PUBLIC TELECOMMUNICATIONS POLICIES IN THE IMPLEMENTATION OF 5G IN BRAZIL

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SUMMARY

This article addresses how public policies and regulatory policies must be aligned to meet the challenge of bringing connectivity to Brazil. Public policies must be carefully planned in orderto properly incorporate a flexible and collaborative regulatory environment that indicates technological progress. To this end, regulatory impact analysis tools should be used to build innovative business models in which the parties participate in a win-win game, rather than the other way around. In order to promote the development of 5G technology and guarantee digitalinclusion in the country, ANATEL held a successful auction, but there are still technical problems which give rise to some regulatory challenges, such as frequency spectrum allocation.The allocation of the frequency spectrum has therefore been the subject of intense discussions between the different players involved, mainly cellular operators and satellite operators, who are claiming compensation as a result of the reallocation of part of the 3.5 GHz band for use bycellular operators to deploy 5G technology. It analyzes the main arguments of both parties and discusses the importance of adopting policies that guarantee an efficient and fair allocation of the frequency spectrum. It also proposes further studies into other regulatory challenges faced in the process of implementing 5G in Brazil.

Keywords: ANATEL. 5G. Frequency spectrum. Satellite regulation. Public telecommunications policies.

1. INTRODUCTION

The aim of this article is to explore how public policies can be shaped to support the implementation of 5G, and the continued importance of satellite services, both of which are important for improving digital inclusion in the country. It also highlights the need for well-founded and planned public policies that guarantee the 5G implementation process in Brazil and

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the incorporation of the regulatory policies adopted by the National Telecommunications Agency (ANATEL). In this regard, the usefulness of creating an experimental regulatory environment, or 'sandbox', which allows regulated parties to test innovative business models ina controlled setting, thus mitigating the risks associated with implementing such a disruptive technology in a dynamic sector such as Information and Communication Technologies (ICTs),is shown.

By presenting these issues, the article aims to deepen the understanding of regulatory challenges and explore solutions that balance 5G technological innovation with operational reality, facing regulatory policy challenges, such as the issue of the dispute over frequency spectrum allocation. In this way, it will explore the discussions on spectrum allocation for 5G in Brazil, focusing on the dispute with the satellite communications sector, the main user of themost valuable frequency band for 5G, including ANATEL's actions, and discuss the measures needed to overcome them.

The arrival of the fifth generation of mobile technology, known as 5G, promises to revolutionize the way people connect and communicate. It is an evolution of 2G, 3G and 4G technologies, enabling mobile data transmission at higher rates, greater capacity and lower latency. 5G has the potential to transform society in many ways, from providing health and education services to managing smart cities and driving autonomous vehicles, and is thereforeseen as one of the infrastructure foundations for Brazil's economic and social development.

The National Telecommunications Agency (ANATEL) is the body responsible for regulating and supervising the sector, ensuring the implementation of policies that not only stimulate investment and technological innovation, but also promote digital inclusion and equity in access to telecommunications services. ANATEL has played an important role in thiseffort, having held the first radio frequency auction for the implementation of the technology in 2021, which is a major step towards the universalization of the 5G connection in Brazil (BRASIL, 2021). This balanced approach is vital to tackle the "digital divide", which separatesthose who have access to modern communication technologies from those who are excluded from these benefits.

The main feature of 5G is its ability to transmit large amounts of data at high speed, allowing a much larger number of devices to be connected simultaneously. In addition, 5G's extremely low latency means that communication between devices will be almostinstantaneous, which opens up new possibilities for real-time applications. To enable this technological evolution, the frequency spectrum must be allocated efficiently and effectively tosupport the demands of 5G. However, this is no simple task, as many frequency bands are already occupied by other systems, such as satellite systems, and spectrum allocation must takeinto account various aspects, such as security, privacy, coverage and network capacity. As such,there is a need for fair allocation of the frequency spectrum without interference with other technologies, and even incentives for investment and protection of users' rights. Adequate regulation is fundamental to guaranteeing the quality of the 5G service and making the most ofits full potential.

