5G and the 3.3-3.8 GHz Range in Latin America

November 2020

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1. Executive summary

5G and the 3.3-3.8 GHz range

The future will be defined by advances in artificial intelligence, IoT automation, Big Data and analytics, machine learning, and virtual and augmented reality. Many of these are dependent on new levels of performance, ultra-high speed and low latency, that only 5G can deliver. In short, the arrival of 5G opens the door for limitless connectivity.

Sectors such as professional, governmental and financial services, manufacturing, entertainment, healthcare and agriculture all stand to make huge gains, benefitting consumers as well as enterprises.

The first fully commercial 5G services in Latin America are expected to launch in 2021, which is an accelerated timeframe compared to leading markets during previous generations, while 5G temporary networks and proof of concepts have already been launched. Whether they can offer the full potential of 5G depends on timely access to the right amount and type of affordable spectrum, under the right conditions. While 5G networks need spectrum in low bands (below 1 GHz) and high bands (mmWaves such as 26, 28, and 40 GHz), access to mid-range frequencies are particularly important. That's because they offer a good mixture of coverage and capacity benefits. The amount available impacts not just performance, but also the cost of building out networks.

BILLIONS OF SUBSCRIBERS, AND BILLIONS IN BENEFITS

- **By the end of year, there will be 5G commercial services from approximately 153 mobile operators, and 145 million connections, according to GSMA Intelligence. By 2025, the number of connections is expected to increase to 1.7 billion, powered by users' demand for quality and reliability.**
- **By 2023, mobile's contribution to the Latin American economy will reach just over $300 billion, as 4G adoption accelerates in Latin America over the next few years. A development that paves the way for 5G.**

Frequencies in the 3.3-3.8 GHz range are already used in a majority of commercial 5G networks and have the biggest ecosystem of devices. That makes them the closest there is to a globally harmonised band. Therefore, it is also expected to unlock 5G in Latin America in the coming years. As the region moves forward with licensing the range, the key recommendations are:

- Regulators should aim to make available 80-100 MHz of contiguous spectrum per operator;
- Inflating spectrum prices should be avoided as it risks limiting network investment, slowing down network speeds, and driving up the cost of services. This includes excessive reserve prices or annual fees, limiting spectrum supply, excessive obligations and poor or over complicated assignment design;
- Regulators should make the plans about the clearing process and the migration of other services (e.g. satellite and defence) public as soon as possible;
- Consider implementing a voluntary refarming mechanism to speed up the process;
- National, exclusive licenses should remain the core of 5G spectrum licensing approach for the 3.3-3.8 GHz range;
- Setting spectrum aside for verticals in priority 5G bands (i.e. 3.5/26/28 GHz) could jeopardise the success of public 5G services and may waste spectrum. Sharing approaches, like leasing, are better options where verticals require access to spectrum;
- To safeguard optimum performance, all TDD networks need to be synchronised on a national level; and
- Governments and regulators need to adopt national spectrum policy measures to encourage rapid deployment and consider reasonable network roll out investment as substitute to upfront cash payment for spectrum fees.

The current situation

Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Mexico, Peru and Uruguay are all part of this report. They were chosen with the aim of having a representative sample of the region, taking into account country size in terms of population and economy, 4G market development and focus on 5G initiatives.

All eleven countries have designated part of the 3.3-3.8 GHz for mobile broadband deployment, ranging from 300-500 MHz. There is, however, current usage in many parts of band in most of the markets, occupied mainly by fixed, mobile and fixed satellite services. Eight, out of the eleven sampled countries (Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Peru and Uruguay), have some spectrum already cleared in the 3.3-3.8 GHz range (See table 1).

ILLUSTRATION 1

Source: ITU's footnotes 5.429D, 5.431B and 5.434 and information from national regulators

Planned use of the 3.3-4.2 GHz range for mobile broadband

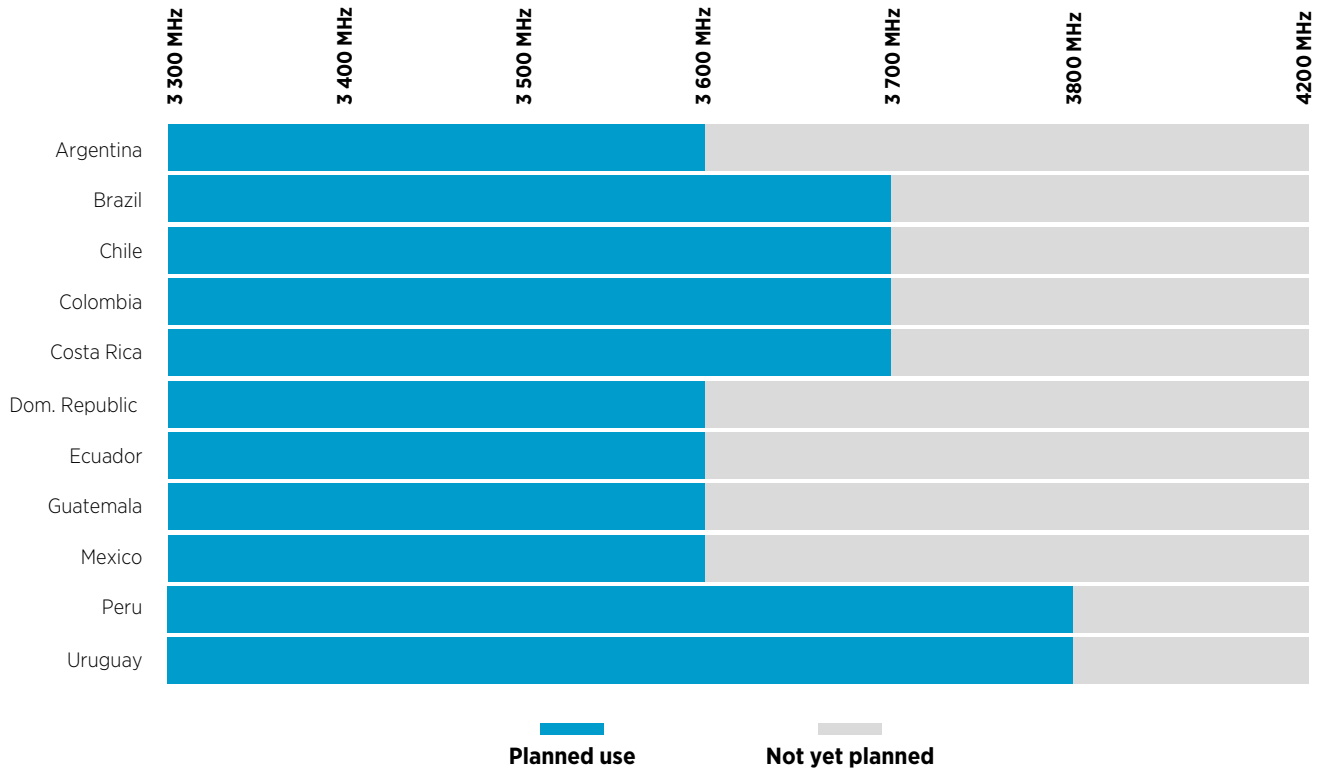


TABLE 1

Source: BlueNote analysis based on information from NRAs of sampled countries

Summary of 3.3-3.8 GHz range cleared spectrum

Country	Cleared spectrum	Range
Argentina	No	N/A
Brazil	No	N/A
Chile	150 MHz cleared	3.3-3.4 GHz 3.60-3.65 GHz
Colombia	400 MHz cleared	3.3-3.7 GHz
Costa Rica	100 MHz cleared	3.3-3.4 GHz
Dominican Republic	260 MHz cleared	3.3-3.4 GHz 3.40-3.46 GHz 3.6-3.7 GHz (guard band)
Ecuador	228.5 MHz cleared	3.3-3.4 GHz 64% of 3.4-3.6 GHz
Guatemala	No	N/A
Mexico	100 MHz cleared	3.35-3.45 GHz
Peru	200 MHz cleared	3.3-3.4 GHz 50% of 3.4-3.6 GHz (Lima and Callao)
Uruguay	200 MHz cleared	3.3-3.4 GHz 3.6-3.7 GHz

Challenges

The main challenges the sampled countries face in terms of the release of the 3.3-3.8 GHz range have been grouped into three categories according to their main focus: political challenges; regulatory challenges; and lastly, technical challenges.

Focus on political challenges are mainly linked to:

- High level of political commitment to 5G as a key enabler of digital economies
- Development of formal 5G strategy and spectrum roadmap
- Identification of key regulation challenges
- Agreements with other industries (e.g: satellite, defence) on timely return of spectrum or other solutions in case those are MNOs

Main solutions: To move forward, every country plan should set out a clear roadmap for the 5G implementation, and should include all studies required to gather the relevant information for the decision makers. It also needs to include clear and well communicated rules and conditions for spectrum awards, taking into account requirements from all relevant stakeholders.

Focus on regulatory challenges is mainly linked to:

- Harmonisation in the frequency arrangements and update of the NTFAs
- Definition of policies, regulatory framework and spectrum assignment mechanisms
- Definition of reasonable spectrum prices, considering the high cost of the required infrastructure for the development of 5G and obligations, if any
- Assessment of the current spectrum situation and consequent revision/lifting of spectrum caps, if needed
- The successful completion of any needed refarming process

Main solutions: Tackling these challenges requires the implementation of international best practices and recommendations by international organisations, such as the Inter-American Telecommunication Commission (CITEL), the International Telecommunication Union (ITU) and the GSMA, as well as thorough industry stakeholder consultations, with a main focus on effective and timely licensing of the spectrum (in terms of market readiness, amount of spectrum (80-100 MHz per operator), price, caps, payment models, obligations).

Focus on technical challenges are those which are mainly linked to:

- Defining the minimum size of the blocks to be offered for IMT
- Deal with current in band as well as adjacent users to avoid interference and promote refarming, when needed
- Define synchronisation frame structure and implementation exceptions
- Agree on cross border interference and synchronisation

Main solutions: Consider best practices and recommendations by international standard bodies, review interference by existing studies, and assess thoroughly the current market status (in terms of current assignments and use, licensing authority's policy objectives and market needs). Lastly, coordinating the 3.3-3.8 GHz range release within operators and neighbouring countries is also important, mainly due to TDD synchronisation requirements.

Licensing guidelines

The following table highlights key licensing guidelines, classified in terms of spectrum planning and spectrum award and licensing.

TABLE 2

Source: GSMA, BlueNote analysis

Key licensing guidelines

Spectrum planning	Spectrum award and licensing
• Follow international **best practices, band plans and trends** • Provide a **roadmap for future availability and release spectrum** as part of national spectrum planning policies (national allocation to mobile and identification for IMT services and licensing schedule and plans), allowing the reshuffling of blocks to guarantee contiguous ranges of **at least 80-100 MHz per operator** • Provide clarity in terms of the **3.3-3.8 GHz range availability and clearing** (when previously occupied), relocating and/or ceasing services currently in the band as soon as practical to vacate at least 300-400 MHz • Provide clarity in terms of **coexistence, synchronisation agreements and cross-border interference** • Remove regulatory barriers to allow **voluntary infrastructure sharing** and wider implementation in order to reduce the costs and accelerate the deployment • Simplify authorisation procedures related to **sites planning, acquisition and management** • Incentivise early **entry of affordable mobile handsets** into the market (i.e. tax reliefs) • Provide early and clear guidance on the **TDD synchronisation frame structure and exceptions**	• When there is competition, use **market-based mechanisms** to award the spectrum • Hold **open consultations** on award rules and conditions prior to the assignment process • Set **reserve prices** below a conservative estimate of market value to allow market discovery to determine price • Prioritise **improved mobile broadband services to achieve socio-economic benefits** – above revenue maximisation – when awarding spectrum • Do **not generate scarcity** in the spectrum award process; artificial limitations on the amount offered or inappropriate lot sizes risk inflating prices and slowing investments • Assign spectrum with **technology neutrality** • Grant longer **licensing periods** (ideally 20 years or longer) to provide long term certainty for network investment • Avoid **taxes and fees** that deter roll-out

Taking into account the best practices and guidelines, and a three-stage roadmap (planning and decision; implementation; and spectrum award), the following framework should work as an easy-to-use checklist during each stage.

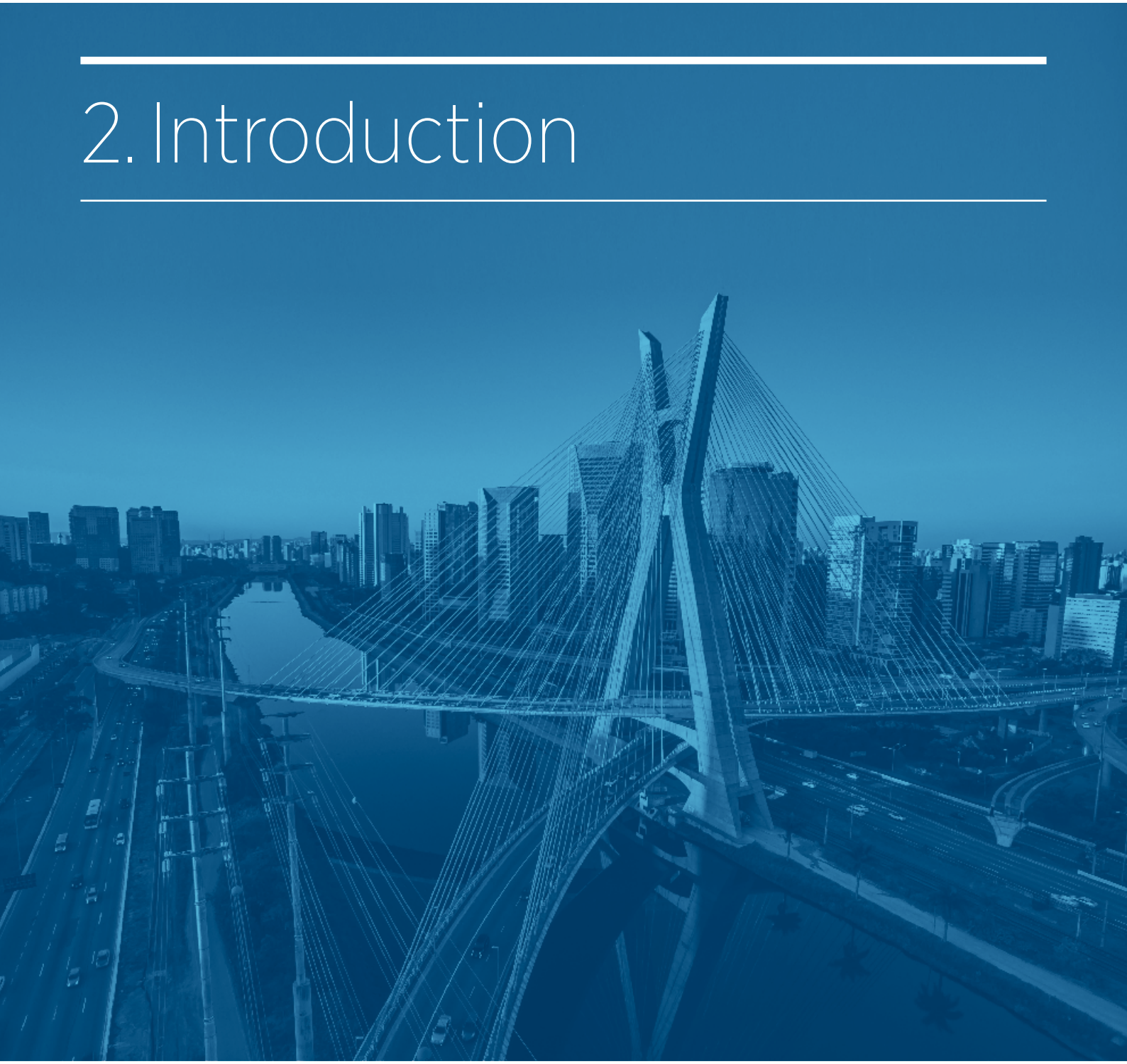
TABLE 3

Source: BlueNote analysis

Q&A - How to release the 3.3-3.8 GHz range

Question	Challenges to overcome	Consequent actions
Is the band considered for mobile broadband?	• Create a national 5G broadband strategy and spectrum roadmap • Understand if changes to the national frequency allocation plan and ITU Radio Regulations are needed	• Designate all or part of 3.3-3.8 GHz as priority band for national 5G plan • Modify the national frequency allocation table and reserve the 3.3-3.8 GHz range for IMT • Make the necessary additions at WRC-23
Is the band currently occupied?	• Understand who is occupying the band • Understand how much of the band is required and actually being used • Confirm the legality of current usage • Assess when existing licences will expire • Consider the regulatory requirement for the band's clearing and defragmentation	• Other industries (e.g. satellite and defence) should return the spectrum that is not in use, updating the regulatory framework, when necessary • If MNOs are using the band, support a wide consultation process with all interested parties to understand a specific way forward • Cease services not in use or in decline, considering low-income families' dependency • Assess legal framework and users' profile to define, together with the sector, a migration strategy, if and when necessary • Assess the possibility of maintaining the adjacent services via filter or power limits so the interested parties can decide on the best approach • Choose the best migration/coexistence strategy for the specific case: incentive scheme, compulsory, coexistence and/or according to licence expiration dates
What are the coexistence issues and the synchronisation needs?	• Consider potential coexistence issues based on existing studies and evaluate current users' migration strategies • Assess the requirement for TDD synchronisation amongst licensees	• Review existing coexistence studies • Coordinate cross-border roadmap • Communicate results to the market • Depending on the market organisation, create a framework for TDD synchronisation, including frame structure and exceptions
Which is the best spectrum award process?	• Effective and timely licensing of spectrum • Aim for 100 MHz per operator • Meet licensing authority's policy objectives • Meet market needs • Provide predictability to support network investment	• Define and communicate (using public consultations) a medium- and long-term spectrum roadmap for 5G in the full range • Identify and launch a work plan to review regulatory challenges, the legal environment and barriers for boosting 5G • Launch 3.3-3.8 GHz range spectrum award process with the most efficient design (considering the affordable and investment-led payment scheme) • Prioritise improved mobile broadband services to achieve socio-economic benefits – above revenue maximisation – when awarding spectrum • Consider all obligations, if any, as a discount on the reserve price • Consider reasonable network roll out investment as substitute to upfront cash payment for spectrum fees

2. Introduction



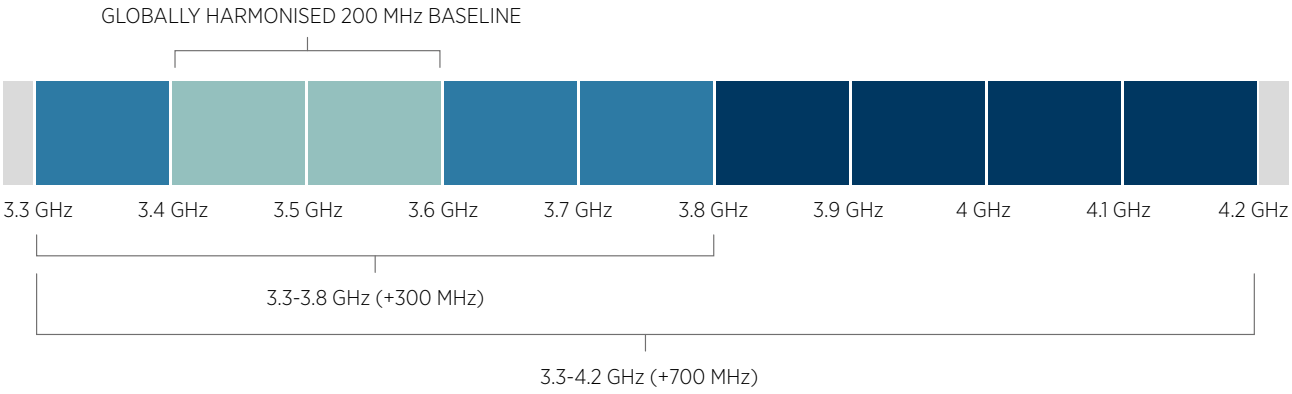
The purpose of this report is to develop a comparative analysis of the occupation and current status of the 3.3-3.8 GHz range in Latin America, the plans on the public agenda in this regard and potential demand. This is in order to share good practice and to accelerate availability of the range in the region. Successful spectrum awards help unlock the full potential of the 5G, regarding speed, latency, coverage and quality of services.

The 3.5 GHz range is a core spectrum band for 5G deployment, being an ideal band for this technology as it is able to provide both capacity and coverage. In this study, the 3.5 GHz range considers the frequencies in the range of 3.3-4.2 GHz.

ILLUSTRATION 2

Source: Economic benefits of 5G in 3.3-4.2 GHz, GSMA

The 3.5 GHz range (3.3-4.2 GHz)



Expanding the available ranges in 3.5 GHz for 5G will lead to positive impact in terms of:

- better performance, higher data rate requirements to address new and existing 5G application needs (i.e. video streaming, virtual reality)
- expansion as a result of new services and demand, leading to added value to the economy
- better quality mobile broadband in urban areas, enabling consumers to carry out more tasks, more efficiently, acting as a multiplier to other industries and the wider economy
- lower infrastructure costs if compared to higher 5G bands, leading to faster deployment to satisfy ever increasing connectivity and data demand

A group of eleven countries in Latin America were selected to assess the status of the range and to make the comparative analysis with their peers in the region. The complete list of countries is Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Mexico, Peru and Uruguay. These countries have been chosen with the aim of having a representative sample of the region, and taking into account country size in terms of population and economy, 4G market development and a focus on 5G initiatives.

Additionally, to meet the objective of this report, it includes the research of case studies in North America (United States and Canada), Europe (United Kingdom, Finland, Italy and Spain) and Asia (South Korea), of the treatment and allocation processes for this spectrum band, as well as the review of the recommendations and opinions of different sector members, including operators and the ITU.

The report is organised in four main sections:

i. Description of the relevant aspects of the mobile broadband in Latin America;

ii. 3.3-3.8 GHz range status in Latin America with a detailed description of the status in each of the eleven sampled countries;

iii. International experience benchmarks; and

iv. Conclusions, with a summary of the main challenges and opportunities, key technical considerations and proposed roadmap with licensing guidelines.

3. Mobile broadband market in LatAm

Public policy for broadband connectivity

Governments have various ways of promoting the development of broadband networks and services within their countries. In most cases, the most effective government strategies are those that seek to harness the power of private sector investment to spur broadband growth, also avoiding continuous decrease on the industry's revenues.

According to the World Bank's Broadband Strategies Toolkit[1], governments should be aware of certain elements as policies and strategies are created:

- Establish specific plans and policies
- Allow ample opportunity for stakeholder input on plans and policies
- Recognise and consider that implementation of the plan will take time and persistence
- Develop research mechanisms to track progress of the plan

Taking this starting point, Latin American governments and policy makers have shown different levels of commitment, execution and success in their plans and policies in promoting the development of broadband connectivity. In line with the goals of the Digital Agendas[2] of the countries in the region, expansion of access in Latin America is expected to keep growing in the coming years. The Digital Agendas usually cover the following key topics:

- Legal and regulatory matters
- Promotion of digital inclusion
- Reduction of barriers to private sector investments

4G status and 5G forecast

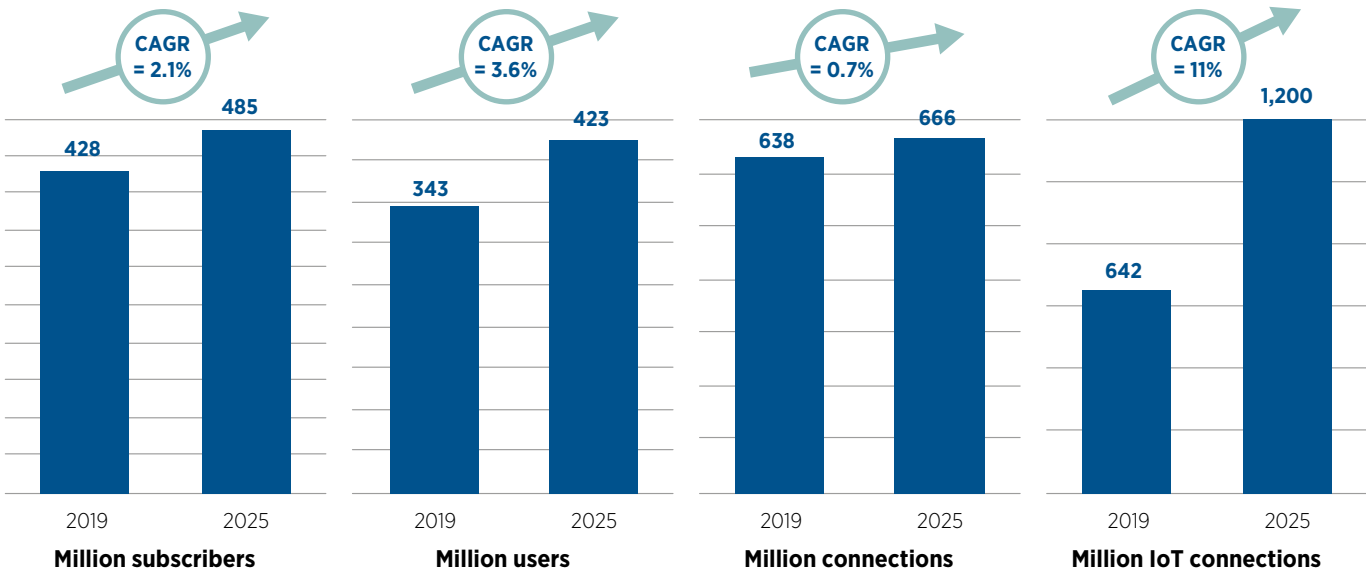
By 2023, the GSMA expects that the mobile's contribution to the Latin American economy will reach just over $300 billion, as countries increasingly benefit from the increased uptake of mobile services and the associated improvements in productivity and efficiency.

Latin America keeps showing a mobile subscribers growth trend for the coming years. Total subscribers are expected to be near 500 million by 2025 (representing a CAGR of 2.1 per cent)[3]. Together with the number of subscribers and internet users, total connections and IoT connections are expected to keep growing in the coming years.

ILLUSTRATION 3

Source: The Mobile Economy 2020, GSMA[4]

Connections and subscribers in Latin America



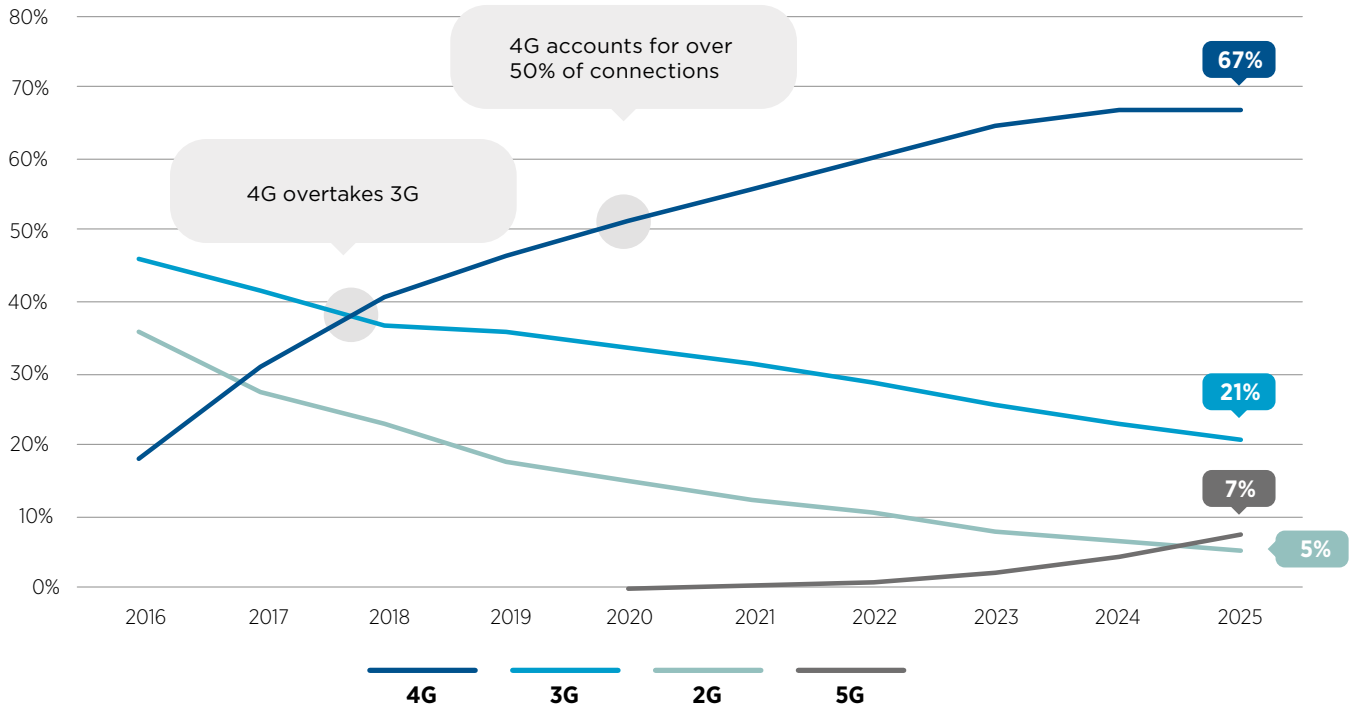
1. Available at 'Broadband Strategies Toolkit' (The World Bank, 2012)
2. A summary of the digital agendas of the eleven Latin-American countries, which are the scope of this report, can be found in the appendix
3. From 428.8 to 485.6 million mobile subscribers in 2019 and 2025 respectively
4. Available at The Mobile Economy 2020. GSMA (GSMA, 2020)

Driven by ongoing network investment, upcoming spectrum assignments and expected flexible new regulations, 4G adoption will accelerate in Latin America over the next few years, and is paving the way for 5G. The first commercial 5G services in Latin America are expected to launch in 2021, this being a shorter timeframe if compared to leading markets on previous technologies. 4G has already overtaken 3G as the prevailing technology in Latin America, with the expectation to account for approximately two thirds of the technology mix in 2025, while 5G will account for 7 per cent of it[5].

