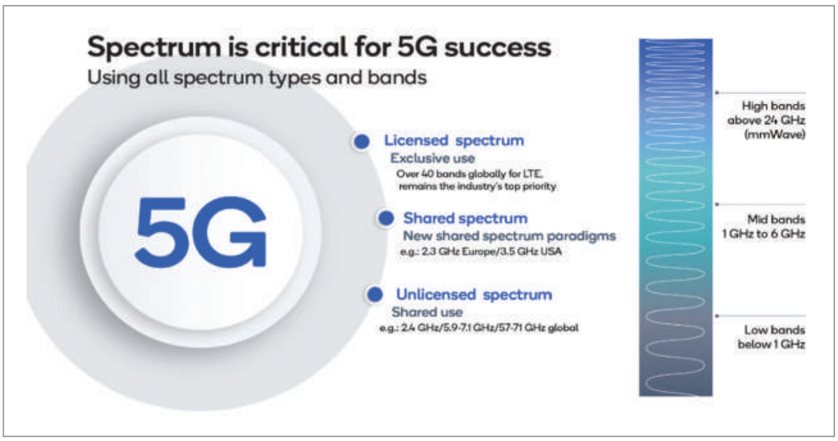
Source: MINTEL (2020)

4.2.3 5G Spectrum Trend

5G technology has been designed from the beginning to support not only licensed but also shared and unlicensed spectrum. However, exclusively licensed spectrum is expected to be the core 5G spectrum management approach, and spectrum sharing and unlicensed bands can play only a complementary role.

Figure 33.

5G Spectrum



Source: Qualcomm (2020)

Tables 16~19 summarize the 5G new radio (NR) frequency listed in Release 16 of 3GPP TS 38.101 in July 2020.[13]

Table 16.

FR1: FDD

5G NR band	Uplink frequency	Downlink frequency	Bandwidth
n1	1920~1980 MHz	2110~2170 MHz	60 MHz
n2	1850~1910 MHz	1930~1990 MHz	60 MHz
n3	1710~1785 MHz	1805~1880 MHz	75 MHz
n5	824~849 MHz	869~894 MHz	25 MHz
n7	2500~2670 MHz	2620~2690 MHz	70 MHz
n8	880~915 MHz	925~960 MHz	35 MHz
n20	832~862 MHz	791~821 MHz	30 MHz
n28	703~748 MHz	758~803 MHz	45 MHz
n66	1710~1780 MHz	2110~2200 MHz	90 MHz
n70	1695~1710 MHz	1995~2020 MHz	15/25 MHz
n71	663~698 MHz	617~652 MHz	35 MHz
n74	1427~1470 MHz	1475~1518 MHz	43 MHz
n91	832~862 MHz	1427~1432 MHz	-
n92	832~862 MHz	1432~1517 MHz	-
n93	880~915 MHz	1427~1432 MHz	-
n94	880~915 MHz	1432~1517 MHz	-

Table 17.

FR1: TDD

5G NR band	Frequency	Bandwidth
n34	2010~2025 MHz	15 MHz
n38	2570~2620 MHz	50 MHz
n39	1880~1920 MHz	40 MHz
n40	2300~2400 MHz	100 MHz
n41	2496~2690 MHz	194 MHz
n48	3550~3700 MHz	150 MHz
n50	1432~1517 MHz	85 MHz

13 See also, 5G America (2017) or GSMA (2020a).

n51	1427~1432 MHz	5 MHz
n77	3300~4200 MHz	900 MHz
n78	3300~3800 MHz	500 MHz
n79	4400~5000 MHz	600 MHz
n90	2496~2690 MHz	194 MHz

Table 18.

FR1: Supplementary Downlink Bands and Supplementary Uplink Bands

5G NR band	Uplink frequency	Downlink frequency	Bandwidth
n29	-	717~728 MHz	11 MHz
n75	-	1432~1517 MHz	85 MHz
n76	-	1427~1432 MHz	5 MHz
n80	1710~1785 MHz	-	75 MHz
n81	880~915 MHz	-	35 MHz
n82	832~862 MHz	-	30 MHz
n83	703~748 MHz	-	45 MHz
n84	1920~1980 MHz	-	60 MHz
n86	1710~1780 MHz	-	70 MHz
n89	824~849 MHz	-	25 MHz
n95	2010~2025 MHz	-	15 MHz

Table 19.

FR2: TDD

5G NR band	Band alias	Frequency	Bandwidth
n257	28 GHz	26.5~29.5 GHz	3 GHz
n258	26 GHz	24.250~27.5 GHz	3.250 GHz
n259	-	39.5~43.5 GHz	4 GHz
n260	39 GHz	37~40 GHz	3 GHz
n261	28 GHz	27.5~28.35 GHz	850 MHz

As shown in the above tables, there is consensus in the industry that 5G needs a combination of sub-1-GHz frequencies, mid-band spectrum around 3 GHz, and mmWave bands:

(1) Low bands (sub-1-GHz spectrum bands): The spectrum below 1 GHz is essential for expanding 5G network coverage in all urban/suburban/rural deployment scenarios,

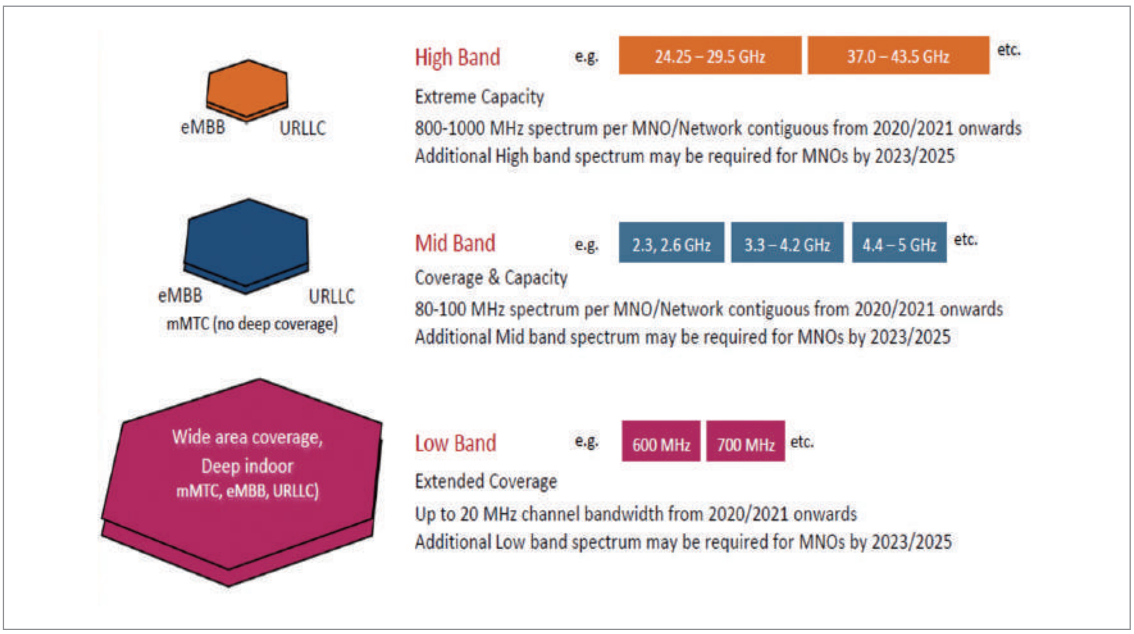
ensuring service continuity across different geographies, enhancing service quality in indoor environments, and helping to close the digital divide. The low-band spectrum can help support IoT services as well. It is known that 40 countries around the world have announced formal plans for allocating 5G-suitable frequencies until 2022, and 35 of them are planning to auction spectrum at 700 MHz. It is worth noting that several key spectrum bands below 1 GHz are also used for LTE and for networks based on 2G or 3G technologies.

(2) Mid-bands (1~6 GHz spectrum bands): The mid-band spectrum range offers a good mix of coverage and capacity benefits. The majority of commercial 5G networks rely on C-band spectrum within the 3.3~4.2 GHz frequency range (n77, n78). The C-band spectrum has been licensed to 64 operators for 5G worldwide as of October 2019. Other mid-bands include 1.8 GHz, 2.3 GHz, and 2.6 GHz. In the long term, more spectrum is needed to maintain 5G quality of service and growing demand, in bands between 3 and 24 GHz.

(3) High bands (mmWave bands over 24 GHz): The mmWave spectrum offers large amounts of bandwidth to support far greater capacity, faster downloads, and more subscribers. It is ideally suitable for high data throughput applications such as video communications, video animation, and data-hungry applications such as virtual and augmented reality.

Figure 34.

Three Key Frequency Ranges of 5G



Even though many operators in the world expressed their interest and announced investment plans for 5G, this new mobile technology is in an early stage of deployment.

- It is reported that 92 networks in 38 countries deployed 5G networks as of July 2020. Figure 35 and Table 20 show the spectrum allocated or targeted for 5G in some countries of the world.

In Ecuador, MINTEL announced in July 2019 that it had plans for auctioning AWS and 2.6 GHz for 4G and 3.5 GHz for 5G. Even though the decision on the high band does not seem to have been made public, making a quick decision is needed after reviewing the needs of the Ecuadorian mobile operators, global trends, and other countries in South America. In the low band, MINTEL reviews reassigning frequencies in the 700 MHz band.

To fledge technical performance of 5G fully, a significant amount of spectrum is required such as 80~100 MHz of contiguous spectrum per operator in prime mid-bands and about 1 GHz per operator in high bands (GSMA, 2018a). The requirement of contiguous spectrum for 5G can be alleviated to some extent, as CA (Carrier Aggregation) will allow operators to combine fragmented spectrum logically. For reference, Deloitte (2018) reports that CA can help overcome spectrum fragmentation issues, though a more contiguous position is still preferable. In addition, globally harmonized spectrum is crucial in establishing economies of scale and thus accelerate the adoption of 5G.

Although we expect the core 5G network will use exclusively licensed spectrum, unlicensed Wi-Fi spectrum can still play roles in a complementary 5G network. Currently, the 5 GHz spectrum band is typically used for Wi-Fi connectivity along with the 2.4 GHz band, but 6 GHz brought new unlicensed bandwidth for Wi-Fi at the ITU World Radiocommunication Conference 2019 (WRC-19).

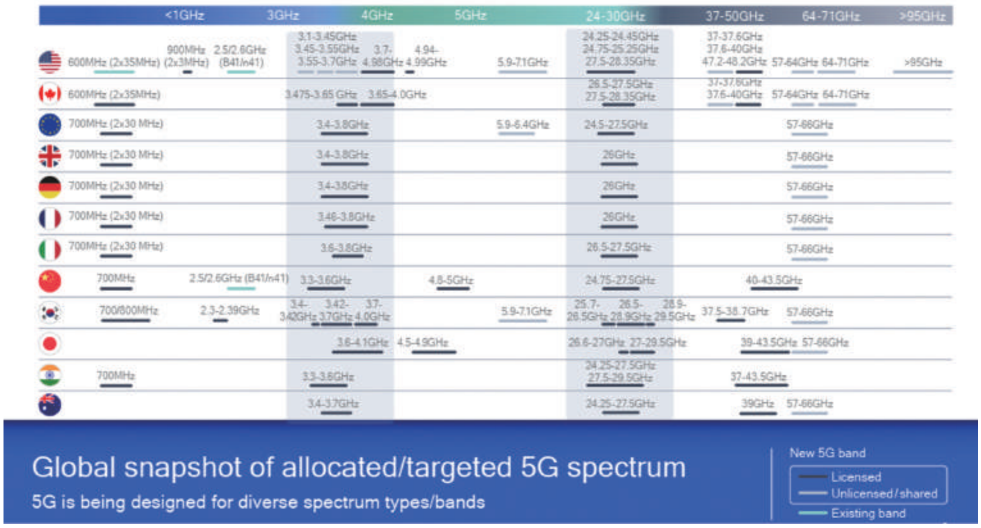
4.2.4 Method for the Spectrum Auction Reserve Pricing

(1) Background

Reserve prices play a pivotal role in the auction design. It is a tool to keep the non-serious bidders out and also a means to ensure a certain minimum revenue for the government. In the past, the reserve prices were mostly linked to the most current auctions. This resulted in its exponential increase, as it was hardly ever corrected to cure market distortions, even though a minority set of bidders might have been responsible for it (overenthusiasm or judgmental mistake, or mere fate accomplice). As a result, other bidders (who wanted to behave responsibly) also suffered since there was no other way for them to get spectrum at a lower price. Staying out would have been tantamount to

Figure 35.

5G Spectrum Allocated/Targeted in some Countries



Source: Qualcomm (2020)

Table 20.

5G Spectrum Allocated/Targeted in some Countries

Country	Sub-6-GHz	mmWave
Europe	3.4~3.8 GHz (awarding trial licenses)	24.25~27.5 GHz for commercial deployments beginning 2020
China	3.3~3.6 GHz (ongoing trial)	Focusing on 24.25~27.5 GHz and 37~43.5 GHz studies
	4.4~4.5 GHz	
	4.8~4.99 GHz	
Japan	3.6~4.2 GHz	27.5~28.28 GHz trials planned beginning 2017 and potential commercial deployments in 2020
	4.4~4.9 GHz	
Korea	3.4~3.7 GHz	26.5~29.5 GHz trials in 2018 and commercial deployments in 2019
USA	3.1~3.55 GHz	27.5~28.35 GHz and 37~40 GHz pre-commercial deployments in 2018
	3.7~4.2 GHz	

them quitting the business altogether. Hence, to rectify the situation, the formula for calculating the reserve price must be declared in advance, which can help in: a) correcting bidding distortions, b) promoting responsible bidding, and c) ensuring optimal prices. However, in order to meet these objectives, the formula must be robust (preventing volatility in prices) and simple to understand (promoting confidence in the bidders). But before we dwell on doing that, we must evaluate the extent of this problem on account of the past approach (linking reserve prices to the last auctions) and its impact on the future prices of auctions.

Auctions have been widely used around the world as a way of allocating spectrum since the mid-1990s. A possible reason is that they generated substantial revenue for the state, as an auction is designed to award the spectrum to the highest bidder. Therefore, under the auction method it is likely to direct the spectrum to the more efficient operators.

It is important to set the correct reserve prices for the spectrum auction. If the reserve price is set too low, there is a risk that the valuable national spectrum resources will be somewhat wasted. On the other hand, if the reserve price is set too high, there is a risk that the auction will fail, and nobody will enter the auction process, which will yield zero revenue for the government.

Ecuadorian mobile operators pay a concession charge every 15 years for the renewal of the concession. In 2008, Claro and Movistar paid USD 480 million and USD 220 million, respectively, for the renewal of the concession in 2009 and 2023. The publicly owned CNT does not pay anything for their license. Claro and Movistar get the radio spectrum free as well as CNT if there is a demand for new mobile telecommunications services or the need to increase spectrum capacities.

Article 52 of the Organic Law of Telecommunications says that the radio spectrum may be allocated by a competitive process such as an auction if there are multiple requests or scarcity, but this is never practiced in Ecuador. The government assigns radio spectrum to mobile operators when there is a demand for the new services or a need for capacity expansion.

Many countries allocate radio spectrum by auction for new services and capacity increase. This corresponds to the policy stance that anyone can enter the mobile market once it wins the spectrum and pay what it is worth. Therefore, each spectrum has to be priced at its market value. For the Ecuadorian case, the concession renewal charge may be interpreted as the sum of the auction prices that would be charged for a period of 15 years. If the concession renewal charge is some portion of the total mobile revenue during the period and the spectrum price in each auction is calculated in a similar way, the sum of the auction prices should be basically the same as the one-time concession charge.

From now on, we will go through the detailed procedure of how to calculate the reserve price of the spectrum auction. Till now, the Ecuadorian government assigned 280

MHz width as a mobile broadband spectrum. Among them, the 180 MHz width's usage duration will expire in 2023.

Table 21.

Spectrum Holding of Mobile Operators in Ecuador (2020)

(Unit: MHz)

<table>
<tr><th rowspan="2">band</th><th colspan="2">CONECEL</th><th colspan="2">OTECEL</th><th colspan="2">CNT</th><th rowspan="2">Total</th></tr>
<tr><th>width</th><th>usage duration</th><th>width</th><th>usage duration</th><th>width</th><th>usage duration</th></tr>
<tr><td>450 MHz</td><td>-</td><td rowspan="8">2023</td><td>-</td><td rowspan="8">2023</td><td>(9.95)</td><td rowspan="8">2031</td><td>(9.95)</td></tr>
<tr><td>700 MHz</td><td>-</td><td>-</td><td>30</td><td>30</td></tr>
<tr><td>800 MHz</td><td>25</td><td>25</td><td>-</td><td>50</td></tr>
<tr><td>900 MHz</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>1900 MHz</td><td>30</td><td>60</td><td>30</td><td>120</td></tr>
<tr><td>1700/2100 MHz</td><td>40</td><td>-</td><td>40</td><td>80</td></tr>
<tr><td>2600 MHz</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>3500 MHz</td><td>-</td><td>-</td><td>(50)</td><td>(50)</td></tr>
<tr><td>Total</td><td colspan="2">95 (34%)</td><td colspan="2">85 (30%)</td><td colspan="2">100 (36%)
(159.95)</td><td>280 (100%)
(339.95)</td></tr>
</table>

Source: MINTEL (2020)

Regarding the 700, 800, 1900, 1700/2100, 2600, 3400~3800 MHz, and 26 GHz bands, the Ecuadorian regulator should prepare the 2023 renewal and provide 2600 and 3500 MHz bands. The multiband assignment is a total width of 700 MHz for broadband and to deploy 5G services.

Table 22.

Assignment (auction) Target Band

<table>
<tr><th>band</th><th>width</th><th>avaliable frequency blocks</th></tr>
<tr><td>700 MHz</td><td>FDD 60 MHz</td><td>6 blocks (2×5 MHz FDD)</td></tr>
<tr><td>800 MHz</td><td>FDD 50 MHz</td><td>5 blocks (2×5 MHz FDD) : 2023 renewal</td></tr>
<tr><td>1900 MHz</td><td>FDD 60 MHz</td><td>6 blocks (2×5 MHz FDD) : 2023 renewal</td></tr>
<tr><td>1700/2100 MHz</td><td>FDD 40 MHz</td><td>4 blocks (2×5 MHz FDD) : 2023 renewal</td></tr>
<tr><td>2600 MHz</td><td>FDD 140 MHz
SDL 50 MHz</td><td>7 blocks (2×10 MHz FDD)
10 blocks (5 MHz SDL)</td></tr>
<tr><td>3400~3800 MHz</td><td>TDD 300 MHz</td><td>15 blocks (20 MHz TDD)</td></tr>
<tr><td>Total</td><td colspan="2">700 MHz
(FDD 350 MHz + SDL/TDD 350 MHz)</td></tr>
</table>

(2) Directions of Reserve Price Settlement

From now on, we will go through the detailed procedure of how to calculate the reserve price of the spectrum auction. First, what are the important factors to consider when calculating the reserve prices? In Korea's case, the legal guidance is provided in the Radio Waves Act, Article 14.2. The Korean regulator considers and reflects the following five factors in the calculation of the auction reserve price:

① Price of radio frequencies for the same or similar use
② Characteristics and bandwidth of the radio frequency
③ License duration, service type, and technical standards
④ Estimated revenue over the entire license duration
⑤ Demand for radio frequencies subject to assignment

[Radio waves Act of Korea]

Article 14 (Standards for Computation, Procedures for Imposition, etc. of Price for Assignment of Radio Frequencies)

(1) The Standards for computing the price for the assignment of radio frequencies under the latter part of Article 11 (3) of the Act are as specified in attached Table 3: Provided, That where any other radio frequency of the use same as or similar to the radio frequency subject to assignment has ever been assigned through an auction, the price for radio frequency assignment may be computed taking account of the following matters:

1. The price for the allocation of radio frequencies of the same or a similar use;
2. Characteristics of the radio frequency subject to assignment and its bandwidth;
3. Period of use and usage of the radio frequency subject to assignment and technical methods;

Article 14-2 (Methods of Determining Auction Reserve Price) The reserve price shall be determined taking account of the following matters:

1. Matters referred to in Article 14 (1) through 3;
2. Estimated revenue from services using radio frequencies subject to assignment;
3. Demand for radio frequencies subject to assignment.

(3) Market Value Pricing

From now on, we will follow the above five-factor analysis.

① Price of radio frequencies for the same or similar use in Ecuador

The charge for the renewal of concession of mobile communications may be used as a proxy of prices of spectrum for the same or similar use in Ecuador. Some cases in Ecuador took place long ago, but some cases deserve consideration. Cases that are too old are not suitable to be referenced in the pricing of new technology bands like 5G.