Firstly, Public Policies in Telecommunications are discussed, analyzing how the government and regulatory bodies are shaping the environment for digital inclusion and economic development through 5G. To this end, a comprehensive overview of policies aimed at guaranteeing universal connectivity and market competitiveness is provided. It also discusseshow public policies

can be shaped to support the implementation of 5G, while considering thecontinued importance of satellite services, both of which are important for improving digital inclusion in the country.

The following is about Frequency Spectrum Allocation, a central issue in the implementation of 5G. The dispute over spectrum, especially between cellular operators and satellite operators, has generated intense discussions and challenges. Some of ANATEL's decisions will be analyzed, as well as their impact on the different players involved. RegulatoryImpact Analysis (RIA) is a crucial tool for drafting efficient public policies, which allows the costs and benefits of proposed regulatory changes to be assessed. It discusses how RIA has been applied in the context of 5G and the challenges faced in this process. Finally, the issue ofcompensation for indirect expropriation (clearing) of the frequency spectrum is addressed, in the light of a concrete case which was the 5G auction. The reallocation of spectrum for 5G, resulting from this auction, required the vacating of bands previously used by other services, which raised questions about the need for financial compensation for the holders of the rights to use these frequencies, namely the satellite operators. The claims made by satellite operatorsand ANATEL's regulatory responses will therefore be analyzed.

In addition to this issue, other questions were raised about the proposed spectrum allocation for 5G, such as the lack of alignment with the International Telecommunication Union (UN agency specializing in information and communication technologies), which does not identify this band for 5G, and the Brazilian government had not taken a position in favour of including this band at the last World Radiocommunication Conference (WRC-2019). In this case, the question of the independence of the regulator and national sovereignty in relation to definitions issued by decisions of international regulatory bodies is raised, in view of the publicinterest. Secondly, the lack of clarity about how 5G would coexist with satellite services that would continue to operate on frequencies above 3.7 GHz was questioned. There were no studies at the time the Public Consultation was launched and the concern was that 5G services could interfere with the reception of satellite stations, as there was no definition of the filters that would be used to protect stations from interference, nor was there a guard band separating the two services. In this case, it comes back to the question of the RIA, which should have been carried out beforehand and in great detail, in order to address the possible impacts and respective solutions.

2. TECHNICAL DEFINITIONS

In order to provide a better understanding of the article and enrich readers' understandingof the challenges and nuances of implementing 5G in Brazil, this chapter will introduce a shortglossary of technical terms. The aim of this glossary is that it can be accessed while reading the text, conceptualizing the specialized terminology used in this article through clear and accessible definitions, thus seeking to facilitate a full understanding of the regulatory, technological and social challenges discussed.

2G, 3G, 4G: Mobile communication technologies prior to 5G. 2G introduced digital communications and text services; 3G expanded the use of mobile internet; and 4G broughtspeeds comparable to fixed broadband.

5G: The fifth generation of mobile network technology that promises to revolutionize the way people connect and communicate, offering high-speed data transmission, greater capacity and lower latency.

Frequency: In telecommunications, it refers to the number of oscillations of an electromagnetic wave per second, measured in Hertz (Hz). It influences the range, penetration and capacity of data transmission.

Frequency spectrum: The set of all possible electromagnetic wave frequencies, including those used for radio communication, TV, and mobile networks. The allocation of frequency spectrum is crucial for the operation of telecommunications systems, including the implementation of 5G.

Low/Mid/High Band: Segments of the spectrum, each with different range, penetration and data capacity characteristics.

Broadband: High-speed internet connection that supports voice, data and video. It can be provided by cable, fiber, satellite or DSL

Latency: The time it takes for a data packet to travel from a point of origin to a point of destination. Low latency is essential for real-time applications on the 5G network.

Interference: This refers to the phenomenon whereby a radio signal or electromagnetic wave is distorted or degraded by the presence of other signals in the same or nearby frequency range. This can result in noise, loss of signal, or a decrease in the quality of communication.

Satellite: A satellite is an object that has been intentionally placed in orbit around the Earth or other planets. In communications, satellites are used to transmit television signals, radio,internet and telecommunications data between different points on the globe.

Geostationary Satellite: Satellite that remains fixed in relation to the Earth's surface, ideal for telecommunications and meteorological monitoring, which orbits the Earth above the equator at an altitude of approximately 35,786 kilometers.