ILLUSTRATION 4

Source: The Mobile Economy Latin America 2019, GSMA

Latin America Technology mix



5. Expecting the 5G technology mix to be in the range of 50% in North America and Greater China by that time

Regarding 5G, which has already seen the first moves in some regions, this is not the case of Latin America, where certain Latin American countries are taking steps to prepare for eventual 5G deployments in 2021. 5G availability will be constrained in the coming years by long-standing, investment-related, obstacles in much of the region, as operators will be mainly focusing in building their 4G networks before starting the deployment of new technologies. Brazil and Mexico are expected to be, by 2025, the only markets where the 5G technology mix is expected to account for more than 10 per cent[6]. Although this will be happening by 2025, 5G requires deployment efforts to happen in advance, so, many initiatives should be starting prior to this (the assignment of 5G spectrum being one of the main initiatives, together with regulatory changes, infrastructure development, etc).

In terms of data traffic, it is expected to reach 19 GB/sub/month by 2024 (from 3 GB/sub/month in 2018). Mainly driven by smartphone penetration (going by its adoption from 69 per cent in 2018 to 79 per cent in 2025) and the previously mentioned growth of 4G and 5G in the technology mix.

As mobile continues to heavily influence the digital transformation of societies and impact key industry verticals, the transition from 4G to 5G will further strengthen productivity and GDP growth in Latin America. For the region to keep pace with the rest of the world, 5G must be adopted to power areas such as industrial IoT. Besides households and individual use, the greatest opportunity for incremental revenue lies in enterprise and government use cases. Higher data speeds will improve productivity in sectors relying on massive Machine Type Communications (mMTC), as well as in mining, logistics and manufacturing. For this reason, enterprises in the region see enhanced data speeds as the most important 5G capability. Besides the ICT, sectors which will benefit more are expected to be the public sector, professional services, financial services, entertainment, commerce and agriculture.

By 2025, the total number of IoT connections in Latin America (1.3 billion) is expected to account for 5 per cent of global IoT connections. Smart buildings and smart utilities are the largest industrial IoT verticals in the region. IoT deployments for agriculture are also critical. In many Latin American countries, agriculture makes up the core of the tradable sector. Deployments of more efficient solutions in this area will, therefore, have a direct impact on GDP growth. Lastly, healthcare and smart cities are other areas that will have an effect on wider economic stability. For instance, improved city lighting can help reduce crime and energy consumption, while smart city solutions, such as pollution monitoring, can help prevent health hazards.

The mobile industry has also been a strong advocate for SDGs: since 2015, it has increased its impact on all 17 SDGs and the 3.5 GHz range is key to enhancing these goals. In Latin America, the industry has made a strong contribution over the past year specifically on SDG 4 (Quality Education) and 5 (Gender Equality).

Latin America is an attractive region for investment because of its strong smartphone adoption rates and improving infrastructure. For example, SoftBank launched a fund in 2019 to invest $2 billion (with a target of $5 billion) in innovative companies in Latin America[7].

6. Source: The Mobile Economy Latin America 2019 (GSMA Association, 2019)
7. As indicated in Latin American Venture Capital Association's (LAVCA's) article: 'Softbank announces US 5b fund for Latin American tech'

IMT spectrum holdings and demand

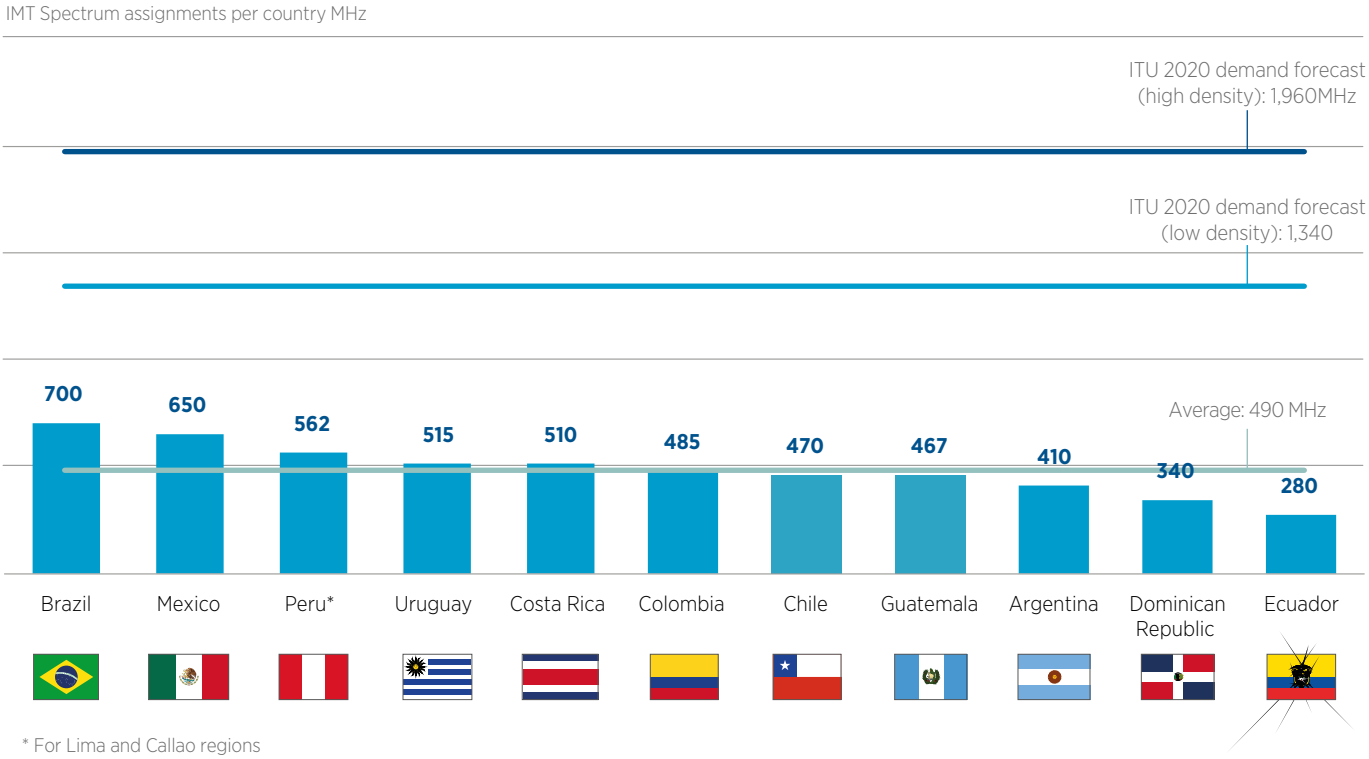
In terms of spectrum demand and its forecast, ITU established the detailed specifications for IMT-2000 and the first 3G deployments commenced around the year 2000. In January 2012, ITU defined the next big leap forward with 4G wireless cellular technology, IMT-Advanced. IMT-2020 Standard are the requirements issued in 2015 for 5G networks, devices and services.

In terms of spectrum holdings, the next illustration shows the amount of spectrum that has been licensed for mobile services in each of the sampled countries in this region.

ILLUSTRATION 5

Source: information from national regulators, BlueNote analysis

Spectrum licensed for IMT services in Latin America



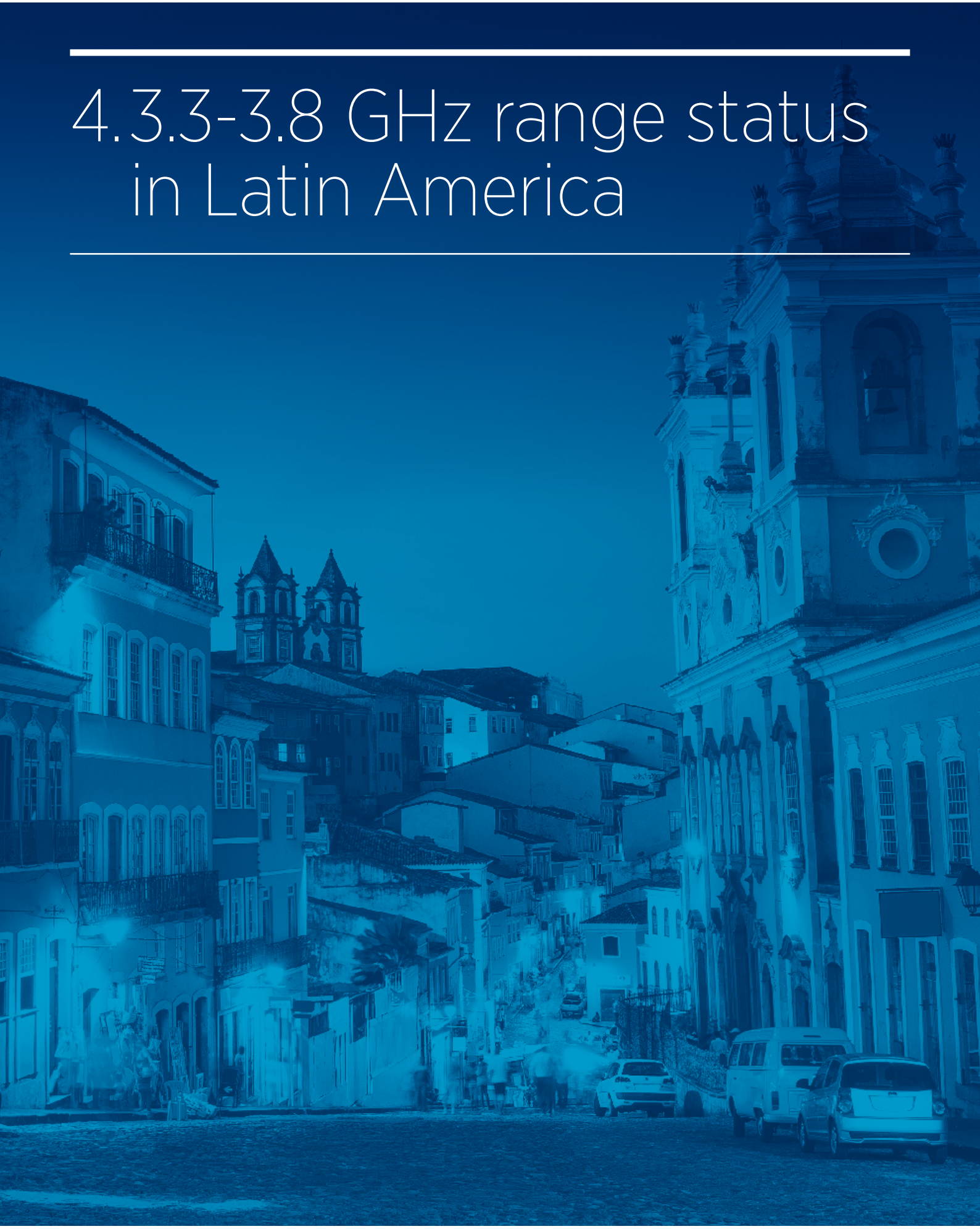
* For Lima and Callao regions

Currently, Latin American sampled countries have an average of 490 MHz licensed for mobile services, which is between 25 per cent and 37 per cent when compared to ITU's 2020 demand forecast, which ranges from 1.3 GHz to 2.0 GHz[8], in the high and low density cases respectively, resulting in 850 to 1,470 MHz of spectrum, on average, yet to be licensed.

It is important to highlight that spectrum licensing is required, not only for 5G, but for the continuous consolidation of the 4G technology, as 5G deployment requires this to happen in its full potential.

8. Available at Report ITU-R M.2290-0 (ITU, 2014)

4. 3.3-3.8 GHz range status in Latin America



Introduction

This section describes in detail the status of the 3.3-4.2 GHz range in Latin America, based on the eleven sampled countries.

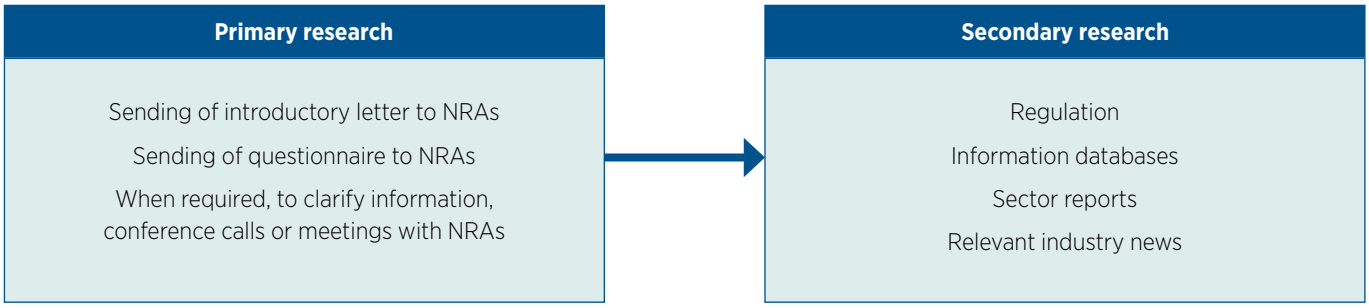
For each country, an initial brief description of spectrum management is completed. Secondly, the mobile allocation and considerations of their national plans for mobile broadband, current holders and licence conditions are described. Each country's section continues with the introduction of public policies and relevant regulatory framework. Lastly, the identified challenges for a timely release of the range are presented.

The gathering of information process has considered both primary and secondary researches below.

ILLUSTRATION 6

Source: BlueNote

Methodological approach in each country



Secondary research has considered access to public sources, information databases, sector reports, relevant industry news, etc. On the other hand, the primary research has considered contact with the NRAs. An initial letter by the GSMA and a questionnaire were sent to the NRAs of the sampled countries and, when required, further follow-ups were conducted through conference calls or meetings.

Key country findings

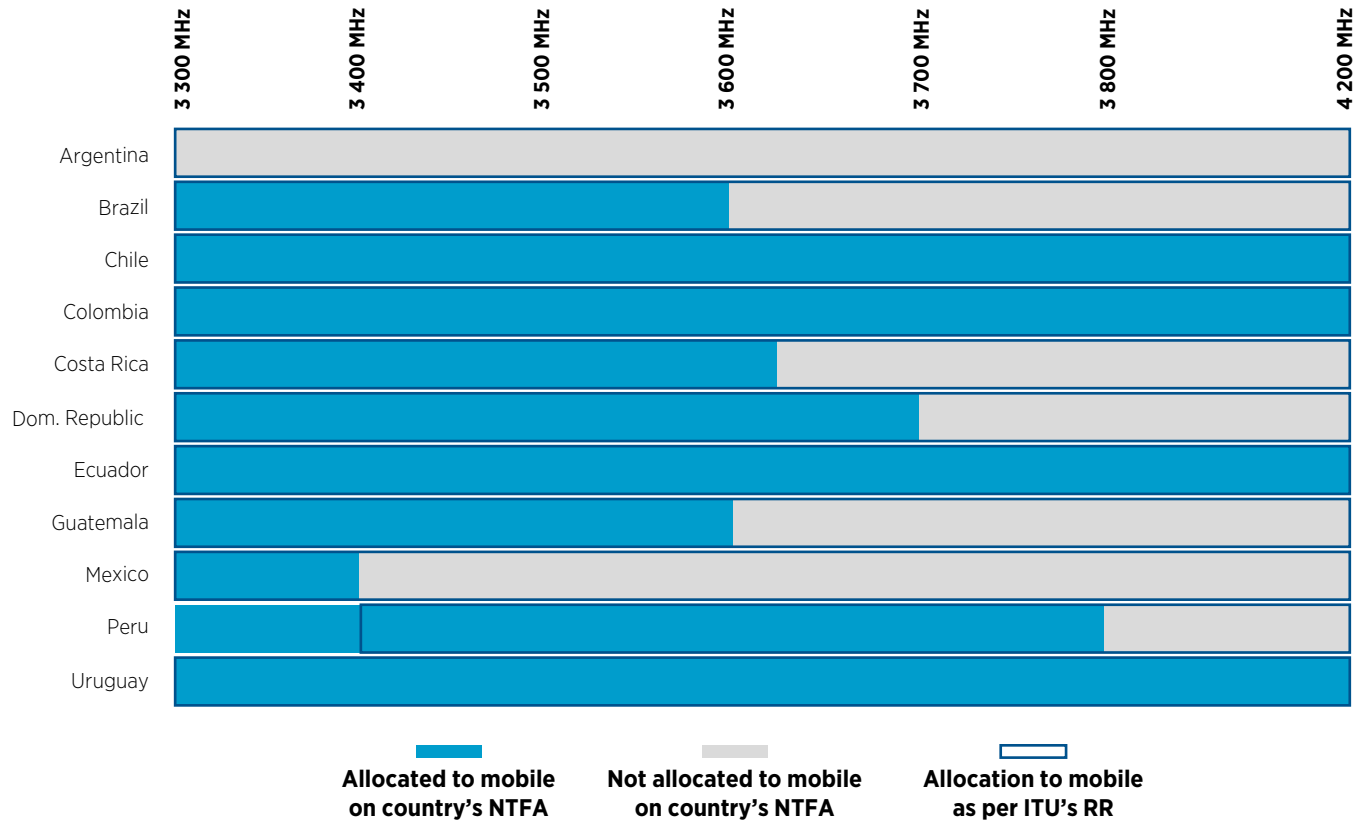
This section assesses the current status of the 3.5 GHz range in Latin America. Firstly, it shows a summary of the current mobile allocation of the range, followed by a comparison of the total range included by the public administrations in their national plans for mobile broadband and the occupation of that range; secondly, it shows detailed information by country. This information is completed with additional data in the Appendix section.

The next illustration shows that the region is heterogeneous in terms of mobile allocation. In fact, considering each country's current NTFA, four countries (i.e. Chile, Colombia, Ecuador and Uruguay) have allocated the full 3.3-4.2 GHz range to mobile services. Peru has allocated 500 MHz (3.3-3.8 GHz), Dominican Republic 400 MHz (3.3-3.7 GHz), Costa Rica 325 MHz (3 300-3 625 MHz), Brazil and Guatemala 300 MHz (3.3-3.6 GHz) and Mexico has allocated 100 MHz (3.3-3.4 GHz). Argentina has no primary allocation to mobile services (it has 100 MHz allocated on a secondary basis to mobile services, 3.3-3.4 GHz). Having said that, it must be highlighted that according to ITU's Radio Regulations[9] (RR), the full 3.3-4.2 GHz range is allocated[10] to the mobile service, except aeronautical mobile, on a primary basis, in the sampled countries, which shows the growth potential the region has in terms of spectrum allocation in this range. As an example, Brazil is planning to license 400 MHz (3.3-3.7 GHz).

ILLUSTRATION 7

Source: countries' NTFAs and Article 5 Frequency Allocations of the ITU Radio Regulations

Current allocation to the mobile service in the 3.3-4.2 GHz range



9. Article 5 Frequency Allocations of the ITU Radio Regulations

10. In the case of Peru, not being included in footnote 5.429C, and according to ITU's RR, the 3.4-4.2 GHz range is allocated to mobile in the country. Although Peru considers the 3.3-3.4 GHz range allocation to mobile in its NTFA

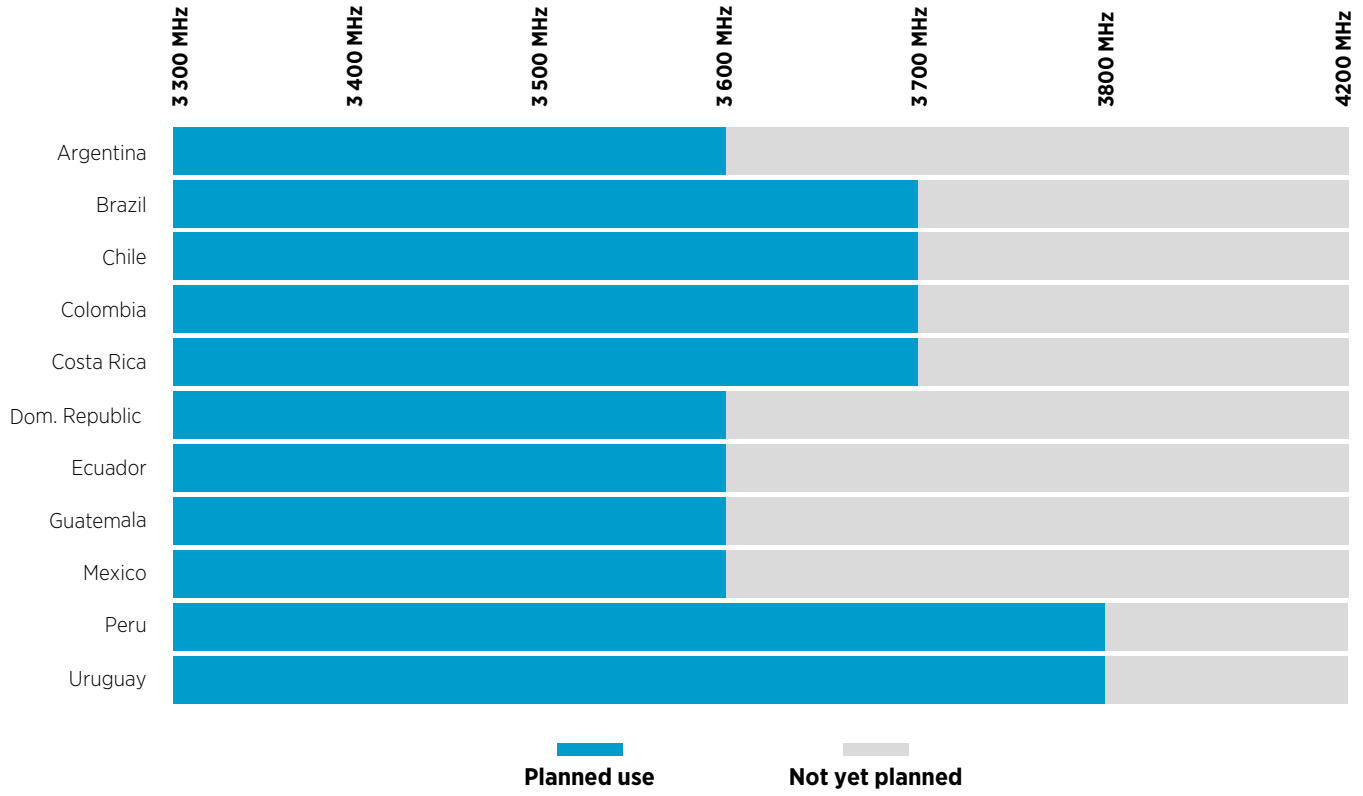
However, the fact that only part of the 3.3-3.8 GHz range is allocated to the mobile service in the NTFA does not mean that other parts of the range are not among the countries' planned use of the range for mobile broadband[11]. For instance, the full 3.8-4.2 GHz range has not yet been considered for these purposes in any of the sampled countries. To fully comply with the ITU polices, NRAs will be required to update their presence in the ITU RR in WRC-23.

The next figure shows spectrum planned use for mobile broadband in each studied country.

ILLUSTRATION 8

Source: ITU's footnotes 5.429D, 5.431B and 5.434 and information from national regulators

Planned use in national broadband plans of the 3.3-4.2 GHz range



Based on information provided by the national regulators, licensing in the 3.3-3.8 GHz range will be commencing in 2021, having Chile, Brazil, Mexico, Peru and Colombia as first markets.

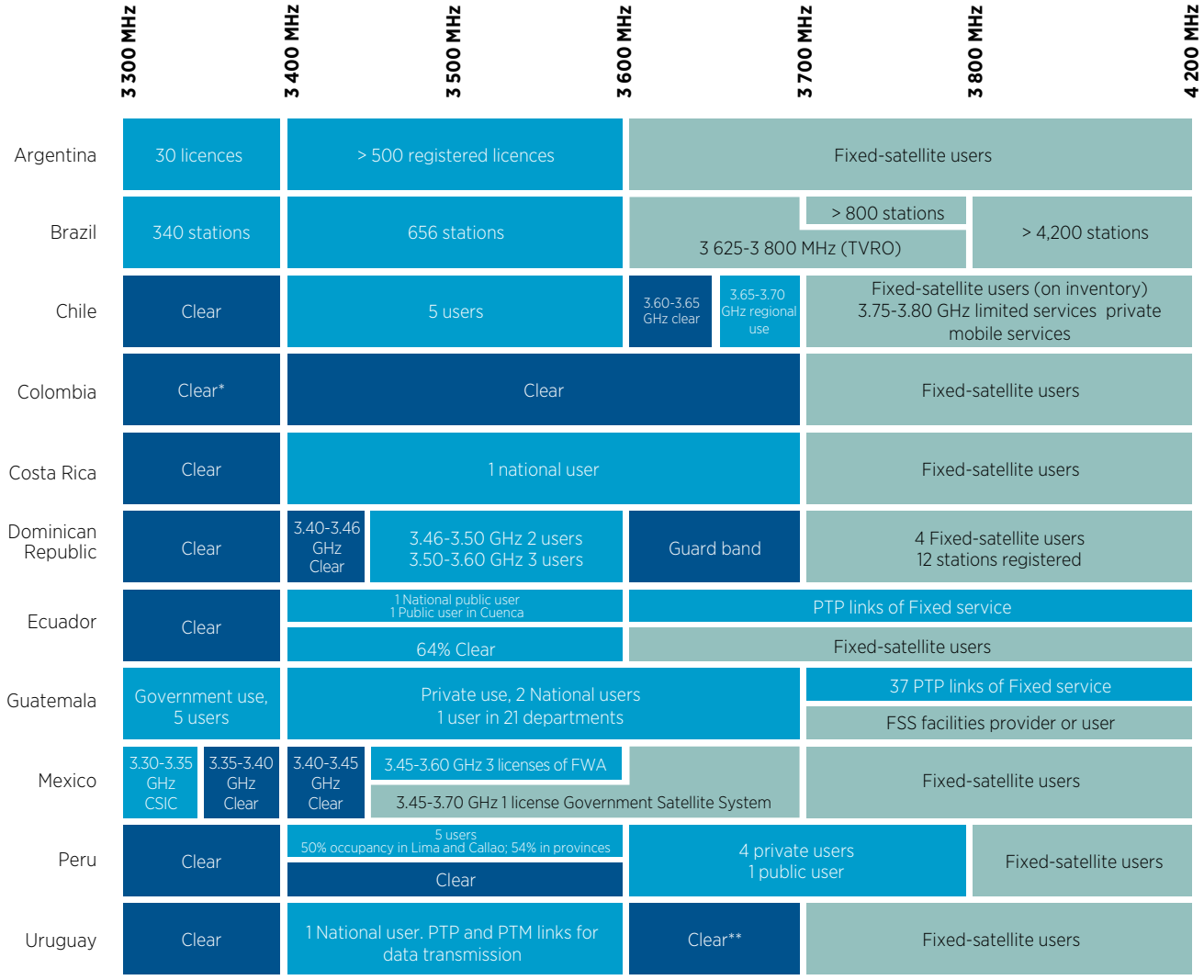
11. Countries' planned use of the 3.5 GHz range considers identifications as per ITU's Radio Regulations (RR) and countries' short-term spectrum planned use of the 3.5 GHz range

The next illustration shows that the occupation of the 3.3-3.4 GHz range is, in some of the countries, already clear. However, it is not the same scenario with the rest of the range, occupied, mainly, by fixed and fixed satellite services.