② Characteristics and bandwidth of the radio frequency

The value of the spectrum of low access frequency under 1 GHz is higher, as its coverage is wider due to good propagation properties. The value of a higher-frequency band over 1 GHz is lower than a low-frequency band. In Korea, the value of the same bandwidth of the low frequency is 1, while that of the high-frequency band between 1 and 6 GHz is 0.7. The value of higher frequencies greater than 6 GHz is not yet established.

Table 23.

Characteristics and Bandwidth of the Radio Frequency

	700 MHz, 800 MHz	1900 MHz, 1700/2100 MHz, 2600 MHz, 3400~3800 MHz	26 GHz
Characteristic (by RA)	under 1 GHz (coefficient 1)	1 GHz~6 GHz (coefficient 0.7)	6 GHz~ (coefficient ?)

③ License duration, service type, and technical standards

In Ecuador, the duration of the mobile business concession is 15 years, and the duration of spectrum use is up to 15 years. With a mobile business concession, a mobile operator is eligible to use IMT spectrum frequencies.

Table 24.

License Duration, Service Type, and Technical Standards

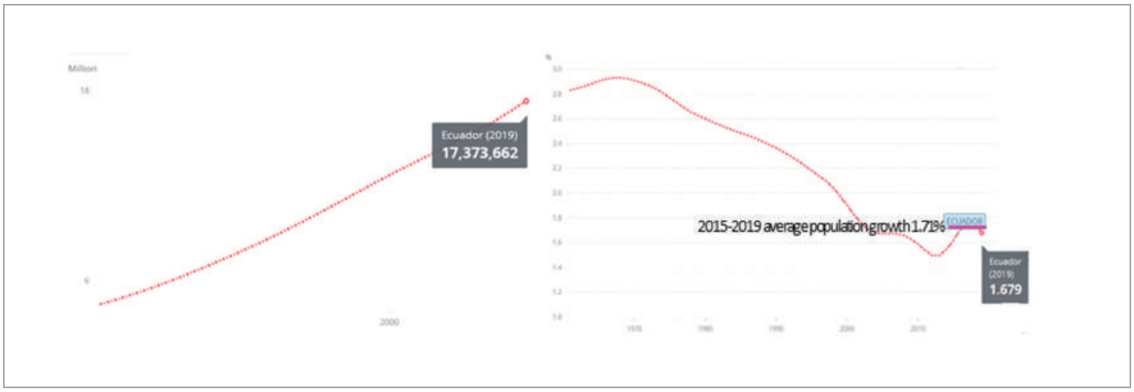
	700 MHz, 800 MHz	1900 MHz, 1700/2100 MHz, 2600 MHz, 3400~3800 MHz	26 GHz
Duration	Assumed as 15 years (Jan. 2024~Dec. 2038.) In 2023, all assigned spectrum of CONCEL & OTECEL will be expired.		
Service Type	for Mobile (IMT) service		
Technical standards	IMT technology of ITU		

④ Estimated revenue over the entire license duration

(Step 1: Subscriber estimation) Estimate the penetration ratio by year using past penetration rates and future penetration rates forecasted by experts, and then estimate the saturation rate using the demand forecasting model (Bass or Logistic). Next, estimate the number of subscribers by multiplying the predicted penetration rate by the estimated population. For an accurate calculation, if possible, it is recommended to obtain a more accurate prediction value based on the method of multiplying the number of subscribers and ARPU for 2G, 3G, 4G, and 5G, rather than multiplying the total number of subscribers by the total ARPU.

Figure 36.

Ecuadorian Statistics: Population and Population Growth (annual %)



Source: World Bank Open Data (August 2020)

Table 25.

Ecuadorian Statistics: Subscriber and ARPU

Operator	2019		
	Subscribers ①	Annual revenue ② (USD million)	Monthly ARPU (②/①/12) (USD)
CONECEL	8,493,054	932.8	9.15
OTECEL	4,456,357	368.0	6.88
CNT EP	2,903,690	182.3	5.23
Total	15,853,100	1,483.1	7.80

Source: MINTEL (2020)

(Step 2: Revenue estimation) First, estimate the ARPU using past ARPU data (2G, 3G, 4G) and expected ARPU (5G and 6G), Second, multiply the ARPU by the estimated number of subscribers. This gives the estimated revenue.

Table 26.

Results of Estimated Revenue of Entire Mobile Market

Periods	Year 1 (2024)	Year 2 (2025)	Year 3 (2026)	Year 4 (2027)	Year 5 (2028)
subscriber* (1000 person)	17,254	1,7548	17,848	18,153	18,463
expected** revenue (mill USD)	1,663	1,702	1,741	1,782	1,823
Periods	**Year 6 (2029)**	**Year 7 (2030)**	**Year 8 (2031)**	**Year 9 (2032)**	**Year 10 (2033)**
subscriber* (1000 person)	18,778	19,099	19,425	19,756	20,094
expected** revenue (mill USD)	1,865	1,908	1,953	1,998	2,044
Periods	**Year 11 (2034)**	**Year 12 (2035)**	**Year 13 (2036)**	**Year 14 (2037)**	**Year 15 (2038)**
subscriber* (1000 person)	20,437	20,786	21,141	21,502	21,869
expected** revenue (mill USD)	2,092	2,140	2,190	2,241	2,293
Periods	**Total (Year 1~15)**				
expected revenue (mill USD)	USD 29,435 mill.				

*Subscribers: 15,853,100 persons in 2019 [assumptions: subscriber annual growth 1.71% (←2015–2019 average population growth 1.71%)].

**Expected revenue: subscriber × monthly ARPU × 12 months [assumptions: ARPU annual growth rate 0.60% (←2015–2019 average inflation 0.60%)].

(Step 3: Estimated profit from this allocation out of the total estimated profit) The total expected revenue is multiplied by the allocation proportion (the proportion of this allocation out of the total bandwidth) to estimate the revenue from this allocation out of the total allocation.

Assignment proportion = ② width of certain assignment / (② width of certain assignment + ① whole width already assigned).

Figure 37.

Assignment Proportion (Defined in the Korean Radio Waves Act as Follows)

$$\text{assignment proportion} = \frac{\text{② width of this assignment}}{\text{② width of this assignment} + \text{① whole already assigned width}}$$

Table 27.

Assignment (auction) Target Band

Band	Width	Available Frequency Blocks
700 MHz	FDD 60 MHz	6 blocks (2×5 MHz FDD)
800 MHz	FDD 50 MHz	5 blocks (2×5 MHz FDD) : 2023 renewal
1900 MHz	FDD 60 MHz	6 blocks (2×5 MHz FDD) : 2023 renewal
1700/2100 MHz	FDD 40 MHz	4 blocks (2×5 MHz FDD) : 2023 renewal
2600 MHz	FDD 140 MHz SDL 50 MHz	7 blocks (2×10 MHz FDD) 10 blocks (5 MHz SDL)
3400~3800 MHz	TDD 300 MHz	15 blocks (20 MHz TDD)
Total	700 MHz (FDD 350 MHz + SDL/TDD 350 MHz)	

Table 28.

Spectrum Holding of Mobile Operators in Ecuador (2020)

(Unit: MHz)

Band	CONECEL		OTECEL		CNT		Total
	width	usage duration	width	usage duration	width	usage duration	
450 MHz	-	2023	-	2023	(9.95)	2031	(9.95)
700 MHz	-		-		30		30
800 MHz	25		25		-		50
900 MHz	-		-		-		-
1900 MHz	30		60		30		120
1700/2100 MHz	40		-		40		80
2600 MHz	-		-		-		-
3500 MHz	-		-		(50)		(50)
Total	95 (34%)		85 (30%)		100 (36%) (159.95)		280 (100%) (339.95)

Source: MINTEL (2020)

Table 29.

Calculation of "Assignment Proportion"

Band	Assignment Proportion
700 MHz	60/800
800 MHz	50/800
1900 MHz	60/800
1700/2100 MHz	40/800
2600 MHz	190/800
3400~3800 MHz	300/800
width of this assignment + whole already assigned width	800 (700+100)

*Before this auction, Ecuador already assigned 100 MHz width as mobile spectrum.

Table 30.

Results of Estimated Revenue by this Assignment among the Whole

	700 MHz	800 MHz	1900 MHz	1700/2100 MHz	2600 MHz	3400~3800 MHz
Estimated revenue of whole mobile market (in step 2) (A)	USD 29,435 mill.	USD 29,435 mill.	USD 29,435 mill.	USD 29,435 mill.	USD 29,435 mill.	USD 29,435 mill.
Portion of this assignment among whole bandwidth (B)*	60/800	50/800	60/800	40/800	190/800	300/800
Estimated revenue by this assignment among whole (C=A×B)	USD 2,208 mill.	USD 1,840 mill.	USD 2,208 mill.	USD 1,472 mill.	USD 6,991 mill.	USD 11,038 mill.

⑤ Demand for radio frequencies subject to assignment

If bidding competition is certainly expected to be high enough, the reserve price can be settled much lower than the expected market value (under value estimation), or even at USD 1 (in some U.S. cases).

If not, the reserve price needs to reflect the value estimation results.

The results of the five-factor analysis were as follows: Carrying out and adopting the above described "④ estimated revenue from whole license duration" is sufficient to satisfy the requirements of the Radio Waves Act articles. The final step is to set the reserve price of certain spectrum bands. In Korea, 3% of the expected revenue is used as the reserve price of the spectrum. Since part of the handset subsidy is included in the mobile service revenue in Korea, 3% in Korea is equivalent to 4% in Ecuador in which there is no handset subsidy.

Table 31.

Reserve Price Calculation (basically 3% of Estimated Revenue)

	700 MHz	800 MHz	1900 MHz	1700/2100 MHz	2600 MHz	3400~3800 MHz
market definition	under 6 GHz mobile market	under 6 GHz mobile market	under 6 GHz mobile market	under 6 GHz mobile market	under 6 GHz mobile market	under 6 GHz mobile market
licence duration	Jan.2024~ Dec.2038 (15 year assumption)	Jan.2024~ Dec.2038 (15 year assumption)	Jan.2024~ Dec.2038 (15 year assumption)	Jan.2024~ Dec.2038 (15 year assumption)	Jan.2024~ Dec.2038 (15 year assumption)	Jan.2024~ Dec.2038 (15 year assumption)
Estimated revenue of whole mobile market	USD 29,435 mill.	USD 29,435 mill.	USD 29,435 mill.	USD 29,435 mill.	USD 29,435 mill.	USD 29,435 mill.
x%	x=3%	x=3%	x=3%	x=3%	x=3%	x=3%
"assignment proportion"	60/800	50/800	60/800	40/800	190/800	300/800
characteristic coefficient	1	1	0.7	0.7	0.7	0.7

Table 32.

700 MHz Band (3%)

Reserve price (band total)

= Estimated revenue × x% × characteristic coefficient × assignment proportion

= (USD 29,435 mill.) × 3% × 1 × (60/800)

= USD 66.23 mill.

Reserve price (per block)

- per FDD 2×5 block: USD 11,038 thousand.

Table 33.

800 MHz Band (3%)

Reserve price (band total)

= Estimated revenue × x% × characteristic coefficient × assignment proportion

= (USD 29,435 mill.) × 3% × 1 × (50/800)

= USD 55.19 mill.

Reserve price (per block)

- per FDD 2×5 block: USD 11,038 thousand.

Table 34.

1900 MHz Band (3%)

Reserve price (band total)

= Estimated revenue × x% × characteristic coefficient × assignment proportion

= (USD 29,435 mill.) × 3% × 1 × (60/800)

= USD 46.36 mill.

Reserve price (per block)

- per FDD 2×5 block: USD 7,727 thousand.

Table 35.

1700/2100 MHz Band (3%)

Reserve price (band total)

= Estimated revenue × x% × characteristic coefficient × assignment proportion

= (USD 29,435 mill.) × 3% × 1 × (40/800)

= USD 30.91 mill.

Reserve price (per block)

- per FDD 2×5 block: USD 7,727 thousand.

Table 36.

2600 MHz Band (3%)

Reserve price (band total)

= Estimated revenue × x% × characteristic coefficient × assignment proportion

= (USD 29,435 mill.) × 3% × 0.7 × (190/800)

= USD 146.81 mill.

Reserve price (per block)

- per FDD 2×10 block: USD 15,453 thousand.
- per SDL 1×5 block : USD 3,863 thousand.

Table 37.

3400~3800 MHz Band (3%)

Reserve price (band total) = Estimated revenue × x% × characteristic coefficient × assignment proportion = (USD 29,435 mill.) × 3% × 0.7 × (300/800) = USD 231.80 mill. **Reserve price (per block)** - per TDD 1×20 block: USD 15,453 thousand.

Through the above calculation process for each band, the result of 3% revenue sharing is as follows.

Table 38.

Reserve Price Determined (3%)

	700 MHz	800 MHz	1900 MHz	1700/2100 MHz	2600 MHz	3400~3800 MHz	Total
Reserve price (band total)	USD 66.23 mill.	USD 55.19 mill.	USD 46.36 mill.	USD 30.91 mill.	USD 146.81 mill.	USD 231.80 mill.	USD 577.29 mill.

By the same methods on the previous page, the results of 4% and 5% of estimated revenue are the following. These can be used as complementary examples to the 3% cases described before.

Table 39.

Reserve Price Determined (4%)

	700 MHz	800 MHz	1900 MHz	1700/2100 MHz	2600 MHz	3400~3800 MHz	Total
Reserve price (band total)	USD 88.30 mill.	USD 73.59 mill.	USD 61.81 mill.	USD 41.21 mill.	USD 195.74 mill.	USD 309.07 mill.	USD 769.72 mill.

Table 40.

Reserve Price Determined (5%)

	700 MHz	800 MHz	1900 MHz	1700/2100 MHz	2600 MHz	3400~3800 MHz	Total
Reserve price (band total)	USD 110.38 mill.	USD 91.98 mill.	USD 77.27 mill.	USD 51.51 mill.	USD 244.68 mill.	USD 386.33 mill.	USD 962.15 mill.

(4) Price of same/similar band — foreign auction

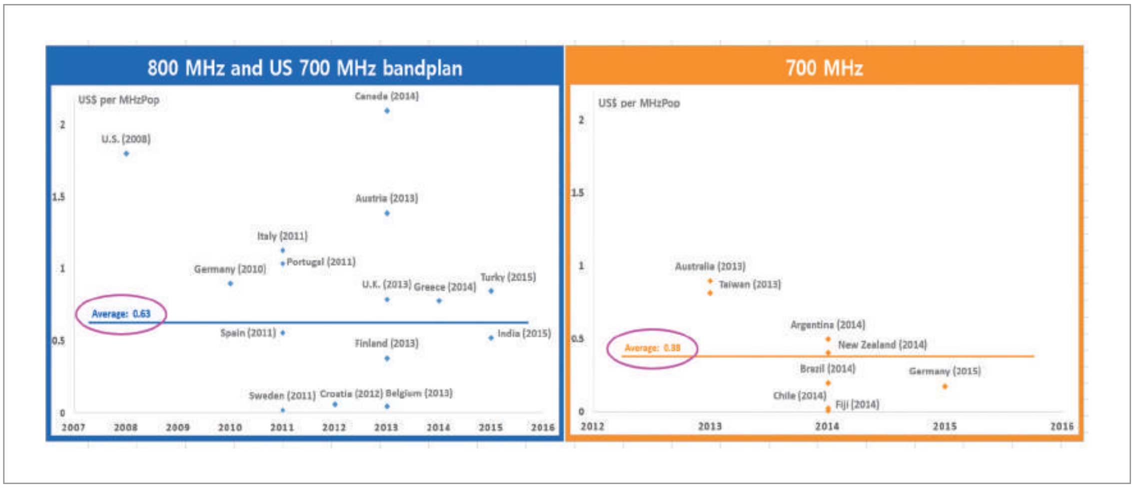
① Unit price (/MHz/pop/year) calculation

①-1. 700 MHz band analysis

The reserve price can be calculated based on the winning bid from previous auctions. We calculated the average winning bid price per MHz and per population with a 15-year license period for the 800 MHz and 700 MHz bands using various country data. We found the price ranges from USD 0.38 to USD 0.63/MHz/pop/15 years (average GDP per capita PPP: USD 28,920.3).

Figure 38.

Auction Price in Completed Auction

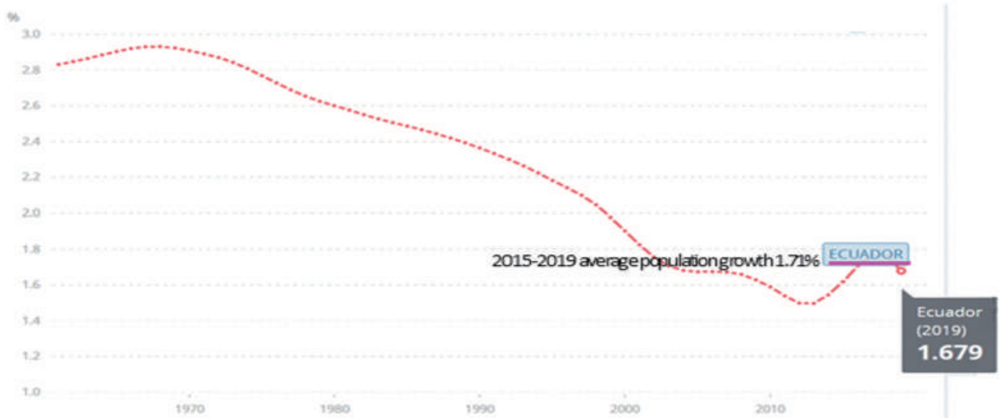


Source: NERA Economic Consulting (2016)

If we convert the price range with the same Ecuadorian purchasing power, the range becomes USD 0.08 to USD 0.13/MHz/pop/15 years.

Figure 39.

Ecuador Statistics: Population Growth (annual %) and GDP per Capita



Ecuador

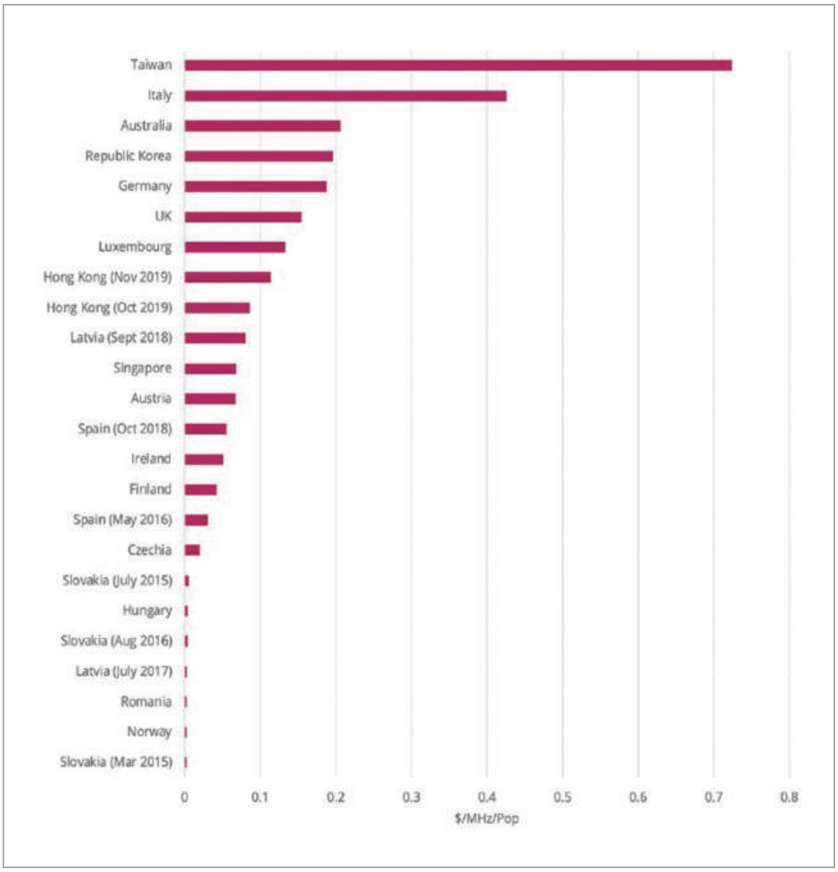
Country Profile	1990	2000	2010	2018
World view				
Population, total (millions)	10.23	12.68	15.01	17.08
Population growth (annual %)	2.4	1.9	1.6	1.8
Surface area (sq. km) (thousands)	283.6	256.4	256.4	256.4
Population density (people per sq. km of land area)	37.0	51.1	60.4	68.8
Poverty headcount ratio at national poverty lines (% of population)	..	..	32.8	23.2
Poverty headcount ratio at $1.90 a day (2011 PPP) (% of population)	..	28.2	5.6	3.3
GNI, Atlas method (current US$) (billions)	14.03	19.66	65.93	104.13
GNI per capita, Atlas method (current US$)	1,370	1,550	4,390	6,090
GNI, PPP [illegible] (billions)	45.49	69.10	134.42	196.87
GNI per capita, PPP (current international $)	4,450	5,450	8,950	11,520

Source: World Bank Open Data (August 2020)

①-2. *C-band (3.3–4.2 GHz) analysis*

We calculated the average winning bid price per MHz and per population with a 15-year license period for the C-band (3.3~4.2 GHz). We found the global average winning price of the C-band to be USD 0.111/MHz/pop/15 years.