Satellite communication: The use of satellites to transmit information between different points on Earth. Spectrum allocation for 5G has an impact on satellite operations, especiallyin the mid-band, also known as C-Band, which is widely used by both 5G and satellites.

3. PUBLIC TELECOMMUNICATIONS POLICIES IN BRAZIL

Nowadays, the use of technology has become essential for the exercise of citizenship, since a large part of social life takes place in the digital environment, whether in the private sphere, such as economic, educational, work and recreational activities, or in the public sphere,with the actions of the digital government. As such, the problems of access to information technologies represent a major challenge for the inclusion of citizens in social, economic and political processes. With the

aim of guaranteeing this right, four amendments to the Constitutionhave already been proposed to include internet access as a fundamental right, either in Article 6, as a social right, or in Article 5. However, these proposals have not yet progressed to the formal constitutional level (LANNES, 2022).

In today's world, public telecommunications policies are essential for guiding the development and implementation of communications infrastructures that sustain the digital economy and connect societies globally. In Brazil, these policies not only define the regulatory framework for the operation and expansion of telecommunications services, but also play a crucial role in ensuring that the benefits of the digital revolution are accessible to all citizens, regardless of their geographical location or social status. According to the Information and Communication Technology (ICT) module of the National Household Sample Survey (PNADContínua) (IBGE, 2022), more than 87% of Brazilians over the age of 10 have some kind of Internet access. However, reaching the remaining 13%, in a vast territory with geographical challenges and many socio-economic inequalities, depends on government public policies.

In Brazil, Decree No. 9,612 of December 17, 2018, establishes the National Telecommunications Policy. This decree is a fundamental document that guides the organization and execution of telecommunications activities in the country, with the aim of guaranteeing universal access to these services and promoting the expansion of telecommunications infrastructure. This decree is therefore a key piece in guiding the future oftelecommunications in Brazil, establishing a robust regulatory framework aimed at improving the quality and accessibility of telecommunications services, fostering technological development and ensuring fair and beneficial competition for all Brazilians. The Internet is a privileged space because it facilitates a variety of activities that enrich a multifaceted reality, including "the search for information, access to knowledge and culture, the development of studies and research, entertainment, doing business, political participation and connecting people" (FACHIN, 2021, p. 233).

The internet, like radio and television, is considered a means of telecommunication, regulated and supervised by ANATEL (National Telecommunications Agency). Efforts to universalize internet access are regulated by specific legislation, such as the General Telecommunications Law (Law 9.472/97) and Law 5.792/72. Several public policies have been implemented with a focus on universal internet access, including the Information Society Program in 1999, the Electronic Government Program in 2002, the Broadband in SchoolsProgram in 2008, the National Broadband Plan (PNBL) in 2010, the Digital Cities Program in2011, the Smart Brazil Program in 2016 and the Internet for All Program in 2017, among others.The main Brazilian programs aimed at the public policy of universalization of the internet focused on the implementation of broadband, as indicated by Decree No. 7.175 of May12, 2010, which established the Internet Steering Committee (CGI) and instituted the PNBL.

The aim was to promote the dissemination and use of Information and Communication Technologies (ICTs), improving the provision of and access to these essential services.

However, these public policies should not be limited to providing access to the virtual environment. It is crucial to consider, in addition to effective access to the Internet, training touse the relevant technologies. The education of the digital citizen and the role of these policiesin this educational process are therefore fundamental.

Digitalization is transforming the way we meet human needs such as communication, food, transport, work, information and education. If before we depended on physical interactions or traditional media such as newspapers, television and radio, today, especially after the COVID-19 pandemic, we see the increasing viability of remote working and digital consumption of information.

Public policies in the telecommunications sector cover a variety of areas, including frequency spectrum allocation, operator licensing, consumer protection and the promotion of competition. In addition, as technologies advance, these policies have also adapted to address new challenges and opportunities presented by the emergence of disruptive technologies such as 5G, satellite communications, and the Internet of Things (IoT).