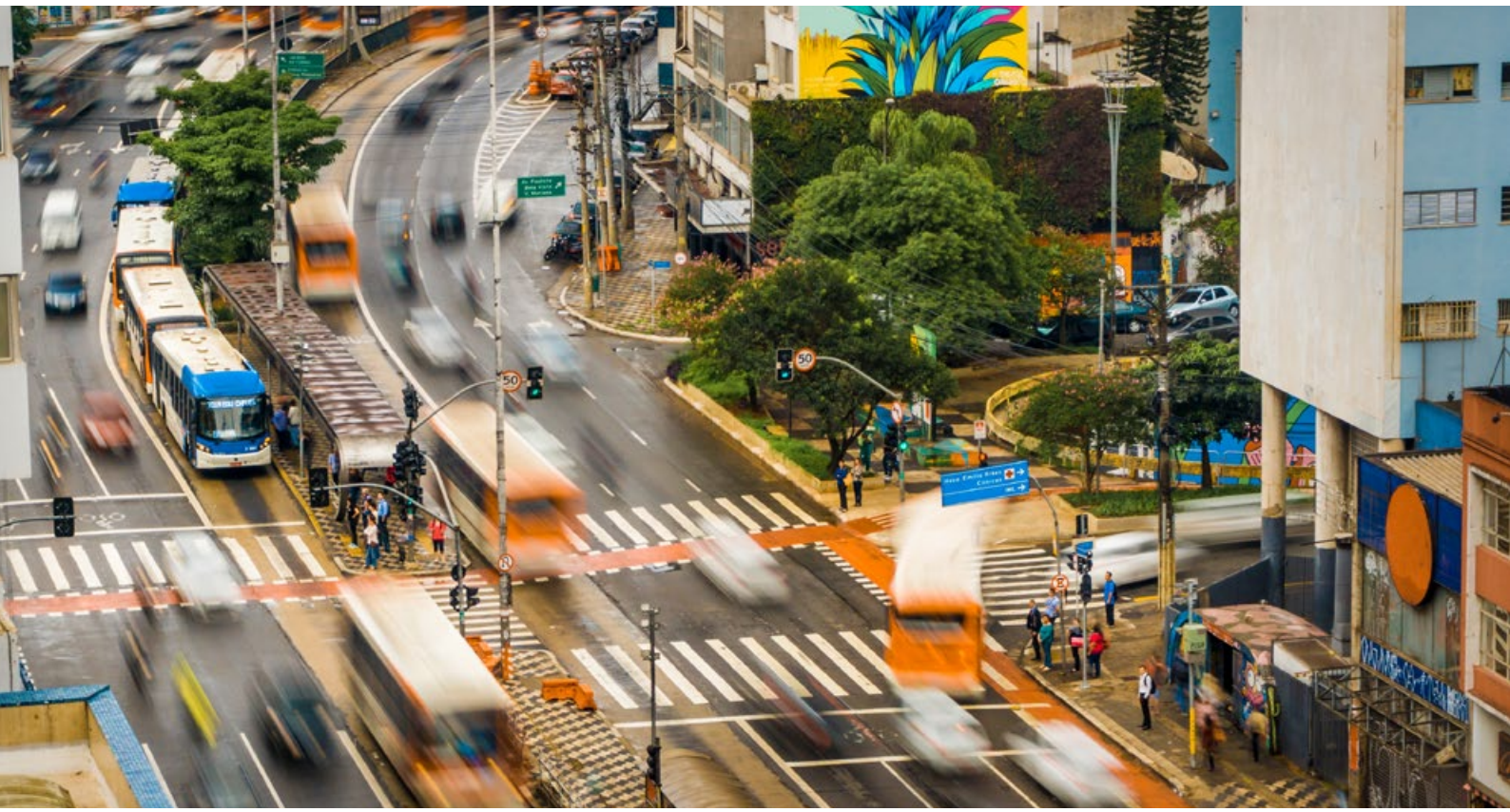
ILLUSTRATION 9

Source: BlueNote analysis based on information from NRAs of sampled countries

Current occupants of the 3.3-4.2 GHz range



* There are fixed point-to-point links with migration plans and permanence clauses until an auction process takes place
** This range is clear but not available for any use nor decision as it is under legal dispute



Although the occupancy of the 3.3-4.2 GHz range is heterogeneous, there is a trend in Latin America towards the release of the 3.3-3.4 GHz and the 3.4-3.6 GHz ranges for IMT. Eight out of the eleven sampled countries (Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Peru and Uruguay) have at least 100 MHz already cleared in the range.

At the present moment, there is no evidence to show the possible co-channel coexistence of IMT with other services in the 3.5 GHz range. Therefore, considering it is assigned on an exclusive basis, co-channel interference analysis would not be necessary. In relation to possible interference between IMT and the FSS in an adjacent band, studies conducted by the ITU[12] and the GSMA[13] should be considered, as they provide measures to be taken to ensure that one service does not cause harmful interference to the other.

It is important to note that synchronisation will be needed. With 5G Time-Division Duplexing (TDD) systems operating in the 3.5 GHz range, there are two levels of synchronisation which are needed; namely inter-operator synchronisation within a country and synchronisation across borders.

Firstly, inter-operator synchronisation within a country is needed for different regions or adjacent channels. This means the same frame structure for the TDD systems is required. If 5G macro-cell networks are not synchronised, arguably an additional guard band and improved filtering of transceivers would be required. The synchronisation of 5G networks becomes the best way to avoid interference. In this way, efficient spectrum usage is ensured – no additional guard band is required – and network equipment costs can be reduced.

Regarding cross-border interference, where harmonised arrangements are not feasible, it will be necessary to define suitable cross border agreements to ensure that the deployment of IMT in one country does not cause interference to existing use in neighbouring countries. In the case that the same frequencies can be deployed for IMT on either side of a national border, synchronising the networks can facilitate coexistence. An approach can be established where operators on both sides of a border adopt the same frame structure. If not agreed, a significant distance between stations will be necessary. Unfortunately, no national synchronisation agreements or international cross-border agreements have been identified in the region, which are necessary.

12. Available at 'Sharing studies between International Mobile Telecommunication-Advanced systems and geostationary satellite networks in the fixed satellite service in the 3 400-4 200 MHz and 4 500-4 800 MHz frequency bands in the WRC study cycle leading to WRC-15'

13. Available at 'Report for GSMA on the mitigations required for adjacent channel compatibility between IMT and ubiquitous FSS Earth Stations in the 3.4 – 3.8 GHz frequency band'

ARGENTINA

- **Current allocation to mobile services in the NTFA (3.3-4.2 GHz range): 0 MHz**
- **Planned use of the 3.3-3.8 GHz range: 300 MHz**
- **Cleared spectrum (3.3-3.8 GHz range): no**
- **MNOs: 3**

In 2019, the Undersecretary of ICT Argentina (SSeTIC) declared the opening of the procedure regarding the document "Public Consultation - Challenges and needs of radio spectrum in Argentina"[14]. The consultation considered the possible allocation of 500 MHz on a primary basis for mobile services as described below:

- 100 MHz in 3.3-3.4 GHz range (currently allocated to fixed and radiolocation; 100 MHz are currently allocated, on a secondary basis, to mobile)
- 200 MHz in 3.4-3.6 GHz range (currently allocated to fixed)
- 200 MHz in 3.6-3.8 GHz range (currently allocated to fixed (3.6-3.7 GHz) and fixed satellite (3.7-4.2 GHz)).

The fact that there is more spectrum being considered to be used in the 3.3-3.8 GHz range than what is currently allocated to mobile services, puts Argentina in the need to increase its current spectrum allocation to mobile services (it has 100 MHz allocated to mobile services on a secondary basis, 3.3-3.4 GHz, in its NTFA, while Article 5 Frequency Allocations of the ITU RR considers 3.3-4.2 GHz range allocation to the mobile service, except aeronautical mobile, on a primary basis).

Internal regulations allow the operation of radiolocation and fixed services in 3.3-3.4 GHz range and fixed services in the 3.4-3.6 GHz range. However, the 3.3-3.6 GHz range is currently not available for new assignments; this in order to keep it reserved for IMT.

The use of the 3.1-3.3 GHz range by radiolocation services is not a minor issue, since the respective technical considerations have to be considered in order to avoid possible adjacent channel interference. A similar situation occurs in the 3.6-3.7 GHz range, allocated on a primary basis to fixed services and in the 3.7-4.2 GHz range, allocated on a primary basis to fixed satellite services since the possible harmonics that may be generated in the mobile service could affect the proper operation of the services to which the range is allocated.

Considering the criteria proposed in the best practices at international level and taking into account the comments received during the procedure of "Public Consultation on Radio Spectrum Challenges and Needs in Argentina", SSeTIC has preliminarily recommended, and subject to a detailed follow-up of the international experiences in the matter, to evaluate the allocation of the 3.3-3.6 GHz range to mobile services and its possible channelling in continuous blocks of 100 MHz contiguous during 2021.

Additionally, SSeTIC has recommended the following:

- To maintain the suspension of frequency assignments in the 3.3-3.6 GHz range[15]
- To maintain the auction as a mechanism for the spectrum licensing award, establishing technical requirements for prequalification of bidders to ensure the presence of operators of recognised technical solvency among the auction participants
- To value the spectrum considering the market potential in each of the regions
- To value the spectrum by setting base prices that do not discourage competition nor further investment and infrastructure deployment. Maximising revenue should not be the goal
- To allocate spectrum for the mid-ranges by service areas that consider population density, area and regional gross product
- To set the term of the licences at 20 years
- To establish in the future an automatic adjustment mechanism for determining the spectrum aggregation limit per operator, distinguishing between low ranges, mid-ranges and millimetre, without prejudice to the acquired rights of the licensees

14. Available at 'Desafíos y Necesidades de Espectro Radioeléctrico en Argentina'
15. Available at RESOL-2019-1464-APN-SGM#JGM

In summary,

- No cleared ranges and no spectrum allocated on a primary basis to mobile services in its NTFA
- 300 MHz (3.3-3.6 GHz range) among the planned use of the 3.3-3.8 GHz range
- No new assignments since 2017 in 3.3-3.4 GHz[16] and reduced number of current licence holders
- Proposal for channelling in continuous and contiguous blocks of 100 MHz for 2021
- The migration of current users does not represent a big issue as the regulator might enforce migration plans
- 3.3-3.6 GHz range would not be available for assignment before 2022

The following are the main challenges which have been identified for a timely release of the 3.3-3.8 GHz range:

- Define new spectrum agenda, which includes a 5G roadmap
- Assess the current situation for the remaining 4G ranges (specific blocks) and define a path to move forward with the assignation, and review the spectrum caps
- As part of a proper planning process, increase spectrum allocation to mobile services and update the NTFA

BRAZIL

- **Current allocation to mobile services in the NTFA (3.3-4.2 GHz range): 300 MHz**
- **Planned use of the 3.3-3.8 GHz range: 400 MHz**
- **Cleared spectrum (3.3-3.8 GHz range): no**
- **MNOs: 4 (national); 2 (regional)**

The National Telecommunications Agency of Brazil (Anatel) intends to award up to 400 MHz in the 3.3-3.7 GHz range in 2021[17]. The purpose of the tender is to license the use of radio frequencies in a primary basis in the ranges of 700 MHz, 2.3 GHz, 3.5 GHz and 26 GHz.

As in Argentina, as there is more spectrum being considered to be used for mobile broadband in the 3. 3-3.8 GHz range than what is currently allocated to mobile services in the NTFA. Brazil needs to proceed with the NTFA update, followed by the licensing and may also consider the identification of 3.6-3.7 GHz in WRC-23 for IMT subsequently.

For the 3.3-3.8 GHz range licensing, considering it is mostly occupied, there will be an obligation to meet the public policy guidelines dictated in 2019 by, at that time, the Ministry of Science, Technology, Innovation and Communications (MCTIC) related to the continuity of open TV reception for beneficiaries of low-income families programmes of the Federal Government that have exclusively domestic satellite dishes, or Television-Receive Only (TVRO) in the 3.5 GHz range. Considering that TVRO exclusive reception unique criteria is yet to be defined, public policy implementation of this matter is under analysis. The successful bidders shall take all reasonable measures to ensure that its radio communication systems do not cause harmful interference to stations operating in adjacent bands.

In January 31, 2020, MCTIC established guidelines for the auction of the 3.5 GHz range in Brazil[18]. Consequently, on February 6, 2020, Anatel approved the terms of the public consultation for the implementation of 5G in Brazil[19]. The proposal considers a traditional auction with a regional 60 MHz block, exclusive for small business providers (PPP), two 100 MHz and one 80 MHz block with national coverage and a regional 60 MHz block, restricted to those who bought earlier blocks.

Brazil still has a significant occupation in 3.3-3.6 GHz due to the size of the country, with about 1,000 stations registered; 3.7-3.8 GHz with more than 800 stations registered; and 3.8-4.2 GHz, with more than 4 200 stations registered; in addition to TVRO broadcast receivers in 3 625-3 800 MHz. The migration of low-income families dependent on the TVRO, to a higher range or other solution with filters will be required.

Ongoing research from Anatel and operators already concluded that both systems (IMT and TVRO) can coexist with filter application and limitations. Better filters are expected soon.

According to the Regulator, there are no plans to limit the use of the 3.3-3.8 GHz range to any particular telecommunication service or application.

In July 2019, after other tests were conducted previously by individual interested parties, Anatel, in partnership with the MNOs, concluded a round of field and laboratory tests aiming to introduce IMT applications in the 3.3-3.6 GHz range. Although a challenging scenario arose as the adjacent range is currently occupied by two different services, the study is still being conducted with great results expected from new filters. On the one hand, there is the professionally operated FSS, widespread throughout the country, and on the other, there is the free-to-air (FTA) satellite television broadcasting application known as TVRO, with a higher number of users within the country.

16. Available at Resolución 171 - E/2017
17. Available at Processo nº 53500.004083/2018-79
18. Available at 'PORTARIA Nº 418, DE 31 DE JANEIRO DE 2020'
19. Available at 'Anatel aprova consulta pública para implementar o 5G'. The Public Consultation had 45 days term for the contributions by the public which will be able to present its suggestions (a public hearing that will be also carried out). Regarding the possible interferences caused by 5G in the reception of open TV by satellite (TVRO), the approved proposal addresses the solution through a model similar to the one adopted for the 700 MHz range, with the creation of a group coordinated by Anatel, and a third and independent entity to operate the solution.

In the first round of tests, the agency concluded that the low-noise block feedhorn (LNBF) equipment, used in TVRO reception, had a significantly positive impact, but was not immune to IMT-2020 emissions on the adjacent range in the worst-case scenario. Consequently, possible constraints would be needed to ensure coexistence between IMT and TVRO FSS in the adjacent ranges. Subsequently, the industry introduced new LNBF models which went through a new round of laboratory tests in January 2020. Even though the new generation of LNBFs is yet to undergo field tests, the laboratory test results are promising. Taking this into account, Anatel has added 100 MHz in the next auction, expected to unfold during Q1 2021, via relocation or new filters.

According to Anatel, the 3.7-3.8 GHz range is expected to be identified for IMT services for the use of private networks, as long as these do not cause harmful interference to FSS. Coexistence mechanisms are being analysed.

In summary[20],

- Auction of 3.3-3.7 GHz expected to happen in Q1 2021: two national blocks of 100 MHz, one national block of 80 MHz and two regional blocks of 60 MHz, one of which is restricted to Small Service Providers (PPP) or new entrants
- For the national blocks, there is the obligation to roll out fibre backhaul to municipalities without this infrastructure
- In the PPP block, the requirement is to serve municipalities with less than 30,000 inhabitants and municipalities without 4G
- Duration of the licence: 20 years, with early interest-free payments, with subsequent extensions of 20 more years
- Obligations are deducted from the reserve price and all premium may be converted into investment agreements

The following are the main challenges which have been identified for a timely release of the 3. 3-3.8 GHz range:

- Continue studies and evaluation of the possibility of migration of low-income family dependent TVRO users to a higher range and/or explicit provisions, including filters
- Synchronisation agreements among all awardees highly needed due to regional assignments
- Increase spectrum allocation to mobile services and update the bands identified for IMT in WRC-23 and in the NTFA

20. Subject to change, available at SACP (Anatel) via Public Consultation N. 9/2020

CHILE

- **Current allocation to mobile services in the NTFA (3.3-4.2 GHz range): 900 MHz**
- **Planned use of the 3.3-3.8 GHz range: 400 MHz***
- **Cleared spectrum (3.3-3.8 GHz range): 150 MHz**
- **MNOs: 5**

Since 2018, the administration has submitted the National 5G Plan for Chile to public consultation in different processes: the first consultation focused on defining the priority ranges for the development of 5G, among which the 3.4-3.8 GHz range was included. In 2018, the Telecommunications Undersecretariat (Subtel) submitted for consideration the granting of 30-year national licences and the refarming of the 3.40-3.65 GHz range in order to achieve more efficient use of the spectrum. By the end of 2019, the administration consulted on the need to establish relevant frequency ranges and channelling for limited telecommunication services through 5G[21]. As a result of these processes, Subtel decided to put the 700 MHz, Advanced Wireless Services (AWS), 3.5 GHz and mmWaves ranges out to tender to begin the process of introducing 5G technology in Chile, in order to face the new challenges of the industry and deepen the Internet access market.

In early 2020, Subtel submitted for public consultation a new process called 'Fundamental Aspects of the Technical Model for Assigning Concessions for Telecommunication Services Operating 5G Networks'[22]. The aim of the consultation was to find out the opinion of stakeholders on the model adopted by Subtel to assign licenses for telecommunications services operating 5G wireless networks.

In mid-2020, the Chilean Supreme Court decided to slightly modify the dynamic spectrum caps established by the Chilean competition authority in 2019. In the case of the 3.0-6.0 GHz range, the cap has remained the same as stated by the competition authority (30 percent). In addition to this, the court has required additional regulatory measures to complement the spectrum cap rules, among which it has established that, on future spectrum awards, winning bidders must present a plan on efficient and effective use of spectrum which must be approved by Subtel.

Finally, on 17 August 2020, Subtel published the final terms of the forthcoming auction, to take place by 19 October 2020. Thus, Chile becomes the first country in the region to move forward with a 5G tender. As expected, the tender is structured as a Beauty Contest, which includes four different processes, one for each band. In the case of the 3.5 GHz range, the range to assign is 3 300-3 400 MHz and 3 600-3 650 MHz.

Besides the spectrum range (3.30-3.40 and 3.60-3.65 GHz) considered for 2020 auction, in the future, new licenses for IMT services could be considered in other frequencies of the 3.5 GHz range

Although the tender is a significant step forward, there are still some challenges in the current tender conditions:

- The minimum block is 10 MHz, far below the minimum bandwidth to secure efficient usage of spectrum, and below the recommendation of the TDLC (i.e. contiguous 80 MHz).
- There are no requirements or guidelines to promote synchronisation.
- The assignment rules are based on the maximisation of fiscal collection, and, therefore, in the case that aggregate spectrum demand exceeds supply, Subtel proposes a combinatorial auction format (unprecedented for Chile) to decide awardees.
- No clear roadmap to secure contiguity in the 3.30-3.80 GHz range.
- Awardees are to present a plan to secure efficient use of spectrum, however, there is no clear guidelines on the content of the plan and approval conditions by Subtel.

* 50 MHz (3.75-3.80 GHz range) are intended for 5G private services (intra-company, industrial zones, ports, mining facilities, etc.) in Chile

21. Available at 'Participación Ciudadana'

22. Chilean Supreme Court Rol Nº 181-2020

Although the occupancy level is low, the main difficulty for the early release of the range for IMT purposes lies in defining the spectrum caps, considering that a Supreme Court ruling required operators to return part of their spectrum. Two operators are, each, returning 20 MHz of national use, and one operator has returned 50 MHz that was used for Fixed Wireless Access (FWA) in a small region of the country. Now it is up to Subtel to analyse the most efficient way to organise the spectrum, considering the duration of the licences, which for now is 30 years, and the occupation of the range as described below:

- 3.30-3.40 GHz: clear
- 3.40-3.60 GHz: five operators
- 3.60-3.65 GHz: clear
- 3.65-3.70 GHz: regional operators and fixed point-to-point (PTP) links
- 3.70-4.20 GHz: satellite operation on inventory at this time
- 3.75-3.80 GHz: limited services, private mobile services

In summary,

- First country in the region to move forward with a 5G tender in 2020, announced for 19 October
- No new assignments since 2018 in the 3.4-3.6 GHz range
- Licence duration: 30 year

The following are the main challenges which have been identified for a timely release of the 3.3-3.8 GHz range:

- Aim to make available 80-100 MHz of contiguous spectrum per operator and clear the 3.6-3.8 GHz range for 5G
- Assessment of the refarming process, including the operators in the range, taking into account their current rights
- Assessment of the reassignment of limited services and private mobile services, to guarantee contiguous ranges

COLOMBIA

- **Current allocation to mobile services in the NTFA (3.3-4.2 GHz range): 900 MHz**
- **Planned use of the 3.3-3.8 GHz range: 400 MHz**
- **Cleared spectrum (3.3-3.8 GHz range): 400 MHz**
- **MNOs: 5**

At the end of 2019, the ICT Ministry (MINTIC) published the road map for 5G development in Colombia[23], identifying feasible frequency ranges in three spectrum ranges: lower ranges (< 1 GHz), middle ranges (1 - 6 GHz) and upper ranges (> 6 GHz), millimetre ranges identified at WRC-19[24]. Considering that the 3.7-4.2 GHz range has primary allocation to fixed satellite services, as well as mobile services, MINTIC has decided not to consider it for IMT at this stage.

There are radiolocation stations in the 3.3-3.4 GHz range used by military forces for national defence purpose (fixed point-to-point links with migration plans and permanence clauses until an auction process takes place). Then, 400 MHz of the 3.3-3.8 GHz range would be clear for being licensed.

In the aforementioned document "5G Roadmap", MINTIC presented the work plan to encourage the first 5G network deployment before 2022, considering the 3.5 GHz range as a key element toward achieving it[25]. In accordance with this plan, the spectrum assignation process of the 3.3-3.8 GHz will be held in the second half of 2021.

Additionally, MINTIC[26] has opened the field to receiving manifestations of interest in carrying out technical trials of 5G technologies in ranges above 3.3 GHz. Interested parties should indicate the range (i.e. 3.3-3.7 GHz, or mmWaves ranges) and the use case (i.e. agriculture, retail, transportation, etc.) for the trial.

The spectrum assignation process of the 3.3-3.8 GHz range (3.3-3.7 GHz) will be held in the second half of 2021

In summary,

- Road map for 5G development is on track
- 400 MHz (3.3-3.7 GHz) is considered in the planned use of the 3.3-3.8 GHz range
- 3.3-3.7 GHz range is available to be licensed
- Call for 5G trials were published in December 2019. To understand 5G case of use (technology applications) is relevant for Colombian administration.
- Duration of the licence: 20 years, extendable for an additional 20 years

The following are the main challenges which have been identified for a timely release of the 3.3-3.8 GHz range:

- Considering today's process of spectrum assignment's pace (i.e. the licence awarding in 700 MHz was a long-lasting process which has taken 7 years), modification of spectrum management model and assignation process should be tailored to the TICs industry in order to fully benefit from 5G's potential
- Reserve prices should be set at reasonable levels so that price determination is through fair market price discovery
- Spectrum policy measures that support 5G investment should be adopted
- Guard band under assessment to protect the fixed satellite service in the 3.7 GHz and above range

23. Plan 5G Colombia. Available at 'Plan 5G Colombia'
24. Available at WRC-19
25. Milestones - 5G roadmap Colombia in Appendix
26. Available at 'Resolución 3209/2019'

COSTA RICA

- **Current allocation to mobile services in the NTFA (3.3-4.2 GHz range): 325 MHz**
- **Planned use of the 3.3-3.8 GHz range: 400 MHz**
- **Cleared spectrum (3.3-3.8 GHz range): 100 MHz**
- **MNOs: 3**

Following WRC-15, Costa Rica is enabling the country to use the 3.3-3.7 GHz ranges for the deployment of IMT systems. The inclusion of these changes in the NTFA will be implemented during 2020[27].

The inclusion of changes in the PNAF to allow the use of frequencies for IMT is being implemented during 2020

The 3 300-3 400 MHz range is cleared and ready to be licensed for IMT services by the, previously mentioned, modification of the NTFA. On the other hand, the 3 625-4 200 MHz range is used by radio links for transport networks[28] and for satellite radio links to Earth stations. There is still a significant occupation of the 3.3-4.2 GHz frequency range as described below:

- 3.3-3.4 GHz: clear
- 3.4-3.6 GHz: nationally assigned to the ICE Group, which operates, with little use, with Worldwide Interoperability for Microwave Access (WiMAX) technology, using carriers with range widths of 3.5 MHz and 5 MHz, concentrated in the segment 3 550-3 590 MHz
- 3.6-3.7 GHz: nationally assigned to the ICE Group, with little use. It operates some carriers of fixed service radio links
- 3.7-4.2 GHz: used by fixed and fixed satellite applications

Currently, the analysis of the availability of the frequency segments that make up the 3.3-3.7 GHz range for the deployment of IMT networks is in progress. The subsequent tender process must respond to the objectives defined by the administration through the guidelines of this process, taking into account in any case the results of the feasibility and needs study prepared by the Superintendence of Telecommunications (Sutel), to determine the viability of this spectrum in the national market. MICITT has not identified interference problems in the 3.3-3.7 GHz frequency range, so no challenges have been observed to limit the entrance in operation of IMT systems in these frequency ranges.

In summary,

- 3.3-3.4 GHz range is available for assignment
- 3.4-3.7 GHz range is assigned, and little used, to ICE Group
- Duration of the licence: 15 years for commercial use, extendable to 25 years. The assignments for the ICE Group are for an indefinite period[29]

The following are the main challenges which have been identified for a timely release of the 3.3-3.8 GHz range:

- Assess the non-utilisation of the resource assigned to the concessionaires in the 3.4-3.7 GHz range
- Define whether the 3.4-3.6 GHz range will be offered for IMT in an upcoming tender given the interest shown by the industry around this range
- Take action in terms of cleaning or refarming the 3.5 GHz range of legacy technologies with low occupation
- Update Costa Rica's NTFA

27. Today not included in the PNAF but their allocation considered in notes CR 076 and CR 077
28. Channelised according to ITU-R F.635 or ITU-R F.382
29. Available at 'Ley N°8642'. ICE Group's indefinite period as pronounced by the General Procuratory of the Nation

DOMINICAN REPUBLIC

- **Current allocation to mobile services in the NTFA (3.3-4.2 GHz range): 400 MHz**
- **Planned use of the 3.3-3.8 GHz range: 300 MHz**
- **Cleared spectrum (3.3-3.8 GHz range): 260 MHz (considering guard range)**
- **MNOs: 3**

There are three types of users in the 3.5 GHz range: licences for the fixed use in 3.3-3.7 GHz for the provision of public telecommunication services; licences in 3.7-4.2 GHz for private PTP links of the fixed service; and private space-to-Earth links of the fixed satellite service with the particular characteristics of each service (in 3 475-3 585 MHz the licences are for national public service while in 3 710-4 190 MHz the licences are for local private use).

The 3.3-4.2 GHz range is channelled in asymmetric blocks of 15 MHz, 25 MHz, 30 MHz, 40 MHz and 100 MHz. The 3.30-3.46 GHz range is clear; however, there is still a significant occupation level in the rest of the range as described below:

- 3 460-3 500 MHz: two operators
- 3 500-3 600 MHz: three operators
- 3 700-4 200 MHz: four operators with 12 stations registered

So far, at least two public telecommunications service concessionaires have expressed to the Dominican Institute of Telecommunications (Indotel) their interest in being able to use frequencies within the 3.3-3.6 GHz range for the provision of mobile services in the future. Indotel has not yet announced, nor decided, in the short or medium term, a public tender for the assignment of frequencies in this frequency range. The Administration has recently updated the NTFA to include the primary allocation of the mobile service in 3.3-3.7 GHz range[30]. The 3.7-4.2 GHz range is allocated to mobile on a secondary basis.

The Administration has recently updated the NTFA to include the primary allocation of the mobile service in 3.3 - 3.7 GHz range

As a result of the adjustments to be made in the 3.4-3.6 GHz range, due to of the reordering of the assignments to the licensees and the potential use of the same under the TDD modality for the provision of mobile services, Indotel's Radio Spectrum Directorate proposes the reordering of the 3.5 GHz range in accordance with the recommendations of the WRC[31]. Consequently, in 2019 Indotel approved the establishment of refarming of the 3.4-3.6 GHz range, as part of the preparatory work for the modification of the National Frequency Allocation Plan[32].

According to Indotel it is not possible to use the 3.7-4.2 GHz range for other possible services due to the intensive use of the range by private space-to-Earth links in the FSS because of the geographical location of the Dominican Republic in the tropical zone, and the susceptibility to the climatic conditions of other higher frequency ranges, which constitute an alternative for the operation of this type of links.

In summary,

- 260 MHz of cleared spectrum in the 3.3-3.8 GHz range
  - 100 MHz (3.3-3.4 GHz) available for licensing
  - 60 MHz (3.40-3.46 GHz) free as a consequence of refarming the 3.4-3.6 GHz range
  - 100 MHz of guard band (3.6-3.7 GHz)
- Intensive use of the 3.7-4.2 GHz range by fixed satellite service
- Duration of the licence: 20 years

The following are the main challenges which have been identified for a timely release of the 3.3-3.8 GHz range:

- Refarming of the band

30. Available at 'Decreto 091-20'
31. Board of Directors Report No. GER-I-000058-18
32. Illustration 12. Dominican Republic 3 400-3 600 MHz range allocation after 2019 refarming in Appendix


HOMENAJE DEL PRIMER CABILDO
DE AMÉRICA AL ADELANTADO
DON BARTOLOME COLON
FUNDADOR EN LA MARGEN ORIENTAL
DEL RIO OZAMA DE LA VILLA
DE SANTO DOMINGO EN EL
5 DE AGOSTO DEL AÑO 1498
PARA LUEGO SER TRASLADADA
A ESTA PARTE POR EL GOBERNADOR
DE LA ISLA HISPANIOLA
FREY NICOLAS DE OVANDO
EN EL AÑO 1502

ECUADOR

- **Current allocation to mobile services in the NTFA (3.3-4.2 GHz range): 900 MHz**
- **Planned use of the 3.3-3.8 GHz range: 300 MHz**
- **Cleared spectrum (3.3-3.8 GHz range): 228.5 MHz**
- **MNOs: 3**

In early 2018 the Telecommunications Regulation and Control Agency (Arcotel) submitted a technical report[33] on the use and channelling of the 3.3-3.4 GHz and 3.4-3.6 GHz ranges and recommended to adopt the type of access recommended by CCP.II[34], which corresponds to TDD; to divide the 3.3-3.6 GHz range into blocks of 10 MHz each and to inform the Executive Directorate of Arcotel of the report and, if appropriate, arrange for the start of the public hearings procedure in relation to the channelling of this range. The 3.3-3.4 GHz range is clear; however, there is still a significant occupation level in the rest of the range as described below:

- 3.4-3.6 GHz: two public telecommunication companies are operating, CNT EP at the national level and ETAPA in Cuenca. Only 71.5 MHz are assigned, which corresponds to 35.75 per cent of the spectrum.[35]
- 3.6-3.7 GHz: PTP links of the fixed service and applications of the FSS.
- 3.7-4.2 GHz: PTP links of the fixed service[36] and applications of the FSS.