Figure 40.
C-band Spectrum Revenue from Auctions/Allocations, USD/MHz/Pop



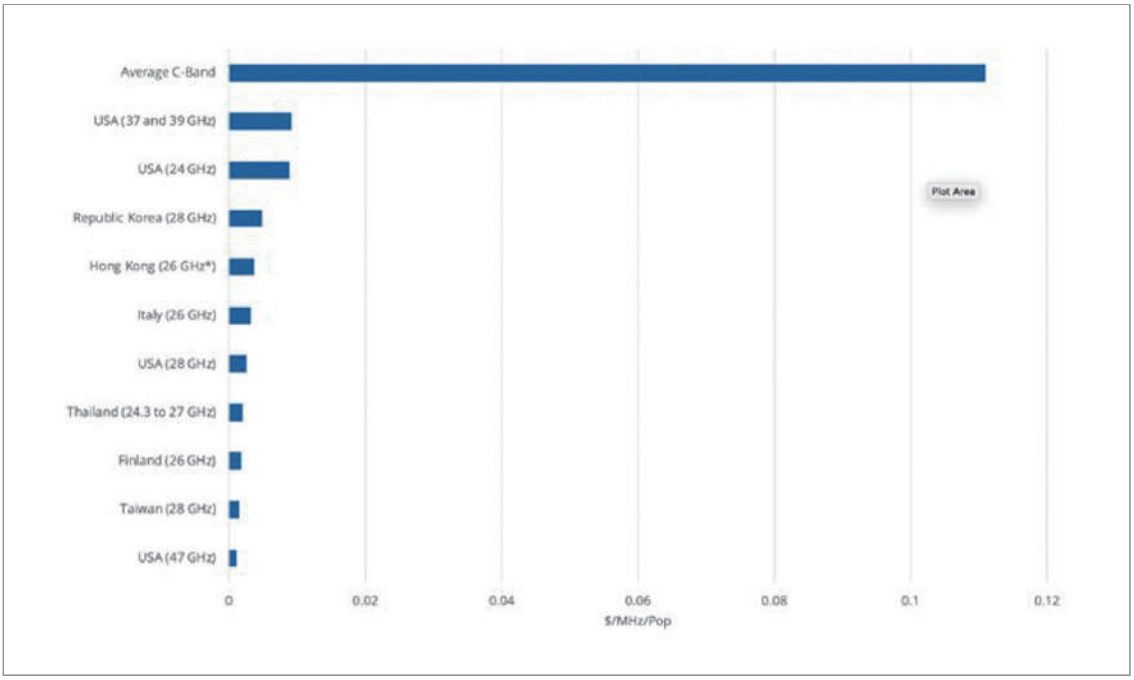
Source: GSA (2020f)

①-3. *mmWave analysis*

We calculated the average winning bid price per MHz and per population with a 15-year license period for the mmWave band. We found the global average winning price to be USD 0.003492/MHz/pop/15 years.

Figure 41.

Prices Paid for mmWave Spectrum, USD/MHz/Pop



Source: GSA (2020f)

We assumed that the Ecuadorian government would supply mmWave (e.g., 26 GHz band) in 2024. The award includes a total of 2.4 GHz (25.1~27.5 GHz) bandwidth. The 2.4 GHz width will be divided into three blocks, i.e., 800 MHz per block.

- Block A: 25.1~25.9 GHz
- Block B: 25.9~26.7 GHz
- Block C: 26.7~27.5 GHz

② Reserve price settlement

The final step is to set the reserve price of certain spectrum bands. With the above unit price of each band, we can calculate the reserve price using the following simple formula:

Reserve price = Unit price × Population × Bandwidth

After we calculate the reserve price for each band, we get the following:

Table 41.

700 MHz Band

Reserve price (band total)

Case 1) Unit $\text{Price}^{\text{Low}}$ = 0.08

= Unit $\text{Price}^{\text{Low}}$ × population × bandwidth

= 0.08 × 17,253,682 × 60

= USD 83.11 mill.

Case 2) Unit $\text{Price}^{\text{High}}$ = 0.13

= Unit $\text{Price}^{\text{High}}$ × population × bandwidth

= 0.13 × 17,253,682 × 60

= USD 137.34 mill.

Reserve price (per block)

Case 1) Unit $\text{Price}^{\text{Low}}$ = 0.08

- per FDD 2×5 block: USD 13,852 thousand.

Case 2) Unit $\text{Price}^{\text{High}}$ = 0.13

- per FDD 2×5 block: USD 22,890 thousand.

Table 42.

800 MHz Band (700 MHz band unit price adopted)

Reserve price (band total)

Case 1) Unit $\text{Price}^{\text{Low}}$ = 0.08

= Unit $\text{Price}^{\text{Low}}$ × population × bandwidth

= 0.08 × 17,253,682 × 50

= USD 69.26 mill.

Case 2) Unit $\text{Price}^{\text{High}}$ = 0.13

= Unit $\text{Price}^{\text{High}}$ × population × bandwidth

= 0.13 × 17,253,682 × 50

= USD 114.45 mill.

Reserve price (per block)

Case 1) Unit $\text{Price}^{\text{Low}}$ = 0.08

- per FDD 2×5 block: USD 13,852 thousand.

Case 2) Unit $\text{Price}^{\text{High}}$ = 0.13

- per FDD 2×5 block: USD 22,890 thousand.

Table 43.

1900 MHz Band (C-band unit price adopted)

Reserve price (band total)
= Unit Price × population × bandwidth
= 0.111 × 17,253,682 × 60
= USD 115.52 mill.
Reserve price (per block)
- per FDD 2×5 block: USD 19,169 thousand.

Table 44.

1700/2100 MHz Band (C-band unit price adopted)

Reserve price (band total)
= Unit Price × population × bandwidth
= 0.111 × 17,253,682 × 40
= USD 76.68 mill.
Reserve price (per block)
- per FDD 2×5 block: USD 19,619 thousand.

Table 45.

2600 MHz Band (C-band unit price adopted)

Reserve price (band total)
= Unit Price × population × bandwidth
= 0.111 × 17,253,682 × 190
= USD 364.22 mill.
Reserve price (per block)
- per FDD 2×10 block: USD 38,339 thousand.
- per SDL 1×5 block : USD 9,585 thousand.

Table 46.

3400~3800 MHz Band (C-band unit price adopted)

Reserve price (band total)
= Unit Price × population × bandwidth
= 0.111 × 17,253,682 × 300
= USD 575.08 mill.
Reserve price (per block)
- per TDD 1×20 block: USD 38,339 thousand.

Table 47.

mmWave (mmWave unit price adopted)

Reserve price (band total)

= Unit Price × population × bandwidth

= 0.003492 × 17,253,682 × 2,400

= USD 144.59 mill.

Reserve price (per block)

- per TDD 1×800 block: USD 48,196 thousand.

Using the above calculation process for each band, the result of the reserve price based on global auctions is as follows:

Table 48.

Reserve Price Determined

	700 MHz	800 MHz	1900 MHz	1700/ 2100 MHz	2600 MHz	3400~ 3800 MHz	mmWave	Total
Reserve price^{Low} (band total)	USD 88.11 mill.	USD 69.26 mill.	USD 115.02 mill.	USD 76.68 mill.	USD 364.22 mill.	USD 575.08 mill.	USD 144.59 mill.	USD 1,427.95 mill.
Reserve price^{High} (band total)	USD 137.34 mill.	USD 114.45 mill.	USD 115.02 mill.	USD 76.68 mill.	USD 364.22 mill.	USD 575.08 mill.	USD 144.59 mill.	USD 1,527.36 mill.

(5) Comparison

If we compare the reserve price based on future revenue and the price based on global auctions, the reserve prices from the previous auctions turned out to be 5% of sales.

Table 49.

Reserve Price Comparison

(Unit: USD million)

	Market value pricing (% of market revenue)			Price of same/similar band Foreign auction
	3%	4%	5%	
700 MHz	66.23	88.30	110.38	83.11~137.34
800 MHz	55.19	73.59	91.98	69.26~114.45
1900 MHz	46.36	61.81	77.27	115.02
1700/2100 MHz	30.91	41.21	51.51	76.68
2600 MHz	146.81	195.74	244.68	364.22
3400~3800 MHz	231.80	309.07	386.33	575.08
Under 6 GHz total	577.29 mill.	769.72 mill.	962.15 mill.	1,427.95~1,527.36 mill.
mmWave	144.59 mill.			
Total	721.88 mill.	914.31 mill.	1,106.74 mill.	1,572.54~1,671.95 mill.

Table 50.

Recent Assignment and Pricing in Ecuador

(Unit: USD million)

	Band	Bandwidth	Spectrum price
License renewal in 2008			
Claro	850 MHz	25 MHz	USD 480 mill.
	1.9 GHz	10 MHz	
Movistar	850 MHz	25 MHz	USD 220 mill.
	1.9 GHz	10 MHz	
Sub total		70 MHz	USD 700 mill.
Allocation in the 2010s			
CNT	700 MHz	30 MHz	-
	AWS 1700/2100	40 MHz	
Claro	AWS 1700/2100	40 MHz	USD 180 mill.
	1.9 GHz	20 MHz	
Movistar	1.9 GHz	50 MHz	USD 150 mill.
Sub total		180 MHz	USD 330 mill.
Grand total		250 MHz	USD 1,030 mill

4.3 Policy Recommendations

4.3.1 Additional Spectrum Allocation

The Ecuadorian government plans to allocate additional IMT spectrum in the near future as summarized in [Table 16]. The first step for this new allocation would be to provide a roadmap for future spectrum availability and a timeline. There were cases in which the government postponed additional spectrum release:

- Between 2017 and 2018, ARCOTEL proposed new band plans for the 900 MHz, AWS, and 3.3~3.6 GHz bands. However, these actions have not yet been carried out (5G America, 2018).
- MINTEL revealed plans to auction starting in November 2019. However, the plan was delayed until Q4 2020 or 2021 (GSA, 2020a).

There is consensus in the industry that 5G needs a combination of sub-1-GHz frequencies, mid-band spectrum around 3 GHz, and mmWave bands. Ecuador's MINTEL announced plans for a spectrum auction in 2019, saying that AWS and 2.6 GHz are for 4G, and 3.5 GHz is for 5G, but the decision on the high band seems to not have been made public.

A spectrum roadmap can reduce regulatory uncertainty over future spectrum supply and make the spectrum release plan more official. In particular, a comprehensive plan should be prepared for the overall demand and supply of spectrum, and its utilization and management. Through this comprehensive plan, Ecuador can improve the reliability and predictability of its policies by diagnosing spectrum usage status, systematically establishing plans for the future, and informing users of the plan. For the next, the need for additional supply reviews and timely supply of internationally preferred bands.

In addition, it is important for the government to account for LATAM's harmonized spectrum plan.[14] As of now, the most popular spectrum bands in the LATAM mobile markets are the 850 MHz, 1.9 GHz, and AWS 1.7/2.1 GHz bands followed by the 700 MHz band.

4.3.2 Reducing Spectrum Costs

As shown in [Table 15] previously (see page 73 for the table),, two private mobile operators in Ecuador (Claro and Movistar) purchased 110 MHz of the IMT spectrum for USD 330 million in 2015. In addition, these

14 The benefits of spectrum harmonization include economies of scale, lower price of devices for consumers. and improved roaming.

operators have to pay monthly recurring spectrum fees for using the IMT spectrum. According to National Telecommunications Council Rev. 4.7.0, the rates for the use of radio spectrum are determined by the following formula:

FEE ERE (f) = (Ka) × (αn) × βn × Bandwidth × Factor (service function)

Ka = inflation adjustment factor value

αn = spectrum assessment coefficient determined by CONATEL

βn = correction coefficient (the value is 1 for private providers regardless of the values set by Conatel)

In addition, they have to pay other regulatory fees to maintain their mobile licenses as shown in [Table 51].

Table 51.

Mobile License Fees of Ecuador

Initial license fees	Different fees set by the regulator at the time of obtaining a spectrum license.
Recurring spectrum fees	Monthly fee based on a formula set by the regulator.
Variable license fees	A percentage set by the regulator at the time of obtaining the license (usually 2.93% of invoiced revenues).
Market concentration fee	0.5%~9%
Universal service fund	1%
Local fee for radio base installation	Different fees depending on the municipality.

Source: GSMA (2018c)

These regulatory fees are in addition to the taxes applying to mobile operators, which are corporate income taxes, personal income taxes on wages, social security contributions, employee profit sharing, remittance taxes, credit transactions taxes, local license taxes, urban property taxes, business net worth taxes, superintendence contribution, and customs duties.

According to GSMA (2018c), recurring spectrum fees constitute about 4% of the total market revenue and variable license fees constitute about 2%. In addition, private operators have to pay a market concentration fee based on the percentage of market concentration. In order to incentivize MBB network investment or make MBB more affordable, the Ecuadorian government has to consider lowering various license fees as shown in [Table 51]. For instance, GSMA (2018c) has recommended: (1) reducing recurring spectrum fees by 50%, (2) reducing market concentration fee by 50%, and (3) removing the special consumption tax on mobile services.

4.3.3 Spectrum Supply for 5G

The Ecuadorian government may license the 2.5 GHz band as TDD (b41/n41, 3GPP release 16) and use it for 5G. Indeed, it is absolutely possible that Ecuador can utilize all the spectrum shown in Table 16 for 5G. It should also be noted that the government must clear the 50 MHz (3400~3425/3500~3525) of WiMax spectrum held by CNT before releasing the core 5G mid-band spectrum (3.3~3.6 GHz). Moreover, mobile operators can upgrade their networks to 5G using spectrum already assigned to them. For example, Claro and Movistar can upgrade their 2G and 3G networks in the 850 MHz band to 5G. Note that each of them holds only 25 MHz in this band. If this spectrum is not broad enough for some 5G applications, one of them may give up using this band spectrum in exchange for receiving contiguous broadband spectrum in the neighboring sub-1-GHz band. The remaining operator will also be able to use contiguous broadband spectrum in this band range from 824 to 894 MHz (n5 of 3GPP). Of course, this procedure would require a reallocation plan by the Ecuadorian government.

4.3.4 Possible Delay of 5G

Perhaps inevitably, the COVID-19 pandemic has had a major impact on the national plans for the assignment of spectrum for mobile services. The second quarter of 2020 saw country after country postpone planned auctions. Consequently, overall progress toward 5G may be postponed or slowed down. Even without COVID-19, 5G take off could be delayed because there are no 5G killer applications and because the 5G network investment cost has not dropped substantially.

4.3.5 Efficient Spectrum Pricing

Auctions have been widely used around the world as a way of allocating spectrum since the mid-1990s. A possible reason is that they have generated substantial revenue for the state, as an auction is designed to award the spectrum to the highest bidder. Therefore, under the auction method, it is likely to direct the spectrum to the more efficient operators.

Ecuadorian mobile operators pay a concession charge every 15 years for the renewal of the concession. In 2008, Claro and Movistar paid USD 480 million and USD 220 million, respectively, for the renewal of the concession during 2009 and 2023. The publicly owned CNT does not pay anything for their license. Claro and Movistar get the radio spectrum free as well as CNT if there is demand for new mobile telecommunications services or the need to increase spectrum capacities.

Article 52 of the Organic Law of Telecommunications says that the radio spectrum may be allocated by a competitive process such as an auction if there are multiple requests or scarcity, but it is never practiced in Ecuador. The government assigns the radio spectrum to mobile operators when there is a demand for new services or a need for capacity expansion.

Many countries allocate the radio spectrum by auction for new services and capacity increase. This corresponds to the policy stance that anyone can enter the mobile market once it wins the spectrum and pay what it is worth. Therefore, each spectrum has to be priced at its market value. For the Ecuadorian case, the concession renewal charge may be interpreted as the sum of the auction prices that would be charged for the period of 15 years. If the concession renewal charge is some portion of total mobile revenue during the period and the spectrum price in each auction is calculated in a similar way, the sum of the auction prices should be basically the same as the one-time concession charge.

Reserve prices play a pivotal role in the auction design. It is a tool to keep the non-serious bidders out and also a means to ensure a certain minimum amount of revenue for the government. Hence, for a smooth auction process, the reserve price must be declared in advance, which can help promote responsible bidding and ensure optimal prices. However, to meet these objectives, the reserve prices for spectrum auction must be carefully determined.

It is important to set the correct reserve prices for the spectrum auction. If the reserve price is set too low, there is a risk that the valuable national spectrum resources will be somewhat wasted. On the other hand, if the reserve price is set too high, there is a risk that the auction will fail, and nobody will enter the auction process, which would yield zero revenue for the government. In addition, before the final rule, the Ecuadorian government must evaluate the extent of the past Ecuadorian spectrum auction reserve price level, and the impact on the future prices of auctions.

Chapter 5.

Universal Service

5.1 Universal Service and Digital Divide

5.1.1 Universal Service

According to Mueller (1993), the term of universal service is initially used by Theodore Vail of the Bell System in a campaign prohibiting competition and establishing a regulated monopoly in the United States.

ITU (2013) explained that the underlying concept of universal service is to ensure that telecommunication services are accessible to the widest number of people (and communities) at affordable prices. ITU (2013) summarized the unique features of universal service as has been widely discussed in a number of publications, the concept of universal service is underpinned by the three following principles:

- *Availability:* the level of service is the same for all users in their place of work or residence, at all times and without geographical discrimination
- *Affordability:* for all users, the price of the service should not be a factor that limits service access
- *Accessibility:* all telephone subscribers should be treated in a non-discriminatory manner with respect to the price, service and quality of the service, in all places, without distinction of race, sex, religion, etc.

According to ITU (2008), the universal service for telephone service, first mentioned in the 1934 Communications Act of the United States, describes the concept of affordability of telephone services, as well as its universal availability for households desiring that service.

Recently many researchers propose the extension of universal service or the revision of universal service scope. Msimang (2012) proposes that universal service is also being extended to include dial-up and broadband internet in its scope. Alleman et al. (2010) suggests that in this ubiquitous communications environment, the whole set of possible communications methods should be considered when defining “universal connectivity”. Moreover, Alleman et al. (2010) insists that the definition of Universal Service Obligation (USO) should be as broad, flexible and comprehensive as possible because the technology of communications is changing dramatically—all forms of wireless, as well as enhanced fixed lines (copper wire, cable and fiber)—as are the services (SMS; VoIP; social networks such as, Twitter and Facebook).

EU (2009) defines universal service as the provision of a defined minimum set of services to everyone on request and at an affordable price. EU (2009) presents that the rationale of universal service is to act as a safety net where market forces do not deliver affordable access to a minimum set of communication services, in order to prevent and economic disadvantages.

Because of the universal service regime, fixed telephones are now available to anyone, anywhere in Korea at affordable prices. Universal service policy played an important role in promoting the deployment of a Public Switched Telephone Network (PSTN) service in Korea. Based on this PSTN, the deployment of Korea's broadband network was possible.

ITU (2003) indicates that because most of the early Internet users in Korea were young, there is high demand for online games, movies, music, and videos. Lau et al. (2005) stated that 67% of stock trading in Korea was done through the internet. This stock trading, in turn, affected the spread of the internet. Aizu (2002) argues the active acceptance culture of Koreans accelerated the acceptance of broadband internet. Kim et al. (2010) and Ovum (2005) assert that the Korean government established the National Informatization Promotion Plan (1996), Cyber Korea 21 (1999), and e-Korea Vision 2006 to promote e-commerce, online public services, and digital education (digital literacy). These policies accelerated the deployment of broadband in Korea.

From 2020, universal service included maximum 100 Mbps broadband internet service in the scope of universal service range. Korean citizens at anywhere in Korea can use wired telephone and broadband internet service through the universal service regime. The people of Korea is the first in the world to receive 100 Mbps broadband Internet as a universal service.

5.1.2 Digital Divide

OECD (2018) defines digital divide as the different levels of access and use of information and communication technologies and, more specifically, to the gaps in access and use of Internet based digital services. Min (2011) explains that digital divide is the phenomenon in which access to knowledge and information is disproportionate by economic class, gender and age. Also Min (2011) presents the phase of change in the digital divide into three stages as follows.