In addition, the emerging Internet of Things (IoT) technology presents significant opportunities to increase productivity and efficiency in sectors such as agribusiness, industry and services, while promising to improve the population's quality of life. To capitalize on these opportunities, it is crucial that Brazil develops an environment conducive to research, innovation and appropriate regulation, in line with the national digital strategy. In this context,the TCU believes that it should continuously monitor the performance of state-owned companies to ensure that they contribute effectively to public policies. It would also be prudentto adopt indicators such as the quality of fixed broadband, the proportion of households with internet access and the number of Brazilians who have never used the internet, in order to assessprogress and direct future public telecommunications policies.

Thus, through effective public policies, the government seeks to ensure that resources such as frequency spectrum are allocated and used in a way that maximizes public welfare, while fostering a competitive and innovative environment among telecommunications operators. These policies are key to shaping the future of communications in Brazil, ensuring that the vast potential of modern telecommunications is harnessed to improve the lives of all Brazilians.

It should be noted that spectrum management began to gain importance after the Second World War, when the increase in military and civilian communications required the regulationof interference between services. Organizations such as the International TelecommunicationsUnion (ITU, 2024) began to define global guidelines for the coordinated use of spectrum. In the 1990s, with the emergence of mobile networks and the expansion of the internet, the need to efficiently manage spectrum became crucial. Auctions became the main distribution tool, encouraging economic use of the resource and allowing operators to compete for frequencies, contributing to improving the quality and variety of services offered.

It should be noted, however, that this is not always the case. In its strategic planning for2023 to 2028, the Federal Court of Auditors (TCU) created a specific strategic objective for the communications sector, in which it proposes improving the management of public policies and planning in this sector. The TCU believes it is essential to establish an integrated planning approach, involving the short, medium and long term, to guide government action in the broadcasting, telecommunications, digital inclusion, digital strategy and postal sectors. Its diagnosis is that, currently, the absence of structured plans compromises the effectiveness of the Ministry of Communications and limits ANATEL's capacity for action, as does the lack ofclear guidelines for Telebrás, the mixed-capital public company that is responsible for implementing certain connectivity policies in Brazil.

Also according to the TCU, sector policy has been characterized by a fragmented and reactive approach, focused on ad-hoc measures to meet specific demands without effective coordination or a consolidated vision of the future. This situation becomes more critical in the face of structural transformations in the sector, including changes in the service provision model, technological advances and changes in user demands. The growing importance of broadband and the imminent renewal of concessions in 2025, together with the underutilizationof resources from sector funds such as Fistel and Fust, highlight the urgent need for more efficient management of the frequency spectrum.

3.1. SATELLITE AND 5G AS KEY ELEMENTS IN PROMOTING DIGITAL INCLUSION

Satellite communications play a crucial role in digital inclusion, especially in remote regions where other forms of connectivity are unfeasible. Satellites enable access to internet services, distance education, remote medical care and critical information for agricultural development and disaster management. This technology is essential not only to connect these isolated communities to the rest of the world, but also to ensure equity in access to informationand opportunities.

On the other hand, 5G technology, with its high speed and low latency, promises to revolutionize urban connectivity, supporting a wide range of new applications, from smart citiesto the Internet of Things (IoT). However, despite its vast capabilities, 5G is not a complete replacement for satellite communications. Geographical limitations and the cost of deploying 5G infrastructure in hard-to-reach areas mean that satellite remains a vital solution for these regions.

In this context, public policies must recognize and value the complementary role of both technologies. While 5G can transform communications infrastructure in urban areas, satellite communications are indispensable for universal and inclusive coverage. Successful policies must therefore support the expansion of 5G, while reinforcing and expanding satellite capacityto ensure that no community is left behind in the digital age.

When outlining these strategies, policymakers should consider coordinated investmentsand regulatory incentives that foster both the modernization of urban infrastructures and the strengthening of communication networks in isolated areas. In this way, it will be possible to

maximize the benefits of both technologies, promoting a truly connected and inclusive society.In order for public policies to be properly implemented, the correct allocation of radio spectrum,a scarce asset disputed by different telecommunications services, directly influences the implementation of new technologies such as 5G and the maintenance of satellite services. The growing demand for spectrum due to the expansion of high-tech services has made the management of this scarce resource a strategic challenge for the government.