The Digital Ecuador strategy objective is to generate development opportunities, promote digital inclusion and innovation, achieving 98% of the population with telecommunications services by 2021

The public spectrum policy proposal determines that the continuity of the services that are currently operating in this band is ensured, since IMT is being prioritised by virtue of the channelisation established for these services which was carried out in 2018. In this regard, Arcotel must consider the early termination of a license and reassignment of frequencies, respectively. In other words, in order to respect the rights of public enterprises that are operating with other services and different channelling with regard to their previous assignment of these frequencies, it is necessary to obtain a prior report from the regulator.

As part of its digitisation plan in the race towards 5G, in mid-2019 the Ministry of Telecommunications and Information Society (MINTEL) signed a new policy for the assignment of the radio spectrum. The ministry's intention was to license two ranges for mobile communications by the end of 2019 (700 MHz and 2.5 GHz), to tender the 3.5 GHz range and to launch tests of the 5G network in 2020, under the principle of connecting the population by guaranteeing accessible price, quality and competition in the market.[37] The initial goal is to provide coverage of 4G to 80 per cent of the Ecuadorian population in 2020. This policy is part of the Digital Ecuador strategy, whose objective is to generate development opportunities, promote digital inclusion and innovation, reaching 98 per cent of the population with telecommunications services by 2021. Although the auctions of 700 MHz and 2.5 GHz ranges, together with 3.5 GHz range, were expected for 2020[38], they were postponed, and the regulator expects to make the valuation of 700 MHz and 2.5 GHz ranges during 2020. Considering this delay, in May 2020 the MINTEL has signed a ministerial agreement by which Arcotel will temporarily assign, for up to twelve months, which may be extended in accordance with the provisions of the law in force[39], the 700 MHz, AWS, 2.5 GHz and 3.5 GHz ranges to telecommunications companies.

The 3.3-3.6 GHz range has been channelled in 10 MHz blocks for IMT. CNT has expressed its interest in the range and, due to the characteristics of its authorisation, the process would be of direct assignment with charge to the development of social projects.

33. Available at 'Uso y canalización de las bandas 3 300-3 400 MHz y 3 400-3 600 MHz'
34. Available at https://www.citel.oas.org/en/SiteAssets/PCCII/Final-Reports/CCPII-2017-29-4380r1c1_i.pdf. Frequency arrangements for the terrestrial component of IMT in the ranges 3.3-3.4 GHz, 3.4-3.6 GHz and 3.6-3.7 GHz, or combinations thereof
35. ARCOTEL (2018). Informe técnico sobre uso y canalización de las bandas 3300-3400 MHZ y 3400-3600 MHz
36. Available at 'Resolución SNT -2012-0321'
37. As indicated in Digital Policy Law article: 'Ecuador lanza política para uso del espectro en la carrera hacia 5G'
38. As indicated in Telesemana article: 'Ecuador también cambia sus planes: pretende licitar bandas de espectro en 2020'
39. As per Acuerdo Ministerial 012-2020 of MINTEL available at https://www.telecomunicaciones.gob.ec/

In summary,

- 300 MHz (3.3-3.6 GHz) considered for use
- 228.5 MHz are available for assignment
- Duration of national-reach licences:
  - Up to 20 years for public companies
  - Up to 20 years for joint ventures between popular economy and solidarity-based companies and private companies
  - Up to 20 years for other companies (change introduced in the reform to organic law on telecommunications el 1/January/2020, moving from 15 to 20 years)

The duration of spectrum allocation is variable and depends on the term remaining for the expiration of the service exploitation title, which is 20 years.

The following are the main challenges which have been identified for a timely release of the 3. 3-3.8 GHz range:

- Reschedule the 3.5 GHz auction (which was initially expected to be held in 2020)
- No challenge has been identified to limit timely release of 228.5 MHz in the 3.3-3.6 GHz range
- The main challenge is the granting rights and fees for the use of frequencies
- High spectrum prices and policies to maximise revenues from spectrum auctions need to be adjusted
- Fees for the use of the infrastructure necessary for the development of IMT are a high cost that could slow down its effective deployment.

GUATEMALA

- **Current allocation to mobile services in the NTFA (3.3-4.2 GHz range): 300 MHz**
- **Planned use of the 3.3-3.8 GHz range: 300 MHz**
- **Cleared spectrum (3.3-3.8 GHz range): No**
- **MNOs: 2**

The Telecommunications Superintendence (SIT) has temporarily suspended, since June 2006, all procedures for the assignment of regulated frequencies[40] in the 3.0-4.0 GHz range. The suspension affects assignment of frequencies in the regulated range, but does not suspend assignment in the State reserved range 3.1-3.4 GHz[41]. However, there is still a significant occupation of the 3.3-4.2 GHz frequency range as described below:

- 3.3-3.4 GHz: national government use. PTP links of five users
- 3.4-3.7 GHz: private use. Two national users and one user in 21 departments
- 3.7-4.2 GHz: several satellite facility provider or user licences and 37 PTP links with different configurations.

The SIT has suspended, since June 2006, all procedures for the assignment of regulated frequencies in the 3.0-4.0 GHz range

According to the Ministry and the SIT, there are no public policies that determine or modify the current allocation and use for the 3.3-3.8 GHz range. However, in 3.3-3.4 GHz, which is reserved for state entities, options are being analysed to allow the continuity of operations corresponding to frequency use authorisations and the increase in identification for IMT, which was formalised internationally by the administration at WRC-19.

The 3.3-3.6 GHz range is not expected to be released in the near future

The administration is not aware of the industry's interest in using the 3.3-3.8 GHz range for purposes other than those currently allocated. However, Guatemala has identified 3.4-3.6 GHz for IMT implementation in the NTFA, although there are no plans in the short or medium term to hold an auction.

The timely release of the 3.3-3.6 GHz range and its possible auction will depend on the spectrum auctions of 700 MHz and AWS bands, that should have been completed in 2019. Taking this into account the 3.3-3.6 GHz range is not expected to be released in the near future.

Considering the band's allocation, in the 3.3-3.4 GHz range the radiolocation and fixed (reserved band[42]) coexist; in the 3.4-3.6 GHz range the fixed services (regulated band[43]) coexist; and in the 3.6-4.2 GHz range the fixed and fixed satellite services coexist.

In summary,

- 300 MHz (3.3-3.6 GHz) considered for use
- Although no new licences have been authorised since 2006, the spectrum is occupied
- Intensive use of 3.6-4.2 GHz range by fixed satellite and fixed services
- Duration of the title of usufruct: 20 years, extendable for equal duration periods[44]

The following are the main challenges which have been identified for a timely release of the 3.3-3.8 GHz range:

- The 3.3-3.6 GHz range is not expected to be released soon
- AWS and 700 MHz band to be licensed before, or together with, the 3.5 GHz range.

40. Regulated frequencies: those that are intended for commercial use
41. Available at 'Resolución SIT-217-2006'
42. Reserved band: intended for exclusive use by State agencies and entities
43. Regulated band: intended for commercial use
44. Available at 'Decreto 34-2012'

MEXICO

- **Current allocation to mobile services in the NTFA (3.3-4.2 GHz range): 100 MHz**
- **Planned use of the 3.3-3.8 GHz range: 300 MHz**
- **Cleared spectrum (3.3-3.8 GHz range): 100 MHz**
- **MNOs: 3**

As part of the planning actions that have been carried out by the Federal Institute of Telecommunications (IFT), the use of the 3.4-3.6 GHz frequency range to current services, i.e. fixed satellite and IMT Fixed Wireless Access, has been maintained to provide continuity to current services and to encourage efficient use of the radio spectrum. The occupation of the 3.3-4.2 GHz range is described below:

- 3.30-3.35 GHz: currently assigned to the Coordination of the Information and Knowledge Society, CSIC[45], however, the IFT is working on a refarming process in order to migrate these operations to an adequate frequency band accordingly.
- 3.35-3.45: cleared spectrum
- 3.45-3.60 GHz: three licenses renewed at the end of 2019 that enable the provision of FWA services
- 3.4-3.7 GHz:
  - One licence used by the Federal Government's satellite system to provide connectivity to government entities for security and social coverage applications.
  - Four licences for landing signals from six foreign satellites, three of which are channelised in the 3 400-3 700 MHz segment, two in the 3 550-3 700 MHz segment and the remaining in the 3 599-3 700 MHz segment
- 3.7-4.2 GHz: widely used for the provision of the fixed satellite service in the space-to-Earth direction

Derived from the renewal of the licenses in the 3.4-3.6 GHz range for FWA, it is considered continuous spectrum would optimize the use of radio spectrum. Consequently, it is estimated that 5G systems can be implemented both in this frequency range and in the lower adjacent range 3.3-3.4 GHz. The 3.3-3.4 GHz range is currently allocated to mobile on a primary basis, while the 3.4-3.6 GHz range is allocated to mobile on a secondary basis.

It is considered that the refarming of the range and realignment of existing licensees is the most viable strategy for WAS and IMT

The regulator expects that the 3.3-3.4 GHz range tender should be starting in the last weeks of 2020; however, this will depend largely on the performance of the Mexican economy in 2019-2020[46]. Spectrum should be cleared before been offered to tender.

Based on information provided by the national regulator, licensing in the 3.3-3.8 GHz range is expected as follows:

- 2020 auction process expected to be commencing by the end of 2020
  - 3.30-3.35 GHz: ongoing migration process
  - 3.35-340 GHz: cleared spectrum, considered in the Annual Frequency Plan for Wireless Access systems (MWA & FWA)
- 3.40-3.45 GHz: clear spectrum ready to be included in an upcoming Annual Frequency Plan
- 3.45-3.60 GHz: licensed, through a renewal process, for FWA

45. IFT. Overview of radio spectrum in Mexico for fifth generation mobile services (2019)
46. As indicated in El Economista article: 'México analiza un rescate de la banda de 3.5 GHz para potenciar su primera subasta de 5G en 2020'

In summary,

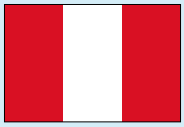
- 300 MHz (3.3-3.6 GHz) considered for use
- Partially occupied by IMT FWA and FSS
- 3.3-3.4 GHz to start auction process for IMT WA (MWA & FWA) at the end of 2020
- 3.45-3.60 GHz currently used for FWA
- Use of 3.6-4.2 GHz by FSS
- Duration of the FSS licenses: 10-20 years (expiring, the latest, on 2029)
- Duration of the FWA licenses: 20 years (expiring on 2039)

The following are the main challenges which have been identified for a timely release of the 3.3-3.8 GHz range,

- The IFT expects that the 3.3-3.8 GHz range tender should be starting in the 2020-4Q; however, this will depend largely on the performance of the Mexican economy in 2019-2020. At this stage, there is an ongoing migration process in the part of the band which is expected to be auctioned

PERU

- **Current allocation to mobile services in the NTFA (3.3-4.2 GHz range): 500 MHz**
- **Planned use of the 3.3-3.8 GHz range: 500 MHz**
- **Cleared spectrum (3.3-3.8 GHz range): 200 MHz**
- **MNOs: 4**



In October of 2019 the Government initiated the refarming of the 3.5 GHz range[47, 48]. The Ministry of Transport and Communications (MTC) planned the multi-range public tender of the 2.3 GHz, 2.5 GHz and 3.5 GHz ranges, and the migration of stations to the FSS for 2021. The range is channelled in blocks of 5 MHz[49].

The 3.3-3.8 GHz range is in reserve and according to NTFA[50]:

- The 3.6-3.8 GHz range is allocated for the provision of public telecommunication services
- The granting of the concession and assignment of spectrum at the national level for the operation of such services will be carried out by means of a public tender
- The 3.6-3.8 GHz frequency range is declared to be reserved; Likewise, in this frequency range, no new assignments, modifications, extensions, transfers or any other act involving variations in the right to use the portion of the radio spectrum are approved
- No new stations will be installed using the 3.6-3.8 GHz range frequency range for fixed satellite services. Likewise, holders of fixed satellite service stations in this frequency range, except those administered by state enterprises, will migrate to the 3.8-4.2 GHz frequency ranges or other related ranges that are supported by their current receiving stations, subject to the terms and conditions determined by the MTC
- The use of the 3.7-3.8 GHz range in the constitutional province of Callao is limited to fixed satellite services operated by state companies until such time as the latter arrange for their migration to the 3.8-4.2 GHz range or other related ranges, or the MTC determines the coexistence of these fixed satellite services with public wireless access telecommunications services
- Without prejudice to the foregoing, stations in the fixed satellite service operating in the frequencies of the 3.7-3.8 GHz range and administered by state enterprises are protected from interference generated by stations of the services allocated in the frequency range 3.6-4.2 GHz

No new stations will be installed using the 3.6-3.8 GHz range for FSS. Holders of FSS stations will migrate to the 3.8-4.2 GHz range

The 3.3-3.8 GHz range is expected to be included in the next spectrum tender. The 3.3-3.8 GHz range is currently allocated, on a primary basis, to mobile. The 3.8-4.2 GHz range is allocated to mobile, but on a secondary basis.

MTC has ordered to start refarming[51] of the 3.4-3.6 GHz range, adapting it to the channelling of the 3.3-3.8 GHz range[52,53]. However, it still has a significant occupation of the 3.4-3.6 GHz range, with 484 devices registered and 57 per cent occupancy rate nationwide. The occupation of the 3.3-4.2 GHz range is described below:

- 3.3-3.4 GHz: clear
- 3.4-3.6 GHz: five operators; 50 per cent occupancy in Lima and Callao; 54 per cent in provinces; 43 per cent available nationally
- 3.6-3.8 GHz: assigned to four private users and one public, and some satellite service companies
- 3.7-4.2 GHz: several users of the fixed satellite service

47. Available at 'R.D. N 358-2019-MTC/27'
48. The refarming process was suspended in March 2020 in accordance with R.D. N 095-2020-MTC/27
49. Available at 'R.D. N 757-2019-MTC/01.03'
50. Available at 'R.M. Nº 757-2019MTC/01.03'
51. Available at 'R.D. N 358-2019-MTC/27'
52. Available at 'Informe N 710-2019-MTC/27'
53. Range refarming schedule 3 400-3 600 MHz - Peru

In summary,

- 500 MHz (3.3-3.8 GHz) considered for use
- 3.3-3.4 GHz range is available for assignment
- 3.4-3.6 GHz range. The MTC will mandate Proinversion to commence the auction structuring. That process is expected to take approximately 12 months
- 3.6-3.8 GHz range in reserve. No new assignments, modifications, extensions, transfers or any other act involving variations in the right to use the radio spectrum are approved. Holders of FSS in this range, except those administered by state enterprises, will migrate to the 3.8-4.2 GHz range
- 6 months trial in the 3.5 GHz frequencies in Lima, Arequipa and Trujillo. Once the trial is completed, operators are to report detailed results
- First Multi-range public tender of the 2.3 GHz and 1.7/2.1 GHz ranges planned for 2H-2020 or 2021
- Second Multi-range public tender of the 2.3 GHz, 2.5 GHz (remainder of the reordering), 3. 3-3.8 GHz (migration of stations in the FSS) and 26 GHz (by allocation) ranges planned for 2021
- Duration of the licence: 20 years

The following are the main challenges which have been identified for a timely release of the 3.3-3.8 GHz range:

- Complete the 3.4-3.6 GHz range refarming process which was suspended in March 2020[54] to solve AWS Second Harmonic interference at 3.4 GHz
- The MTC has identified interference problems mainly in the 3.7-4.2 GHz frequency range

54. Available at 'R.D. N° 095-2020-MTC/27'

URUGUAY

- **Current allocation to mobile services in the NTFA (3.3-4.2 GHz range): 500 MHz**
- **Planned use of the 3.3-3.8 GHz range: 500 MHz**
- **Cleared spectrum (3.3-3.8 GHz range): 200 MHz**
- **MNOs: 4**

In December 2019, the Regulatory Unit of Communication Services (URSEC) completed the competitive procedure for the assignment of rights to use radio frequencies to provide mobile communications services in the 2.6 GHz, 1.8 GHz and AWS ranges. Although the assigned frequencies are intended to provide greater capacities to the current Long Term Evolution (LTE) networks, they will allow mobile operators to offer 5G technology. Nevertheless, in the long run, this frequency there will not be as suitable as 3.3-3.8 GHz to offer 5G technology services.

The 3.3-4.2 GHz range occupancy is described below:

- 3.3-3.4 GHz: clear
- 3.4-3.6 GHz: one operator authorized to provide data transmission services in the terrestrial fixed service by means of LMDS point-to-point (PTP) and point-to-multipoint (PTM) systems at national level
- 3.6-3.7 GHz: clear[55]
- 3.7-4.2 GHz: stations operating under the fixed satellite service allocation

As URSEC has completed at the end of 2019 the competitive procedure for the allocation of rights of use for radio frequencies for the provision of mobile communications services in the 2.6 GHz, 1.8 GHz and AWS ranges, and as these frequencies can be used for the deployment of 5G networks, the consideration of assignment for IMT of the segments of the 3.5 GHz range that are clear is not foreseeable in the very short term. In addition, the three operators authorised to provide IMT services (Antel, Telefonica and Claro) have been advancing deployment plans in other frequency ranges. Antel, for example, which has spectrum in 28 GHz, initially assigned for Local Multipoint Distribution Service (LMDS), has deployed a pilot 5G in this frequency range. Telefonica and Claro have submitted requests to be authorized to use spectrum in 26 GHz for the deployment of 5G.

Given that the 2.6 GHz, 1.8 GHz and AWS ranges can be used for the deployment of 5G, the need to release the 3.3-3.8 GHz range for the same purposes is not foreseeable in the short term

Licences for the use of the radio spectrum for IMT were granted for 20 years, except in the last competition (2.6 GHz, 1.8 GHz and AWS ranges) which was granted for 25 years. Since the first auction was held in 2002, when they reach expiration, the newly designated administration will decide whether to hold another auction or to continue with the licences. The idea of increasing the term to 25 years was mainly linked to economic reasons, in order not to lower the reserve value of the block and to give greater financial facilities to the operator. It is likely that in a future auction (i.e, the 3.3-3.8 GHz range), the term of the licence would again be granted for 25 years, but this will have to be defined by the new administration.

The 3.3-3.8 GHz range is part of the frequency block to be considered within the 'Coordination Manual in the Mercosur' border zone. However, not much progress has been made in relation to it since Mercosur has mainly focused on the 700 MHz range.

According to the regulator, no interference measurements have been made recently in the 3.5 GHz range and adjacent ranges since, except for specific cases. However, the respective measurements will have to be made before an auction process can be initiated, mainly in the segments below 3.8 GHz.

55. This range is clear but not available for any use nor decision as it is under legal dispute

In summary,

- Although not in the very short term, 500 MHz (3.3-3. 8 GHz) are in consideration for the future deployment of IMT
  - 3.3-3.4 GHz already cleared spectrum and according to footnote 5.429D
  - 3.4-3.6 GHz: according to footnote 5.431B (although with high occupation by a national user which has been migrated to this range in the past)
  - 3.6-3.8 GHz: although yet under assessment stage, the URSEC might be considering this range on its broadband plan
- Procedure for the assignment of rights to use radio frequencies to provide mobile services in the 2.6 GHz, 1.8 GHz and AWS ranges completed
- Duration of the licence: 20 years, except in the last contest (2.6 GHz) in which 25 years was granted

The following are the main challenges which have been identified for a timely release of the 3.3-3.8 GHz range:

- Publication of 5G National Plan, including a spectrum roadmap
- High spectrum prices and policies to maximise revenues from spectrum auctions need to be reviewed
- Make progress with the 'Coordination Manual of Mercosur' in regard to the coordination required for the deployment of systems for IMT services in border areas
- Given that the deployment of systems in the 2.6 GHz, 1.8 GHz and AWS ranges are being performed, licensing processes in the 3.3-3.8 GHz range is not foreseeable in the very short term

5. International experience

Introduction

An international benchmark of seven selected countries (Canada, Finland, United States, United Kingdom, South Korea, Spain and Italy) is presented in this section. The objective is to describe how the 3.5 GHz range has been licensed in other countries and to learn from the identified challenges and takeaways in these countries.

The benchmark has been mainly conducted performing secondary research, which means that all the information has been obtained from public sources, information databases, sector reports, relevant industry news, etc.

Key country findings

The following table shows a summary of the main findings of the international benchmark. For each of the seven countries, the spectrum which has been licensed, a summary of main 5G public policies, most relevant auction data and the challenges to the 5G deployment in the 3.5 GHz range is shown.

TABLE 4

Source: BlueNote analysis

Summary of international experience

Country	Licensed spectrum	5G Public Policy	Auction highlights	Challenges to timely release the 3.5 GHz range
Canada	• Not used by mobile services	• Different consultations, on policy and licensing framework for the auction of spectrum licences in the band 3 450- 3 650 MHz, have taken place • Seeking comments on the policy and licensing considerations, including auction format, rules and processes, as well as on conditions of license for spectrum in the 3.5 GHz range	• N/A	• Aeronautical and maritime radars and government radiolocation systems will require relocation outside the 3 450-3 500 MHz range • FWA users will not accept the flexible use of spectrum, but in practice, it is already being used this way
Finland	• 3.4-3.8 GHz	• Telecommunications ministers adopted 5G conclusions and discussed data economy and privacy protections, • turning Finland into the world leader in communications networks - Digital Infrastructure Strategy 2025	• Term: 15 years • Channelling: 130 MHz • Cap: maximum of 1 block per operator • Auction format: simultaneous price increase and multiple bids	• The Government established that the use of the spectrum from 3.4-3.8 GHz would be in accordance with the results of the auction, so no barriers are seen to exist, at least for this portion of the spectrum • Radar services in 3.3-3.4 GHz • Intensive use of fixed satellite links and not standardised Earth stations and Very Small Aperture Terminal (VSAT) in 3.8-4.2 GHz
United States	• Not licensed yet • 3.7-4.2 GHz auction: 4Q-2020	• The Federal Communications Commission (FCC) created a three-tiered access and authorisation framework to coordinate shared federal and non-federal use of the band	• Term: 10-year renewable licences • Channelling: 40 MHz • Cap: no caps • 80 MHz reserved for GAA[56] use	• Dynamic frequency assignment is used. This is an advantage, since no interference analysis is required for each user • The intensive use of the 3.7-4.2 GHz range by fixed and FSS services is a major barrier to the early release of the 3.5 GHz range

56. GAA: general authorised access

TABLE 4

Source: BlueNote analysis

Summary of international experience (cont.)

Country	Licensed spectrum	5G Public Policy	Auction highlights	Challenges to timely release the 3.5 GHz range
United Kingdom	• 3 410-3 580 MHz • 120 MHZ in 3.6-3.8 GHz range to be auctioned in 2020	• Key highlights: planning in advance of the migration of existing services in these bands and avoiding defragmentation	• Term: 20 years • Channelling: 24 blocks of 5 MHz • 37% cap (416 MHz)	• 150 MHz have already been licensed and 120 MHz to be licensed in 2020, so no relevant challenges were identified
South Korea	• 3 420-3 700 MHz	• 5G mobile strategy defined early in 2013 with $1.5 bn investment by the government • Cost sharing for the deployment of a nationwide 5G network among operators • 2017's national broadband plan indicates the possibility of extending the 28 GHz band by up to 2 GHz to provide access to a total of 3 GHz, 26.5-29.5 GHz • 5G+ Spectrum Plan aims to make a further 2,640MHz of bandwidth available for use in 5G networks by 2026	• Term: 10 years • Channelling: 10 MHz blocks • Cap: 100 MHz • 5G network commercial use launched in December 2018 for business users and in April 2019 for end users	• Reserve prices were considered excessively high
Spain	• 3.6-3.8 GHz • Previous licences in place in 3.4-3.6 GHz	• Developed the 5G National Plan for the 2018-2020 period • Launch of a 5G National Observatory • Pilot projects development	• Term: 20 years • Channelling: 5 MHz blocks • Cap: 120 MHz	• No relevant challenges have been identified to date • Important to highlight the fact of having a plan and international cooperation initiatives
Italy	• 3.6-3.8 GHz	• 5G strategy launched in 2016 with a fact-finding survey for the development of mobile and wireless systems towards the 5G • In 2017, the Government selected five 5G trial cities	• Term: 20 years • Channelling: two blocks of 80 MHz and two blocks of 20 MHz • Cap: 100 MHz (any operator could get one, but only one block) • Coverage obligations	• Auction resulting in high prices, due to scarcity of spectrum (just 200 MHz), its channelisation and the number of operators bidding for it among the main reasons • Payment in four annual instalments • Part of 3.4-3.8 GHz used by government/ military and 120 MHz was awarded as WiMAX

In Canada, an aspect to be highlighted is that Innovation, Science and Economic Development (ISED) will no longer accept new first-come, first-served spectrum licence applications in the 3 475-3 650 MHz band, considering the significant reorganisation of current licensees' spectrum holdings, and the intention to issue flexible use licences in this band following an upcoming auction. Another issue to be highlighted is that, given the support expressed in the comments received during the consultation period, policy and licensing framework will include an auction format with price discovery. Although the inclusion of price discovery may preclude faster and simpler licensing processes, there are clear benefits with respect to reducing uncertainty about value of spectrum.

In Finland 390 MHz were licensed in the 3.4-3.8 GHz range to three operators, each receiving 130 MHz; the amount of spectrum awarded is a base for the 5G development, based on which verticals can be promoted. Additionally, the arrangement of multiple frequency bands to be auctioned avoids, on the one hand, the weakening of competition and, on the other hand, the concentration of the spectrum by ensuring that nobody can be awarded a large number of frequencies. An auction model with simultaneous price increase and multiple bids is very suitable for auctioning in this frequency range. The auction model chosen offers operators the opportunity to value each frequency band individually, even more so when the availability of some frequency bands has more geographic usage restrictions than others.

In the case of United States, it is important to highlight that the allocation of the 3.7-4.2 GHz band balances the joint goals of making spectrum available for new wireless uses while providing desired speed to the market, efficiency of use, and effectively accommodating incumbent fixed satellite service, fixed service and mobile service operations in the band. The co-channel sharing of spectrum between the FSS and mobile systems would be complicated because the movement of the devices would require analyses and interference mitigation to FSS Earth stations in 3.7-4.2 GHz band over many locations within any given geographic area. In addition, because the 3.5 GHz range satellites are in geostationary orbit, approximately 36,000 km above the equator, the signals received at the Earth stations are extremely weak. This means that terrestrial mobile operations could cause harmful interference to the Earth station receivers.

The United Kingdom has already awarded 150 MHz in the 3.4-3.6 GHz band and is planning to auction additional 120 MHz in the 3.6-3.8 GHz band. Main takeaways are the advanced planning of the migration of existing services in these bands through public consultation procedures and the importance of which is being given to the defragmentation (taking into account operators preference of, at least, 80 MHz blocks and the possibility to trade spectrum blocks after the spectrum has been awarded, so as to allow operators to assure the holding of contiguous blocks and reduce fragmentation in their possession of radio spectrum).

The Korean government held the world's first 5G spectrum auction in 2018 and has the aim to become the country in the world with the most spectrum availability. In 2018 South Korea awarded 100 MHz to two operators (and 80 MHz to a third) in the 3.5 GHz range and 800 MHz per operator in the 28 GHz band, which is in line with the 5G need of new harmonised mobile spectrum. It is expected that the deployment of nationwide 5G networks will be fully completed by 2022 or 2023. In April 2018 a shared 5G deployment and network agreement was signed, which aimed to avoid a very costly launch campaign as when 4G came to reality back in 2011, generating cost savings of nearly $1 billion. After launching the service for end users[57] in April 2019, and business users in December 2018, a total number of 3.5 million 5G subscribers[58] was reached by the end of September 2019.

The February 2018 Winter Olympics in PyeongChang provided a stage for displaying 5G innovation. KT was very active. Samsung and KT provided a 4K streaming video service via a 5G network using 28 GHz spectrum. KT provided the 5G data network through a collaboration led by Intel with partners including Ericsson, Nokia and Alibaba, while Samsung unveiled its 5G mobile tablet device to deliver a 4K streaming video via Intel's base stations. KT demonstrated on its 5G network four types of data-heavy video streaming services: Sync view, Timeslice, 360 VR and Omnipoint view. KT also showed a 5G Connect Bus using 5G, capable of autonomous driving using Lidar sensors and the V2X technology. Hyundai demonstrated five Level 4 autonomous cars on a 196 km trip to PyeongChang; the cars were connected to the KT 5G net for entertaining the passengers.

Spain has put in place a specific 5G plan, which establishes the roadmap for the deployment of 5G, including the 3.4-3.8 GHz band as one of the main bands for the new technology development. So far, the 3.6-3.8 GHz band has been auctioned. The licences of four 2x20 MHz blocks of previous assignments in the 3.4-3.6 GHz band are expiring in 2030.

Italy has already auctioned 5G spectrum in the 3.4-3.8 GHz band. Although only 200 MHz were auctioned as the remaining ones are still being used by the government/ military and by WiMAX licences which expire in 2023. The main takeaway from Italy's 2018 5G auction is the resulting high price it has achieved due to an extremely bad design of the spectrum assignment process. The scarcity of spectrum, its channelisation and the number of operators bidding have been among the reasons for the high prices.

57. Available at 5G Observatory Quarterly Report – Report 5 (European Commission, 2019)

58. Available at 'Korea plots 5G spectrum boost'

6. Conclusions

Main challenges and potential action plan

The main challenges the sampled countries face in terms of the release of the 3.3-3.8 GHz range have been grouped according to their main focus (and these challenges have been included in the group in which they fit best): those with a focus on political challenges, those with a focus on regulatory challenges and, lastly, those with a focus on technical challenges.