- Introduction period: access divide
- Expansion period: usage divide
- Saturation period: divide stemming from the quality of use

5.2 Review of Universal Service Plan 2018~2021 of Ecuador

5.2.1 Program 1: Access to Telecommunication Service[15]

The objective of program 1 is to increase capacity and universalize access to public telecommunications networks. Ecuador has a diverse geography with mountain ranges, valleys, rain forest and remote areas, which in some cases represent a barrier to the deployment of telecommunications infrastructure. For this reason, it is common that marginal rural and urban areas lack basic infrastructures for the provision of telecommunications services, which constitutes one of the main challenges of public policies, plans and projects of the State, together with the providers of Telecommunications services.

In this framework, it is necessary to promote investment in infrastructure, so that the population at the national level benefits from the widespread use of telecommunications networks and technological devices. For its part, fixed technologies will continue to be crucial for connectivity, highlighting the importance of fiber optics or new last-mile technologies.

In order to achieve the proposed objective, this program foresees, through the accrual of spectrum, projects with service providers, the generation of incentives and Public-Private Partnerships (PPPs), among others:

- Promote the deployment of telecommunications infrastructure, as an enabling element to increase and expand access to public telecommunications networks
- Encourage migration to the new generation networks in the country, particularly fiber optic networks and high-speed

15 MINTEL(2018)

wireless IMT networks, focusing efforts on underserved areas, and providing public access points to the networks.

- The lines of action in program 1 are as follows.
- Promote the deployment of telecommunications infrastructure, mainly in rural, border areas, Amazonia and Galapagos

According to the National Development Plan 2017~2021, the State promotes social and economic progress throughout the national geography, for which, one of the guidelines is to increase access to public services for telecommunications and information and communication technologies, especially in the rural sector, border, Amazon and Galapagos. For this reason, this line of action proposed to ensure access to the telecommunications services that make up the universal service, on equal terms to all Ecuadorians, promoting projects aimed at providing telecommunications infrastructure in prioritized parishes.

Encourage migration to new generation, high-speed networks

The convergence of voice, video and data services, among others, means that high-capacity networks become a critical pillar for the development of the digital ecosystem. Through this line of action, the deployment of high-speed wireless IMT technologies, the promotion of tenders for new frequency bands destined for IMT services. The deployment of next-generation broadband networks will show an increase in transmission speed, which benefits the growth of the telecommunications sector, the development of new business models and the strengthening of production processes.

Ensure universal access to ICTs in rural parishes

The availability of ICT, as well as its adoption, has grown greatly in recent years considering the potential of ICT in the development of a country. This line of action encourages the development of community access centers for ICT, such as Infocentres and free Wi-Fi access points, aimed at those social strata who, due to their socioeconomic status, find it difficult to access with their own resources.

5.2.2 Program 2: Universal Service

The objective of this program is to promote the universal service of ICT in the population.

The lines of action in this program are as follows:

Develop measures to improve the affordability of universal service, with an emphasis on priority attention groups

Promote preferential rates for voice and data services, aimed at priority attention groups that, due to their special needs or due to physical, economic or other characteristics, have access limitations to services, regardless of their geographical location. This line of action focuses on the provision of preferential rates to increase the penetration of voice and data services of the universal service.

Coordinate actions so that public institutions and Micro, Small & Medium Enterprises (MSMEs) are connected to the internet

Connectivity is essential for the proper functioning of state services. This line of action seeks to extend the coverage of telecommunications services. It is essential to encourage investment by MSMEs in ICT services to improve their skills in the digital environment, which will allow them to incorporate ICT into their productive activities, and advance technologically in fields such as electronic commerce, for which one of the main enablers is internet connectivity.

5.2.3 Internet for Everyone[16]

This service provides cheap internet to farmers and the residents of rural areas. The program initially aims to provide 214 rural parishes with fixed and mobile internet via one state-run and two private telecommunications companies.

According to Michelena, who is Telecommunications Minister, four out of 10 Ecuadorian households are connected to the internet, or 37 percent, and one out of 10 households (11 percent) has either a desktop computer or mobile device.

5.2.4. The Evaluation of Universal Service Plan

The policy direction of universal service is very appropriate. It is setting policy goals to improve availability, affordability, and accessibility, which are the basic goals of universal services.

Ecuador's universal service plan consists of two programs.

16 XINHUANET (2019)

Program 1 is Access to telecommunication services. Program 1 mainly focuses on improving availability and accessibility. To improve availability & accessibility, Program 1 proposes spectrum distribution, joint projects with operators, and Public-Private-Partnership. The objective of universal service regulation is to extend telecommunication coverage which is not be covered by market functions. Program 1 will be a very appropriate and effective solution if it will be done properly.

Program 2 is a program to increase the ability of users to pay. In order to increase the feasibility of payment, there is an option to provide a service at a low rate and a rate reduction for the low-income class. Providing special rates for the vulnerable social stratum is also a very good option. In this respect, "Internet for everyone", which started last year, is a very suitable program. This would be a good example of PPP.

However, as the policy objectives of universal service cover both the supply side and the demand side, there is a possibility that resources may be dispersed. In order to ensure the possibility of paying, it is necessary to create a rate reduction or universal service tariff plan in Program 2 to enable the use of telecommunication services at a low rate. We think one of these means is the internet for everyone. In the case of Korea, the rate reduction is borne by the telecommunication service provider. This rate reduction system is operated as a universal service regime.

5.3 The Case Studies of Broadband Universal Service

5.3.1 UK[17]

In March 2018, the Secretary of State made the Order to extend the universal service to broadband connections and services. In March 2018, the UK Government finalized the terms of a new Universal Service Obligation (USO) by issuing secondary legislation ("the Order"). The Order is Electronic Communications Universal Service Broadband Order which came into force on 23 April 2018.

From 20 March 2020, broadband internet, which is a download speed of 10 Mbps and an upload speed of 1 Mbps is available as universal service in the UK. There is 100 GB Cap/month in broadband universal service. Ofcom research shows that 10 Mbps is the minimum speed currently needed to meet an average household's digital needs. It should be fast enough for multiple people in a household to be online at once.

The USO for broadband is a UK-wide measure intended as a "safety net" to deliver broadband to those premises that do

17 Georgina Hutton (2020)

not have access to a decent and affordable connection. The government has defined a decent connection as one that can deliver 10 Mbps download speed and 1 Mbps upload speed (along with other defined quality parameters). Ofcom has defined an affordable connection as one that costs less than £45 per month. The USO provides a legal right to request a decent broadband connection, up to a cost threshold of £3,400. BT (and KCOM in Hull) have been designated as the Universal Service Providers responsible for fulfilling requests from eligible consumers.

UK defines affordable broadband connections and services must be provided throughout the UK with a download speed of at least 10 Mbps and other specific technical characteristics. The Universal Service Obligation aims to improve broadband coverage to household and business in hard to reach areas.[18] Affordable Broadband means that £45/month, which includes VAT, connection charges, the monthly payment and other broadband charges spread over the life of the contract. Throughout the UK means that the USO apply to the whole of the UK and is intended to help the gap left by existing broadband rollout programs, including both commercial and publicly-funded program.

Eligibility

Someone who will be eligible if it has no access to a decent and affordable (£46.1/month) broadband and will not be covered by a public broadband scheme offered by the UK and devolved governments in the 12 months. The connection will cost no more than £3,400 to build (or the customer has chosen to pay the excess above £3,400). Access to decent broadband connection means that any connection including wireless connections such as home broadband packages delivered over mobile (4G) networks.

Technology[19]

Any technology capable of delivering the minimum technical USO standards could be considered to deliver connections, including mobile broadband. In practice, most connections under the USO are likely to use full-fiber or Fiber-to-the-Cabinet (FTTC) technology. Depending on the technology used to deliver the connection some consumers may receive a higher quality connection than the minimum standards.

The USO is technology neutral. This means that any technology capable of delivering the minimum technical standards could be considered to deliver the service. Depending on the technology used to deliver the connection some consumers may receive a higher quality connection than the minimum standards. The choice of technology is up to the

18 Ofcom (2019)
19 Ofcom (2020)

Universal Service Provider (so long as it meets the minimum criteria). Ofcom reported in June 2019 that technologies that would meet the specifications for the USO include:

- Full-fiber (also called Fiber-to-the-Premises, FTTP);
- FTTC (in most cases, depending on how far the premises is from the cabinet);
- fixed wireless networks, including 4G mobile broadband (in most cases).

Ofcom stated that other technologies such as satellite and TV White Space were unlikely to be able to deliver the USO specifications at its time of implementation. To claim compensation for an unfair cost burden from industry, the provider must demonstrate that the costs incurred were efficient, which could impact the technology choice.

5.3.2 US[20]

The Federal Communications Commission (FCC) adopted a Notice of Proposed Rulemaking seeking comment on establishing the 5G Fund for Rural America. 5G represents the next leap in mobile wireless technology, bringing significantly increased speeds, reduced latency, and better security than 4G LTE networks, and enabling cutting-edge applications and technologies benefitting consumers, businesses, precision agriculture, education, and healthcare.

The Notice proposes to distribute up to USD 9 billion through the Universal Service Fund across rural America for 5G wireless broadband connectivity. The 5G Fund would help ensure that rural Americans enjoy the same benefits from our increasingly digital economy as their urban counterparts—more than 200 million of whom already have access to major providers' 5G networks—and would include a special focus on deployments that support precision agriculture.

In addition to 5G networks already coming online in urban and suburban areas, the Commission conditioned approval of the T-Mobile/Sprint transaction on T-Mobile's commitment to deploy its 5G network to 90% of rural Americans. Today's Notice proposes to make available up to USD 8 billion in Phase I to support deployment of 5G networks in rural areas that are unlikely to see timely deployment without this support or as part of the T-Mobile transaction deployment commitments. The second phase would target at least USD 1 billion in support to bring wireless connectivity to harder to serve and higher cost areas, including farms and ranches, to help facilitate adoption of connected precision agriculture technologies.

The 5G Fund for Rural America would use a competitive reverse auction format to award funding for wireless broadband services,

20 FCC (2020)

building on the success of the FCC's recent Connect America Fund Phase II auction and the design for the upcoming Rural Digital Opportunity Fund Phase I auction. The Notice seeks comment on two different approaches to identifying eligible areas for the Phase I reverse auction: One approach would hold an auction in 2021 by defining eligible areas based on current data sources that identify areas as particularly rural and thus in the greatest need of universal service support and prioritize funding to areas that have historically lacked 4G LTE or even 3G service. An alternative option would delay the 5G Fund Phase I auction until at least 2023, after collecting and processing improved mobile broadband coverage data through the Commission's new Digital Opportunity Data Collection. The proposed 5G Fund budget also includes USD 680 million reserved to support 5G networks serving Tribal lands as part of Phase I.

5.3.3. South Korea

Universal service policy in Korea launched in 2000. Before 2000, there was no universal service regime in Korea. At that time, the local telephone market was a monopoly market and KT, the monopoly operator, was obliged to provide local telephone calls nationwide whenever there was a request to install a local telephone.

In 1999 competition was introduced into the local telephone market and a universal service system began in 2000. New operators entered only profitable areas to dissipate profits. Therefore, local telephone service could not be provided in unprofitable areas without loss. Korean government imposed the universal service obligation to KT, the SMP in the local telephony market. Korean government has imposed obligations on other telecommunications operators to share losses according to the sales ratio.

Because of the universal service regime, fixed telephones are still available to anyone, anywhere in Korea at affordable prices. Universal service policy played an important role in promoting the diffusion of the PSTN service in Korea. Based on this, the diffusion of Korea's broadband network was possible.

Telecommunication Business Act in Korea defines universal service as essential telecommunications services which must be provided at affordable prices for all consumers at any time and any place. Universal service includes: local telephone service, broadband service, public payphone service, maritime communication service, emergency call service and rate reduction support for low-income family and handicapped citizens.

The Korea government included 100 Mbps fixed broadband internet in the scope of universal service from 2020. The target speed is maximum 100 Mbps. The target building is unserved building at the time of subscription. In principle, it takes a technology neutral position. However, FTTH or FTTC is actually used to satisfy the speed standard. Currently, KT (broadband universal service provider in Korea) does not provide universal services for broadband universal service with mobile communication technology.

The universal service system in Korea is a system that partially compensates for the losses caused by the provision of universal services. The universal service providers provide services and major telecommunications carriers share the losses incurred according to their sales revenue in telecommunication market. Korean government does not bear the burden of sharing losses due to provision of universal services obligation. There is no real fund, but mutual settlement between telecommunications operators. This system is called a virtual fund system. The Korean government calculates losses and acts as a mediator in the settlement process between telecommunications operators.

5.4 National Broadband Policy of Korea[21]

5.4.1 Policy Driver for Broadband Success

The Korean Government's approach to promote ICT in general and the broadband market in particular, has been to formulate strategic development frameworks through the use of consecutive informatization master plans which run over a number of years. Through each framework, the Government has outlined broad policy objectives, and has laid out a number of supply and demand-side supporting policies, including for example:

- plans for public investment in broadband infrastructure and incentives for private investment;
- initiatives to aggregate and expand demand for broadband services;
- policies to promote universal access to broadband; and
- various supporting industrial policies.

5.4.2 Informatization Master Plan, 1996~2015

Since 1996 the Korean Government has established a number of master plans for the development of an information society:

21 Ovum(2009)

Figure 42.

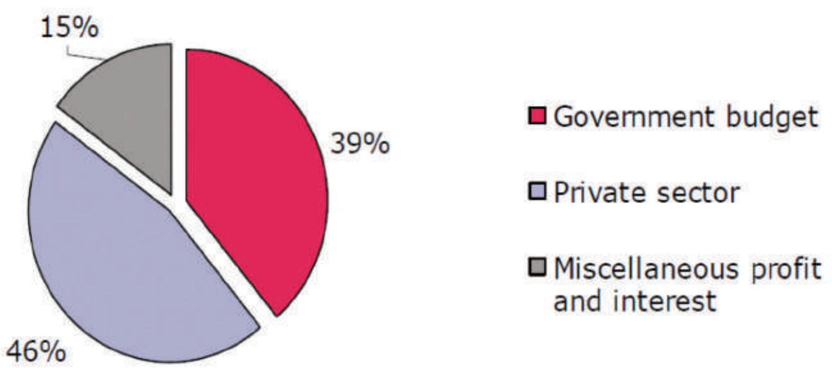
Informatization Master Plan in Korea

Year	Initiative
1996 – 2000	First National Informatisation Promotion Plan
1999 – 2002	Cyber Korea 21
2002 – 2006	e-Korea Vision 2006
2003 – 2007	Broadband IT Korea Vision 2007
2006 – 2015 2006 – 2010 2011 – 2015	U-Korea Master Plan Phase 1 Phase 2

The government has also implemented an informatization Promotion Fund to finance projects which foster the use of information. The fund includes contributions from both the Government and the telecommunications operators, through spectrum licensing fees, revenue-based contributions and earnings from the operation of the fund, including loans. Between 1993 and 2002, the total value of the informatization promotion fund was USD 7.8 billion of which almost half came from the private sector.

Figure 43.

Source of informatization Promotion Funding



Source: Ovum (2009)

Money from the fund is used to support ICT-related R&D, to develop and encourage standardization in the ICT industry, to train ICT human resources, to promote broadband network roll-out and to promote e-government. In addition to its informatization master plans, the Government's supply-side broadband policies can be categorised into infrastructure and application development policies.

5.4.3 Infrastructure and Application Development Policies in Korea

Three key broadband infrastructure policies have been implemented since the mid 1990s:

Figure 44.

Broadband Infrastructure Policies

Year	Initiative	Speed	Technology
1995 – 2005:	Korea Information Infrastructure	2Mbps	ATM, ADSL, Cable Modem
1995 – 1997	Phase 1		
1998 – 2000	Phase 2		
2001 – 2005	Phase 3		
2004 – 2010	IT839 and Broadband convergence Network	50 – 100Mbps	VDSL, FTTB, FTTH, WiBro, W-CDMA, HSDPA
2004 - 2005	Phase 1		
2006 - 2007	Phase 2		
2008 – 2010	Phase 3		
2009 - 2013	Ultra Broadband Convergence Network	100 – 1Gbps	FTTH, WiBro, W-CDMA, HSDPA

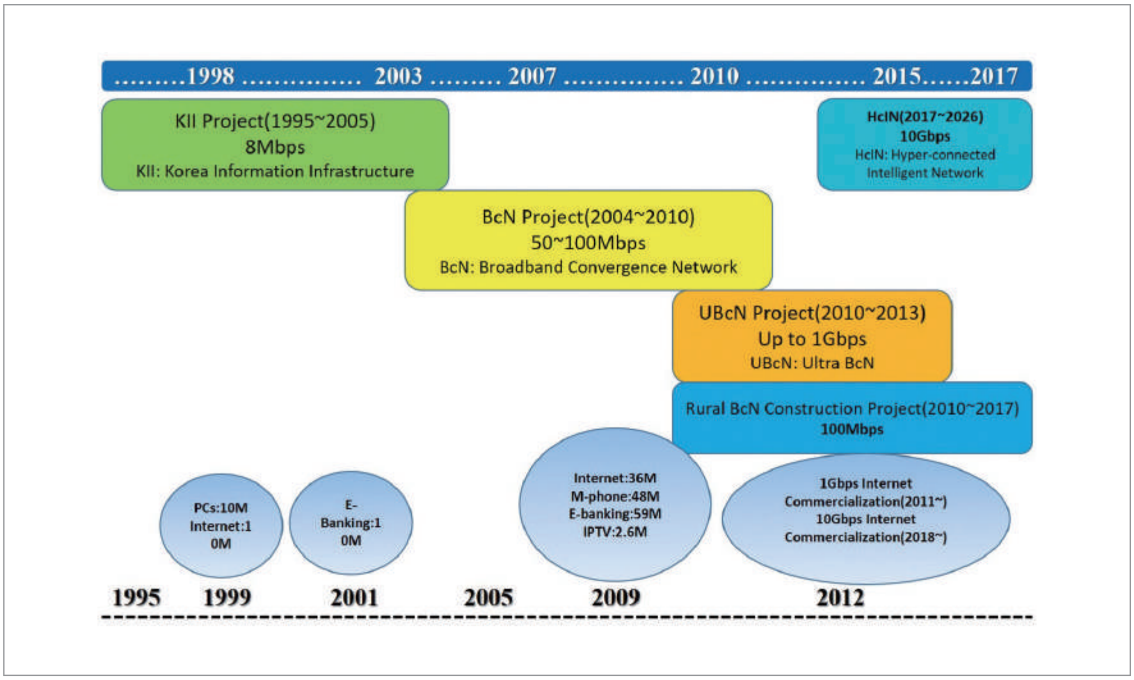
Surprisingly given the Government's extensive policy involvement in the ICT sector, the majority of funding for Korea's broadband infrastructure projects has come from the private sector rather than the public sector. Overall, the Government invested more than USD 900 million in the Korea Information Infrastructure (KII) project. However this is only a small proportion compared to the total investment of USD 33 billion overall (NCA). The government's total budget for Broadband Convergence Network (BcN) is far smaller, at just USD 62 million, again a drop in the ocean compared to the overall level of investment that will be made by the private sector. Investment in Ubiquitous Broadband Convergence Network (UBcN) infrastructure will also primarily come from the private sector, with the split between public and private funding estimated to be KRW 1.3 trillion (USD 1.1 billion) and KRW 32.8 trillion (USD 27.8 billion) respectively (KCC).

Korea implemented its first national broadband policy in 1995. At that time, broadband network was thought of as a high-speed network. The first national broadband policy targeted only speed of 8 Mbps for rural areas with over 50 households. That program was the “High Speed Network Construction Loan Support Project.”

Broadband policy in Korea consists of three big projects which were consecutively set up and implemented. The first is the KII project. The second is the BcN project. The third is the Hyper-connected Intelligent Network (HcIN) project.

Figure 45.

National Broadband Policy in Korea



Source: Yoo, Si-hyung (2018)

For KII strategy, Broadband Infrastructure Construction Plan has been implanted by MIC (Ministry of Information and Communication, former MSIT) since 1995. The goal of this policy was to build the nationwide fiber optic core network and to secure a network capable of delivering 8Mbps speed.

Additionally, the Broadband Infrastructure Construction Plan includes the High Speed National Network Project. Under BcN and UBcN strategies, there was the BcN Construction Master Plan from 2004 to 2010 by MIC and the UBcN Development Plan from 2009 to 2017 by the KCC (Korea Communications Commission). The goal of the

BcN Construction Master Plan was to secure 100 Mbps of network speed. The goal of UBcN Development Plan was to secure 1 Gbps. There was also the BcN Infrastructure Construction Project and the Giga Internet Infrastructure Construction Project.

In 2017, Korean government launched a HcIN policy for 10 Gbps Hyper-connected network. There exists the Hyper-connected Network Leading Project and the 10 Gbps Internet Promotion Project.