In the case of 5G, the need for additional frequencies has led to the restructuring of bands previously used by other services. ANATEL, as the regulatory body, has been coordinating spectrum auctions for 5G with the aim of ensuring that new operators have accessto adequate frequencies to implement high-speed networks. The 2021 auction, for example, opened up crucial slots in the 700 MHz, 2.3 GHz and 3.5 GHz bands for 5G networks. The introduction of this technology in the country brings clear advantages, such as higher transmission speeds, reduced latency and support for the Internet of Things.

On the other hand, the reallocation of spectrum for 5G has raised concerns in the satellite sector, which traditionally uses the C-band (partly auctioned off for 5G). This band is widely used for satellite TV transmission and essential communications in remote regions. To mitigate the negative impacts of frequency migration, ANATEL implemented a fund to pay for the migration of satellite TV customers to other broadband solutions and to mitigate possible interference between 5G and satellite services. However, satellite operators have expressed dissatisfaction at the lack of full compensation for investments made in satellite infrastructure.

These policies, although controversial, seek to balance the advance of state-of-the-art mobile networks with the preservation of satellite services. If, on the one hand, the vast majorityof Internet access in Brazil is via cell phone, the government must continue to work on policiesthat promote digital inclusion and comprehensive connectivity, without compromising the quality of satellite communication services that are vital to reaching the 13% of the populationover the age of 10 who do not have Internet access (IBGE, 2022). In this context, it is importantthat future public policies consider detailed impact assessments to ensure a fair and beneficial reallocation of spectrum for all involved.

3.2. RECOMMENDATIONS FOR IMPROVING THE MANAGEMENT OF PUBLIC TELECOMMUNICATIONS POLICIES

Spectrum reallocation, as we have seen, is a critical process that can boost innovation and improve the quality of telecommunications services. However, this reallocation must be conducted in a balanced way, considering public interests and the needs of all stakeholders, including both 5G and satellite services. It is therefore important that the reallocation of spectrum meets public interests, and to this end we suggest some continuous review mechanisms to assess the impact of these policies.

3.2.1. BROAD AND INCLUSIVE CONSULTATION

To ensure that all interested parties have a voice in the spectrum reallocation process, itis essential to hold wide-ranging public consultations. These consultations should include 5G operators, satellite service providers, government representatives and civil society. Inclusive participation helps to identify and mitigate concerns before they become significant problems. Public consultations should be held at various stages of the relocation process to ensure continuous feedback. Hearings and forums should be organized to allow for an exchange ofideas and concerns. In addition, it is important to provide access to clear and understandableinformation about the relocation process so that all parties can participate in an informed manner.

3.2.2. PROTECTING EXISTING SERVICES

It is crucial to implement protective measures to ensure that essential satellite services, especially those serving remote regions and providing critical services, are not negatively impacted by spectrum reallocation. This can include designating specific frequency bands thatare protected from interference or allocating alternative spectrum for satellite services.

In addition, it must be ensured that satellite services can continue to operate effectively during and after the transition. This may involve updating technical regulations to reduce interference between 5G and satellite services and providing technical support to help satellite operators, and consequently their users, adapt to the new spectrum conditions.

3.2.3. REGULATORY IMPACT ASSESSMENT (RIA)

Before implementing spectrum reallocation, it is necessary to conduct detailed regulatory impact assessments. These assessments should analyze the implications of the reallocation on the existing infrastructure, the continuity of services and the associated costs. The analysis should consider how the reallocation could affect coverage, quality of service and past investments.

Impact assessments should be conducted by multidisciplinary teams that include telecommunications engineers, economists and public policy experts. The results of these assessments should be published and used to adjust relocation policies as necessary, ensuring that negative impacts are minimized.

3.2.4. REGULATORY SANDBOX

A regulatory sandbox is an experimental environment in which the regulator allows, ina controlled manner and for a fixed period, exemption from compliance with certain regulatory obligations in order to test innovative business models through pilot studies.

This tool is crucial because the regulatory process at ANATEL, as defined by Internal Resolution No. 8 of February 26, 2021, requires that any changes to regulations be included inthe

biennial Regulatory Agenda. This agenda is a planning and transparency instrument that brings together all the Agency's regulatory actions for a specific period and may require regulatory changes.