The following table shows a summary of the main challenges with proposed solutions for the region:

ILLUSTRATION 10

Source: BlueNote analysis

Summary of main challenges with proposed solutions

Political		
Challenge	**Description**	**Proposed solutions**
High level political commitment to 5G	• Endorse 5G as a key enabler of digital economies	• Recognise 5G as the driver of Forth Industry Revolution, and that an enenabling policy environment is a prerequisite for 5G success. Accordingly, policymakers need to foster a pro-investment and pro-innovation environment for the mobile ecosystem
Prepare formal 5G strategies and a spectrum roadmap	• Define a 5-year plan to implement 5G in the country, to help coordination and provide certainty	• Develop a 5G country plan and include key policies on: timeline, license guidelines, users demand and traffic, spectrum roadmap, required infrastructure, invetment-friendly awards, etc.
Identify key regulation challenges	• Promote visibility of key regulation reforms needed to promote 5G and promote efficiency of the 3.3-3.8 GHz range	• Identifiy key aspects of current regulation framework and develop a work plan to remove barriers. Several barriers may require a longer period to implement reforms
Agreements with other industries	• Assess the utilisation of the resource assigned to other services in the 3.3-3.8 GHz range	• Other industries (e.g. satellite and defence) should return the spectrum that is not in use, updating the regulatory framework, when necessary • If MNOs are using the band, support a wide consultation process with all interested parties to understand a specific way forward • Study case by case the spectrum assigned and take the appropiate decisions to refarm the spectrum for 5G after consultation with the stakeholders • Direct spectrum assignments should be treated differently to open assignment processes and competitive processes, including investment obligations

ILLUSTRATION 10

Source: BlueNote analysis

Summary of main challenges with proposed solutions (cont.)

Regulatory		
Challenge	**Description**	**Proposed solutions**
Harmonisation in the frequency arrangements 	• Consider regional and international harmonisation in the selection of the frequency arrangements • NTFAs need to be formally updated	• Implement the agreements reached at The Inter-American Telecommunication Commission (CITEL) and confirmed at WRC • NTFAs should be replicated to the RR in the next WRC for ITM identification as indicated by best practices
Definition of policies, regulatory framework and spectrum assignment mechanisms 	• Modify the 5G regulatory framework and establish new mechanisms for spectrum assignment to facilitate the development of IMT	• Take into account best practices in the implementation of IMT in the 3.3-3.8 GHz range
Review of spectrum fees and the cost of required infrastructure for the development of IMT 	• Value spectrum • Define news charges and voluntary models for infrastructure sharing	• Prioritise improved mobile broadband services to achieve socio-economic benefits – above revenue maximisation – when awarding spectrum • Promote voluntary infrastructure sharing and define cost on marginal basis • Relate the decision to spectrum award models that can promote investment agreements (e.g. beauty contests, network roll out investment as substitute to upfront cash payment for spectrum fees)
Assessment of current situation of spectrum and revision of caps 	• Gauge spectrum demand • Revise cap policies	• Assessment of the current spectrum situation and consequent revision/lifting of spectrum caps
Successful completion of refarming process 	• Define specification, timeline and procedure for reordering of the 3.5 GHz range after the auction	• Define mechanism that assures minimum block of 80-100 Mhz per operator and contiguity • Avoid spectrum blocks fragmentation

Technical		
Challenge	**Description**	**Proposed solutions**
Dealing with current users 	• Migrate current users to a different range • Assess the licensing of spectrum with restrictions and interference provisions	• Sample/inventory and define users to be migrated • Define scenario to mitigate intereference with users based on international best practices • Include decision specification in the auction rules and guarantee deduction from reserve prices • In Brazil, the migration of low-income family dependent TVRO users to a higher range or other solution with filters will be required
Avoiding possible harmful interference in the 3.3-3.8 GHz range 	• Avoid possible harmful interference in the range. This includes interference generated by the second harmonic of AWS	• Apply the technical recommendations of capable organisations, such as the GSMA, Third Generation Partnership Project (3GPP), the European Conference of Postal and Telecommunications Administrations (CEPT) and ITU related to interference analysis
Define the minimum size of the blocks to be offered for IMT 	• Define the minimum size of the blocks to be offered for IMT in an upcoming bidding process	• Establish a minimum channelisation of 10 MHz and an assignment of contiguous blocks of at least 80-100 MHz (minimum acquisition block) • Create a roadmap for future assignments and reshuffling processes (when not possible to achieve immediate 80-100 MHz per operator)
Cross border and synchronisation agreements 	• Need of formal documents on synchronisation (inter countries and nationally)	• Develop synchronisation frame structure for national decisions via executive groups and, if not agreed, via NRAs resolution, including extensive consultations with stakeholders • E.g. development of a specific chapter on synchronisation and cross border in the Manual of Mercosur

Proposed licensing guidelines and roadmap

As a final conclusion for the report, and with the aim of proposing a preliminary action plan for the countries in the region, a set of proposed guidelines has been developed. These guidelines intend to be a reference for regulators and policy makers.

The development of a clear roadmap is among the licensing guidelines which should be considered.

PROPOSED LICENSING GUIDELINES

As stated on the GSMA's report 'The 5G Guide'[59], prior to deploying their 5G networks and infrastructure, where the 3.3-3.8 GHz range plays a key role, operators will assess the readiness and enabling conditions of the market for this deployment. In the report the GSMA structures the readiness and enabling conditions around three main considerations:

- Technology readiness
- Policy readiness
- Market/operator readiness

In this section the focus will be mainly on the policy readiness, which regulators should provide to operators as an enabling condition to assess their business models. An enabling policy environment is a prerequisite for 5G success. Among the policy readiness, spectrum access of the 3.3-3.8 GHz range is crucial. The proposed licensing guidelines provide regulators and policy makers with a first check of important aspects of the 3.5 GHz range spectrum access that must be considered for its licensing.

In most of the countries of Latin America the 3.3-3.8 GHz range will be the entry point to 5G technologies, so these guidelines, or best practices, should be tackled from a broader point of view, not only considering the specific needs of this band but also considering the deployment of a new technology.

Although there is no country in Latin America that has already licensed the 3.3-3.8 GHz range, the following highlights have been identified in the sampled countries plans provided by the regulators:

- There is a trend towards early release of the 3.3-3.4 GHz and the 3.4-3.6 GHz range for IMT, but also the extension up to 3.8 GHz is seen.
- Regarding the occupied ranges, there is relatively limited public information about the clearing process and about the migration of other services (e.g. satellite and defence) to other ranges.
- Size of contiguous blocks per operator and spectrum availability in the award process should be solved before the design of these processes takes place, aiming for 100 MHz per operator.
- In none of the sampled countries the synchronisation issue or the cross-border interference have been brought up as relevant aspects to be considered nor were those identified among the tasks to be completed in the short term, although highly needed.
- Reasonable prices, voluntary sharing and joint development should be identified, considering the high level of investment the 5G requires, and the high capital demand operators should expect to face.

The following table shows the proposed key licensing guidelines, classified in terms of spectrum planning and spectrum award and licensing.

59. Available at 'The 5G Guide. A Reference for Operators' (GSMA, 2019)

TABLE 5

Source: GSMA, BlueNote analysis

Key licensing guidelines

Spectrum planning	Spectrum award and licensing
• Follow international **best practices, band plans and trends** • Provide a **roadmap for future availability and release spectrum** as part of national spectrum planning policies (national allocation to mobile and identification for IMT services and licensing schedule and plans), allowing the reshuffling of blocks to guarantee contiguous ranges of **at least 80-100 MHz per operator** • Provide clarity in terms of the **3.3-3.8 GHz range availability and clearing** (when previously occupied), relocating and/or ceasing services currently in the band as soon as practical to vacate at least 300-400 MHz • Provide clarity in terms of **coexistence, synchronisation agreements and cross-border interference** • Remove regulatory barriers to allow **voluntary infrastructure sharing** and wider implementation in order to reduce the costs and accelerate the deployment • Simplify authorisation procedures related to **sites planning, acquisition and management** • Incentivise early **entry of affordable mobile handsets** into the market (i.e. tax reliefs) • Provide early and clear guidance on the **TDD synchronisation frame structure and exceptions**	• When there is competition, use **market-based mechanisms** to award the spectrum • Hold **open consultations** on award rules and conditions prior to the assignment process • Set **reserve prices** below a conservative estimate of market value to allow market discovery to determine price • Prioritise **improved mobile broadband services to achieve socio-economic benefits** – above revenue maximisation – when awarding spectrum • Do **not generate scarcity** in the spectrum award process; artificial limitations on the amount offered or inappropriate lot sizes risk inflating prices and slowing investments • Assign spectrum with **technology neutrality** • Grant longer **licensing periods** (ideally 20 years or longer) to provide long term certainty for network investment • Avoid **taxes and fees** that deter roll-out

ROADMAP

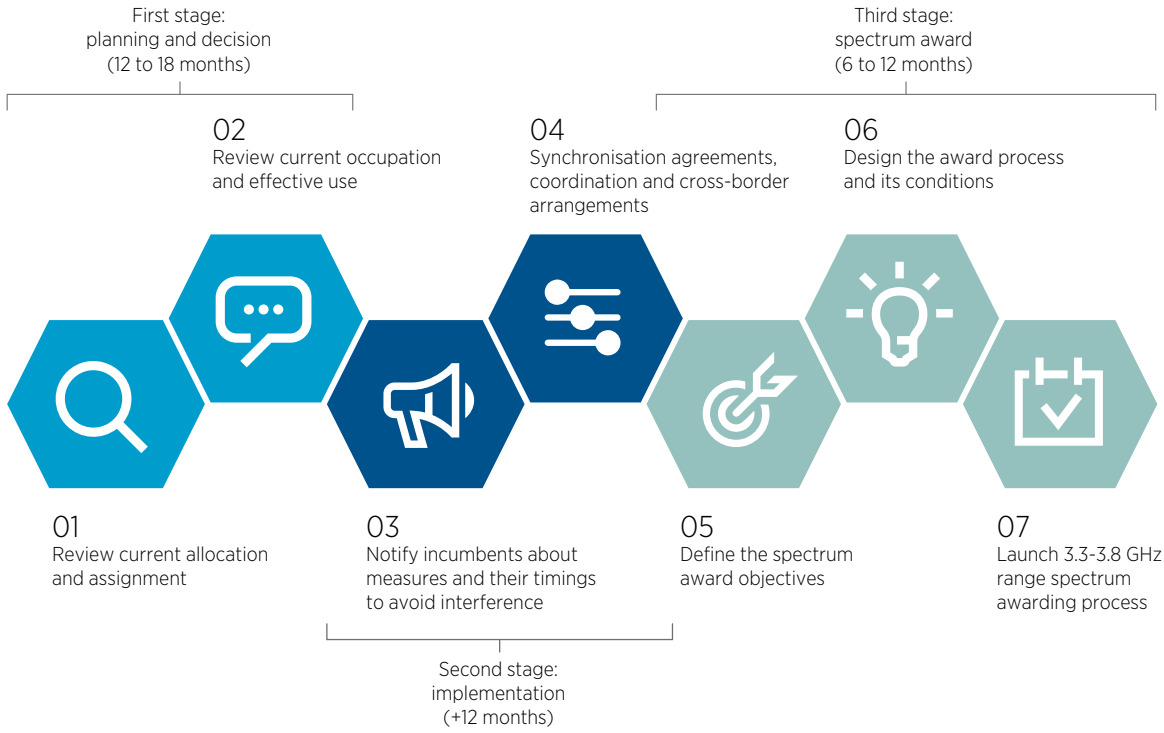
Preparing a strategy for the licensing of the 3.3-3.8 GHz range and translating it into a roadmap is a milestone that must be present in the agendas of governments. As stated before, the existence of a clear roadmap has been identified among the best practices and guidelines for the licensing of the 3.3-3.8 GHz range.

This roadmap will vary according to the characteristics of each country and to the 3.3-3.8 GHz range current status, although, it will have points in common that must also be taken into account. Three phases are recommended for the preparation of the roadmap: the first, planning and decision-making, the second, implementation, and, lastly, the spectrum award.

ILLUSTRATION 11

Source: GSMA, BlueNote analysis

The three stages 3.3-3.8 GHz range roadmap



The whole process is expected to last approximately 3 years, but the entire duration of the process may be shorter, depending on the second stage, the implementation, in which, when applicable, other (e.g. satellite and defence) users will be notified about the need to move them to another band and how and when this clearing of the band is implemented. As a matter of fact, in order to shorten this timing, activities on the second stage can sometimes be conducted alongside the rest of the process or even after the spectrum awarding process is completed.

Together with it, cross-border coordination and synchronisation arrangements must be planned and, if possible, executed during this stage. The length of this stage depends mainly on the legal framework, the current users and their usage intensity and on the expiration date of their licences. Of course, it must be noted that the 3.3-3.8 GHz range does not need to be awarded all together, it will be awarded as the band gets cleared taking into account the 80 to 100 MHz per operator availability as a trigger, what means 300-500 MHz in Latam.

Taking into account the best practices and guidelines and the proposed roadmap, the following framework, structured in different questions that regulators should ask and should be able to clearly answer, may work as an easy-to-use checklist during the three stages of the roadmap.

TABLE 6

Source: BlueNote analysis

Q&A - How to release the 3.3-3.8 GHz range

Question	Challenges to overcome	Consequent actions
Is the band considered for mobile broadband?	• Create a national 5G broadband strategy and spectrum roadmap • Understand if changes to the national frequency allocation plan and ITU Radio Regulations are needed	• Designate all or part of 3.3-3.8 GHz as priority band for national 5G plan • Modify the national frequency allocation table and reserve the 3.3-3.8 GHz range for IMT • Make the necessary additions at WRC-23
Is the band currently occupied?	• Understand who is occupying the band • Understand how much of the band is required and actually being used • Confirm the legality of current usage • Assess when existing licences will expire • Consider the regulatory requirement for the band's clearing and defragmentation	• Other industries (e.g. satellite and defence) should return the spectrum that is not in use, updating the regulatory framework, when necessary • If MNOs are using the band, support a wide consultation process with all interested parties to understand a specific way forward • Cease services not in use or in decline, considering low-income families' dependency • Assess legal framework and users' profile to define, together with the sector, a migration strategy, if and when necessary • Assess the possibility of maintaining the adjacent services via filter or power limits so the interested parties can decide on the best approach • Choose the best migration/coexistence strategy for the specific case: incentive scheme, compulsory, coexistence and/or according to licence expiration dates
What are the coexistence issues and the synchronisation needs?	• Consider potential coexistence issues based on existing studies and evaluate current users' migration strategies • Assess the requirement for TDD synchronisation amongst licensees	• Review existing coexistence studies • Coordinate cross-border roadmap • Communicate results to the market • Depending on the market organisation, create a framework for TDD synchronisation, including frame structure and exceptions
Which is the best spectrum award process?	• Effective and timely licensing of spectrum • Aim for 100 MHz per operator • Meet licensing authority's policy objectives • Meet market needs • Provide predictability to support network investment	• Define and communicate (using public consultations) a medium- and long-term spectrum roadmap for 5G in the full range • Identify and launch a work plan to review regulatory challenges, the legal environment and barriers for boosting 5G • Launch 3.3-3.8 GHz range spectrum award process with the most efficient design (considering the affordable and investment-led payment scheme) • Prioritise improved mobile broadband services to achieve socio-economic benefits – above revenue maximisation – when awarding spectrum • Consider all obligations, if any, as a discount on the reserve price • Consider reasonable network roll out investment as substitute to upfront cash payment for spectrum fees

Technical considerations

Regarding the technical considerations, migration strategies and synchronisation concerns are described as follows.

MIGRATION STRATEGIES

Migration strategies range widely in the sampled countries, with legal framework being the pivotal lever. We can identify four generic models of migration strategies:

a. Incentives mechanisms to release spectrum and/or negotiation with current users;

b. Compulsory models;

c. Smooth release according to expiration dates; and

d. Coexistence.

Migration strategies depend, to a large extent, on the legal framework and the legal aspects of licences and permits for the use of the radio spectrum and vary from country to country. Furthermore, it depends on the type of operator involved, whether it is public or private, mobile or not, on the charging scheme applied, whether the payment is recurrent or not, for example, and on the incentive scheme to motivate the current user of the frequency range to move to another range. The strategies used in the sample countries are presented below.

- **Argentina and Ecuador:** current legal framework empowers the authorities to release the spectrum and to ask current users to migrate to other bands[60]
- **Brazil:** migrate low-income family dependent TVRO users to a higher range (e.g. 3.8 GHz +) and/or provide a plan considering the filters to be available
- **Colombia:** in the case of the 3.5 GHz range the spectrum was mostly returned to avoid the annual fee[61]. The general rule is to expect that the incumbent's licences (e.g. satellite) will reach their expiration and, in case they opt to continue with the current service, they will be migrated to other ranges
- **Costa Rica:** negotiation with the current (public) user of the spectrum to encourage release of a large portion of the 3.5 GHz range (a key argument is that spectrum is underused)
- **Mexico:** negotiation with the user of the spectrum, inviting the return of it. Spectrum rearrangement by means of range change, which may be carried out ex officio or at the request of a party between the licensee and the IFT or between licensees, subject to authorisation by the IFT
- **Peru:** a specific migration regulation was introduced, by which current mobile users are encouraged to give back spectrum allocated to fixed services and receive mobile spectrum[62] in return
- **Uruguay:** it is expected that the incumbent's (e.g. satellite) licences will reach their expiration and, in case they opt to continue with the current service, they will be migrated to other ranges

To choose and define a migration strategy, regulators should complete several activities. Key milestones of such strategies are:

1. Assess the current occupation level in each portion of the band
2. Complete inventory of current users, discriminated by type of user (i.e. public/private), type of operator (i.e. mobile, pure ISP, TV), current services offered
3. Analyse legal framework of licence and permits
4. Develop a timeline of expiration date of current users
5. Estimate effective use of the spectrum and assess incentives of current users to renew licence or give back the spectrum
6. Identify available spectrum for relocation of other services (e.g. satellite and defence)
7. Analyse interference issues (i.e. adjacent services) and propose mitigation scenarios
8. Define migration model, after assessing feasibility, cost and benefits of the generic models
9. Develop a document explaining the migration plan and communicate it to stakeholders
10. Reorganise frequency bands in continuous and contiguous blocks for the provision of IMT services through TDD

60. In the case of Argentina, that provision excludes spectrum assigned via public auction. In the case of Ecuador, that provision requires a statement of public interest.
61. And considering the key service in the band, i.e. Wimax, has very limited success in that market.
62. The portion of mobile spectrum to be received is lower than the total portion given back by the operator.

SYNCHRONISATION

When more than one TDD network operates in the same geographic area and in the same band, severe interference may impair network performance if the networks are uncoordinated, i.e. if some equipment is transmitting while other equipment is receiving in the same timeslots. In that case, guard band and/or additional filtering and/or other techniques can often be used in order to reduce interference. However, in the case of TDD-TDD coexistence, another way to avoid all interferences without using guard band and specific filtering is to synchronise base stations so that they roughly transmit and receive in the same time. More precisely, synchronised operation means that no simultaneous uplink and downlink occur between any pairs of cells which may interfere with each other in the same band[63].

Within a country the synchronisation problem can easily be solved by agreement between the different users of the band perhaps with regulator guidance, but in the case of cross-border situations where the same frequency band is used, the problem becomes more acute where IMT is deployed on one side of the border and FSS, fixed services, mobile services or radars on the other. The ideal situation is to adopt harmonised arrangements across the whole region, but where harmonised arrangements are not feasible it will be necessary to define suitable cross border agreements to ensure that the deployment of IMT in one country does not cause interference to existing use in neighbouring countries. This is likely to require the definition of restriction zones or coordination zones where a specified power flux density cannot be exceeded over a given frequency range[64].

The different timings anticipated for use of available spectrum per country and the different spectrum that will be allocated has implications for cross border agreements. In order to achieve synchronised operation, the following needs to be implemented on all stations that may interfere with each other (both within the user and between other users in the same frequency range):

- Having a common reference phase clock (i.e. for the start of frame). The desired accuracy depends on the technology, but the order of magnitude for currently considered IMT technologies is about 1 to 3µs of clock drift between base stations. In practical deployments Coordinated Universal Time (UTC) is mostly used as a common time reference.
- Configuring compatible frame structures (i.e. length of frame, TDD ratio, etc.) in order to align uplink/downlink switching points. This is straightforward in the case of the same technology, but it needs careful analysis in the case of cross-technology synchronisation.

Although nothing has been found in the sampled countries related to the need of synchronisation of networks to ensure a more efficient use of the spectrum. The 3.5 GHz range is considered in Mercosur as part of the Border Coordination Manual, anyhow, there is limited progress as main focus has been centred on the 700 MHz range.

In any case, to introduce IMT services in the 3.5 GHz range in order to deploy synchronised TDD mobile networks in a multi-operator context (without guard bands), the regulators should be taking into account agreement needs relating to:

- A common phase clock reference and accuracy/performance constraints
- A compatible frame structure in order to avoid uplink/downlink overlapping
- A commitment not to interfere with each other
- Ensuring the reliability of the reference clock and protection mechanism and/or procedure when losing this reference clock
- The conditions where cross-operator synchronisation must apply, depending on the decisions taken by an executive forum or the regulations of each country involved

63. CEPT. (2014). ECC Report 216
64. GSMA. (2019). Roadmap for C-band spectrum in ASEAN

7. Appendix

Latin-American countries' Digital agendas

TABLE 7

Source: BlueNote research

Digital Agendas in Latin America

Country	Digital Plan	Publication date	Main highlights
Argentina	Digital Agenda 2030[65]	2018	• Aims to redefine the existing institutional framework and set new foundations for digital development in Argentina • Aims to allow integration of all areas of Government in the consolidation of a dynamic and thriving digital economy • Based on eight objectives, which, among other things, includes the promotion of legal frameworks to take advantage of digital opportunities, regards appropriate treatment of public and private information and facilitates the development of infrastructure and accessibility that connects everyone intelligently • Created a Planning and Monitoring Council of the Argentine Digital Agenda
	National Digital Inclusion Plan[66]	2018	• Plan considers the following: infrastructure development, digitalisation, digital literacy activities promotion, development of digital skills for public employees and training in digital skills for public and professional development
Brazil	Brazilian Digital Transformation Strategy[67] (2018-2021)	2017	• Comprises a set of seven thematic axes: 1) Digital citizenship; 2) Broader ICT access and use; 3) Research, development and innovation; 4) Security and trust in ICT use; 5) Education and ICT; 6) International governance; and 7) Digitalisation of the economy • In order to assess the contribution of digital transformation to Brazil's global competitiveness, this strategy takes into account some indicators and metrics that provide international comparison: Infrastructure: ITU ICT Development Index (IDI); Cybersecurity: ITU Global Cybersecurity Index (GCI); E-commerce: United Nations Conference on Trade and Development Business-to-Consumer E-commerce Index (UNCTAD B2C); Electronic Government: UN E-Government Development Index (EGDI) • An important focus of the Brazilian Strategy for Digital Transformation is to propose strategic actions under the perspective of SDGs[68] of the 2030 Agenda of the United Nations

65. Available at 'Agenda Digital 2030'
66. 'Plan Nacional de Inclusión Digital'
67. Available at 'Estratégia Brasileira para a Transformação Digital'
68. Available at UN Sustainable Development Goals

Country	Digital Plan	Publication date	Main highlights
Chile	Digital Matrix 2018-2022[69]	2019	• Government roadmap for digital connectivity. • National plan to position Chile at the technological forefront of the region and to reduce the digital and telecommunications divide in the country • The Matrix has three axes: 1. Digital citizens' rights, 2. Investment and infrastructure and 3. Digital development
Colombia	Live Digital Plan (2010-2014) (2014-2018)[70]	2010	• Aims to give the country a technological leap by the massification of the Internet and the development of the national digital ecosystem • Some of the objectives of the plan were to increase the number of municipalities connected to the information highway, connect small- and medium-sized enterprises (SMEs) and homes, and increase the number of internet connections • Strengthening of the digital ecosystem was aimed by expanding infrastructure, creating services at lower prices, developing applications and digital content, fostering ICT adoption and use
	TIC Plan 2018-2022[71]	2018	• Slogan of the plan: 'Digital future belongs to everybody' • Aims to close Colombia's digital gap • Addresses the most immediate needs of the country: to connect all Colombians by solving the last mile network deficit, create and strengthen digital skills in all citizens, generate more digital businesses and strengthen entrepreneurship • Four pillars: 1) ICT environment for digital development; 2) Citizens and households empowered by the digital environment; 3) Digital social inclusion; and 4) Sectorial and territorial digital transformation
Costa Rica	National Telecommunications Development Plan (2015-2021)[72]	2015	• Promotes three pillars: 1) Digital inclusion; 2) Transparent and electronic government; and 3) Digital economy
Dominican Republic	Digital Agenda 2016-2020[73]	2015	• The objectives of the Agenda are framed in the National Development Strategy 2030 • Roadmap offers a clear vision of the challenges facing the country in accelerating its sustainable development process and its insertion into an information society based on the intensive use of information and communication technologies • The agenda has five strategic pillars: 1) Infrastructure and access; 2) E-government and digital services; 3) ICT skills development;4) Productive development and innovation; and 5) Enabling environment

69. Available at 'Matriz Digital 2018-2022'
70. Available at 'Plan Vive Digital'
71. Available at 'Plan TIC 2018-2022. El Futuro Digital es de Todos'
72. Available at 'Plan Nacional de Telecomunicaciones 2015-2021'
73. Available at 'Agenda Digital de la República Dominicana 2016-2020'

TABLE 7

Source: BlueNote research

Digital Agendas in Latin America (cont.)

Country	Digital Plan	Publication date	Main highlights
Ecuador	Ecuador Digita[74]	2019	• Three pillars: 1) Ecuador connected; 2) Ecuador efficient and cyber secure; and 3) Ecuador innovative and competitive • Aims to deliver quality and more accessible prices, to rapidly advance online government, build smart cities and to implement a digital economy
	Broadband National Plan[75]	2011	• Aims to generate radioelectric spectrum uses to adapt new ways in the industry that provide wireless services, to ensure efficient use of the spectrum and healthy competition and meet the demand for services and promote price reduction • Main objectives are to improve the quality of life of Ecuadorians through the use, introduction and appropriation of new information and communication technologies, to reduce access prices to the broadband internet service, to promote the deployment of networks and services nationwide and to allow all Ecuadorians access to broadband services
Guatemala	Digital Nation	2017	• The objective is to promote actions with which to reduce the digital gap, as well as improve internet services and access to information technologies • It includes the following main axes: health, education, security, development and transparency
Mexico	National Digital Strategy (EDN)[76]	2013	• Action plan to build a 'Digital Mexico', in which technology and innovation contribute to achieving the great development goals of the country • Identifies five key objectives: 1) Government transformation; 2) Digital economy; 3) Educational transformation; 4) Universal and effective health; and 5) Civic innovation and citizen participation • Identifies five main enablers: 1) Open data; 2) Legal framework; 3) Interoperability and digital identity; 4) Inclusion and digital skills; and 5) Connectivity
Peru	Peruvian Digital Agenda 2.0[77]	2011	• Public policy that identifies ICT as a vehicle in the search for a more equitable and sustainable human development • The new Digital Agenda is being prepared with the joint participation of the civil society, the academy and the business sector • Eight key objectives are identified: 1) Access by the population of urban rural areas to the ICT; 2) Develop ICT skills; 3) Use of ICTs that ensure social inclusion, access to social services that allow the full exercise of citizenship and human development; 4) Promote research and development and innovation (R&D&I); 5) Increase productivity and competitiveness through innovation in the production of goods and services; 6) Develop a competitive and innovative national ICT industry with international presence; 7) E-government; and 8) Insert the Digital Agenda into the local, regional, sectorial and national policies • CODESI is the Permanent Multisectoral Commission for the monitoring and evaluation of the plan

74. Available at 'Ecuador Digital'
75. Available at 'Plan Nacional de Banda Ancha'
76. Available at 'Estrategia Nacional Digital'
77. Available at 'Plan para el Desarrollo de la Sociedad de la Información y el Conocimiento, Agenda Digital 2.0'

Country	Digital Plan	Publication date	Main highlights
Uruguay	Digital Agenda Uruguay 2020[78]	2006	• The Digital Agenda Uruguay 2020 integrates the different priority initiatives in order to advance the country's digital transformation in an inclusive and sustainable manner, through the smart use of technologies • Four key pillars: 1) Social policy and inclusion: 2) Sustainable economic development; 3) Government management; and 4) Governance for the information society • Nine main objectives: 1) Digital skills for inclusive progress; 2) Innovation for social welfare; 3) Strategic investment in infrastructure; 4) Digital economy and innovation for competitiveness; 5) Smart management of environmental information and emergencies; 6) Proximity government; 7) Whole-of-government and smart government; 8) Trust and security in the use of digital technologies; and 9) Production of national ICT statistics • Uruguay has developed four digital agendas: 2006-2008, 2008-2010, 2010-2015, 2020

78. Available at 'Agenda Uruguay Digital 2020'

Latin-American sampled countries

SPECTRUM AUTHORITIES IN THE REGION

TABLE 8

Source: BlueNote research

Spectrum authorities in the region

Country	Authority	Liability
Argentina	• National Telecommunications Authority (ENACOM)	• Responsible for defining spectrum-related public policies (such as allocation and planning).
	• Secretariat of Information and Communication Technologies (SSeTIC)	• Promotes the updating and international coordination of the National Allocation Table for Radio Spectrum Ranges, with a view to the universalisation of internet and mobile services.
Brazil	• National Telecommunications Agency (ANATEL)	• Responsible for implementing the national telecommunications policy, representing Brazil in international telecommunication organisations and for managing the radio spectrum and the use of satellite orbits.
Chile	• Telecommunications Undersecretariat (SUBTEL)	• Agency under the Ministry of Transport and Telecommunications, responsible for coordinating, promoting, fostering and developing telecommunications in the country.
Colombia	• ICT Ministry (MinTIC)[79]	• Responsible for defining public policies and assigning spectrum licences.
	• National Spectrum Agency (ANE)[80]	• As the ICT ministry's technical advisor, is responsible for the allocation, planning, monitoring and control of the spectrum.
Costa Rica	• Science, Technology and Telecommunications Ministry (MICITT)[81]	• Governing body for telecommunications, responsible for formulating policies for the use and development of telecommunications. • In matters of spectrum use, it is responsible for approving or rejecting the technical criteria of the Superintendence of Telecommunications, on the award, extension, extinction, resolution, assignment, reassignment and rescue of concessions and permits for radio frequencies.[82]
	• Superintendence of Telecommunications (SUTEL)[83]	• A body attached to the Public Services Regulatory Authority, responsible for administering the National Telecommunications Fund, carrying out the contractual activity, managing its resources and budget, as well as for signing the contracts and agreements required for the performance of its functions. • It is responsible for regulating, applying, monitoring and controlling the legal framework for telecommunications. • It is responsible for monitoring and checking the efficient use of the radio spectrum, radio emissions, as well as the inspection, detection, identification and elimination of harmful interference and numbering resources, in accordance with the respective plans.[84] Spectrum allocation in Costa Rica is regulated through the National Frequency Allocation Plan, PNAF[85].