The aim of the initial policy was to facilitate competition in the market by the government initiating the projects involving high risks, which private firms were reluctant to invest in. Today's high-speed internet network in Korea is the result of 20 years of facility-based competition. It is generally true that competition is the best policy for network investment and innovation. Especially in the initial stages, infrastructure-based competition is required for market competition. There were three programs to induce investment. These three programs mainly aimed at rural areas. In the urban areas, telecom operators invested actively based on their future market evaluation. Therefore, policy intervention was necessary only in rural areas. Consequently, Korea implemented a low-interest-rate loan support program. There were many cases of company mergers and acquisitions between 2002 and 2011. Mergers and acquisitions between operators in the market can cause deterioration of competition. Because of the deteriorating competition, the Korean government imposed additional obligations as part of the mergers and acquisitions in this market due to the possibility of underinvestment in the broadband network.

Table 52.

Detailed National Broadband Policy in Korea

Strategy	KII (1995~2005)	BcN (2004~2010) UBcN (2009~2017)	HcIN (2017~2026)
Policy	• Broadband Infrastructure Construction Plan (1995, MIC)	• BcN Construction Master Plan (2004, MIC) • UBcN Development Plan • (2009, KCC)	• K-ICT Network Development Plan (2015, MSIT)
Outline	• 8 Mbps Internet, e-commerce	• 100 Mbps Broadband • 1 Gbps Broadband, IPTV, SNS • ALL-IP	• 10 Gbps Hyper-connected Internet, AR, VR, IoT, UHDTV
Project	• High Speed National Network Project (1995~2005)	• BcN Infrastructure Construction Project (2004~2010) • Giga Internet Infrastructure Construction Project (2009~2017)	• Hyper-connected Network Leading Project (2017~) • 10 Gbps Internet Promotion Project (2018~)

Source: Yoo, Si-hyung (2018)

5.4.4 BCN Construction in Rural Areas

The Korean government began BcN construction in rural areas as part of its national broadband policies. This program provided a matching fund in which the central government (25%), local governments (25%), and the network operator (50%) shared the funding responsibilities. This program ended at the end of 2017. The program aimed to upgrade the network from xDSL to FTTH in rural villages with less than 50 households.

Table 53.

BcN Construction in Rural Areas

Year	2010~2017
Background	Because of poor profitability, telcos avoided network investment in small rural villages of the mountain and island areas.
Target Area	13,217 villages with under 50 households including 360 island villages (total of 450,000 households, 960,000 people)
Target Access Technology	From xDSL to fiber-optic access network based on FTTH (availability of 100 Mbps broadband)
Performance	By 2017, 13,473 Villages (100%)
Budget	USD 132 million (2010~2017)
Funding	Matching fund (Central government, 25%; local government, 25%; KT, 50%) USD 33 million by central government

Source: MSIT (2017)

That was implemented between 2010 and 2017. This policy was produced because of cream skimming of broadband operators which is to invest only in profitable area not in unprofitable area. Broadband operators tend to avoid network investment in small rural villages of the mountainous area or remote area. This policy aimed to upgrade network in 13,473 villages which are under 50 households. They are very small villages and remote villages. Generally they are unprofitable areas for broadband operators. The size of total budget was USD 132 million. The Korean government funded USD 33 million. Also local government funded USD 33 million. The rest of fund was funded by KT which is the No. 1 Korea Broadband operator. This program is a matching fund. To get local and governmental fund, operators should invest in that area. This is a kind of public private partnership.

5.5 Last Mile Access Technology

5.5.1 Fixed Wireless Technology

There are two main types of last mile access technologies: a method using an optical cable and fixed wireless method.

The optical access network comprises the following three types of scenarios: FTTH, FTTC and FTTB. The differences among those network options are mainly due to different services and devices.

Fixed Wireless Broadband (FWB), sometimes known as Fixed Wireless Access, is an alternative means of providing internet connectivity that uses wireless network technology rather than fixed (physically cabled) lines. The purpose of a fixed wireless broadband is to enable data communications between two sites or buildings. Fixed wireless broadband links are often a cost-effective alternative to leasing fiber or installing cables between sites.

Fixed wireless technologies include LTE, Wimax, and superwifi.

Figure 46.

Fixed Wireless Technologies

LTE	• Around 25 countries and 52 operators use LTE for fixed wireless broadband service • FDD is dominant for fixed wireless broadband according to LTE eco system report • Serviced by CPE, MiFi and furthermore, outdoor modem is used to expend service coverage in rural area
WiMAX / CDMA	• WiMAX, CDMA fixed wireless technology is migrated to LTE • Argentina SKYMAX, Malaysia P1, Malaysia Yes used WiMAX until 2015 and it is going to LTE • Kazakhstan, New Zealand Woosh used CDMA until early of 2016 and it is going to LTE
Super WiFi	• Super WiFi using TV white Space is deploying for trial service of special purpose • There is no case found for commercial service • TV white space frequency is only used for backhaul and 2.4GHz, 5GHz are used for access

ITU (2019a) recently presented a good example of providing Internet service using fixed wireless technology. Djibouti is a country in Africa, next to Ethiopia. To assist the scale-up of the country's digital transformation, the ITU, in partnership with the Ministry of Communication, Post and Telecommunication (MCPT) of Djibouti, has been implementing a project to deploy 4G wireless broadband technologies to boost Internet connectivity across the country.

Given the relatively low cost associated with the deployment of WiMAX, the technology was seen as a viable solution for 'last-mile' wireless Internet access in remote locations, including schools and health care centers in Djibouti. The WiMAX Network has the capacity to provide connectivity over a radius of 50Km.

According to OECD (2018), the 5G wireless ranges from existing rural towers will likely be less than fixed wireless using 3G or LTE (4G). According to Engebretson (2017), Some fixed wireless providers such as Rise Broadband in the United States say that this is why LTE (4G) will provide superior coverage in rural areas than 5G simply because more towers or small antennas or repeaters would be needed and this may not be economical.

5.6 Lessons from Case Study

5.6.1 Competition Enhancement

The government should intervene only when the market does not produce a smooth supply of products and services. Korea's national broadband plan is not a national intervention on the market by the government, but a remedy for market failure. Broadband operators are reluctant to provide broadband to poorly performing areas. The role of government is important in these areas. In the case of profitable urban areas, governments should implement policies that encourage competition.

In the case of the United Kingdom and the United States, the areas subject to universal broadband Internet service are areas where services are not currently provided. Regions that are sufficiently provided by market competition are not subject to universal service.

In Korea, 100 Mbps broadband internet is also provided as a universal service, but the target area is targeting buildings where 100 Mbps internet is not currently provided. Regions with active competition are excluded from universal services to minimize regulatory intervention.

On the demand side, the demand increase and acceptance of Korean users and the government's demand promotion policy contributed to the deployment of broadband.

ITU (2003) indicates that because most of the early Internet users in Korea were young, there is high demand for online games, movies, music, and videos. Lau et al. (2005) stated that 67% of stock trading was through the Internet. This stock trading affected the spread of the Internet. Aizu (2002) argues the active acceptance culture of Koreans accelerated the acceptance of broadband Internet. Kim et al. (2010) and Ovum (2005) assert that the Korean government established the National Informatization Promotion Plan (1996), Cyber Korea 21 (1999), and e-Korea Vision 2006 to promote e-commerce, online public services, and digital education (digital literacy). These policies accelerated the deployment of broadband in Korea.

5.6.2 Technology Neutral and Competition Neutral

The government's policy to increase the deployment of broadband internet should be technology-neutral and competition-neutral. It is technology neutrality that government regulations should not affect technology development. Competition neutrality is that government regulations should not affect market competition. When the government sets service attributes, operators will choose the most efficient technology that satisfies those attributes.

The universal service policy must also maintain competition neutrality and technology neutrality. In the case of Korea, it is currently decided to provide a universal service broadband internet by wire. However, this is not desirable. In this respect, the Ecuadorian system, which provides mobile broadband as a universal service, is better.

5.7 Policy Recommendations

5.7.1 Classification of Areas (Parishes or Canton) Requiring Universal Service

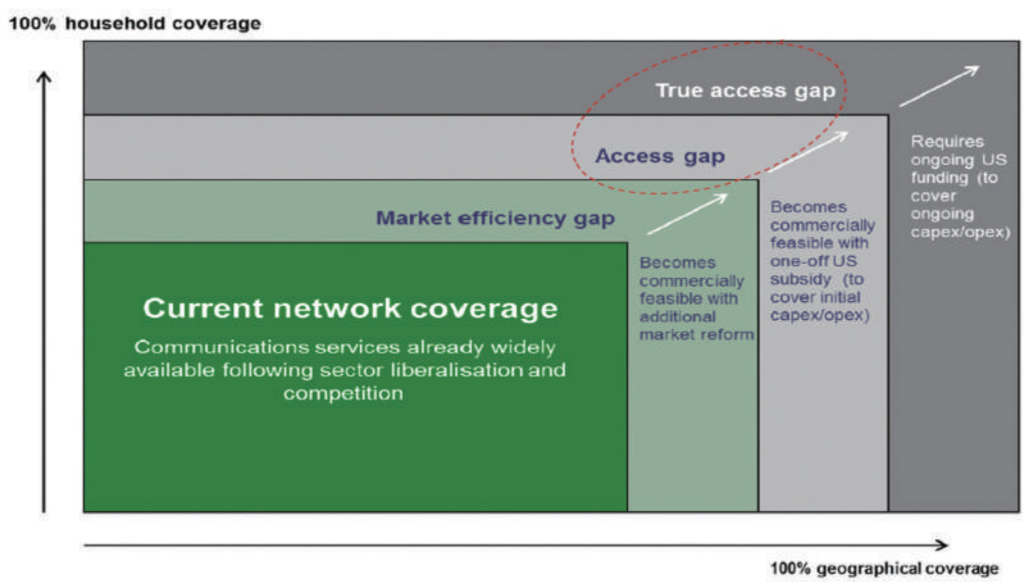
[Figure 47], shown below, demonstrates distinctions within the access gap. The horizontal axis indicates geographical coverage. The vertical axis indicates household coverage. There are three types of gaps between the current market coverage and total coverage. The market efficiency gap can be covered through the promotion of competition. The access gap can be covered through temporary support, which can take the form of a subsidy or incentive. The true access gap can be covered through persistent support such as universal service support or obligation.

There are three policy options to overcome this gap: regulation, incentives, and direct investment. Regulation involves imposing network extension obligations on network operators. According to the OECD and IDB (2016), any obligation imposed on operators regarding coverage should be carefully evaluated in terms of costs and benefits (OECD & IDB, 2016). Obligations can be applied through universal service obligations, licenses for fixed telephony, license conditions or spectrum auction, conditions on company mergers and acquisitions, and conditions on significant market power.

Incentives for operators to extend broadband access aim to bridge the investment gap in areas where the expected returns do not justify network deployment (OECD and IDB, 2016). Incentives can be applied through partial or total tax exemptions, lower or no fees for spectrum licenses in certain areas associated with the obligation to provide coverage, direct partial/total subsidization of rural or backbone deployments, or low-interest loans and matching funds.

Figure 47.

Distinctions within the Access Gap



Source: Windsor Place Consulting (2015)

The areas where universal service policy is needed should be clearly identified. Regions requiring universal service policy are largely classified into three groups. It should be divided into high-density, medium-density and low-density areas and prioritized. Regions with high priority should be targeted for universal service policy. In the case of Ecuador, since there is no available budget for universal service, it is practical to impose a universal service obligation as a frequency allocation condition. True access gap area and access gap should be classified. Areas where services are not provided by a market function should be designated as the target of universal service, and financial resources should be aggressively invested in these areas.

5.7.2 Advanced Mobile Service

A technology-neutral universal service policy is needed. As in the case of Korea and the UK, it is necessary to present an appropriate internet download speed as a service requirement for universal service. From a technology-neutral point of view, let the operator choose the most appropriate technology that meets the minimum speed criteria. Provide financial support such as loss compensation or PPP in order to provide incentives to broadband universal service providers.

In Ecuador, both wired broadband internet and wireless broadband internet are included in the scope of universal service. This is a very positive part as it maintains a technology-neutral view of regulation.

The exact service level of the broadband universal service has not been established. It is necessary to set the minimum speed of service. The available speed of LTE service is adequate. If set in this way, operators will provide SMA through LTE, and in the case of wired Internet, it will be possible to provide wired and fixed wireless technology. In the case of the UK, at least 10 Mbps is set as the broadband universal service level.

5.7.3 Fixed Internet Access Service

Regarding the deployment of the fiber optic trunk network, in order to induce active participation of business operators, it is necessary to introduce a PPP. As in the case of Korean rural BcN construction project, PPP is needed to promote fixed internet access. The primary targets of a fixed broadband universal service should be public facilities like schools, hospitals and government offices. As in case of United States, these public facilities should have fiber-optic connections installed on a government budget.

The AP (Access Point) should be connected to the public facilities' internet network and made available to Ecuador citizens for free.

Chapter 6.

Digital Radio

6.1 Introduction on Digital Radio

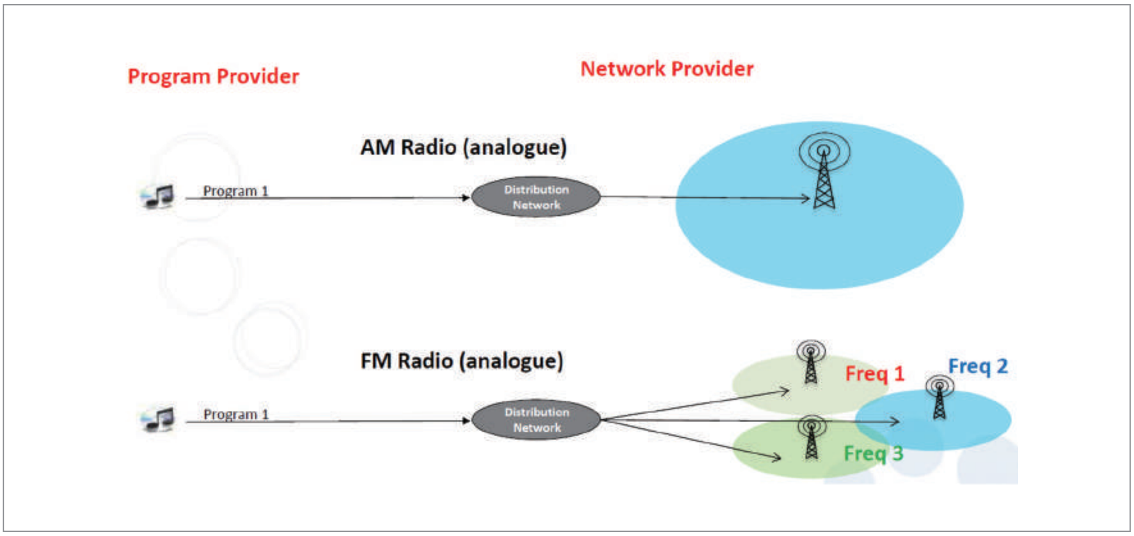
6.1.1 Why is It Necessary to Switch to Digital Radio Broadcasting?

Digital technology has steadily transformed the way in which programs are made in the last twenty years. Broadcasters have invested in digital systems for contribution, production and for some, the switch from analogue to digital is moving along the broadcasting chain into transmission. At the same time, digital developments are drawing together the broadcasting, telecommunications and computer industries in a process of convergence. For all broadcasters, this is leading to a new and challenging business environment.

Radio broadcasting is an excellent medium that has the following technical advantages and differentiation from other media. The Amplitude Modulation (AM)/Frequency Modulation (FM) analogue radio transmission system transmits with high power, and uses frequency band width to cover each area with a certain service area. Especially, FM radio is the best broadcasting service medium that occupies the center frequency of the excellent Very High Frequency (VHF) band. The great strength of the present analogue transmission systems is the world-wide standardization of just two systems (FM and AM). This enables listeners to use one radio to receive programs at any location. However, the frequency for FM radio service is exhausted, so it is impossible to accommodate further services.

Figure 48.

Analogue Radio Transmission System



Source: Stockmann, Jens (2016)

The expected effects of digitizing radio broadcasting are as follows:

- Improved reception on mobile car radios and portables
- Improved audio quality
- Improved frequency utilization efficiency
- Power savings for transmission power to cover same coverage
- Provision of useful data services including disaster warning services, These can be used to generate additional revenue
- Lowed transmission power to cover same coverage

The financial gains for governments in switching off analogue radio would be considerably smaller. Only a few nations have developed national regulatory plans for the analogue to digital transition for radio.

Furthermore, there are countless millions of analogue radios in the public's hands, in the home and vehicles, and switching off analogue radio could be unpopular and unfair on economically less advantaged users.

However, the eventual transition from analogue to digital for all communications systems including radio is inevitable and will happen in time. The decision for managers today is to find the best balance in timescale for the public interest for their environment. Broadcasters and regulators need to evaluate the alternative systems and decide which is the optimum system for their environment.

6.1.2 History and Types of Digital Radio Broadcasting System Development

Digital radio research and development began in 1986 with a project named Eureka-147 in the European Union, and the DAB (Digital Audio Broadcasting) method was born as a fruit. In 1995, the BBC of the UK started commercial digital radio service for the first time in the world using this DAB method. Since then, another digital radio systems have been developed and provided with the history.

Table 54.

Milestone of Digital Radio Developments

Year	Digital Radio Development/Standardization/Commercial Launching
1986	EU, Eureka-147 project started
1994	EU, ETSI 300 401 "Digital Audio Broadcasting (DAB); DAB to mobile, portable and fixed receivers"
1995	EU, BBC Started the world's first commercial DAB broadcasting EU, Started DRM development (digitalized AM and shortwave radio)
1996	US, Participated in field tests such as Eureka-147, AT&T IBAC, VOA/JPL system, etc. US, Decided to adopt proprietary technology that can be used in AM and FM frequency bands
2000	US, The digital radio system in the US is unified by the IBOC
2001	EU, DAB revised ETS 300 401 v1.3.3 and DRM European Standard (TS) released
2002	EU, DRM ITU standard establishment (Short, Medium, Long-Wave Digital Radio)
2002	US, FCC approves iBiquity HD Radio™ IBOC technology (US digital radio broadcasting System)
2003	EU, DRM IEC international standard establishment (January) EU, DRM European Standard (ES) established (May)
2003	US, Started the first commercial HD Radio broadcasting
2009	EU, DRM+ technical standard established (IBC announcement in September) EU, DAB+ technical standard established

DRM (Digital Rights Management) was developed by European Union in 2003 for the first time, and it was developed to DRM+ in 2009. And another system named HD radio was developed in 2003 in US. There are three representative types of digital radio: DAB/DAB+, DRM/DRM+, and HD Radio.

When it comes to the digitalization of radio broadcasting, it is necessary to consider the selection of digital radio standard.

6.2 Features of Digital Radio System

6.2.1 DAB/DAB+

The DAB/DAB+/DMB family of standards is the globally most widespread digital radio broadcasting platform, offering radio broadcasters significant cost advantages and offering regulators considerable spectrum efficiencies over analogue and other digital systems.

It was developed under the Eureka-147 project in Europe for reception by mobile, portable and fixed receivers with a simple non directional antenna, and can be used in terrestrial broadcast networks. It was originally planned for implementation in two spectrum bands: VHF Band III and L Band, although the use of L Band has now been deprecated. The DAB family of standards includes DAB, DAB+ and T-DMB and is collectively referred to here as DAB, although DAB+ is the variant which is currently being deployed globally for the delivery of digital radio.

The Eureka-147 project was established in 1985 by 17 countries and the European Union to encourage a bottom up approach to technological development and to strengthen the competitive position of European companies in the world market. The Eureka-147 Consortium was founded in 1987 with 16 partners from Germany, France, the Netherlands and the UK. The Eureka-147 standard was defined in 1993 with ITU Recommendations released in 1994 and an initial ETSI (European Telecommunication Standards Institute) standard released in 1995. And WorldDAB was formed in 1995 to encourage international cooperation and coordination for the introduction of DAB to the consumer market. DAB/DAB+ is defined by international ITU recommendations, ETSI, Cenelec and IEC standards and national standards. WorldDAB defines and promotes DAB by offering support on all aspects of the switch from analogue to digital radio. This includes regulation, licensing, technology trials, network build out, marketing and production of digital radio content.