Although the Regulatory Agenda offers greater transparency and predictability for regulated parties and consumers about ANATEL's actions, there may be a mismatch between the current regulatory framework and new business models arising from disruptive technologies. This mismatch is due to the time needed for the regulatory process in a sector asdynamic as the ICT sector.

The regulatory sandbox tries to mitigate this mismatch by allowing regulated parties to implement new business models, in a controlled manner and for a fixed term, which would be unfeasible under current regulations. This arrangement also allows the regulator to collect information on the impact of these new business models on the sector, providing valuable inputsthat can support future regulatory changes, if justified by the information collected (ANATEL,2024).

The implementation of a regulatory sandbox is an effective strategy for testing the feasibility of spectrum reallocation before large-scale implementation. These pilot studies makeit possible to identify technical and operational challenges, collect empirical data and adjust policies as necessary.

The pilot studies contained in the sandbox should be designed to represent a variety of operating conditions and contexts. This can include densely populated urban areas, rural and remote regions, and different types of existing infrastructure. The results of these studies shouldbe analyzed in detail to inform relocation planning and execution across the country.

3.2.5. ONGOING CONSULTATIONS

Establishing a process of continuous consultation with all stakeholders is crucial duringpilot studies and gradual implementation. These consultations should be used to monitor progress, address emerging problems and adjust strategies in response to feedback received.

Ongoing feedback can be obtained through regular meetings, discussion forums and online platforms where stakeholders can share their experiences and concerns. This constant dialog helps ensure that the relocation process remains transparent and responsive to stakeholders' needs.

3.2.6. INCENTIVES FOR MIGRATION

Offering financial and technical incentives can facilitate the migration of satellite services to alternative frequencies. This could include covering migration costs, offering technical support to minimize service disruption and providing tax incentives or subsidies for operators who invest in upgrading their infrastructure.

Incentives should be designed to offset the costs and risks associated with migration andto

encourage the adoption of new technologies. This helps ensure that satellite operators can continue to provide high-quality services while adapting to new spectrum conditions.

3.2.7. REGULAR REVIEWS

Conducting regular reviews of relocation policies based on the data collected through ongoing monitoring is key to ensuring that policies remain effective and relevant. These reviews should assess the need for adjustments to the policies and implement changes as necessary to address any problems identified.

Reviews should be conducted by review committees that include stakeholder representatives, technical experts and regulators. The results of the reviews should be publishedand used to inform future policy decisions.

3.2.8. TRANSPARENCY AND ACCOUNTABILITY

Ensuring that the entire spectrum reallocation process is conducted in a transparent manner, with regular reporting to regulators, stakeholders and the public, is essential to maintaining stakeholder trust and support. Regular reports on progress, challenges and policy changes should be made publicly available.

Transparency can be promoted by publishing detailed reports, holding public meetingsand creating online platforms where stakeholders can access information and provide feedback. Accountability also involves implementing mechanisms to respond to stakeholder concerns and complaints in an effective and timely manner.

Spectrum reallocation is a complex process that requires a careful balance between promoting new technologies such as 5G and protecting existing satellite services. By adoptinga balanced approach that includes broad consultations, pilot studies and continuous review mechanisms, Brazil can ensure that spectrum reallocation meets public interests and contributesto a more efficient and inclusive telecommunications sector.

4. FREQUENCY SPECTRUM ALLOCATION

The allocation of frequency spectrum for 5G is one of the biggest regulatory challengesfor the implementation of this technology in Brazil. Spectrum is a limited source of radio frequency resources and is fundamental to the operation of telecommunications systems. For 5G, it is necessary to allocate large frequency bands to support the high data transmission ratesand low latency required by the technology.

In addition, spectrum allocation for 5G must be carried out in a balanced way, guaranteeing equal access to resources for all service providers. In turn, efficient spectrum allocation consists of

the rational and balanced use of the electromagnetic spectrum for the provision of telecommunications services, optimizing the use of available resources. Thus, theapplication of the principle of administrative efficiency (art. 37, CF) in the allocation of spectrum is fundamental to guaranteeing the use of this resource in an efficient and fair manner,maximizing its potential for the provision of telecommunications services. ANATEL has the role of regulating spectrum allocation to ensure that society's needs are met and that competition is preserved. Efficient spectrum allocation is therefore a crucial issue for the development of technologies such as 5G, since the availability of frequencies is limited and the increase in demand for mobile services requires efficient management of this resource.