79. MinTIC: Ministerio de Tecnologías de la Información y las Comunicaciones (https://www.mintic.gov.co/portal/inicio/)
80. ANE: Agencia Nacional del Espectro (http://www.ane.gov.co/SitePages/Inicio.aspx)
81. MiCITT: Ministerio de Ciencia, Tecnología y Telecomunicaciones (https://micit.go.cr/)
82. Available at Ley 8660
83. https://sutel.go.cr/pagina/que-hacemos-0
84. Available at Ley 8660
85. https://sutel.go.cr/normatica/plan-nacional-de-atribucion-de-frecuencias-pnaf

Country	Authority	Liability
Dominican Republic	• Dominican Institute of Telecommunications (INDOTEL)[86]	• Responsible for ensuring the efficient use of the public domain radio spectrum in the country.
Ecuador	• Ministry of Telecommunications and the Information Society[87]	
	• Telecommunications Regulation and Control Agency (ARCOTEL)[88]	• Responsible for the administration, regulation and control of telecommunications and radio spectrum and their management, as well as the technical aspects of the management of media using radio spectrum frequencies or installing and operating networks.
Guatemala	• Ministry of Communications, Infrastructure and Housing (MICIVI)[89]	• Responsible for the formulation of policies and the enforcement of the legal regime applicable to the establishment, maintenance and development of the country's communication and transport systems, the use and development of radio frequencies and airspace. • To propose for adoption and implement the regulatory instruments for radio and television frequencies, telecommunications, post and telegraphs, ensuring their prompt, strict and efficient application. • To administer matters relating to the use and exploitation of the radio spectrum.
	• Telecommunications Superintendence (SIT)[90]	• As the ICT ministry's technical advisor, it is responsible for managing and supervising the use of the radio spectrum, which includes preparation of plans for the use of frequency ranges to optimise the use of the radio spectrum and to allow the introduction of new telecommunications technologies into the country, the preparation and updating of the NTFA[91] and the planning and execution of auctions of rights for use of radio frequencies, among other things.
Mexico	• Communications and Transport Secretariat (SCT)[92]	• Responsible for the public policies of the government and to include the National Spectrum Program in the National Development Plan.
	• Federal Institute of Telecommunications (IFT)[93]	• As technical body, it is responsible for managing, planning, regulating, promoting and monitoring the use, development and exploitation of the radio spectrum, networks and the provision of telecommunications and broadcasting services. The Institute has been active in various ITU-R forums, including Working Parties 5D, TG 5/1 and WRC.
Peru	• Ministry of Transportation and Communications (MTC)[94]	• Responsible for the design, formulation, coordination and evaluation of national policies and regulations on communications infrastructure and services as well as the evaluation, granting and recognition of rights in the field of telecommunications services through authorisations, licences, among other things.
Uruguay	• Regulatory Unit of Communication Services (URSEC)[95]	• Responsible for managing, defending and controlling the national radio spectrum and granting authorisations for its use.

86. INDOTEL: Instituto Dominicano de las Telecomunicaciones (https://www.indotel.gob.do/)
87. https://www.telecomunicaciones.gob.ec/
88. ARCOTEL: Agencia de Regulación y Control de las Telecomunicaciones (https://www.arcotel.gob.ec/)
89. MICIVI: Ministerio de comunicaciones, infraestructura y vivienda (http://www.civ.gob.gt/)
90. SIT: Superintendencia de Telecomunicaciones (https://sit.gob.gt/)
91. Available at Tabla Nacional de Atribución de Frecuencias (TNAF)
92. SCT: Secretaría de Comunicaciones y Transportes (https://www.gob.mx/sct/)
93. IFT: Instituto Federal de Telecomunicaciones (http://www.ift.org.mx/)
94. MTC: Ministerio de Transporte y Comunicaciones (https://www.gob.pe/mtc)
95. URSEC: Unidad Reguladora de los Servicios en Comunicaciones (https://www.gub.uy/unidad-reguladora-servicios-comunicaciones/)

ARGENTINA

TABLE 9

Source: CABFRA – Enacom Argentina (2019)

3.3-4.2 GHz range allocation - Argentina

Range	Allocation	Comments
3 300-3 340 MHz	FIXED RADIOLOCATION Amateur Amateur-Satellite Mobile	Protection of Radio Astronomy Service. National note N45. Currently not available for assignment.
3 340-3 376 MHz	FIXED RADIOLOCATION Amateur Amateur-Satellite Mobile	Protection of Radio Astronomy Service. National note N45. Frequency coordination in the fixed service. National note N52. Currently not available for assignment.
3 376-3 400 MHz	FIXED RADIOLOCATION Amateur Amateur-Satellite Mobile	Protection of Radio Astronomy Service. National note N45. Currently not available for assignment.
3 400-3 500 MHz	FIXED	Currently not available for assignment.
3 500-3 600 MHz	FIXED	Currently not available for assignment.
3 600-3 625 MHz	FIXED	
3 625-3 700 MHz	FIXED Fixed-satellite (FSS space-Earth)	
3 700-4 200 MHz	FIXED-SATELLITE (FSS space-Earth) Fixed	

BRAZIL

TABLE 10

Source: PADDF – Anatel Brazil (2018), Anatel (2020)

3.3-4.2 GHz range allocation - Brazil

Range	Allocation	Comments
3 300-3 400 MHz	RADIOLOCATION FIXED MOBILE Amateur	Allocated to FIXED and MOBILE, except aeronautical mobile. Footnote 5.429C of RR. Identified for IMT. Footnote 5.429D of RR. Resolution No. 688 of Nov 7/17. Resolution No. 697 of Aug 28/18. Resolution No. 711 of May 28/19.
3 400-3 500 MHz	IXED MOBILE Fixed-satellite (FSS space-Earth) Amateur	Allocation to MOBILE, except aeronautical mobile. Subject to agreement under No. 9.21. Footnote 5.431A of RR. Identified for IMT. Subject to agreement under No. 9.21. Footnote 5.431B of RR. Resolution No. 78 of Dec 18/98. Resolution No. 295 of Apr 19/02. Resolution No. 697 of Aug 28/18. Resolution No. 711 of May 28/19.
3 500-3 600 MHz	FIXED FIXED-SATELLITE (FSS space-Earth) MOBILE	Footnote 5.431A of RR. Subject to agreement under No. 9.21. Identified for IMT. Subject to agreement under No. 9.21. Footnote 5.431B of RR. Resolution No. 78 of Dec 18/98. Resolution No. 295 of Apr 19/02. Resolution No. 697 of Aug 28/18. Resolution No. 711 of May 28/19.
3 600-3 800 MHz	FIXED-SATELLITE (FSS space-Earth)	
3 800-4 200 MHz	FIXED FIXED-SATELLITE (FSS space-Earth)	Resolution No. 103 of February 26 1999.

TABLE 11

Source: PADDF – Anatel Brazil (2018), Anatel (2020)[102]

Channelling of the different services in 3.3-4.2 GHz range in Brazil

Regulation	Subject	Channelling
Resolution No. 78/98[96]	Approves the regulation on Frequency range Allocation Guidelines for wireless fixed access systems for the provision of STFC	3 400-3 425 MHz (10 MHz + 15 MHz) 3 425-3 450 MHz (15 MHz + 10 MHz) 3 500-3 525 MHz (10 MHz + 15 MHz) 3 525-3 550 MHz (15 MHz + 10 MHz)
Resolution No. 103/99[97]	Approves the regulation on Channelling and Conditions of Use for the 4 GHz range	3 824.5-3 969.5 MHz (29 MHz) 4 037.5-4 182.5 MHz (29 MHz) Rec ITU-R F 382-7
Resolution No. 295/02[98]	Assigns radio frequency ranges for use of Multimedia Communication Service (SCM) and STFC for use by the general public	3 450-3 500 MHz 3 550-3 600 MHz
Resolution No. 688/17[99]	Approves the regulation on Destination and Conditions of Use of Radio Frequencies for Auxiliary Broadcasting and Related Services (SARC), Television Replay (RpTV), Closed Circuit Television with Use of Radio link (CFTV), Limited Service Aeronautical Mobile (SLMA) and Limited Private Service (SLP), and of other provisions	Sub-range M 3 300-3 400 MHz (10 MHz)
Resolution No. 697/18[100]	Assigns and allocates radio frequency ranges to the Amateur Radio Service and approves the regulation on Conditions of Use of Radio Frequencies by the Amateur Radio Service	3 300-3 400 MHz 3 400-3 410 MHz 3 410-3 500 MHz
Resolution No. 711/19[101]	Approves the destination radio frequency ranges and approves the regulation on Conditions of Use for the 3.5 GHz Radio Frequency range	3 300-3 400 MHz (100 MHz) 3 400-3 500 MHz (100 MHz) 3 500-3 600 MHz (100 MHz) It is expected that the resolution will be soon updated to include 3.6-3.7 GHz

96. https://www.anatel.gov.br/legislacao/resolucoes/1998/315-resolucao-78
97. https://www.anatel.gov.br/legislacao/resolucoes/1999/412-resolucao-103
98. https://www.anatel.gov.br/legislacao/resolucoes/2002/107-resolucao-295
99. https://www.anatel.gov.br/legislacao/resolucoes/2017/954-resolucao-688
100. https://www.anatel.gov.br/legislacao/en/resolucoes/2018/1157-resolucao-697
101. https://www.anatel.gov.br/legislacao/en/resolucoes/2019/1285-resolucao-711
102. https://www.anatel.gov.br/legislacao/resolucoes/

CHILE

TABLE 12

Source: Subtel Chile (2006, 2010, 2011)[103], WRC-15, WRC-19

3.3-4.2 GHz range allocation - Chile

Range	Allocation	Comments
3 300-3 400 MHz	RADIOLOCATION MOBILE except aeronautical mobile Amateur Fixed	Allocated to MOBILE, except aeronautical mobile. Footnote 5.429C of RR. Identified for IMT. Footnote 5.429D of RR.
3 400-3 500 MHz	FIXED MOBILE except aeronautical mobile Fixed-satellite (FSS space-Earth)	Allocation to MOBILE, except aeronautical mobile. Subject to agreement under No. 9.21. Footnote 5.431A of RR. Allocated to MOBILE, except aeronautical mobile. Decree 156/10.
3 500-3 600 MHz	FIXED MOBILE except aeronautical mobile Fixed-satellite (FSS space-Earth)	Allocated to MOBILE, except aeronautical mobile. Decree 156/10.
3 600-3 700 MHz	FIXED MOBILE except aeronautical mobile Fixed-satellite (FSS space-Earth)	Allocated to MOBILE, except aeronautical mobile. Decree 156/10. Identified for IMT. Footnote 5.434 of RR.
3 700-4 200 MHz	FIXED FIXED-SATELLITE (FSS space-Earth) MOBILE except aeronautical mobile	

TABLE 13

Source: Technical Data Sheet Public Competitions for the Deployment of High-Speed Wireless Networks (LTE Advanced pro 5G or higher)[105]

Radio spectrum available for each of the four tenders - Chile

Range	Available spectrum	Duplexing	Number of blocks	Blocks' range width
700 MHz	703-713 and 758-768 MHz	FDD	1	20 MHz
AWS	1 755-1 770 and 2 155-2 170 MHz	FDD	1	30 MHz
3.5 GHz	3 300-3 400 and 3 600-3 650 MHz	TDD	15	10 MHz
mmWaves	25.9-27.5 GHz[104]			

103. Official Journal of the Republic of Chile 20060418. GENERAL PLAN FOR THE USE OF THE RADIO SPECTRUM
104. According to 'Resolución 42.665' of May 2020. Although, initially, the 25.9-27.5 GHz range has been announced for mmWaves, additional mmWaves could be used for 5G in the future
105. https://www.subtel.gob.cl/wp-content/uploads/2020/01/20200113_Texto_Ficha_Tecnica_consulta_ciudadana_5G.pdf

COLOMBIA

TABLE 14

Source: National Allocation Table – ANE Colombia (2019)

3.3-4.2 GHz range allocation - Colombia

Range	Allocation	Comments
3 300-3 400 MHz	MOBILE, except aeronautical mobile RADIOLOCATION Fixed Amateur	Allocated to MOBILE, except aeronautical mobile. Footnote 5.429C of RR. Identified for IMT. Footnote 5.429D of RR.
3 400-3 500 MHz	FIXED MOBILE, except aeronautical mobile Amateur	Allocation to MOBILE, except aeronautical mobile. Subject to agreement under No. 9.21. Footnote 5.431A of RR. Identified for IMT. Subject to agreement under No. 9.21. Footnote 5.431B of RR.
3 500-3 600 MHz	FIXED MOBILE, except aeronautical mobile	Identified for IMT. Subject to agreement under No. 9.21. Footnote 5.431B of RR.
3 600-3 700 MHz	FIXED MOBILE, except aeronautical mobile	Identified for IMT. Subject to agreement under No. 9.21. Footnote 5.434 of RR.
3 700-4 200 MHz	FIXED FIXED-SATELLITE (FSS space-Earth) MOBILE, except aeronautical mobile	Fixed services adopt channelisation plan defined in REC. ITU-R F.382 and REC. ITU-R F.635 (Tables 19 – 21).

COSTA RICA

TABLE 15

Source: PNAF – MICITT Costa Rica (2020)[106]

3.3-4.2 GHz range allocation - Costa Rica

Range	Allocation	Comments
3 300-3 400 MHz	FIXED MOBILE except aeronautical mobile RADIOLOCATION Amateur	Allocated to MOBILE, except aeronautical mobile. Footnote 5.429C of RR. Identified for IMT. Footnote 5.429D of RR. Allocated to FIXED and MOBILE, except aeronautical mobile. National note CR 076 of the NTFA.
3 400-3 625 MHz	FIXED FIXED-SATELLITE (FSS space-Earth) MOBILE	Allocated to IMT. National note CR 077.
3 625-4 200 MHz	FIXED FIXED-SATELLITE (FSS space-Earth)	Amended by Article 1 paragraph 1 of Executive Decree No. 36754 of August 1 2011, in order to recognize that frequency band for non-exclusive basis, according to PNAF dispositions.

106. http://www.pgrweb.go.cr/scij/Busqueda/Normativa/Normas/nrm_texto_completo.aspx?param1=NRTC&nValor1=1&nValor2=65675&nValor3=114460&param2=2&strTipM=TC&lResultado=13&strSim=simp

DOMINICAN REPUBLIC

TABLE 16

Source: PNAF – Indotel Dominican Republic (2020)[107]

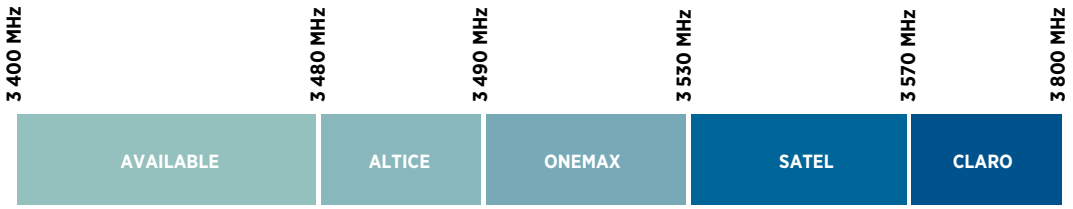
3.3-4.2 GHz range allocation - Dominican Republic

Range	Allocation	Comments
3 300-3 400 MHz	RADIOLOCATION MOBILE except aeronautical mobile FIXED	Allocated to FIXED and MOBILE, except aeronautical mobile. Footnote 5.429C of RR Identified for IMT. Footnote 5.429D of RR Allocated to MOBILE and identified for IMT. National note DOM50A.
3 400-3 500 MHz	FIXED MOBILE except aeronautical mobile Fixed-satellite (FSS space-Earth) Radiolocation	Allocation to MOBILE, except aeronautical mobile subject to agreement under No. 9.21. Footnote 5.431A of RR Allocated to MOBILE and identified for IMT. National note DOM50A
3 500-3 600 MHz	FIXED MOBILE except aeronautical mobile Fixed-satellite (FSS space-Earth) Radiolocation	Allocated to MOBILE and identified for IMT. National note DOM50A
3 600-3 700 MHz	FIXED MOBILE except aeronautical mobile Fixed-satellite (FSS space-Earth) Radiolocation	
3 700-4 200 MHz	FIXED FIXED-SATELLITE (FSS space-Earth) Mobile except aeronautical mobile	

ILLUSTRATION 12

Source: Indotel (2020)

Dominican Republic 3 400-3 600 MHz range allocation after 2019 refarming



107. GSMA-BMC - Range 3.5 Study – Questionnaire responses

ECUADOR

TABLE 17

Source: Arcotel Ecuador (2018)[108], WRC-15, WRC-19

3.3-4.2 GHz range allocation - Ecuador

Range	Allocation	Comments
3 300-3 400 MHz	MOBILE except aeronautical mobile Fixed	Allocated to MOBILE, except aeronautical mobile. Footnote 5.429C of RR. Identified for IMT. Footnote 5.429D of RR and National Note EQA.40.
3 400-3 500 MHz	FIXED MOBILE except aeronautical mobile	Allocation to MOBILE, except aeronautical mobile. Subject to agreement under No. 9.21. Footnote 5.431A of RR. Identified for IMT. Subject to agreement under No. 9.21. Footnote 5.431B of RR and National note EQA40.
3 500-3 600 MHz	FIXED MOBILE except aeronautical mobile	Identified for IMT. Subject to agreement under No. 9.21. Footnote 5.431B of RR and National note EQA40.
3 600-3 700 MHz	FIXED FIXED-SATELLITE (FSS space-Earth) MOBILE except aeronautical mobile Radiolocation	Use of 3600-4200 MHz range for fixed service links. National note EQA.25
3 700-4 200 MHz	FIXED FIXED-SATELLITE (FSS space-Earth) MOBILE except aeronautical mobile	Use of 3 600-4 200 MHz range for fixed service links. National Note EQA.25.

108. RCOTEL (2017). National Frequency Plan

GUATEMALA

TABLE 18

Source: TNAF – SIT Guatemala (2020)[109], WRC-19

3.3-4.2 GHz range allocation - Guatemala

Range	Allocation	Comments
3 300-3 400 MHz	RADIOLOCATION FIXED MOBILE except aeronautical mobile	Allocated to FIXED and MOBILE, except aeronautical mobile. Footnote 5.429C of RR. Identified for IMT. Footnote 5.429D of RR.
3 400-3 500 MHz	FIXED MOBILE except aeronautical mobile Radiolocation	Allocation to MOBILE, except aeronautical mobile. Subject to agreement under No. 9.21. Footnote 5.431A of RR. Identified for IMT. Subject to agreement under No. 9.21. Footnote 5.431B of RR and National note GTM-18. Amateur-Satellite service may be operated in 3 400-3 410 MHz on condition that it does not cause interference to other services to which the range is allocated. National note GTM-43.
3 500-3 600 MHz	FIXED MOBILE except aeronautical mobile Radiolocation	Identified for IMT. Subject to agreement under No. 9.21. Footnote 5.431B of RR and national note GTM-18.
3 600-3 700 MHz	FIXED FIXED-SATELLITE (FSS space-Earth) Radiolocation	The operation of FSS has priority over other allocated radio services. National note GTM-23. The operation of the mobile service within the national territory is not considered. National note GTM-24.
3 700-4 200 MHz	FIXED FIXED-SATELLITE (FSS space-Earth)	The operation of FSS has priority over other allocated radio services. National note GTM-23. The operation of the mobile service within the national territory is not considered. National note GTM-24.

109. https://sit.gob.gt/gerencia-de-frecuencias/frecuencias/tabla-nacional-de-atribucion-de-frecuencias/

MEXICO

TABLE 19

Source: CNAF – IFT Mexico (2020) [110]

3.3-4.2 GHz range allocation - Mexico

Range	Allocation	Comments
3 300-3 400 MHz	FIXED MOBILE except aeronautical mobile Amateur	Allocated to FIXED and MOBILE, except aeronautical mobile. Footnote 5.429C of RR. Identified for IMT. Footnote 5.429D of RR
3 400-3 500 MHz	FIXED FIXED-SATELLITE (FSS space-Earth) Amateur Mobile	Identified for IMT. Subject to agreement under No. 9.21. Footnote 5.431B of RR.
3 500-3 600 MHz	FIXED FIXED-SATELLITE (FSS space-Earth) Mobile except aeronautical mobile Radiolocation	Identified for IMT. Subject to agreement under No. 9.21. Footnote 5.431B of RR.
3 600-3 700 MHz	FIXED-SATELLITE (FSS space-Earth) Radiolocation	
3 700-4 200 MHz	FIXED-SATELLITE (FSS space-Earth) Fixed	

110. http://cnaf.ift.org.mx/

PERU

TABLE 20

Source: PNAF – MTC Peru (2019)

3.3-4.2 GHz range allocation - Peru

Range	Allocation	Comments
3 300-3 400 MHz	MOBILE except aeronautical mobile RADIOLOCATION FIXED Amateur	Identified for IMT. National notes P51A and P73A.
3 400-3 500 MHz	MOBILE except aeronautical mobile FIXED FIXED-SATELLITE (FSS space-Earth) Amateur Radiolocation	Allocation to MOBILE, except aeronautical mobile. Subject to agreement under No. 9.21. Footnote 5.431A of RR. Identified for IMT. Subject to agreement under No. 9.21. Footnote 5.431B of RR. National notes P47, P51A and P73.
3 500-3 600 MHz	MOBILE except aeronautical mobile FIXED Fixed-satellite (FSS space-Earth) Radiolocation	Identified for IMT. Subject to agreement under No. 9.21. Footnote 5.431B of RR. National notes P51A and P73.
3 600-3 700 MHz	MOBILE except aeronautical mobile FIXED Fixed-satellite (FSS space-Earth) Radiolocation	Identified for IMT. National notes P51A and P73B.
3 700 – 3 800 MHz	MOBILE except aeronautical mobile FIXED FIXED-SATELLITE (FSS space-Earth)	Identified for IMT. National notes P51A and P73B.
3 800 – 4 200 MHz	FIXED FIXED-SATELLITE (FSS space-Earth) Mobile except aeronautical mobile	

URUGUAY

TABLE 21

Source: CNAF – URSEC Uruguay (2020)[111], WRC-19

3.3-4.2 GHz range allocation - Uruguay

Range	Allocation	Comments
3 300-3 400 MHz	FIXED MOBILE except aeronautical mobile Amateur	Allocated to FIXED and MOBILE, except aeronautical mobile. Footnote 5.429C of RR. Identified for IMT. Footnote 5.429D of RR
3 400-3 500 MHz	FIXED FIXED-SATELLITE (FSS space-Earth) Amateur Mobile	Identified for IMT. Subject to agreement under No. 9.21. Footnote 5.431B of RR.
3 500-3 600 MHz	FIXED FIXED-SATELLITE (FSS space-Earth) Mobile except aeronautical mobile Radiolocation	Identified for IMT. Subject to agreement under No. 9.21. Footnote 5.431B of RR.
3 600-3 700 MHz	FIXED-SATELLITE (FSS space-Earth) Radiolocation	
3 700-4 200 MHz	FIXED-SATELLITE (FSS space-Earth) Fixed	

111. https://www.gub.uy/unidad-reguladora-servicios-comunicaciones/comunicacion/publicaciones/cuadro-atribucion-frecuencias

International benchmark countries

CANADA

Allocation and current status of the 3.3-4.2 GHz band

In Canada only part of the 3.5 GHz range, 3 500-3 700 MHz, is already allocated to mobile services, but this primary allocation is shared with other services as described below.

- 3.30-3.45 GHz band: Radiolocation and amateur services, with focus on the international notes of R.R. 5.433, 5.149 and 5.282[112] and national note C5[113].
- 3.45-3.475 GHz band: Fixed, radiolocation and amateur services, with focus on the international note of R.R. 5.433 and national note C15 (in certain locations in Canada the radiolocation service has priority over the fixed service in the 3 450-3 500 MHz band, and over the mobile service in the 3 475 to 3 500 MHz band. ISED Canada; legally, the Department of Industry, will identify the general area of radiolocation system operation through spectrum policy).
- 3 475-3 5000 GHz band: Fixed, mobile and radiolocation services, with focus on the international note of R.R. 5.433 and national note C15.
- 3.50-3.65 GHz band: Fixed, fixed satellite (space-to-Earth) and mobile services, with focus on the national note C20 (in the frequency band 3.50-3.65 GHz, the fixed satellite Earth-stations will be located in areas so as not to constrain the implementation of fixed wireless access and mobile systems).
- 3.65-3.70 GHz band: Fixed, fixed satellite (space-to-Earth) and mobile services, with focus on the national note C33.
- 3.7-4.2 GHz band: Fixed satellite (space-to-Earth) service.

Other considerations related to the allocation and use of the 3.3-4.2 GHz range are described below.

- Even though in Canada, the 3.1-3.5 GHz band is allocated to radiolocation on a primary basis; however, radiolocation is not used in the 3 475-3 500 MHz portion of the band.
- Radiolocation use in the 3 300-3 450 MHz band is limited to government use.
- The 3 400-3 475 MHz portion of the band is reserved for aeronautical and maritime radars, but currently has limited use.
- The 3 450-3 475 MHz band is also allocated to fixed services on a co-primary basis.
- The 3 475-3 650 MHz band is currently allocated to fixed and mobile services on a co-primary basis (radiolocation and fixed satellite services are other co-primary services in separate parts of the band), and is being used for fixed wireless access systems as flexible-use licences have not yet been issued.
- Although the 3 650-3 700 MHz band has co-primary allocations for fixed, mobile and fixed satellite services in Canada, it is primarily used for fixed PTM services. Licensees can use this spectrum for both fixed and mobile applications. These licences are issued on a Tier 4 basis for a one-year term and can be renewed annually.
- The 3 650-3 700 MHz band is currently licensed on a shared "all-come, all-served" basis. That is, there is no limitation on the number of WBS licences that may be issued for the same spectrum and geographic area, which has resulted in some challenges (i.e. coordination between licensees). At this time, there are 927 licences issued to 281 licensees. The majority of licensees are using the spectrum to provide broadband internet services, many to rural and remote communities. There are also several old FSS Earth stations in the 3 650-3 700 MHz band. The current band plan for WBS in Canada includes two unpaired 25 MHz blocks with restrictions on the use of the upper block in urban areas to equipment that employs unrestricted contention-based protocols.
- The 3 700-4 200 MHz band is licensed for use by fixed satellite service for the delivery of telephony and internet in northern and remote communities. The band is the downlink portion of 3.5 GHz range fixed satellite systems, paired with 5,925-6,425 MHz as the uplink. However, the Earth stations can be used in either the uplink/downlink configuration, or as receive-only (i.e. space-to-Earth only). Most of the receive-only fixed satellite service usage within Canada falls under license-exempt authorisation. Therefore, in most cases ISED does not have any information about the location or parameters of any of those receiver stations. In addition to these services, there are unlicensed broadcast receivers that are currently being used to receive TV programming from satellites, which is then distributed over cable infrastructure. Broadcast studios also use unlicensed receivers for programming. There are currently limited terrestrial fixed PTP links in operation in the 3 700 to 4 200 MHz band, which are mainly used for backhauling.

112. https://www.itu.int/pub/R-REG-RR-2016

113. For the exclusive use of the Government of Canada

Public policy on the 3.5 GHz range

In June 2019 ISED initiated a consultation on a policy and licensing framework for the auction of spectrum licences in the 3 450-3 650 MHz[114] band.