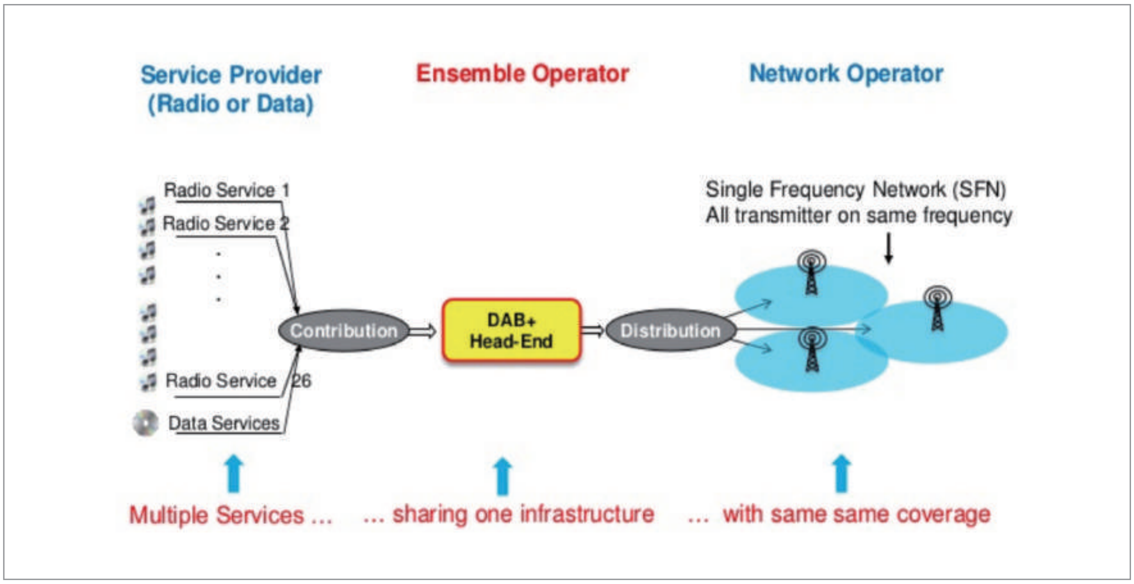
Many ancillary aspects, such as multimedia delivery, distribution interfaces and user interactivity are also formally defined in ETSI standards.

The DAB+ family is the most widely adopted digital radio standard. DAB+/DAB/DMB is on air in nearly 40 countries and is popular because it:

- Is an open standard with no annual license fees to be paid by broadcasters;
- Allows AM and FM broadcasters to move to a common digital platform;
- Is proven to be far greener and more cost effective to build and operate than any other analogue or digital radio standard;
- Allows broadcasters more capacity and listeners more choice and functionality;
- Has the largest and most diverse range of low cost receivers;
- Is being integrated as standard by the majority of motor vehicles manufacturers worldwide.

Figure 49.

ADAB+ Transmission System

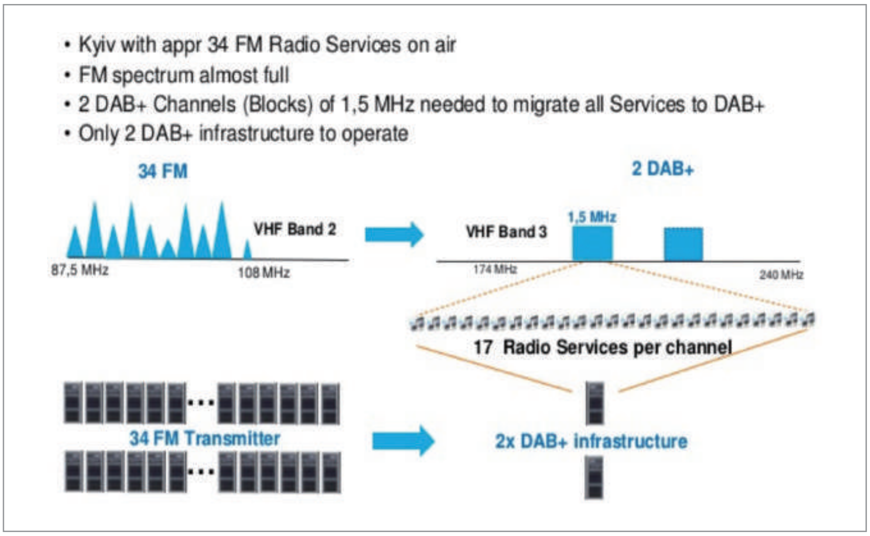


DAB+ family type digital radio is accommodated by multiplexing multiple radio broadcasting channels using one frequency called ensemble. It transmits low power and uses SFN (Single Frequency Network) technology to cover multiple service areas with one frequency, so the frequency and power are very efficient.

DAB+ family is an improved method of DAB and supports high-quality radio services at a low bit rate using MPEG4 AAC+ HEAC (High Efficiency Audio Codec). DAB+ is capable of service in the 174~240 MHz band, so it is not possible to recycle the existing analog broadcasting equipment because the frequency is different from the FM radio that uses the 87.5~108 MHz band.

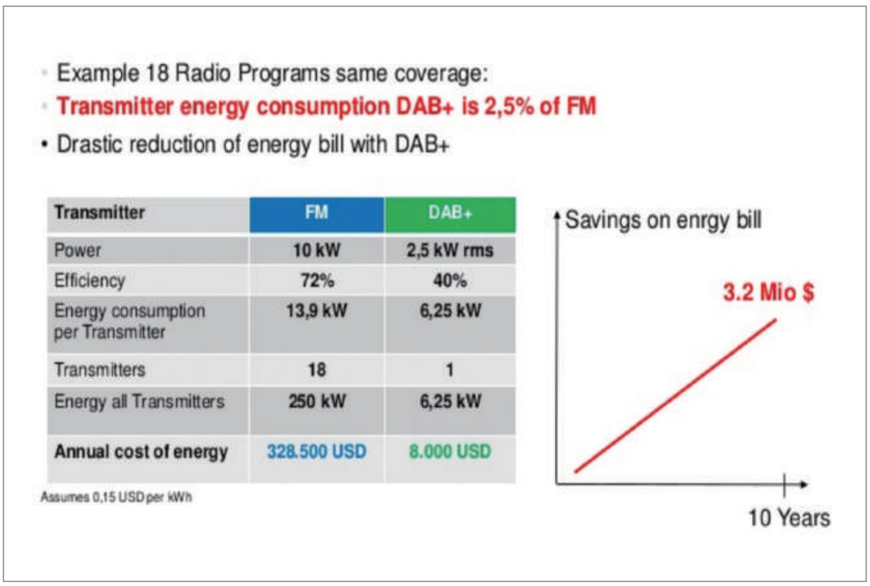
There is a case where 34 analog broadcasting channels are converted to DAB+ method using 2 DAB+ ensemble frequencies. In this case, there is no need to operate 34 analog transmitters, and only two DAB+ transmitters can be used to provide the same broadcasting service, resulting in cost savings in equipment and transmission power.

Figure 50.
Migration Example of FM to DAB+



Source: Stockmann, Jens (2016)

Figure 51.
Energy Savings with DAB+ Compared to FM



Source: Stockmann, Jens (2016)

The DAB+ family system is the oldest digital radio method, and has the most adopted countries and various terminals are on the market. More than 40 countries have legislated for the integration of DAB/DAB+/DMB Digital Radio in Europe and Worldwide. Outside Europe, the key areas of development are currently found in Australia, South East Asia, Korea, China, the Middle East and South Africa. In the UK, Norway, Denmark and Switzerland, the standard is well established with household penetration of at least 50% in each of those markets. Norway was the first country in the world to set a date (2017) for complete Analogue Switch Off (ASO).

In 2011, Germany launched DAB+ services. The Netherlands launched national services in September 2013; and, in June 2014, France launched DAB+ services in Paris, Nice and Marseille, with a further plan for additional multiplexes. Italy has trial services covering 75% of the population with regular services launched in Trentino in December 2012.

The European Broadcast Union (EBU) has called for the adoption of digital broadcast radio across Europe, alongside Hybrid radio services (for example, using RadioDNS). At the same time, government administrations are looking to build cross-border links to develop a European consensus about radio's digital future.

Automotive

- All major car manufacturers are fitting DAB in their vehicles
- In the UK 91%, Switzerland 85% and Norway 98% of new cars come with DAB/DAB+ as standard
- WorldDAB has established an automotive task force, collaborating with car manufacturers on installation of digital radio as standard across Europe and beyond
- Territories with national DAB coverage account for 60% of all new car sales in Europe, and car makers are planning accordingly
- Australia successfully launched DAB+ in 2009, followed by Hong Kong in 2011
- Indonesia launched permanent services in Jakarta in April 2016
- South Africa has an ongoing DAB+ trial covering 21% of the population
- Turkey, Tunisia, United Arab Emirates and Kuwait are trialing DAB+

Receivers

- DAB receivers are now available from €12 with prices continuing to drop
- Receivers with color screens now retail for less than €65
- There is ongoing work to create consistent receiver specifications in different countries, building on work already undertaken in the UK and Germany

Figure 52.

DAB/DAB+ Emerging Markets

Figure 53.

DAB/DAB+ Receivers

6.2.2 HD Radio

The HD Radio system was developed by the United States based iBiquity Digital. HD Radio was designed to offer digital radio services for regions where a limited spectrum prevents the allocation of new frequencies for digital broadcasting. The HD Radio system allows broadcasters to simultaneously transmit both an analogue and digital signal without the need for additional spectrum for the digital signal. The HD Radio system is designed to work in hybrid mode (compatible analogue and digital) as well as to migrate to an all-digital system once analogue radios have been largely replaced in the future. The HD Radio system offers a number of advantages for broadcasters, consumers and regulators. The HD Radio system replicates the existing coverage patterns of each radio station thereby retaining the existing economic value of the station. Broadcasters can convert to digital broadcasts with a relatively modest investment and retain the vast majority of their existing physical plant. In addition, the introduction of the digital signal in the existing channel allows the broadcaster to retain the station's existing dial position. Because the system supports simulcast of the analogue and digital signals, consumers are able to upgrade to digital over an extended period, taking into account normal equipment replacement cycles. Regulators benefit from this approach because there is no need for extra spectrum allocations or licensing of new stations immediately.

The HD Radio system offers the following features:

- CD quality audio in the FM-band and FM quality audio in the AM band
- Digital coverage nearly equivalent to existing analogue coverage
- In areas where the digital signal is lost, the system automatically blends to the analogue back-up signal to ensure coverage is never less than existing coverage
- Advanced coding technologies and time diversity between the analogue and digital signals ensure a robust signal
- The FM system has demonstrated significant robustness in the presence of severe multi-path, and the AM system has demonstrated significant robustness in the presence of impulse noise
- The FM system offers options for introducing new data services ranging from 1 to 300 kbps depending on the mode of operation

The HD Radio system is designed to permit a smooth evolution from current analogue AM and FM radio to a fully digital. This system can deliver digital audio and data services to mobile, portable, and fixed receivers from terrestrial transmitters in the existing Medium Frequency (MF) and VHF radio bands. The system is designed to allow broadcasters to continue to transmit analogue AM and FM simultaneously with new, higher-quality and more robust digital signals, allowing broadcasters and their listeners to convert from analogue to digital radio while maintaining each station's current frequency allocation.

The HD Radio system allows a broadcast station to offer multiple services.

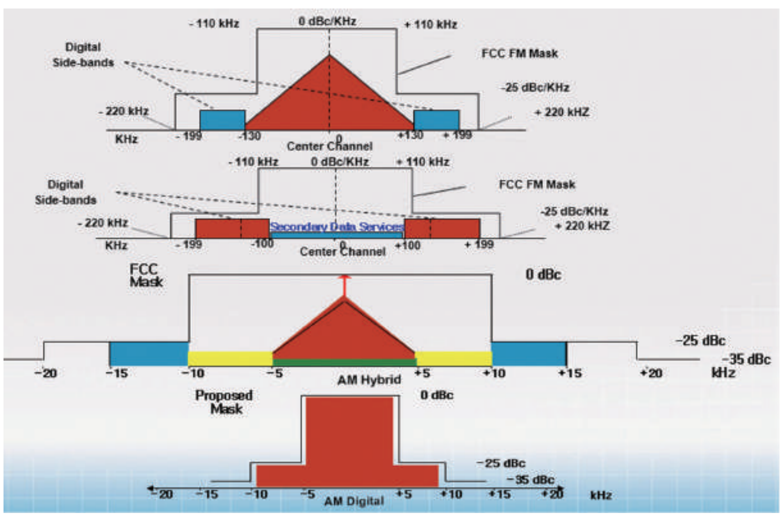
The system employs audio encoding to reduce the sampled audio signal bit rate and baseband signal processing and forward error correction to increase the robustness of the signal in the transmission channel. This allows a high quality audio signal plus ancillary data to be transmitted in adjacent frequency partitions and at low levels that do not interfere with the existing analogue signals.

The HD Radio system provides a flexible means of transitioning to a digital broadcast system by providing three new waveform types: Hybrid, Extended Hybrid, and All Digital. The Hybrid and Extended Hybrid types retain the analogue FM signal, while the All Digital type does not.

All three waveforms operate well below the allocated spectral emissions mask as currently defined by the United States Federal Communications Commission (FCC).

The digital signal is modulated using Orthogonal Frequency Division Multiplexing (OFDM). OFDM is a parallel modulation scheme in which the data stream modulates a large number of orthogonal subcarriers, which are transmitted simultaneously. OFDM is inherently flexible, readily allowing the mapping of logical channels to different groups of subcarriers.

Figure 54.
Spectrum of HD Radio with Operation Mode



The conversion of stations to HD Radio broadcasts has been accompanied by the introduction of HD Radio receivers for every major receiver segment. As of December 31, 2013, more than 17.5 million HD Radio receivers were in the commercial market. HD Radio technology is available as original equipment and aftermarket automobile receivers as well as in home AVR (Automatic Voltage Regulator), table-top and portable receivers. Virtually all automobile manufacturers serving the North American market offer HD Radio receivers in their vehicles as standard equipment. Aftermarket HD Radio receivers can be purchased online and at thousands of traditional retailers.

HD Radio receivers are in use, and additional receivers are being sold routinely in the U.S., Canada and Mexico. Alpine, Clarion, JVC, Kenwood, Pioneer, and Sony sell aftermarket automobile receivers with HD Radio technology in Canada. Denon, Onkyo and Yamaha offer HD Radio home AVR products. The following automotive brands offer HD Radio receivers in their cars sold in North America: Acura, Audi, Bentley, BMW, Buick, Cadillac, Chevrolet, Dodge, Ford, GMC, Hyundai, Infiniti, Jaguar, Jeep, Land Rover, Lexus, Lincoln, Mazda, Mercedes-Benz, Mini, Mitsubishi, Porsche, Ram, Rolls-Royce, Scion, Subaru, Tesla, Toyota, Volkswagen, and Volvo.

These receiver sales reflect the trend by manufacturers to standardize products for global or regional rather than national markets. Consumers will have the benefit of lower prices and a larger selection of HD Radio receivers by leveraging the commercial success of HD Radio technology in other North American markets. HD Radio receivers are inherently simpler and cost lower than new band receivers since much of the circuitry required for the digital signals is common to that used to process the existing analogue signal. As a result, HD Radio receivers typically cost no more than 20% more than existing analogue receivers. HD Radio receivers are affordable with many models and the range of radio products available including portable radios, personal navigations devices, home receivers, and car receivers.

Figure 55.

HD Radio Receivers

6.2.3 DRM/DRM+

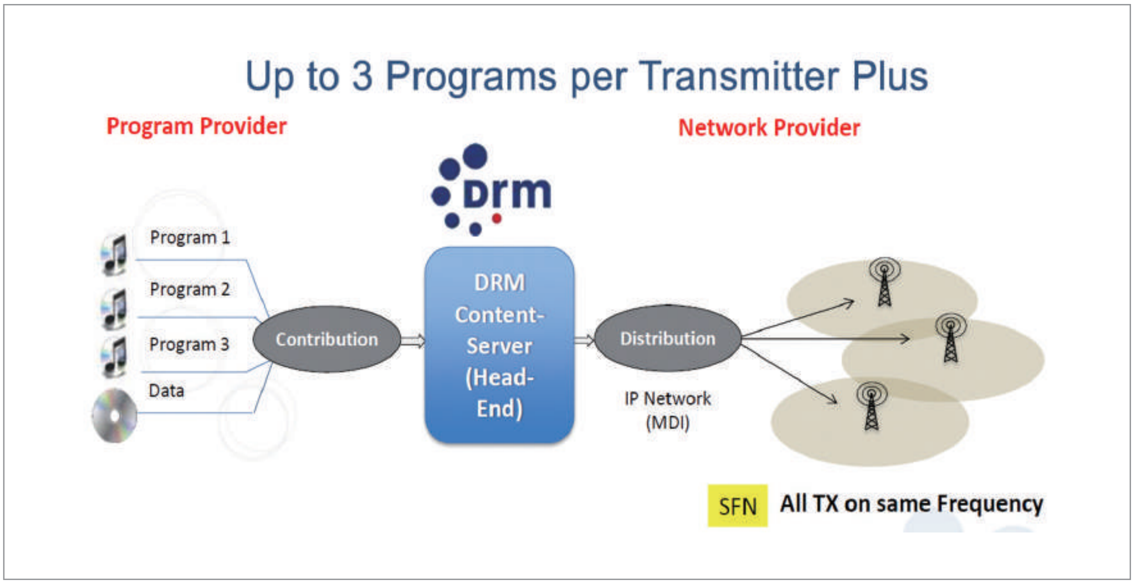
DRM is a digital radio standard for the existing radio broadcast bands (as deployed for analogue AM and FM radio). It supports both local/regional coverage scenarios, as well as large-area and international transmissions. DRM focuses on digitizing and enhancing radio services and transmissions of individual broadcasters.

The DRM system is a flexible digital sound broadcasting system for use in all the terrestrial radio broadcasting bands below 300 MHz (i.e. AM bands and VHF bands). In the consumer radio receiver, the DRM system provides the capability to receive digital radio (including sound, program related data such as advanced text, and other data such as EPG, still pictures and traffic information) in all the broadcasting bands below 300 MHz.

DRM enables a broadcaster to provide between one to four services on a single transmission signal: single-channel MW transmissions may typically carry one to two audio services accompanied by text-based data applications. FM transmissions provide the capacity for up to three audio services along with various accompanying and stand-alone data applications. This enables broadcasters to enhance their overall listenership by providing additional services tailored to wider audiences.

Figure 56.

DRM Transmission System

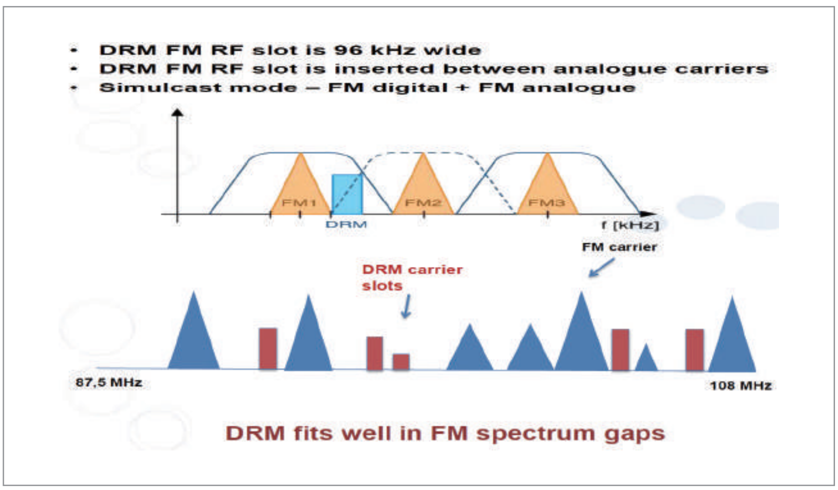


DRM's EWF (Emergency Warning Functionality) allows to instantly alert DRM listeners in case of pending natural or man-made catastrophes.

The DRM standard has two main configurations, depending on the frequency of transmission. "DRM30" is the term applied when the frequency is below 30 MHz (traditional AM bands). "DRM+" is the term applied when the frequency is in the VHF bands, that is between 30 MHz and 300 MHz. DRM30 can be used in either 9 or 10 kHz channels, and also provides high capacity modes using double channel bandwidths. DRM+ is used in 100 kHz channels. Therefore DRM can operate in the existing channel assignments defined in the past for analogue transmissions.

Figure 57.

FM and DRM Spectrum/ Introducing DRM Carrier

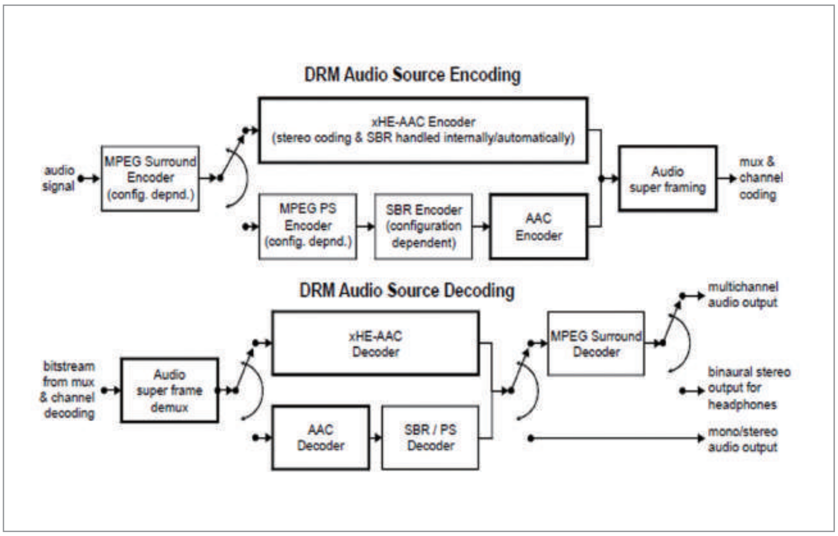


It employs xHE-AAC (Extended High Efficiency Advanced Audio Coding) audio coding, which is the most advanced audio coder currently available. This audio coder provides equally high quality for music and speech signals, including stereo reproduction, even at very low bit rates.