The services competing for frequency spectrum with 5G include broadcasting services, mobile telecommunications services (2G, 3G, 4G), fixed broadband services (Wi-Fi), satellite communications services, radio navigation services, as well as other military uses. In addition,other emerging uses, such as the Internet of Things (IoT) and the connected car, are also requiring more and more frequency spectrum. Therefore, efficient spectrum allocation is essential to ensure that all these services can coexist without interference and to allow 5G technology to develop its full potential.

5G services require a combination of different spectrum bands that affect their speed and coverage, the main bands being the low band (1 to 2.6 GHz), the medium band (3.5 to 6 GHz) and the high band (24 to 40 GHz). Wireless operators thus face the challenge of securingaccess to large amounts of spectrum to provide faster mobile broadband speeds with lower latency, enabling new applications such as video on demand and autonomous vehicles. In this way, operators must use low-band, mid-band and high-band spectrum to offer the kind of 5G experience that customers demand. The GSM Association (GSMA), the organization that represents the interests of mobile network operators worldwide, recommends that regulators and government agencies that control the allocation of 5G spectrum make 80 to 100 MHz of contiguous spectrum available per operator in the medium band (3.5 GHz) and around 1 GHz of spectrum per operator in the high band (26 GHz). Low-band spectrum provides a wider coverage area, but with little performance improvement over 4G networks. Medium-band spectrum offers good coverage combined with good building penetration, making it ideal for urban use. High-band spectrum provides super-fast speeds, but is limited due to its coverage and susceptibility to interference.

All this need for frequency bands means that regulators need to balance the needs of different users and sectors when allocating spectrum for 5G networks. This includes ensuring that there is enough spectrum available for mobile network operators to deploy 5G networks, as well as ensuring that other critical applications, such as public safety and satellite communications, are not negatively impacted. Spectrum allocation is therefore a critical regulatory challenge that must be addressed to ensure the successful deployment of 5G networks. By carefully managing spectrum allocation, regulators can help ensure that 5G networks are deployed efficiently and equitably, and that all users and applications can benefitfrom the increased capacity and faster speeds offered by 5G technology.

With regard to spectrum allocation, the deployment of 5G in Brazil has been a challengefor the National Telecommunications Agency (ANATEL). The main challenge has been to ensure that there is enough spectrum available for the deployment of 5G, especially in higher frequencies, such

as the 3.5 GHz bands (also called Band C), which range from 3.3 to 4.2 GHz.This band is the one that best offers the possibility of achieving high speeds, capacity and goodcoverage. However, part of these frequencies are occupied by satellite services, both professional and residential stations, which needed to be relocated to other frequency bands, since the signal coming from 5G stations could potentially interfere with satellite receiving stations operating in this frequency band. This generated great difficulty and questions, as Brazil has an estimated 20 million homes that receive free-to-air TV signals (VALENTE, 2021), as well as thousands of professional satellite stations operating in this band. ANATEL, after carrying out Public Consultation 09/2021 (BRASIL, 2020), decided that 400 MHz in the 3.5. GHz band, more specifically from 3.3 to 3.7 GHz, would be allocated to 5G, since in Brazilthere are three major national operators, Claro, Vivo and TIM, in addition to the need to allocatespectrum to allow new operators to enter the market.

As a result, satellite stations operating in this band would have to release the spectrum.The decision was that residential stations, which received free-to-air TV programming, wouldmigrate to the Ku Band (11 to 14 GHz band), with a subsidy coming from the proceeds of the auction to cover the migration costs and so that low-income users would receive an antenna andreceiver kit to tune into this new band (approximately 8 million homes).

As for the professional stations, they should remain in the C Band due to technical characteristics, since migration to the Ku band could reduce the reliability of professional transmissions in the event of rain. Therefore, the auction would bear the costs of relocating the stations to higher frequencies (above 3.7 GHz) and protecting them against possible interference from operating at frequencies close to those of 5G. In this way, ANATEL would be able to model spectrum allocation in a way that meets the needs of the market.