Subsequent to the initial consultation entitled SLPB-004-18, "Consultation on Revision to the 3 500 MHz Band to Accommodate Flexible Use and Preliminary Consultation on Changes to the 3 800 MHz Band"[115], released in June 2018, and the resulting policy decisions announced in the document SLPB-001-19, "Decision on Revisions to the 3 500 MHz Band to Accommodate Flexible Use and Decisions on Preliminary Changes to the 3 800 MHz Band"[116] (referred to as the 2019 Decision), released on June 5, 2019, ISED is now seeking comments on the policy and licensing considerations including auction format, rules and processes, as well as on conditions of license for spectrum in the 3 500 MHz band. ISED is also proposing a set of updated conditions of license intended to cover all existing fixed wireless access licences in the 3 400-3 700 MHz band.

In the 3 500 MHz consultation, ISED sought comments on its proposal to add a primary mobile allocation to the 3 450-3 475 MHz band, remove the radiolocation allocation in the 3 450-3 500 MHz band, and suppress footnote C15 in the Canadian NTFA. ISED is adopting the changes to the NTFA. It is also adopting a flexible use licensing model for fixed and mobile services in the 3 450 - 3 475 MHz band, which will provide them with the ability to issue flexible use licences in a 200 MHz frequency range from 3 450-3 650 MHz.

ISED is not establishing a geographically differentiated spectrum utilisation policy with respect to the use of the spectrum for mobile and fixed services. Consequently, the department will not establish a rural or urban classification of Tier 4 service areas. A new flexible use band plan and licensing framework will be developed after future consultations. Until such time, all licences in the 3 500 MHz band will remain fixed only licences. As part of the Outlook Consultation, ISED received general comments on different licensing approaches and auction formats. ISED recognises that there are a number of options to consider when selecting the format for a spectrum auction, each with its own set of advantages and disadvantages. To better understand the priorities of stakeholders with regards to auction format and timing, in the 3 500 MHz Consultation, ISED sought comments on the importance of price discovery in a future licensing process, noting that an auction format with such capabilities would require more time to implement, resulting in a later auction start date. ISED will develop and consult on a proposed auction format that includes price discovery as part of the consultation on the policy and licensing framework for flexible use licences in the 3 500 MHz band.

Takeaways

An aspect to be highlighted is that ISED will no longer accept new first-come, first-served spectrum licence applications in the 3 475-3 650 MHz band, considering the significant reorganisation of current licensees' spectrum holdings, and the intention to issue flexible use licences in this band following an upcoming auction.

Another issue to be highlighted is that given the support expressed in the comments received, proposals developed under the consultation on a policy and licensing framework will include an auction format with price discovery. Although the inclusion of price discovery may preclude faster and simpler licensing processes, there are clear benefits with respect to reducing uncertainty about value of spectrum.

114. https://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/SLPB-002-19EN.pdf/$file/SLPB-002-19EN.pdf
115. https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11401.html
116. http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11437.html

FINLAND

Allocation and current status of the 3.3-4.2 GHz band

The 3 300 to 4 200 MHz frequency band is already allocated to mobile services, but this primary allocation is shared with other services as described below.

- 3.3-3.4 GHz band: Radiolocation
- 3.4-4.2 GHz band: Fixed, mobile, fixed satellite (space-to-Earth) and amateur services

Other considerations related to the allocation and use of the 3.3-4.2 GHz range are described below.

- The 3 300-3 400 MHz band is primarily used to provide radar services with radiated peak power max 100 dBW and military use
- The 3 400-3 408 MHz band is used to provide amateur services with maximum transmitter power in the elementary class 30 W
- The 3 400-3 800 MHz band is used to provide fixed and mobile services with terminals exempt from licensing
- The 3 800-4 200 MHz band is used to provide fixed satellite (space-to-Earth) services with non-standardised Earth stations and VSAT
- The 3 810-3 955 MHz, 3 824.5-3 969.5 MHz, 4 023-4 168 MHz and 4 037.5-4 182.5 MHz bands are used to provide fixed radio links with channel plan according to ITU-R F.382 and transmitter power max 10 W
- The 3 930–4 170 MHz band is used to provide fixed radio links with channel plan according to CEPT Recommendation ERC/REC 12-08 Annex A
- Although the Radio Frequency Regulations, issued in Helsinki on 9 January 2019, in Finland, establishes this frequency allocation and use, the planned use of the 3 410-3 800 MHz band will be in accordance with the results of the auction that ended on 1 October 2018

Public policy on the 3.5 GHz range

The Finnish government has regulated the auction (917/2014) in the 3 410-3 800 MHz frequency band, establishing that in the 3 410-3 600 MHz band, two 60 MHz bands and one 70 MHz band would be auctioned. Within this frequency band, no more than one frequency spectrum can be awarded to any company or entity. The government decreed changes in the use of radio frequencies and in the frequency plan (1246/2014) and set restrictions on the use of frequency bands for mobile networks in the following geographical areas: A (rectangle including the municipalities of Espoo, Kauniainen, Helsinki and Vantaa), B (circle with a radius of 4 km including the following municipalities or parts thereof: Lempäälä, Kangasala and Tampere), C (circle with a radius of 4 km comprising the following municipalities or parts thereof: Pirkkala and Tampere) and D (triangle comprising the following municipalities or parts thereof: Haukipudas, Kiiminki and Oulu). It was established that, for product development, testing and educational use to provide electronic communications services in airborne systems, restrictions would apply to the following frequencies within the areas defined as such: Range A: 3 600-3 670 MHz band, Ranges B and C: 3 670-3 730 MHz band and Range D: 3 730-3 800 MHz band. Commercial use of the frequency band would begin in early January 2019 when other uses of the frequency band had ceased, which is mandatory.

TABLE 22

Source: Ministry of Transport and Communications (LVM) (2018)[117]

Frequencies Plan / blocks - Finland

Spectrum Block	Auction Label	Bandwidth (MHz)	Frequency (MHz)
A	A	130	3 410-3 540
B	B	130	3 540-3 670
C	C	130	3 670-3 800

117. https://www.lvm.fi/en/-/spectrum-auction-concluded-984712

Auction structure and results

According to Article 8 of the Act, licences for new mobile networks can be allocated by a comparative procedure or using the auction method. It was decided to auction the band for commercial use. The initial price for the spectrum to be auctioned would be EUR 16,000,000 for 60 MHz and EUR 19,000,000 for 70 MHz in the 3 410-, 600 MHz band, per frequency band. The initial price for the spectrum to be auctioned would be EUR 4,000,000 for 60 MHz and EUR 5,000,000 for 70 MHz in the 3 600-3 800 MHz frequency band, per frequency band.

The starting price was determined by considering the auctioned prices of similar frequency auctions in Europe, the actual prices of the 700 MHz and 800 MHz frequencies previously auctioned in Finland and their relation to the sales prices in other EU countries for the 3 400-3 800 MHz band. In addition, the assessment takes into account the exceptional use of Finnish mobile data compared to other EU countries, the nationality of the spectrum to be auctioned, the duration of the license, the availability of terminals at present and uncertainty about the timing of frequency availability. Limitations on the technical availability of frequencies (restrictions on frequency use in Russia) have also been considered. Current restrictions on spectrum use in Russia reduce the current economic value of frequencies in Finland.

The company or entity registered for the auction should pay EUR 40,000 to cover the costs of organising the auction. The license fee shall be paid in five equal annual instalments from the date of issuance of the licence.

The auction of 3.5 GHz spectrum arranged by the Finnish Communications Regulatory Authority was completed in five days starting on 26 September and was concluded on 1 October 2018. The 130 MHz licences were awarded to the three players in place. The winning operators were Telia Finland Oyj, Elisa Oyj and DNA Oyj. Overall, the auction raised EUR 77.6 million, a fairly reasonable amount, in line with government base prices. The price of a MHz per PoP for 10 years was EUR 2.4 c. The same amount of spectrum was proposed for sale in three licences that will be valid for a 15-year period from 1 January 2019 to 2033.

TABLE 23

Source: LVM (2018)[118]

Auction results - Finland

Frequency bands	Winner	Winning bid
3 410-3 540 MHz (A)	Telia Finland Oyj	€ 30,258,000
3 540-3 670 MHz (B)	Elisa Corporation	€ 26,347,000
3 670-3 800 MHz (C)	DNA Plc	€ 21,000,000

Takeaways

In Finland 390 MHz were licensed in the 3.4-3.8 GHz range to three operators, each having received 130 MHz; the amount of spectrum which has been awarded is a base for the 5G development, based on which verticals can be promoted.

Another aspect to highlight is that the arrangement of multiple frequency bands to be auctioned avoids, on the one hand, the weakening of competition and, on the other hand, the concentration of the spectrum, by ensuring that no one company can acquire a much larger number of frequencies.

An auction model with simultaneous price increase and multiple bids is very suitable for auctioning in this frequency range. The auction model chosen offers operators the opportunity to value each frequency band individually, even more so when the availability of some frequency bands has more geographic usage restrictions than others.

118. https://www.lvm.fi/en/-/spectrum-auction-concluded-984712

USA

Allocation and current status of the 3.3-4.2 GHz band

In the United States only part of the 3.3-4.2 GHz range, 3 550-3 700 MHz, is already allocated to mobile services, but this primary allocation is shared with other services as described below.

- 3.3-3.5 GHz band: Allocated in the Federal Table (FT) to radiolocation service, with focus on the national notes US108, US342 and G2; additionally, the band is allocated in Non-Federal Table (NFT) to amateur and radiolocation services, with focus on the national notes US108 and US342 and international note of R.R. 5.282.
- 3.50-3.55 GHz band: Allocated in the FT to radiolocation and aeronautical radio navigation (ground-based) services, with focus on the national notes G59 and G110; additionally, the band is allocated in NFT to radiolocation service.
- 3.55-3.65 GHz band: Allocated in the FT to radiolocation and aeronautical radio navigation (ground-based) services, with focus on the national notes G59, G110 and US105, US107, US245 and US433. Additionally, the 3.55-3.60 GHz band is allocated in NFT to fixed and mobile services, except aeronautical mobile services, with focus on the national notes US105 and US433 and the 3.6-3.65 GHz band is allocated in NFT to fixed, fixed satellite (space-to-Earth) and mobile services, except aeronautical mobile services, with focus on the national notes US107, US245, US105 and US433.
- 3.65-3.70 GHz band: Has no allocation in the FT but particular focus on the national notes US109 and US349; additionally, the 3.65-3.7 GHz band is allocated in NFT to fixed, fixed satellite (space-to-Earth) and mobile services, except aeronautical mobile services, with particular focus on the national notes NG169, NG185, US109 and US349.
- 3.7-4.2 GHz band: Allocated in the US exclusively for non-federal use on a primary basis for fixed and fixed satellite (space-to-Earth) services, with focus on the national note NG457A.

Other considerations related to the allocation and use of the 3.3-4.2 GHz range are described below.

- The 3 300-3 500 MHz band is primarily used to provide private land mobile service according to number 90 from the Code of Federal Regulations (CFR)[119] and amateur radio service according to number 97 from CFR.
- The 3 500-3 550 MHz band is primarily used to provide private land mobile service according to number 90 from CFR.
- The 3 550-3 600 MHz band is primarily used to provide citizens broadband radio service according to number 96 from CFR.
- The 3 600-3 700 MHz band is primarily used to provide satellite communications service according to number 25 from CFR and citizens broadband radio service according to number 96 from CFR.
- The 3 700-4 200 MHz band is primarily used to provide satellite communications service according to number 25 from CFR and fixed microwave band service according to number 101 from CFR. For fixed service, 20 MHz paired channels are assigned for PTP common carrier or private operational fixed microwave links.

119. The Code of Federal Regulations (CFR) annual edition is the codification of the general and permanent rules published in the Federal Register by the departments and agencies of the Federal Government produced by the Office of the Federal Register (OFR) and the Government Publishing Office.

Public policy on the 3.5 GHz range

In 2015, the FCC adopted rules for shared commercial use of the 3.5 GHz band. It created a three-tiered access and authorisation framework to coordinate shared federal and non-federal use of the band.

In June 2017, CTIA and T-Mobile filed petitions for rulemaking, which asked the commission to re-examine several of the Part 96 rules related to Priority Access Licenses (PALs). CTIA proposed several changes to the PAL licensing rules, including much larger licence areas, longer license terms, and renewability. T-Mobile supported CTIA's proposals and made additional proposals, including changes to the amount of spectrum available for PALs and to the technical rules governing the 3.5 GHz band.

On 24 October 2017, the commission issued a Notice of Proposed Rulemaking seeking comment on potential changes to the PAL rules, including significantly larger geographic licence areas, longer license terms, PAL renewability, and changes to the way in which PALs are assigned and auctioned. The commission also sought comment on relaxing the emissions limits for Citizens Broadband Radio Service Devices (CBRSD) and/or End User Devices to allow operation over wider bandwidths without power reduction.

This year, the commission looks forward to initiating two mid-band spectrum auctions: the 3.5 GHz auction on 25 June 2020, and an auction in the 3.7-4.2 GHz band in the latter part of 2020.

FCC created a three-tiered access and authorisation framework to coordinate shared federal and non-federal use of the band as described below.

- Incumbents comprise the first tier (Incumbent Access) and receive protection from all other users;
- PALs, the second tier (Priority Access); and
- General Authorised Access (GAA), the third tier.

The commission adopted service and technical rules governing the 3.5 GHz band as the new Part 96 of its rules[120].

- Over half of the band —a minimum of 80 MHz— is reserved for GAA use.
- PALs receive protection from GAA operations but must protect and accept interference from incumbents.
- GAA is licensed-by-rule and must avoid causing harmful interference to higher tier users and accept interference from all other users, including other GAA users.
- GAA users can operate throughout the entire 150 MHz of the 3.5 GHz band on any frequencies not in use by PALs.
- Automated frequency coordinators, known as Spectrum Access Systems (SAS), will coordinate operations between and among users in different access tiers.

By public notice, the commission seeks comment on the procedures to be used for Auction 105, the auction of PALs in the 3 550-3 650 MHz band.

- Bidding in the auction is scheduled to commence on 25 June 2020.
- Auction 105 will offer seven PALs in each county-based licence area.
- Each PAL consists of a 10 MHz unpaired channel within the 3 550-3 650 MHz band.
- The auction will offer a total of 22,631 PALs.
- PALs are 10-year renewable licences.
- Priority Access Licensees may hold up to four 10 MHz channel licences (out of a total of seven) within the band in any licence area at any given time.
- A frequency coordinator (SAS) will assign the specific channel for a particular licensee on a dynamic basis. Individual PALs will not be identified by specific spectrum blocks.
- Although priority access licensees may request a particular channel or frequency range from an SAS following the auction, bidders should be mindful that licensees are not guaranteed a particular assignment.
- Potential bidders should also understand that an SAS may dynamically reassign a PAL to a different channel as needed to accommodate a higher priority incumbent access user.
- An SAS will "assign geographically contiguous PALs held by the same priority access licensee to the same channels in each geographic area" and "assign multiple channels held by the same priority access licensee to contiguous frequencies within the same licence area," to the extent feasible. However, an SAS may temporarily reassign individual PALs to non-contiguous channels to the extent necessary to protect incumbent users from harmful interference or if necessary, to perform its required functions.
- Each priority access licensee must register its CBRSDs with an SAS before operating those devices in the band.

120. 47 CFR, Part 96. While the Commission adopted a complete set of rules and policies for commercial use of the 3.5 GHz band in the 2015 Report and Order, it also determined that a few focused issues required further record development, and simultaneously released the 2015 FNPRM. The Commission resolved these issues in its 2016 Report and Order. At the same time, the Commission addressed multiple petitions for reconsideration of the 2015 Report and Order in a simultaneously released Order on Reconsideration. See generally Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band, GN Docket No. 12-354, Order on Reconsideration and Second Report and Order, 31 FCC Rcd 5011 (2016) (2016 Order on Reconsideration and 2016 Report and Order, respectively).

- A CBRSD registration includes its geographic location, antenna height, CBRSD class, requested authorisation status, FCC identification number, call sign, user contact information, air interface technology, unique manufacturer's serial number, sensing capabilities (if supported), and information on its deployment profile.
- An SAS relies on this information to coordinate access for priority access licensees and GAA users, and an SAS administrator may charge priority access licensees and GAA users a reasonable fee for its services.
- The commission proposes to conduct Auction 105 using an ascending clock auction design, in which bidders indicate their demands for generic licence blocks in specific geographic areas —in this case, counties. The proposed clock auction format would proceed in a series of rounds, with bidding being conducted simultaneously for all spectrum blocks in all counties available in the auction.

The FCC believe that increased terrestrial use of the band is appropriate to meet their mandate under the MOBILE NOW Act to identify (with the National Telecommunications and Information Administration [NTIA]) 255 MHz of spectrum for mobile and fixed wireless broadband use. The FCC proposed to amend 47 CFR parts 1, 2, 25, and 27 including the Mid-Band Flexible Use Service in the 3.7-4.2 GHz band. Consequently, they ordered to amend Section 2.106, the NTFA, by revising page 41 and, under "NON-FEDERAL GOVERNMENT (NG) FOOTNOTES," adding footnote NG182 to read as follows:

"NG182 In the band 3.7-4.2 GHz, the following provisions shall apply to geostationary satellite orbit (GSO) Fixed satellite service (space-to-Earth) operations: (a) Space stations authorized prior to, or authorized as a result of an application filed prior to, June 21, 2018 may continue to operate on a primary basis, but no applications for new space station authorizations or new petitions for market access shall be accepted for filing after that date, other than applications by existing operators in the band seeking to make more efficient use of the band. Applications for extension, cancellation, replacement, or modification of existing space station authorizations in the band will continue to be accepted and processed normally. (b) Earth station operations shall not claim protection from terrestrial stations, unless the requirements of 47 CFR § 25.203(n) are satisfied."

In the same way, the commission ordered to amend Section 25.203 by adding paragraph (n) to read as follows:

"(n) Earth stations operating in the 3 700 - 4 200 MHz band shall receive interference protection from terrestrial stations only to the extent that (1) the Earth station was operational as of April 19, 2018 (2) the Earth station was licensed or registered (or had a pending application for license or registration) in the IBFS database as of October 17, 2018, and (3) the operator timely certified the accuracy of information on file with the Commission. Earth stations failing to satisfy any of the above may continue to operate, but such operations shall be on an unprotected basis."

Finally, the commission ordered to amend Section 27.13 by adding paragraph (m) to read as follows: "(m) 3.7-4.2 GHz band. Authorizations for the 3.7-4.2 GHz band will have a term not to exceed 15 years from the date of issuance or renewal."

On the basis of the FCC mandate, the 3.7-4.2 GHz band is allocated on a primary basis for fixed, fixed satellite (space-to-Earth) and mobile services, except aeronautical mobile services, with focus on the national notes NG180 and NG182. The 3.7-4.2 GHz band would be primarily used to provide satellite communications service according to number 25 from CFR, wireless communications according to number 27 from CFR and fixed microwave band service according to number 101 from CFR.

Takeaways

One aspect to highlight is that the allocation of the 3.7-4.2 GHz band balances the joint goals of making spectrum available for new wireless uses while also balancing desired speed to the market, efficiency of use, and effectively accommodating incumbent fixed satellite service, fixed service and mobile service operations in the band.

The co-channel sharing of spectrum between the FSS and mobile systems would be complicated because the movement of the devices would require analyses and interference mitigation to FSS Earth stations in the 3.7-4.2 GHz band over many locations within any given geographic area. In addition, because the 3.5 GHz range satellites are in geostationary orbit approximately 36,000 km above the equator, the signals received at the Earth stations are extremely weak. This means that terrestrial mobile operations could cause harmful interference to the Earth station receivers over large distances absent of adequate protection.

UNITED KINGDOM

Allocation and current status of the 3.3-4.2 GHz band

In April 2018, together with 2.3 GHz band, the Office of Communications (Ofcom) awarded 3.4 GHz spectrum. The names of the winning bidders to whom licences were granted are the following.

TABLE 24

Source: Ofcom

Auction results - United Kingdom 2018

Winning bidders to whom licence was granted	Frequency bands
EE Limited	3 540-3 580 MHz
Hutchinson 3G UK Limited	3 460-3 480 MHz
Telefonica UK Limited	2 350-2 390 MHz
	3 500-3 540 MHz
Vodafone Limited	3 410-3 460 MHz

At present, frequencies in the 3.6-3.8 GHz band are used for fixed links, FSS (to receive space-to-Earth transmissions) and wireless solutions (provided by UK Broadband) (Ofcom, 2019)[121].

In October 2017, Ofcom published a statement which confirmed that, in order to facilitate deploying future mobile services in the band across the UK, Ofcom would vary existing Permanent Earth Station (PES) licences and grants of Recognised Spectrum Access (RSA) such that we would no longer take satellite Earth stations with a receiver component in the band into account for frequency management purposes from 1 June 2020. Ofcom also said it would revoke fixed links licences with a notice period of five years, but would aim for fixed links operations to migrate out of the band by June 2020 where possible. In February 2018, an update was published setting out the decisions which were taken on individual licences and grants. Ofcom issued notices to revoke all fixed links licences, effective on 23 December 2022. Ofcom varied 12 PES licences and grants of RSA with an effective date of 1 June 2020, and one grant of RSA with an effective date of 1 September 2020.

The effect of these decisions is that spectrum will be available to enable future mobile services in the 3.6-3.8 GHz band to be deployed in many areas from June 2020, but not necessarily nationwide before the end of 2022. It was also noted that Ofcom would aim for fixed links operations to migrate to alternative frequencies or technologies by June 2020 where possible.

Given the notice periods for the revocation of fixed link licences and variation of PES licences and grants of RSA, there may be some constraints on new use of this spectrum in some areas of high population, such as the south-east of England and parts of the Midlands, in the intervening period following the award. However, the spectrum is not being used for fixed links and/or satellite services in large parts of the UK. As a result, there are many areas of the UK, such as most of the north of England, southern Scotland, Northern Ireland and Wales, where future use by licensees would only be expected to be negligibly affected by maintaining existing authorisations, if at all. Spectrum could be useable in those areas immediately after an award.

UK telecoms regulator, Ofcom, has announced that the next tranche of 5G frequencies will be made available to operators during 2020. The spectrum consists of 80 MHz of the 700 MHz band and 120 MHz in the 3.6-3.8 GHz band. The 700 MHz is a lot more valuable to operators because it covers much greater distances than the higher frequency spectrum. Thus, Ofcom is proposing a reserve price of up to GBP 240 million per 2×5 MHz lot of that, compared to a reserve price of up to GBP 25 million for each 5 MHz lot of 3.6-3.8 GHz spectrum. Ofcom is not attaching any coverage obligations to this auction, after a dea[l][122] which was reached with operators[123].

121. Available at 'Consultation: Award of the 700 MHz and 3.6-3.8 GHz spectrum bands'

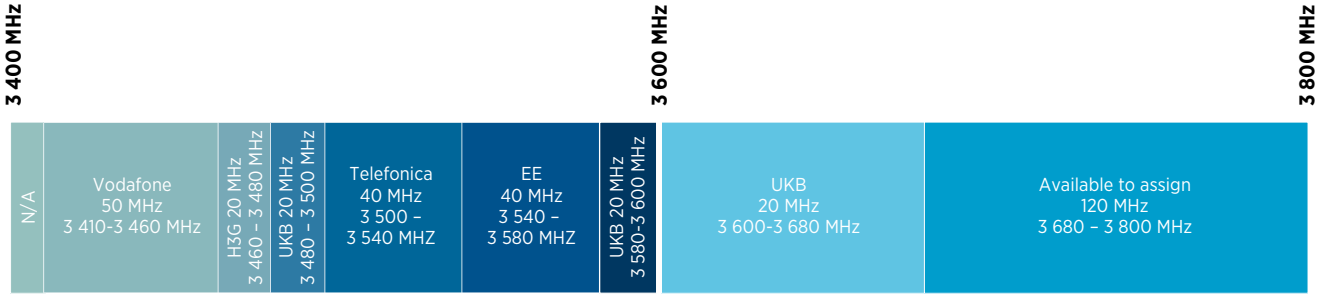
122. Ofcom previously intended to impose a coverage obligation on the 700MHz band, which would have required two winning bidders/mobile operators to extend outdoor data coverage (4G / 5G) to at least 90% of the UK's entire land area within four years of the award in return for discounts, among other things.

123. Available at Award of the 700 MHz and 3.6-3.8 GHz spectrum bands. Revised proposal on auction design (Ofcom, 2019)

ILLUSTRATION 13

Source: Ofcom

The 3.6-3.8 GHz award band, alongside the already awarded 3.4 GHz band



As shown in the previous illustration (which also covers the frequencies in the 3 410-3 480 MHz band that were awarded in April 2018), the 3.6-3.8 GHz band sits immediately above the spectrum holdings of UK Broadband, a wholly owned subsidiary of H3G. On December 2018, a licence variation requested by UK Broadband was granted[124]. As a result of this variation, UK Broadband will hold a block of 80 MHz starting from 3 600 MHz (3 600-3 680 MHz) at the time of the auction, instead of a block of 84 MHz starting from 3 605 MHz (3 605-3 689 MHz).

The spectrum will be made available for bids in the following lots:

- Six lots of 2×5 MHz (60 MHz in total) in the 700 MHz band
- Four lots of 5 MHz (20 MHz in total) of 700 MHz downlink-only spectrum
- 24 lots of 5 MHz (120 MHz in total) of the 3.6-3.8 GHz spectrum

For the auction planned for 2020 by Ofcom, through the revision of its proposal regarding the design of the auction, has allowed that, once the auction has concluded and the radio spectrum has been assigned, winners can negotiate and exchange the blocks obtained in order to achieve contiguous blocks and reduce fragmentation in their possession of radio spectrum.

The mechanics of the auction will be similar to the 2018 one, Simultaneous Multiple Round Auction (SMRA)[125] auction format, Combinatorial Clock Auction (CCA) format was initially considered but this was modified after the consultation which took place. The 37 per cent cap (416 MHz) on spectrum ownership still applies, which means EE (formally Everything Everywhere) can only win a maximum of 120 MHz, 3G a maximum of 185 MHz and Vodafone 190 MHz. On the other hand, O2 has so little spectrum that, in practice, it has no cap limitations on the assignment of the spectrum to be auctioned.

After 2020's auction and radioelectric spectrum assignment, there will be a period of time between the award of the spectrum in 2020 and the variation or revocation of existing satellite and fixed links authorisations in the band, during which time we will need to maintain protections for these users. During the interim period prior to the notice period, new licensees in the 3.6-3.8 GHz band will need to submit technical information to Ofcom about each new base station they intend to deploy. Ofcom will use that information to assess whether the new base station is likely to undermine benchmark spectrum quality for existing registered satellite Earth stations and fixed links. New licensees will not be permitted to transmit from new base stations unless the planned deployment passes the coordination process.

124. Available at 'Statement: Variation of UK Broadband's spectrum access licence for 3.6 GHz spectrum'

125. SMRA: Simultaneous Multiple Round Auction

Of the frequencies[126] in the 3.8-4.2 GHz band, identified for IMT services, Ofcom has conducted different consultations regarding opportunities for innovation and shared access.

This band is currently used by satellite Earth stations, PTP fixed links and wireless access applications (fixed) by UK Broadband. Deployments in the band are technically coordinated by Ofcom on a first come, first served basis. Ofcom intends to consult on proposals for greater shared access in this band. The band could be used for private networks that automate processes in a range of industries and more broadly support IoT. It is adjacent to the 3.4-3.8 GHz band which has been identified as a primary 5G band in Europe. 5G technology standards cover this band and radio chipsets supporting this band are available for equipment vendors to develop equipment.

Companies will apply to Ofcom for a licence for a specific location. For each licence application, Ofcom will assess interference with regards to and from other licensees in the band. Assignments will be made on a first come, first served basis with regards to other users in the band (both new and incumbent).

Two types of licence (distinguished primarily by permitted power levels) to cater for different types of potential uses are proposed by Ofcom:

- Low power licence for local connectivity (per area licence). This would allow users to deploy as many base stations as they like within a 50-metre radius circle without further authorisation from Ofcom. Potential licensees could apply for multiple adjacent licence areas if the required coverage area is larger than the area defined by a single licence.
- Medium power licence for longer range connectivity (per base station licence). Given the higher transmit power and larger potential interference area, medium power base stations are proposed to be authorised on a per base station basis and to initially limit deployments to rural areas only.

Ofcom proposed cost-based licence fees to recover Ofcom's cost of managing the licensing process where spectrum demand does not outstrip supply.

Public policy on the 3.5 GHz range

Ofcom's main duty in relation to our spectrum management functions is to secure optimal use of the spectrum. Improving mobile coverage for consumers is a key policy priority, Ofcom's ambition is comprehensive mobile coverage for people right across the UK.

In addition to improving mobile coverage, Ofcom also intends to use the 2020 award to achieve a number of further policy objectives, such as the promotion of competition and the encouragement of innovation and investment.

Regarding the defragmentation of the 3.4-3.8 GHz band, of the auction to be held in 2020, Ofcom has stated that:

- The 3.4-3.8 GHz band has been harmonised for mobile and identified as part of the primary band for introducing 5G in Europe. There is a general consensus, including among MNOs and European regulatory bodies, that optimal deployment of 5G will be best achieved through large contiguous spectrum blocks
- Operators consider a minimum of 80 MHz of contiguous spectrum to be desirable for 5G
- Defragmentation of the 3.4-3.8 GHz band may well be desirable given the benefits that contiguity of spectrum holdings can bring. In the absence of contiguous spectrum, an operator may benefit from having its separate blocks of 3.4-3.8 GHz spectrum sufficiently close to each other. This may allow it to avoid higher costs of equipment.