The two audio codecs supported in the DRM standard are: MPEG xHE-AAC and MPEG AAC with SBR (Spectral Band Replication) and PS (Parametric Stereo). They can operate in a range of bit rates and configurations, including mono, stereo and even stereo decoder compatible 5.1 Surround Sound modes.

The xHE-AAC is the latest MPEG (Moving Picture Experts Group) audio codec development, a superset of the widely used. HE-AAC v2 codec—xHE-AAC—unifies music and speech-coding and supports low-bitrate configurations as common for many DRM transmission modes, Internet streaming and mobile music download services. The xHE-AAC encoder automatically chooses the optimum audio configuration for the specified target bit rate, thereby eliminating the need for the broadcaster to get involved with the detailed audio configuration parameters.

Figure 58.
DRM Audio Encoding and Decoding



Due to the adoption of xHE-AAC, it is a realistic scenario for broadcasters to plan for two stereo services within a single MW transmission (a standard channel of 9 or 10 kHz bandwidth), three high-quality stereo transmissions in a single FM band broadcast, or FM-like audio quality for a SW transmission with even the most robust signal configuration. SBR is a special means of enhancing the perception of a spectrally truncated low band audio signal by utilizing, on a dynamic basis, the spectral content of the low band information to simulate the missing higher band behaviour. SBR is automatically used for xHE-AAC services, while in the case of AAC it can be enabled for certain audio configurations.

In the DRM method, three or four radio broadcasts can be provided using a single broadcast frequency, and SFN technology can be applied to cover multiple adjacent broadcast areas with one broadcast frequency. DRM also can be applied to radio broadcasting of all frequency bands from low broadcasting frequency radio such as LW, MW, SW, etc. to FM radio as mentioned.

With DRM if one FM radio was provided with 10 KW output and 200 KHz bandwidth, switching to DRM method can accommodate 3 radio broadcasting channels with 1KW output, enabling efficient use of electric power and frequency. In addition, the DRM/DRM+ method can also reuse existing analogue radio equipment.

Figure 59.
DRM Available for All Bands

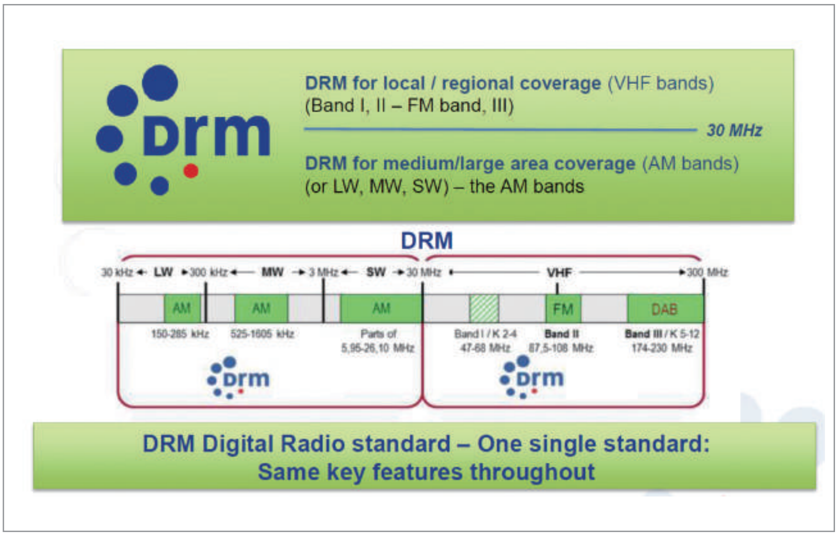
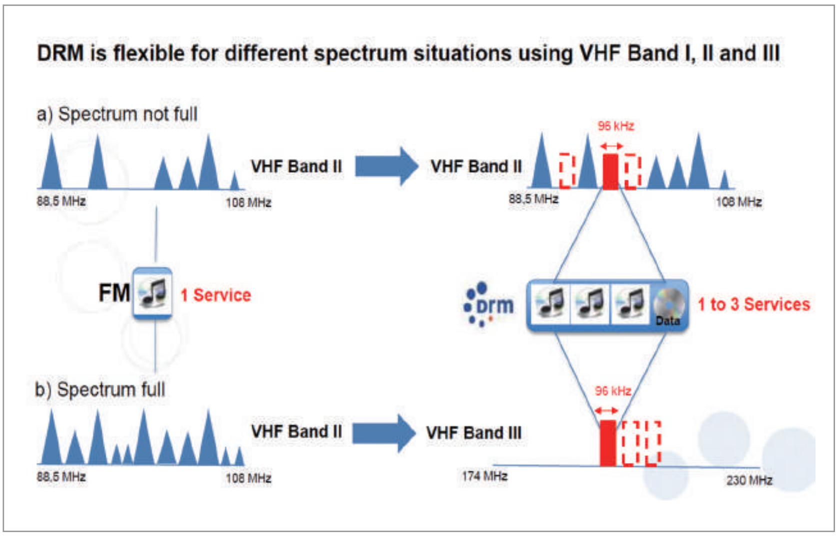


Figure 60.
Flexibility of DRM Operation



6.2.4 Comparison of Digital Radio Systems

Each of the three types of Digital Radio has its own advantages. And choosing one of these methods will not be an easy decision. So, if we compare the features of DR from several perspectives, this difficult choice might be a little easier.

Now let's compare it from several perspectives of three digital radio systems.

First, in terms of service band, DAB/DAB+ uses Band III band, HD Radio supports AM/FM broadcast band, and DRM/DRM+ supports all radio broadcast bands. Second, in terms of In Band/Out Of Band, DAB/DAB+ is Out Of Band, HD Radio and DRM/DRM+ are In Band. Next, in terms of analogue radio broadcasting and simultaneous broadcasting, DAB/DAB+ is not available, HD Radio and DRM/DRM+ are available. In terms of recyclability of the existing analogue radio broadcasting system, DAB/DAB+ may not be possible, HD Radio and DRM/DRM+ may be partially enabled.

Next, in terms of the need for frequency allocation for new digital radio broadcasting, DAB/DAB+ is required, HD Radio and DRM/DRM+ are unnecessary. In terms of ease of transition from analogue radio broadcasting to digital radio broadcasting (listener-oriented) HD Radio and DRM/DRM+ would be easier than DAB/DAB+. Next, in terms of the efficiency of the transmitted power, DAB/DAB+, HD Radio and DRM/DRM+ are all good. Finally, in terms of the possibility of providing value-added data services, DAB/DAB+, HD Radio and DRM/DRM+ all work.

These characteristics between digital radio methods are summarized in the <Table 55>.

Table 55.

Comparison of Digital Radio Systems

	DAB/DAB+	HD Radio	DRM/DRM+
Service Band	Band III	AM/FM Band	LW, MW, SW, Band I, II, III
In Band / Out of Band	Out of Band	In Band	In Band
Analogue / Digital Simulcating	Not Available	Available	Available
Existing System	Not Available	Partly Available	Partly Available
Need of new frequency	Yes	No	No
Transition		Easy	
Tx. Energy Efficiency	Good	Good	Good
Tx. License Sharing	Need	No	Need/No
Dara Service	Yes	Yes	Yes

DRM has been developed and standardized most recently, and various and high-performance audio codec technologies have been installed. In addition, it is possible to cover all radio frequency bands in one method, and there is no need to secure a separate frequency for digital broadcasting, and it is evaluated as the best method capable of simultaneous analogue and digital broadcasting. However, due to the short commercialization period, there is a regret that compared to other methods, there is still insufficient performance and the diversity of receivers is also low.

However, many countries, including Indonesia, are considering introducing them with interest. In August 2020, the Indonesian Broadcasting regulator, KOMINFO, conducted an evaluation of the DRM technology in FM band as part of the digital radio transmissions of Radio Republik Indonesia (RRI). The trials and measurements were conducted together with RRI in Jakarta. This follows the successful installation and commissioning of 5 DRM FM digital radio transmitters at 5 locations in Java, Sulewesi and Sumatra areas of Indonesia. Currently, 5 DRM FM transmitting stations are operating in Indonesia, each carrying two audio services and the Journaline text service. The tests in Jakarta were carried out, among other objectives, to verify the functioning of the EWF feature in the DRM digital radio standard.

Extensive tests and field trials have been conducted throughout the world using the DRM system. The results confirm that the DRM system (both the DRM in AM and DRM in VHF/FM variants) performs according to the specification and that it can be implemented to meet a wide range of requirements in all types of environments.

Figure 61.

DRM Receivers

Figure 62.

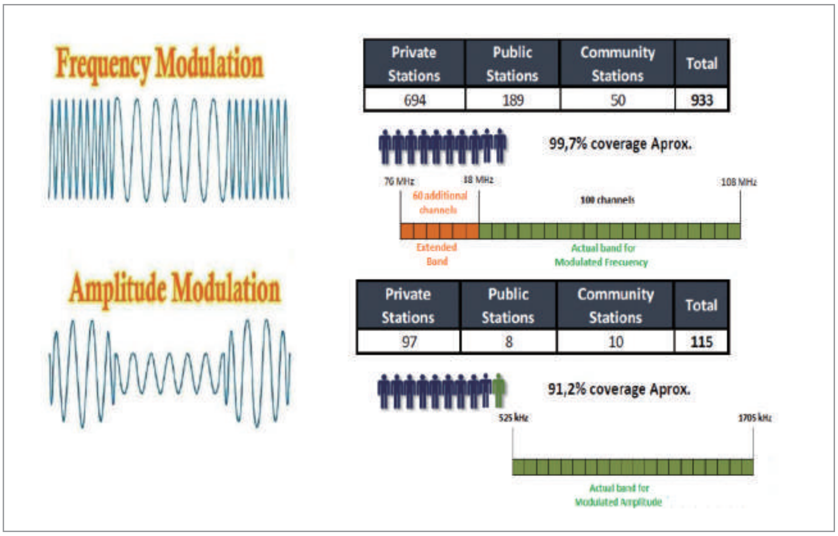
Hyundai Cars with DRM Receivers

6.3 Status of Ecuadorian Radio Broadcast Service

6.3.1. Status of FM/AM Radio Service

There are 506 FM radio stations 115 AM radio stations in Ecuador, and the radio stations advertise by the second, according to the advertising time, they charge an amount of money. And data service including the disaster alert service is not implemented, while the RDS (Radio Data System) service is contemplated in the current FM technical standard, but its implementation is not mandatory. The coverage of the FM sound broadcasting service is 99.7 %, however there is no audience data for example by ages, genre, etc.

Figure 63.
Status of Ecuadorian Radio Broadcast



FM broadcasting service (88~108 MHz) stations

- Private stations: 425
- Public stations: 59
- Community stations: 22

AM broadcasting service (535~1705 kHz) stations

- Private stations: 97
- Public stations: 8
- Community stations: 10

In the technical standard of the FM sound broadcasting service, new spectrum was included and the band was extended from 76 MHz to 88 MHz, extending the FM band from 76 MHz to 108 MHz, however, of which there is no planned to digitize the FM broadcasting service.

Regarding the 6 MHz bandwidth TV channels, the 6 MHz is assigned to a single concessionaire, bandwidth in which it can provide various services (for example Standard, HD and Full HD).

6.3.2 Ready for Digital Radio and Requirements

It is not planned to digitize the sound broadcasting service either in FM modulated frequency or AM modulated amplitude.

The emergency alert services and real-time traffic information would be very useful as value-added data services including high precision location information service (i.e. DGPS/RTK), and real-time traffic information service.

- DGPS: Differential GPS (Global Positioning System)
- RTK: Real Time Kinematic

6.4 Policy Recommendations

6.4.1 The Need for Digital Radio Broadcasting

The existing AM and FM analogue systems suffer from inherent short-comings and neither can offer uniform reception quality throughout the coverage area. AM radio reception is constrained by bandwidth limitations which restrict the audio quality, and by interference from other co-channel and adjacent channel transmissions. This is particularly troublesome during the hours of darkness. The start of FM services in the 1950s improved the audio bandwidth and overcame the night-time interference. And when listened to it in vehicles or on portables, reception suffered from the effects of reflected signals (multipath) and other forms of interference, particularly in suburban and city areas. Another aspect of AM and FM analogue transmissions is the inefficient use of the spectrum (relative to what is possible using digital technology). As pressure on the radio spectrum rises, this finite resource becomes scarcer. There are many ways in which digital radio systems can improve upon analogue systems:

Digital transmission technology can offer improved coverage and availability. In basic form, digital radio is an application of the technology in which sound is processed and transmitted as a stream of binary digits. The development of digital radio has led to improved spectrum efficiency, more channel capacity, or a combination of these benefits. Digital compression techniques used in audio systems have improved sound quality at low bit rates to the extent that radio broadcasts can be made on location and then transmitted to the broadcaster's production studios over telephone circuits in high quality.

6.4.2 Considerations for Digital Radio

The digital conversion of radio broadcasting will require initial system investment and continuous system operation costs, in addition to selecting the digital radio method. Also, users will be burdened by having to replace the radio receiver. Therefore, all of these factors should be considered and the most advantageous method should be selected, and after a detailed conversion plan has been established, the conversion should be promoted based on this.

In addition, FM radio will be switched first at the beginning of the transition, but ultimately, AM radio will be considered as well, so a method that can be applied to AM and FM radio broadcasting in one way would be advantageous.

One characteristic of Ecuador is that a new band of 76 MHz to 88 MHz has been added to the existing FM radio band and is being serviced. In the case of the in-band method, it is important to support this frequency band. In addition, the performance of digital radio transmission technology and audio codec will be important factors.

In the transition from analogue to digital radio, users cannot change radio receivers at once. So at the beginning of the transition, it would be advantageous to have both analogue and digital radios serviced. In addition, it is necessary to consider the possibility of providing not only audio services but also data services that can create high added value by using broadcasting networks in future environments such as autonomous vehicles.

Chapter 7.

Policy Recommendations

7.1 Clear Spectrum Policy Roadmap

The longer the spectrum usage period is, the more exclusive the use is, the more likely that large-scale capital investments such as the establishment of infrastructure will expand. However, from the government's point of view, various reviews such as scarcity of radio resources, efficiency in use, validity of utilization decisions, and equity among multiple users are indispensable, which can also conflict with user requirements.

It is recommended to establish a national spectrum long-term strategy to encourage the mobile communications market and long-term large-scale investment. And regulators must consult stakeholders in advance to ensure spectrum awards and licensing approaches consider technical and commercial deployment plans

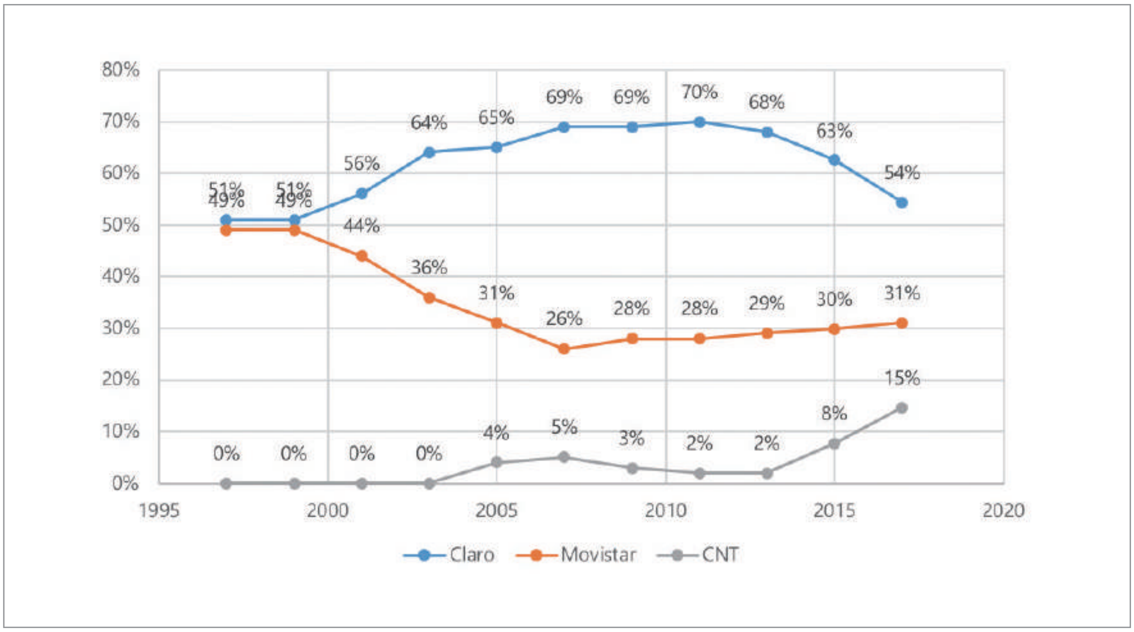
- Have a clear roadmap of spectrum assignment over the medium and long-term
  - Long-term planning can provide a basis for effective spectrum management to ensure that spectrum is efficiently allocated and assigned to accommodate constantly evolving spectrum requirements by new systems and their applications.
- It is necessary to check the current status of spectrum usage, international trends, raising demand from operators, and to consider supplying adjacent spectrum over broadband.
  - Global preferred bands are recommended as priority supply bands
    - Low band: 700 MHz, 900 MHz
    - Mid band: AWS band, 2.5 GHz, 3.5 GHz
    - High band: 24.25~27.5 GHz, 37~43.5 GHz, 45.5~47 GHz, 47.2~48.2 GHz, 66~71 GHz

7.2 From Effective Competition to Fair Competition in Mobile Market

Before the commencement of 4G LTE in 2014, Claro led Ecuador's mobile market. As displayed in [Figure 64], Claro's share had increased in the early 2000's and remained over 65%.[22] Following Claro, Movistar was the second largest carrier of Ecuador, whose market share in the 2010's was about nearly 30%. The competition by these two operators was far from fierce, and the mobile market was developed only slowly. In this market environment, Ecuadorian government perhaps wanted to increase Internet connection using MBB in order to make up for the lack of fixed-line investment. The government had to encourage CNT, the public-owned MNO, to catalyze 4G network investment by Claro or by Movistar.

Figure 64.

Changes in MNO's Market Share



However, as CNT was a relatively new entrant of mobile market and was not able to compete with Claro or Movistar, the government chose to enable CNT to become more competitive in 4G LTE market and to compete with Claro and Movistar more effectively by assigning LTE spectrum to CNT ahead of its two private competitors and by exempting CNT from paying spectrum license fees.[23] This policy to promote 'effective competition' may not be

22 Claro's high market share was the reason for the controversial market concentration fee.

23 Korean government had also used this effective competition policy.

efficient in a static point of view, but may be efficient dynamically.

- Static efficiency is concerned with the most efficient combination of existing resources at a given point in time. On the other hand, dynamic efficiency is concerned about the development of better technology and working practices which improve the efficiency of production over a period of time. Achieving static efficiency may not be consistent with achieving dynamic efficiency.

[Figure 64] would reveal that this effective competition policy had been effective: CNT's mobile market share began to rise sharply since 2014. [Table 56] shows CNT's market share in September 2018. We also provide changes in Ecuadorian MBB share from 2014 in [Table 57]. These two tables may imply that the competitive edge of CNT in MBB market (or LTE market) would have improved owing to the effective competition policy.