126. Available at 'Enabling opportunities for innovation' (Ofcom, 2018) and at '3.8 to 4.2 GHz band: opportunities for innovation' (Ofcom, 2016)

Consistent with previous spectrum awards carried out by Ofcom, including the 2018 auction of spectrum in the 2.3 and 3.4 GHz bands, the licences to be auctioned should be:

- Issued for an indefinite duration
- Issued soon after the conclusion of the award, when winning bidders have made any outstanding payments to cover their licence fees
- Issued for an initial period of 20 years starting from the date of issue in the case of the licences in the 3.6-3.8 GHz bands. The initial operational term of a licence should be long enough to earn an appropriate return on investment, and it is believed that 20 years is consistent with this consideration.
- Revocable before the expiry of the initial period only on certain limited grounds (i.e. at the request or with the consent of the licensee; for non-payment or late payment of the relevant licence fee; for breach of any of licence terms; for breach of auction regulations; for breach of trading regulations; for national security or to comply with international agreements; or under direction of the Secretary of State).
- Revocable from any point after the expiry of the initial period on the grounds set out above and, additionally, for spectrum management reasons, subject to five years notice. Once the initial period has expired, the licence will remain in force and continue to be held by the licensee. However, there may be circumstances in which regulatory intervention is justified in the public interest (for example, to overcome a specific market failure).

Both, the 2018 and the next 2020 auctions, have contemplated UK wide radioelectric spectrum awards.

Takeaways

The UK has already awarded 150 MHz in the 3.4-3.6 GHz band and is planning to auction an additional 120 MHz in the 3.6-3.8 GHz band.

Important takeaways are the advanced planning of the migration of existing services in these bands through public consultation procedures and the importance which is being given to the defragmentation (taking into account operators preference of 80 MHz in contiguous blocks and the possibility to trade spectrum blocks after the spectrum has been awarded, so as to allow operators to assure the holding of contiguous blocks and reduce fragmentation in their possession of radio spectrum).

SOUTH KOREA

Allocation and current status of the 3.3-4.2 GHz band

In June 2018 South Korea's Ministry of Science and ICT (MSIT) revealed the details of the winning bids for its sale of spectrum suitable for the planned deployment of 5G technology, with 280 MHz bandwidth of 3.3-3.8 GHz range (in 28 blocks) and 2,400 MHz bandwidth of 28 GHz spectrum (in 24 blocks) awarded to three of the nation's incumbent mobile network operators. The regulator noted that, with the auction having been conducted in two phases, the first of these determined the quantity of frequencies each operator would get, with the second determining the position of the spectrum.

The details of the frequencies in respect of which the licences were granted are given in the table below.

TABLE 25

Source: Ministry of Science and ICT Korea

Auction results - South Korea 2018

Winning bidders to whom licence was granted	Frequency bands	Awarded spectrum
SK Telecom	3 600-3 700 MHz	100 MHz
	28.1-28.9 GHz	800 MHz
KT	3 500-3 600 MHz	100 MHz
	26.5-27.3 GHz	800 MHz
LG Uplus	3 420-3 500 MHz	80 MHz
	27.3-28.1 GHz	800 MHz

Sources close to the operators who spoke to them after the auction have claimed that all three telcos were content and satisfied the outcome of the spectrum allocation. However, they did convey complaints in relation to the fact that they were not consulted about the reserve prices, which they considered to be excessively high, particularly since the 3.3-3.8 GHz range licence is valid for only ten years[127].

During 2018 auction there was a cap on the amount of spectrum a mobile carrier could be allocated, 100MHz in the 3.5 GHz spectrum[128] and 1,000MHz in the 28 GHz spectrum.

In 2018 the three mobile operators announced plans, which were approved by the government, to share the costs for the deployment of a nationwide 5G network in the Asian nation. The initiative reportedly will be carried out by SK Telecom, KT, LG U+ as well as broadband operator SK Broadband. This shared infrastructure project has the main aim of avoiding redundant investment in 5G deployments, according to government officials (the plan covers operators' core fibre resources rather than Radio Access Networks [RANs]).

3.5 GHz band licences were issued for a 10-year period with a nation-wide reach.

Public policy on the 3.5 GHz range

In South Korea, the Korean Government (Ministry of Science, ICT and Future Planning) and the public-private partnership, 5G Forum, which was established in Seoul on 30 May 2013, defined the 5G mobile strategy as early as January 2014. For that purpose, the government allocated $1.5 billion.

The program of the 5G Forum (www.5gforum.org) runs over the seven-year period of 2014-2020 with a joint investment of 1.6 trillion KRW by both the government and the private sector. Some 26 companies/institutions are part of the project comprised of private companies (operators, equipment vendors), research institutes and universities.

A national broadband plan was published early 2017, indicating the possibility of extending the 28 GHz band by up to 2 GHz to provide access to a total of 3 GHz, 26.5-29.5 GHz. There is interest in more spectrum for 5G in the longer term, though it is not yet decided in which frequency band.

127. Available at 'South Korea conducts one of the world's first 5G auctions'

128. SK Telecom expressed discontent about the lower-than expected cap on the 3.5-GHz frequency. The company wanted to acquire at least 120MHz in the spectrum, claiming that it has the largest number of Long-Term Evolution service subscribers.

South Korea has been the first country, in 2018, to simultaneously allocate the middle band (3.5GHz) and ultra-high band (28GHz) for 5G service.

The South Korean carriers agreed in mid-2018 to build a single 5G network to save money and time. 5G services were jointly launched by the three MNOs on 3 April 2019.

MSIT has revealed it is aimed to make a further 2 640MHz of bandwidth available for use in 5G networks by 2026[129]. Under what has been named the '5G+ Spectrum Plan' (The Ministry of Science and ICT Policy Coordination Division. The Government of the Republic of Korea, 2019)[130], the regulator is reportedly looking to almost double the amount of 5G-suitable spectrum in the country, up from the current 2 680MHz that has already been allocated, aiming for South Korea to lead the world in radioelectric spectrum availability. It is understood that the thinking behind the plan is to ensure that there is enough bandwidth to cater for an expected explosion in traffic over 5G networks, while also allowing for the use of spectrum by new industries that are expected to be 5G-based. As it stands, the MSIT has yet to announce details of exactly what frequencies it will offered, nor has it laid out a timeline for deployment.

The following are the key directions of Korea's 5G+ Plan:

- Establishment of a support system for 5G+ strategic industries
- Development of a joint growth model for upstream and downstream industries based on private-public partnership
- Creation of a safe environment to promote 5G services

Takeaways

As it can be seen in 2018's spectrum awards, South Korea has awarded 100 MHz to two operators (and 80 MHz to the third) in the 3.3-3.8 GHz range and 800 MHz per operator in the 28 GHz band, which is in line with the 5G need of new harmonised mobile spectrum. It is expected that the deployment of nationwide 5G networks will be fully completed by 2022 or 2023.

The Korean government held the world's first 5G spectrum auction in 2018 and has the aim of becoming the country in the world with the most spectrum availability.

South Korea launched its commercial use 5G network in December 2018 for business users and in April 2019 for end users[131]. SK Telecom, LGU+ and KT launched their 5G service in a number of cities on 1 December 2018 for business customers. The launches came earlier than previously announced and thus expected. In fact, in July 2018 all MNOs announced their intentions to jointly launch 5G in March 2019. This intention arrived one year after a first agreement was signed in April 2018 on a shared 5G deployment and network. This first agreement's intention aimed at avoiding a very costly launch campaign when 4G came to reality back in 2011 and generating heavy cost savings of nearly $1 billion over the next ten years. In early March 2019, the commercial launch was delayed following the rejection by the government of proposed 5G pricing plans submitted by operators.

The operators, which launched the service in early April 2019, ended September 2019 with a combined total of nearly 3.5 million 5G subscribers[132].

The February 2018 Winter Olympics in PyeongChang provided a stage for displaying 5G innovation. KT was very active. Samsung and KT provided a 4K streaming video service via a 5G network using 28 GHz spectrum. KT provided the 5G data network through a collaboration led by Intel with partners including Ericsson, Nokia and Alibaba, while Samsung unveiled its 5G mobile tablet device to deliver a 4K streaming video via Intel's base stations. KT demonstrated on its 5G network four types of data-heavy video streaming services: Sync view, Timeslice, 360 VR and Omnipoint view. KT also showed a 5G Connect Bus using 5G, capable of autonomous driving using Lidar sensors and the V2X technology. Hyundai demonstrated five Level 4 autonomous cars on a 196 km trip to PyeongChang; the cars were connected to the KT 5G net for entertaining the passengers.

129. Available at 'South Korea seeking to double the allocation of spectrum for 5G by 2026'
130. Available at 5G+ Strategy
131. Available at 5G Observatory Quarterly Report – Report 5 (European Commission, 2019)
132. Available at 'Korea plots 5G spectrum boost'

SPAIN

Allocation and current status of the 3.3-4.2 GHz band

At the time of Spain's 5G National Plan, developed by the end of 2017, the following was the situation of harmonised frequency bands in Spain for 5G use:

- 3.4-3.6 GHz: awarded. Can be used to deliver 5G services pursuant to the General Telecommunications Law 9/2014. Four licences have 2 x 20 MHz. The remaining 2 x 20 MHz are used for radiolocation and guard bands.
- 3.6-3.8 GHz: release process underway in 2018 (it was used in the past for television signal transmission radio links). Currently available, as still used, though rare.

Other bands which are considered in Spain for the deployment of 5G are the 700 MHz and the 26 GHz band. In addition to these bands, which are specifically identified by the Radio Spectrum Policy Group (RSPG) for 5G in Europe, the 1.5 GHz and 2.3 GHz bands could also be relevant for the delivery of 5G services in Spain.

In 2018, in line with the 5G National Plan expectations, and as per Orden ETU/531/2018[133], the 3.6-3.8 GHz band auction took place. The following are the results of this auction.

TABLE 26

Source: Ministerio de Economía y Empresa de España

3.6-3.8 GHz auction results - Spain 2018

Winning bidders to whom licence was granted	Awarded spectrum
Orange	60 MHz
Telefónica	50 MHz
Vodafone	90 MHz

The mechanics of the auction was a SMRA auction format in 5 MHz blocks and the licences were awarded for a 20-year period with a national reach. A spectrum cap holding of 120 MHz in the 3.4-3.8 GHz band was set. The final value of the licences was made up of the auction price divided into 20 payments, interest[134] and the reserve fee for the spectrum.

As previously stated, there are four previous licences in the 3.4-3.6 GHz band.

TABLE 27

Source: Ministerio de Economía y Empresa de España

3.4-3.6 GHz previous holdings - Spain 2018

Winning bidders to whom licence was granted	Awarded spectrum	Comments
Orange	40 MHz	Until 2030
Telefónica	40 MHz	Until 2030
Vodafone	0	N/A
Más Móvil (Yoigo)	80 MHz	Until 2030 Acquired 40 MHZ from Eurona

133. Available at Orden ETU/531/2018

134. 2.35% interest rate p.a.

Public policy on the 3.5 GHz range

In April 2016, the European Union adopted the 5G Action Plan for Europe, which establishes a common roadmap to achieve a homogeneous 5G deployment in the EU. The objective of the plan is to promote coordination between member states in order to improve European competitiveness in the development of 5G technology.

Based on this European plan, the Ministry of Energy, Tourism and Digital Agenda of Spain (MINETAD) has developed the 5G National Plan[135] for the 2018-2020 period, considering every input, insight and conclusions gathered during the July 2017 consultation[136]. This 5G national plan establishes the roadmap for the deployment of 5G. The plan marks the steps to be followed in the introduction of this fifth generation of mobile broadband, including the following main pillars:

- Management and planning of the radio spectrum necessary for the provision of communications services based on 5G networks
- Boost to 5G technology: network and services pilot test and R+D activities. Actions will be carried out to foster pioneering experiences with the use of this technology
- Regulatory aspects: development of legal framework and legal certainty assurance
- 5G plan coordination and international cooperation

In July 2017, MINETAD signed, alongside its European counterparts, the Ministerial Declaration of Tallinn on making 5G a success for Europe. The steps identified therein are listed below:

- Make more spectrum available in a timely and predictable manner
- Encourage front-runners and support peer learning and increased transparency
- Strengthen basic principles of spectrum management
- Place coverage and connectivity focus in large cities and throughout the main communication pathways
- Preserve 5G interoperability
- Facilitate fibre optic deployment
- Facilitate small cells implementation
- Set-up a strategic dialogue with stakeholders

Another important aspect of the 5G National Plan 2018-2020 is the launch of a 5G National Observatory, which is expected to invest EUR 1.5 million in the first three years: EUR 900,000 contributed by Red.es (the public entity of the Ministry of Economic Affairs and Digital Transportation of Spain to boost the digital economy and information and communication technologies) and EUR 600,000 by Mobile World Capital Barcelona. The headquarters will be shared at the MWCapital facilities in Barcelona and Madrid, and its objective will be to accelerate the standardisation, innovation and development of solutions based on 5G technology throughout the national territory. This will result in studies and reports related to the uses of 5G and its possible socioeconomic impact, as well as with workshops, online courses and workshops to train companies, mainly SMEs, in the possibilities of new technology.

As part of the spectrum management and planning, the 5G plan included the calling for a tender of the 3.6-3.8 GHz band and the definition of scenarios for the rearrangement of the 3.4-3.6 GHz band. The plan also contemplated different initiatives in the L-band (1,452-1,492 MHz), the 2.3 GHz band, the second digital dividend (700 MHz) and the 26 GHz band.

The 5G national plan of Spain included these initiatives in the area of pilot projects development:

- Facilitate interim frequency range authorisations on the various 5G bands, specifically on the 3.4-3.8 GHz and on the 26 GHz bands
- Call for one or more pilot projects for the experimental deployment of 5G networks in order to validate the network's new capabilities and develop sector-based real applications and use cases
- Use such infrastructure to test other third-party applications
- Monitor and disseminate pilot projects and their outcomes
- Adopt R&D&I measures in 5G technologies

The following illustration shows the 5G national plan roadmap and key actions.

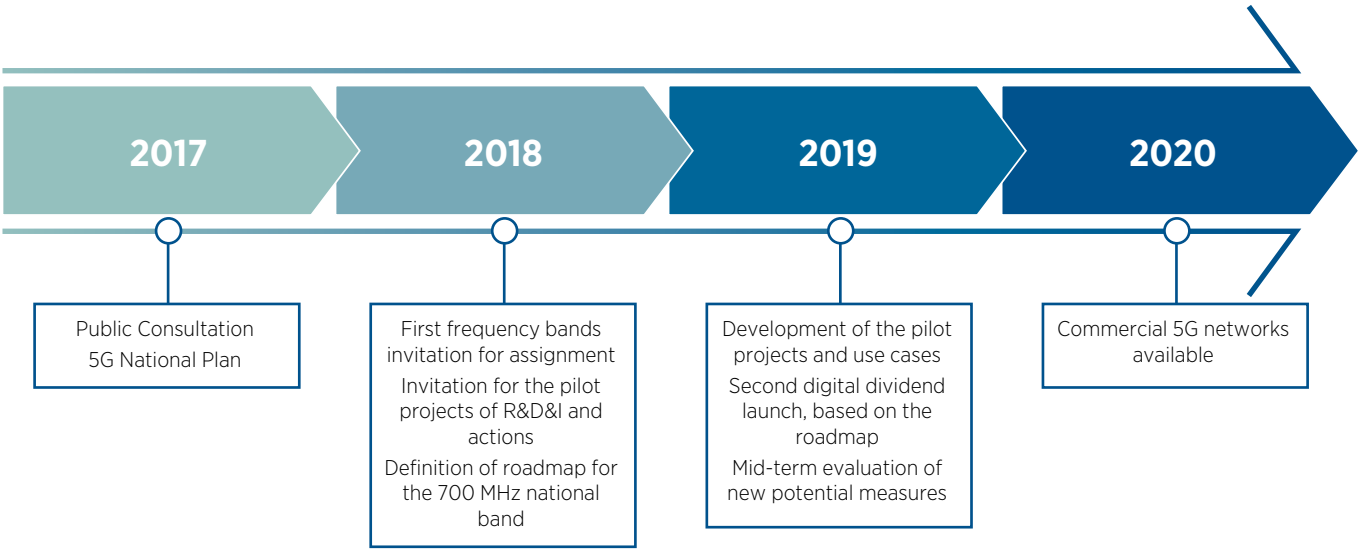
135. Available at 'Spain's 5G National Plan 2018-2020' (Ministerio de Energía, Turismo y Agenda Digital, 2017)

136. Available at 'Consulta Pública sobre el Plan Nacional de 5G'

ILLUSTRATION 14

Source: 5G National Plan (MINETAD)

Spain 5G National Plan roadmap and key actions



Takeaways

Spain has put in place a specific 5G plan which establishes the roadmap for the deployment of 5G, including the 3.4-3.8 GHz band as one of the main bands for the new technology development.

So far, the 3.6-3.8 GHz has been auctioned, with the second digital dividend auction expected to happen during 2020. The licences of four 2x20 MHz blocks of previous assignments in the 3.4-3.6 GHz band are going to be rearranged to allow for contiguous spectrum for all operators..

ITALY

Allocation and current status of the 3.3-4.2 GHz band

Italy auctioned 200 MHz in the 3.6-3.8 GHz band in September/October 2018. This spectrum was auctioned together with 60 MHz of the 700 MHz spectrum and all the upper part of 26 GHz frequencies (1 GHz divided in five 200 MHz blocks in 26.5-27.5 GHz). The multi-band auction ended on 2 October 2018, 14 days and 171 rounds after it started. Telecom Italia and Vodafone won the largest blocks of spectrum (80 MHz each), while Wind and Iliad each were awarded 20 MHz.

The following table shows the results of this first 5G spectrum auction in Italy.

TABLE 28

Source: AGCOM

3.6-3.8 GHz auction results - Italy 2018

Winning bidders to whom licence was granted	Awarded spectrum
TIM	80 MHz
Vodafone	80 MHz
Wind	20 MHz
Iliad	20 MHz

Just 200 MHz of spectrum were available in the 3.4-3.8 GHz band, a relatively small amount, especially given that there are four Italian MNOs wanting some of the band. In contrast, also in October, 390 MHz were auctioned in Finland to just three mobile operators; this difference may have led to a higher price paid in Italy for the spectrum.

The 200 MHz were offered as two lots of 80 MHz and two lots of 20 MHz. Italy has three main mobile operators, with similar market shares and annual revenues. However, this lot structure meant that only two of the three MNOs could come away with large blocks of 3.4-3.8 GHz spectrum, which would allow them to offer competitive 5G services. This created additional artificial scarcity.

The reason why only 200 MHz of the 400 MHz in the 3.4-3.8 GHz band were auctioned is that 80 MHz of this band is still in use by the government/military. The remaining 120 MHz was awarded as WiMAX licences, which will expire in 2023. The Authority for Guarantees in Communications (AGCOM) has offered six-year extensions to these licences for a fee based on this recent auction. Therefore, it looks unlikely that any additional 3.6-3.8 GHz spectrum beyond the 200MHz already auctioned will become available for 5G in the near future.

Two blocks of 80 MHz and two of 20 MHz were sold in the 3.7 GHz band, with a spectrum cap of 100 MHz per operator. The licences were awarded with a 20-year period. In contrast to most spectrum auctions, which require winning bidders to pay for their spectrum up-front, the payment schedule in Italy is in four annual instalments (with the bulk of payments being made in 2021).

To ensure widespread improvements in mobile coverage across Italy, the Ministry of Economic Development, based on the national regulatory authority (AGCOM) rules, has established coverage obligations for the 700 MHz FDD band and 3.6-3.8 GHz band. In regards to the 3.6-3.8 GHz band, the coverage obligations require 80 MHz winning bidders to roll out improved mobile coverage in a mandatory list of municipalities. Within 90 days from the date of the award, the winning bidders will have to submit a list of municipalities to be covered to the ministry of economic development. Then, the winning bidders have 72 months from the date of the award to prove they are ready to provide the 5G service on demand in all municipalities of their mandatory list. Finally, concerning the 3.6-3.8 GHz band, the coverage obligations require 20 MHz winning bidders to reach the coverage of 5 per cent of the population of each Italian region.

Public policy on the 3.5 GHz range

The Italian 5G strategy kick-started late in 2016 when the domestic NRA announced the start of a fact-finding survey for the development of mobile and wireless systems towards 5G and the utilisation of the spectrum above 6 GHz. In March 2017, the Government selected five 5G trial cities, including Milan (Vodafone), Prato (Wind Tre-Open Fiber), L'Aquila (Wind Tre-Open Fiber), Bari and Matera (Telecom Italia-Fastweb-Huawei Technologies), which will use 100 MHz of 3.6-3.8 GHz spectrum. Provisional licences are valid from September 2017 to 2020.

At year-end 2017, the "Bari-Matera plan" involving MNOs, cities, research centres and equipment vendors was unveiled and began. The EUR 60 million over four years (2018-2021) plan gathers 55 partners including seven universities and research centres, public interest communities, vertical leaders, start-ups and telecom players (TIM, Fastweb, Huawei). The plan focuses on ten application areas including media/virtual reality, smart port, smart city, smart agriculture, public safety, industry 4.0, health 5.0, road safety, tourism and culture, and environmental monitoring over 70 use cases.

In May 2018, the NRA announced 5G multi-band spectrum auctions (in the 700 MHz, 3.6-3.8 GHz and 26 GHz bands). 700 MHz and 26 GHz spectrum auctions ended respectively in September and October 2018.

Takeaways

Italy has already auctioned 5G spectrum in the 3.4-3.8 GHz band. Although only 200 MHz were auctioned as those remaining are still being used by the government/military. The remaining 120MHz was awarded as WiMAX licences.

The main takeaway from Italy's 2018 5G auction is the resulting high price it achieved due to an extremely bad design of the spectrum assignment process. The scarcity of spectrum, its channelisation and the number of operators bidding have been among the reasons for the high prices.

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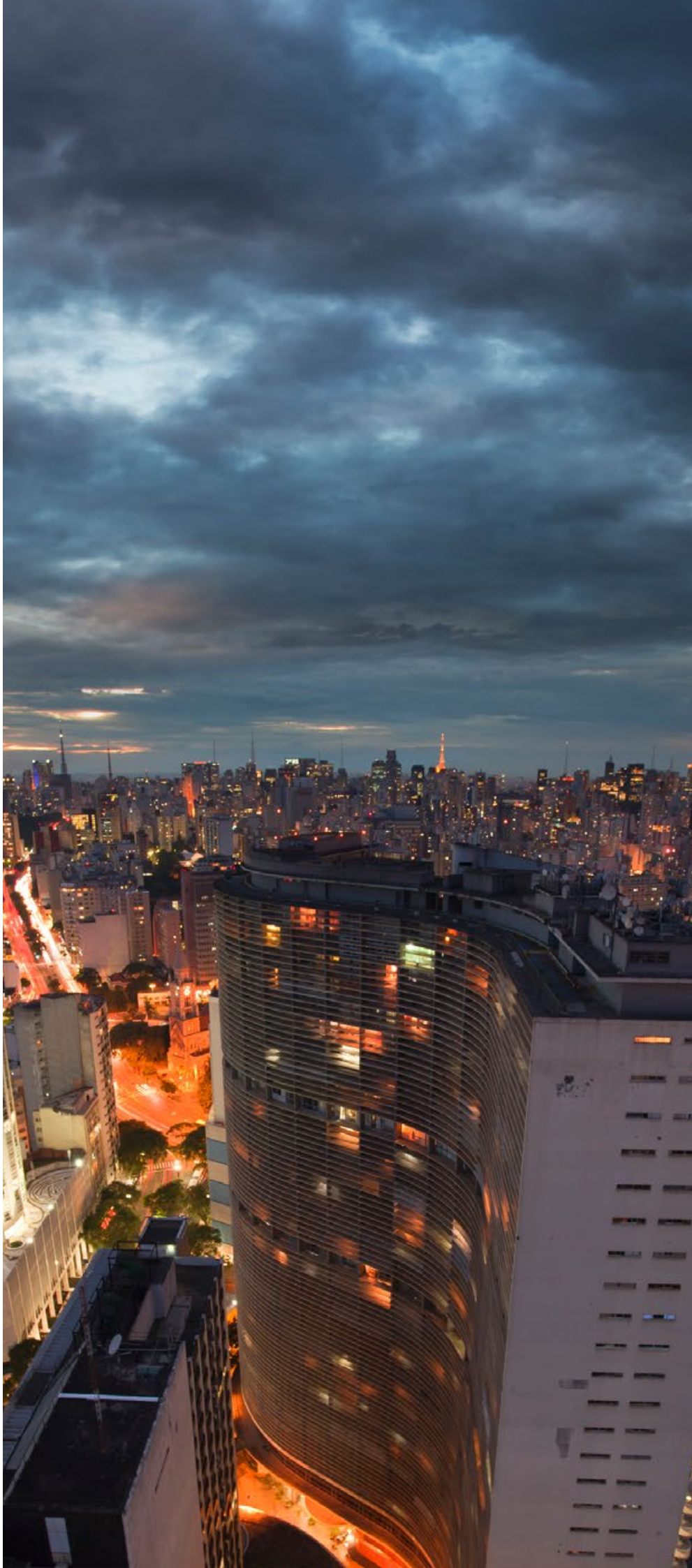
List of abbreviations

Term	Description
3.5 GHz range	3.3-4.2 GHz
3G	Third Generation of mobile telecommunications technology
3GPP	Third Generation Partnership Project
4G	Fourth Generation of mobile telecommunications technology
5G	Fifth Generation of mobile telecommunications technology
AGCOM	Authority for Guarantees in Communications (Italy)
Anatel	National Telecommunications Agency (Brazil)
ANE	National Spectrum Agency (Colombia)
ARCOTEL	Telecommunications Regulation and Control Agency (Ecuador)
AWS	Advanced Wireless Services
B2C	Business-to-Consumer
CABFRA	National Table of Frequency Allocations (Argentina)
CAF	Corporación Andina de Fomento (Development Bank of Latin America)
CAGR	Compound Annual Growth Rate
CBRSD	Citizens Broadband Radio Service Devices
CCA	Combinatorial Clock Auction
CCP	Permanente Consulting Committee
CEPT	European Conference of Postal and Telecommunications Administrations
CFR	Code of Federal Regulations (United States of America)
CITEL	The Inter-American Telecommunication Commission
CNT EE	National Telecommunications Corporation (Ecuador)
dBW	Decibel watt
ECC	Electronic Communications Committee
EDN	National Digital Strategy (Mexico)
EGDI	UN E-Government Development Index
ENACOM	National Telecommunications Authority (Argentina)
FCC	Federal Communications Commission (United States of America)
FDD	Frequency-Division Duplexing
FSS	Fixed Satellite Service
FT	Federal Table (United States of America)
FTA	Free-to-air
FWA	Fixed Wireless Access
GAA	General Authorised Access
GCI	Global Cybersecurity Index
ICT	Information and Communication Technology

Term	Description
IDI	ICT Development Index
IFT	Federal Institute of Telecommunications (Mexico)
IMT	International Mobile Telecommunications
INDOTEL	Dominican Institute of Telecommunications (Dominican Republic)
IoT	Internet of Things
ISED	Innovation, Science and Economic Development (Canada)
ITU	International Telecommunication Union
LAVCA	Latin American Venture Capital Association
LMDS	Local Multipoint Distribution Service
LNBF	Low-noise block feedhorn
LTE	Long Term Evolution
LVM	Ministry of Transport and Communications (Finland)
MCTIC	Ministry of Science, Technology, Innovation and Communications (Brazil)
MICITT	Science, Technology and Telecommunications Ministry (Costa Rica)
MICIVI	Ministry of Communications, Infrastructure and Housing (Guatemala)
MINETAD	Ministry of Energy, Tourism and Digital Agenda (Spain)
MINTEL	Ministry of Telecommunications and the Information Society (Ecuador)
MINTIC	ICT Ministry (Colombia)
mMTC	massive Machine Type Communications
MNO	Mobile Network Operator
MSIT	Ministry of Science and Information and Communication Technology (South Korea)
MTC	Ministry of Transport and Communications (Peru)
NFT	Non-Federal Table (United States of America)
NRA	National Regulatory Agency
NTFA	National Table of Frequency Allocations
NTIA	National Telecommunications and Information Administration (United States of America)
Ofcom	Office of Communications (United Kingdom)
OFR	Office of the Federal Register (United States of America)
OSIPTEL	Supervisory Organization of Private Investment in Telecommunications (Peru)
PAL	Priority Access License (United States of America)
PES	Permanent Earth Station
PNAF	National Table of Frequency Allocations
PPP	Small business providers (Brazil)
PTM	Point-to-multipoint
PTP	Point-to-point
RAN	Radio Access Network
R&D&I	Research and development and innovation
RpTV	TV Relaying
RR	Radio Regulations
RSA	Recognised Spectrum Access
RSPG	Radio Spectrum Policy Group

Term	Description
SAS	Spectrum Access Systems
SCT	Communications and Transport Secretariat (Mexico)
SDG	UN Sustainable Development Goals
SIT	Telecommunications Superintendence (Guatemala)
SME	Small and medium-sized enterprises
SMRA	Simultaneous Multiple Round Auction
SSETIC	Undersecretary of ICT (Argentina)
STFC	Fixed Switched Telephone Service
SUBTEL	Telecommunications Undersecretariat (Chile)
SUTEL	Superintendence of Telecommunications (Costa Rica)
TDD	Time-Division Duplexing
TNAF	National Table of Frequency Allocation
TVRO	Television Receive Only
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
URSEC	Regulatory Unit of Communication Services (Uruguay)
VSAT	Very Small Aperture Terminal
WAS	Wireless Access Service
WiMAX	Worldwide Interoperability for Microwave Access
WRC	World Radiocommunication Conference



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