Table 56.
Mobile Market Share at September 2018

	Market Share	
	All	4G LTE
Claro	52.5%	30.8%
Movistar	29.9%	33.4%
CNT	17.6%	35.8%

Table 57.
MBB Share

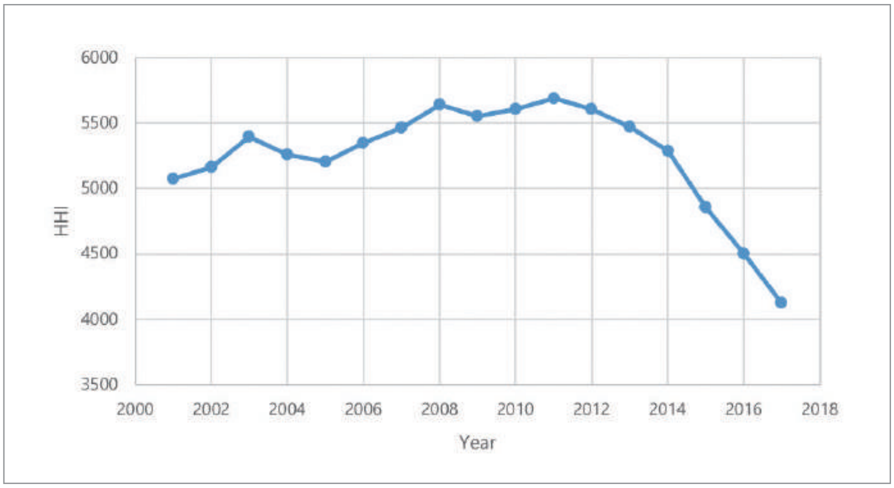
Year	Movistar	CNT	Claro
2014	30.4%	5.7%	63.9%
2015	34.0%	5.7%	63.4%
2016	32.0%	10.4%	57.1%
2017	29.7%	11.6%	58.7%
2018 (Feb.)	32.0%	12.0%	56.0%
2019 (Mar.)	27.0%	14.0%	59.0%

This seemingly improvement of CNT's competitiveness can also be captured in the changes in Herfindahl-Hirschman Index (HHI).[24] Moreover, Ecuador's 4G network coverage expanded from 34% in 2014 to about 52% in 2019, which would be another supporting evidence for the effective competition policy.

24 HHI is a commonly accepted measure market concentration.

Figure 65.

Trends of HHI



Yet, it is still too early to conclude that this competition policy is successful. First, despite the growth in market share, it is still doubtful that CNT has secured competitive edge in providing MBB services. The cost advantage of CNT in 4G LTE market over its two competitors is largely resulted from reducing its spectrum costs. CNT's cost advantage is not fair and is obtained at the cost of efficient spectrum management.[25] The social cost induced by giving up efficient spectrum policy seems very high, since CNT holds the largest IMT spectrum bandwidth among the three mobile operators even excluding those frequencies in the 450 MHz and 3.5 GHz.[26]

Table 58.

Three MNOs Spectrum Holdings and Mobile Market Share

	CNT	Claro	Movistar
Spectrum (MHz)	100	95	85
Market share (%)	19.05	53.21	27.73

Source: ARCOTEL

Second, it is also doubtful that the government's effective competition policy had triggered 4G network investment by Claro and Movistar. That is, it appears that the two global operators could have invested 4G networks regardless of the competition policy as they provide 4G services in other Latin American countries.

In preparing for 5G era, the policy regime of 'effective competition' has

25 Refer to Section 7.3 for more discussions regarding efficient spectrum management.

26 In addition, CNT's licenses are valid until 2031, while the licenses of Claro and Movistar will expire in 2023.

to be reconsidered, and the government should determine whether to switch to 'fair competition' policy. The effective competition scheme is applied at the early stage of the entry of competitors when the new entrants do not enjoy economies of scale/scope compared with the incumbent. Favorable call termination charges for new entrant and roaming obligation and the facility sharing obligation on the incumbent operators are some means of effective competition policy. When the new entrants get substantial market share, the need for the effective competition diminishes and fair competition is more desirable to achieve efficient market outcomes. Yet there is more important reason to discontinue effective competition policy regime in 5G era: The competitiveness of 5G is resulted not only from mobile but from fixed network infrastructure such as fiber optic cables and ducts/poles. CNT is dominant in Ecuador's fixed market, and can possibly exercise market power in the related 5G mobile market.

7.3 Efficient Spectrum Pricing

Mobile operators use radio spectrum in providing mobile services, and induce spectrum costs which consist of the opportunity costs of holding exclusive licenses and of the costs associated with managing and regulating radio frequencies. Spectrum management can encourage efficient use of the spectrum when the opportunity costs are collected properly. Also, it can enhance fair competition only when the costs of spectrum management are recovered from all operators regardless of private or public.

In Ecuador, however, CNT is exempt from paying the regulatory fees in [Table 51], which implies that the spectrum management costs induced by CNT are passed on to its two private competitors (see page 103 for the table). As a result, CNT is unfairly cost competitive than its two competitors. It is worth to note that CNT holds the largest IMT spectrum bandwidth among the three mobile operators even excluding those frequencies in the 450 MHz and 3.5 GHz.[27] Ecuadorian government had reasons to subsidize CNT in expanding MBB network coverage. However, it would be more desirable to stop providing CNT this unfair cost advantage. Moreover, subsidizing this public company is not desirable anymore since 4G or 5G is a premium mobile network for broadband services and since lowering MBB data price appears more effective for increasing MBB penetration. Nevertheless, the government may still subsidize CNT to increase MBB network coverage in the context of USO. That is,

27 In addition, CNT's licenses are valid until 2031, while the licenses of Claro and Movistar will expire in 2023.

it is useful for the government to subsidize CNT to mandatorily invest MBB network in regions where Claro or Movistar are reluctant to expand their MBB network coverage.

In order to promote fair competition in the market, the government should consider replacing the current spectrum management practice as well. The government assigns IMT spectrum using Direct Assignment (DA) method which does not seem to reflect opportunity cost of spectrum holdings in determining initial spectrum fee. All regulatory license fees shown in [Table 51] do not aim at recovering the costs of managing spectrum. Hence, it would be necessary to introduce an efficient method which can properly pricing spectrum.

Following ITU (2016), spectrum prices are established by using either an administrative method or a market-based method.

- Administrative mechanisms include spectrum fee formulas that recover the regulatory costs of spectrum management and administrative incentive pricing (AIP) reflecting the opportunity cost of the spectrum.
- Market-based mechanisms typically involve a market exchange such as spectrum auctions and (in the secondary market) spectrum trading.

Many spectrum regulators of the world have used or announced to use spectrum auction in allocating 5G spectrum. However, it would be difficult for Ecuadorian government to introduce spectrum auction due to economic crisis in 2008 and COVID-19 pandemic. Nevertheless, the government may consider using the administrative method to replace the current practice to price spectrum more properly. More specifically, this method calculates the initial license fee by using AIP to reflect the opportunity cost of holding spectrum, and sets the level of spectrum license fees excluding the initial license fee to recover all costs associated with managing and regulating radio frequencies. Of course, all costs of managing and regulating spectrum need to be identified before setting the regulatory fee level.

7.4 Simplifying Spectrum Price and Setting the Correct Reservation Price

Auction has been widely used as a way of allocating spectrum from the mid-1990s around the world. A persuasive reason is probably that they have generated substantial revenue for the state as an auction is designed to award the spectrum to the highest bidder. Therefore under the auction method is that it is likely to direct the spectrum to the more efficient operators.

Ecuadorian mobile operators pay a concession charge every 15 years for the renewal of the concession. In 2008, Claro and Movistar paid USD 480 million and USD 220 million respectively for the renewal of the concession during 2009 and 2023. The publicly owned CNT does not pay anything for their license. Claro and Movistar get the radio spectrum freely as well as CNT if there is a new demand for new mobile telecommunications services or need to increase spectrum capacities.

Article 52 of The Organic Law of Telecommunications says that the radio spectrum may be allocated by a competitive process such as auction if there are multiple requests or scarcity. But it is never practiced in Ecuador. The government assigns radio spectrum to mobile operators when there is a demand for the new services or a need for capacity expansion.

Many countries allocate radio spectrum by auction for the new services and capacity increase. This corresponds to the policy stance that anyone can enter the mobile market once it won the spectrum and paid what it is worth. Therefore, each spectrum has to be priced with its market value. For the Ecuadorian case, the concession renewal charge may be interpreted as the sum of the auction prices that would be happening for the period of 15 years. If the concession renewal charge is some portion of total mobile revenue during the period and spectrum price in each auction is calculated in similar way, the sum of the auction prices should be basically the same as the one-time concession charge.

It is important to set the correct reserve prices for spectrum auction. If the reserve price is set too low, there is a risk that the valuable national spectrum resources are somewhat wasted. On the other hand, if the reserve price is set too high, there is a risk that the auction will fail and nobody enters the auction process which yields zero revenue for the government.

In setting the reserve price for the auction, the Ecuadorian government may refer to the case of Korea and other countries. There are only three operators in Ecuador, and one is a dominant operator while the other two are smaller operators. In this kind of situation, the auction may not be active in bidding. Considering this possibility, the government may set a reserve price that reflects the radio spectrum's value. The reserve price should be set at a reasonable level so that the spectrum fee out of all the spectrum can also be in the sustainable percentage of total revenue.

7.5 Access Technology and Service Requirements

In Ecuador, both wired broadband Internet and wireless broadband Internet are included in the scope of universal service. This is a very positive part as it maintains a technology-neutral view of regulation.

It is appropriate to designate a certain level of speed as a service requirement for Fixed Internet Access Service and not to regulate technology. Among the technologies for providing a certain level of service, allowing the operator to select the most efficient technology can promote technological development and industrial development.

The exact service level of the broadband universal service has not been established. It is necessary to set the minimum speed of service. The available speed of LTE service is adequate. If set in this way, operators will provide SMA through LTE, and in the case of wired Internet, it will be possible to provide wired and fixed wireless technology. In the case of the UK, at least 10 Mbps is set as the broadband universal service level.

7.6 Financial Support for Parishes in Need of Universal Service

Regions with high priority should be targeted for universal service policy. In the case of Ecuador, since there is no available budget for universal service, it is practical to impose a universal service obligation as a frequency allocation condition. True access gap area and access gap should be classified. Areas where services are not provided by a market function should be designated as the target of universal service, and financial resources should be aggressively invested in these areas.

Areas in need of universal service should be identified, and the government should provide aggressive financial support to these areas. However, we think it will not be easy to provide financial support because the Universal Service Fund, which is 1% of the sales received from telecommunication service providers, cannot be used in Ecuador.

In this case, there is a plan to impose universal service obligations at the time of allocation of frequencies or to secure budgets from other government funds. If this method is not feasible, we propose a plan for the Ecuadorian government to designate CNT as a mandatory provider of universal services obligation, benefit from spectrum allocation, and expand the regional coverage of universal services every year using PPP.

7.7 Considerations for Selecting Digital Radio System

The existing AM and FM analogue systems suffer from inherent short-comings and neither can offer uniform reception quality throughout the coverage area. AM radio reception is constrained by bandwidth limitations which restrict the audio quality, and by interference from other co-channel and adjacent channel transmissions. This is particularly troublesome during the hours of darkness. The start of FM services in the 1950s improved the audio bandwidth and overcame the night-time interference. And when listened to in vehicles or on portables, reception suffered from the effects of reflected signals (multipath) and other forms of interference, particularly in suburban and city areas. Another aspect of AM and FM analogue transmissions is the inefficient use of the spectrum (relative to what is possible using digital technology). As pressure on the radio spectrum rises, this finite resource becomes scarcer. There are many ways in which digital radio systems can improve upon analogue systems.

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Therefore, all of these factors should be considered and the most advantageous method should be selected, and after a detailed conversion plan has been established, the conversion should be promoted based on this.

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In the case of the in-band method, it is important to support this frequency band. In addition, the performance of digital radio transmission technology and audio codec will be important factors.

In the transition from analog to digital radio, users cannot change radio receivers at once. So at the beginning of the transition, it would be advantageous to have both analog and digital radios serviced. In addition, it is necessary to consider the possibility of providing not only audio services but also data services that can create high added value by using broadcasting networks in future environments such as autonomous vehicles.

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Websites

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World Bank Open Data: https://data.worldbank.org

HD Radio: https://hdradio.com/

DRM: https://www.drm.org/

Appendix 1.

5G in Americas

USA

With FCC's 5G FAST plan, there has been an extensive push towards allocating more spectrum for 5G broadband services (FCC, 2020). Initially the focus was on high-band spectrum above 24 GHz, but since 2017 the FCC has increased its efforts to identify mid-band spectrum suitable for 5G applications.

- Low-bands: The FCC focuses on the 600 MHz, 800 MHz, and 900 MHz bands. In particular, 2×35 MHz of FDD spectrum in the 600 MHz band (uplink 663~698 & downlink 617~652, n71) became available through broadcast incentive auction completed in March 2017.
- Mid-bands: The FCC works on the 2.5 GHz, 3.5 GHz, and 3.7~4.2 GHz bands to make more than 600 MHz available for 5G deployments. The first mid-band 5G opportunity is likely to be CBRS (Citizens Broadband Radio Service), which will open up 150 MHz frequencies in the 3.5 GHz band with 3-tier sharing. The FCC optimized rules in October 2018 and allowed initial GAA (General Authorized Access) deployments in September 2019. PAA (Priority Access License) auction (Auction 105) was supposed to be conducted in June 2020, but postponed in light of COVID-19 Pandemic.
- High-bands: The FCC concluded its first 5G spectrum auctions in the 28 GHz band, the 24 GHz band, and the upper 37 GHz, 39 GHz, and 47 GHz bands. With these auctions, almost 5 GHz of 5G spectrum was released into the market—more than all other flexible use bands combined.

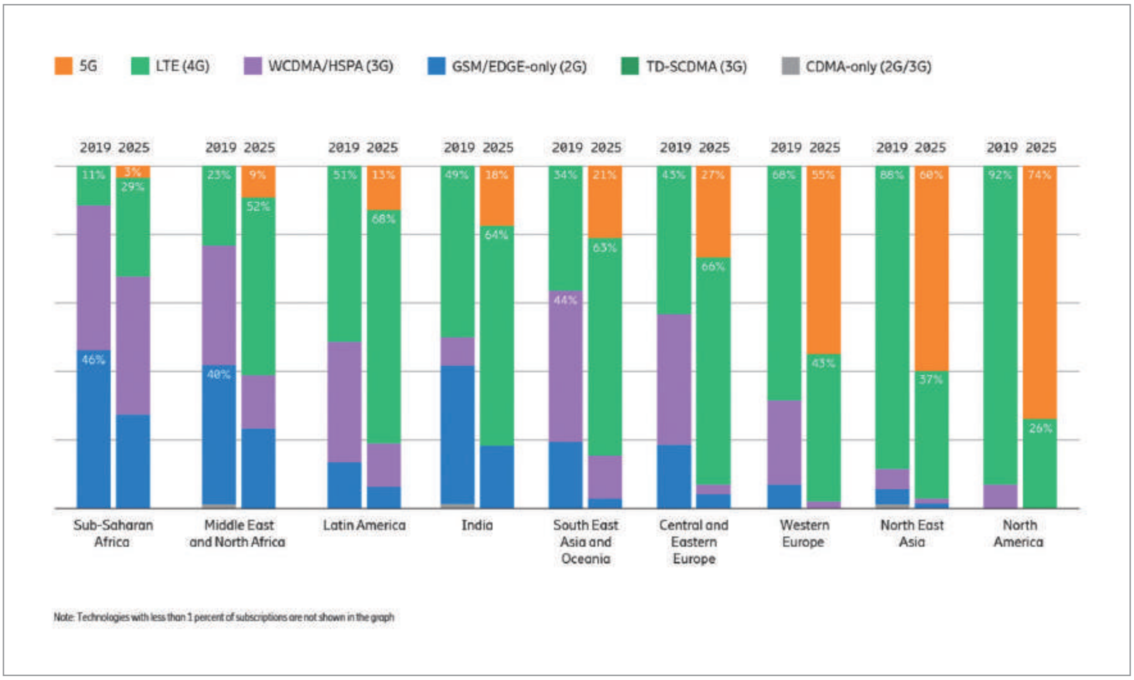
Together with exclusively licensed spectrum, the FCC has recognized the importance of unlicensed spectrum for 5G. The FCC is considering new opportunities for the next generation of Wi-Fi in the 6 GHz and above 95 GHz band. The FCC has also emphasized the importance of spectrum sharing for 5G, and backed a number of initiatives moving in this direction.

Latin America

Even though auctions and public consultations for 5G are underway or planned in some LATAM countries, there are still significant works ahead to pave the way for the fullest possible use of 5G technologies. The first 5G network deployments are expected soon, with Argentina, Brazil, Chile, Colombia and Mexico anticipated to be the first countries. However, it is not likely that 5G will become the dominant radio access technology before 2025 in this region. Refer to [Figure 65] by Ericsson (2020).

Figure 66.

Mobile Subscriptions by Region and Technology

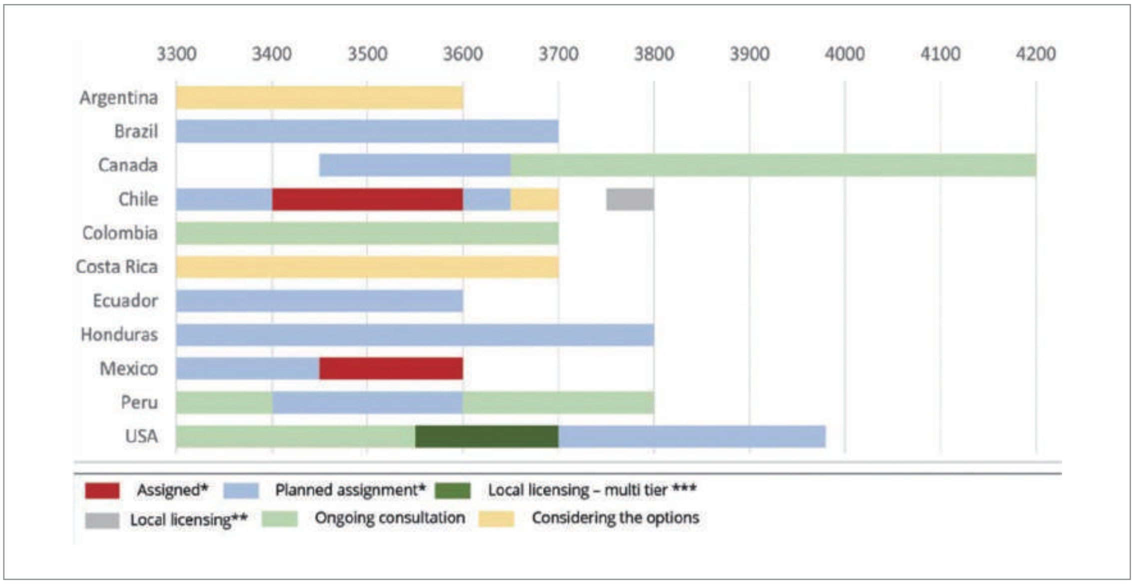


Source: Ericsson (2020)

The current 5G spectrum positions in Americas are as in the following two figures. These figures would show that Ecuador is preparing for allocating 300 MHz in the C-band but does not consider allocating mmWave bands.

Figure 67.

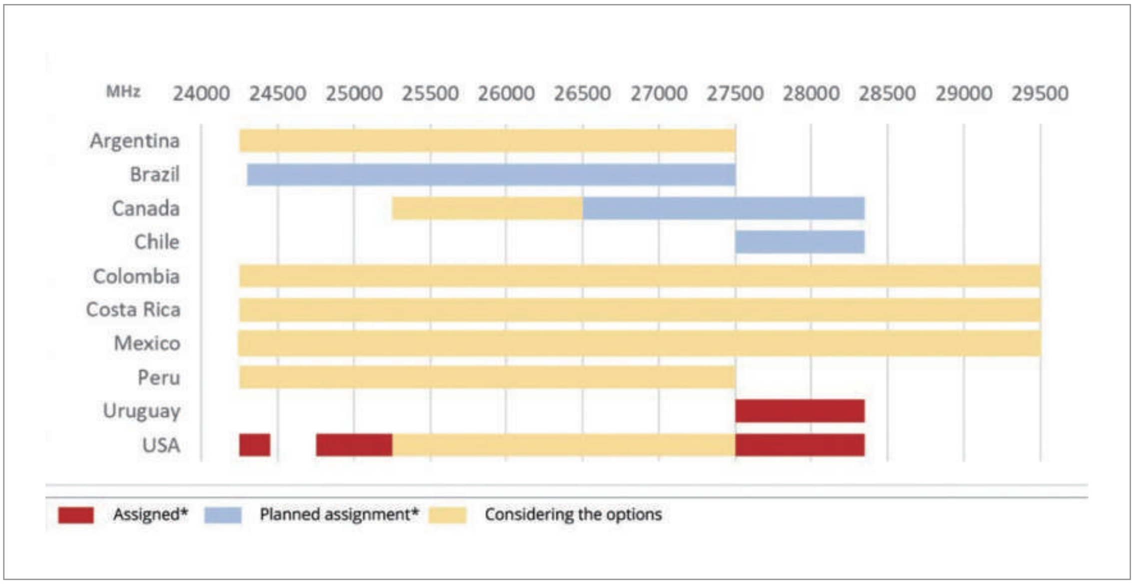
5G Spectrum Positions in the C-band



Source: GSA (2020b)

Figure 68.

5G Spectrum Positions in the mmWave Bands



Source: GSA (2020c)

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Policy for Spectrum Allocation and Efficient Use in Ecuador

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