Nevertheless, there were questions from satellite operators, who held the right to exploitthe Band C band, about the way ANATEL defined how the frequency spectrum should be reallocated for 5G, mainly because of the late inclusion of the 3.6 to 3.7 GHz band, which wasnot initially planned and was used by the sector to provide domestic and professional services.Among the sector's main complaints was the lack of a Regulatory Impact Analysis (RIA) and the lack of compensation for the frequency band reallocated to 5G.

4.1. REGULATORY IMPACT ANALYSIS (RIA)

Regulatory Impact Analysis (RIA) is a public policy instrument that has been used in several countries, including Brazil, as a way of improving regulatory decision-making. In Brazil, RIA has been applied mainly within the scope of administrative law, as a way of assessing the impacts of rules and regulations issued by public administration bodies and entities. (SILVA, 2022)

RIA has been considered an important tool for improving the quality of regulation in Brazil, especially in terms of reducing costs and increasing the effectiveness of public policies.However, its application is still limited and it faces challenges such as the lack of accurate dataand information and the lack of training for regulators. It is important to note that the aim of RIA is not to eliminate regulation, but rather to improve it, in order to ensure that the rules andregulations issued by the

public administration are more efficient, effective and appropriate to the interests of society and based on evidence.

In this regard, the satellite sector, in its response to Public Consultation 09/2020, considered that there was a lack of Regulatory Impact Analysis (RIA) for the inclusion of the

3.5 to 3.7 GHz band, since this band was only included late, and was not part of the original RIA that had been drawn up for the 5G process. According to the Union of Satellite Telecommunications Companies (SINDISAT), the RIA is fundamental to guaranteeing the legitimacy and validity of any significant change in the regulatory environment. Its aim is to ensure that the measures taken to achieve an intended objective are proportionate and appropriate. In the process of approving a public notice that implies important regulatory changes, such as the amendment of ANATEL Resolution No. 711/2019 (BRASIL, 2019), which provided for the bands to be allocated to the Personal Mobile Service, which is the serviceused by cellular operators to provide mobile communication, which only provided for the allocation of the band up to 3.6 GHz for 5G. Therefore, a full regulatory impact analysis shouldbe conducted before implementing the change. In addition, according to the Manual of Regulatory Practices (BRASIL, 2018) and the Agency's Internal Regulations in force (BRASIL,2013), acts of a normative nature must be preceded by an assessment of regulatory consequences, except in expressly justified cases. The way ANATEL proposed modifying Resolution No. 711/2019 to include the 3.6 to 3.7 GHz band, used by the satellite sector, shouldtherefore comply with the regulatory requirement established by the regulatory body itself.

5. THE QUESTION OF COMPENSATION FOR EXPROPRIATION OF THE SPECTRUM

A central issue in the spectrum reallocation process is the appropriateness of compensation for the expropriation of the frequency spectrum granted to a given service. Spectrum expropriation is the process by which the government or regulatory agencies withdraw the allocation of a spectrum band from a particular service or user, often for reallocation to another service considered to be of greater public or strategic need. In the case of 5G, there was no provision for compensation for the frequency spectrum to be withdrawn from the Fixed Satellite Service and reallocated to the Personal Mobile Service (cellular), whichwould be due to the current holders of rights to use the 3.6 to 3.7 GHz sub-band and, in fact, the C-band as a whole. All that was envisaged was reimbursement of migration costs and protection of users against interference.

According to the union of satellite companies (SINDISAT), in response to Public Consultation 09/2020, it indicated that compensation should only take into account the prices paid for rights of use, which does not reflect the economic reality of a satellite project. The space capacity provision industry has unique characteristics, where the investment in a satelliteis the most significant component and operating costs are low compared to the initial investment. In addition, investments in satellites are considered sunk costs, because once launched, they can only be used to provide space capacity in the designed orbital position and for the market, applications and geography for which they were designed and built.

When talking about geostationary satellites, it is important to clarify that, considering the time when the subject was under discussion, this equipment has rigid technical characteristics, i.e. once it has been manufactured based on predefined parameters and launchedinto orbit, its technical characteristics can no longer be changed. Before launch, the frequenciesthat will be used throughout the satellite's lifetime are defined. Therefore, a secure and stable legal-regulatory environment is needed to provide predictability for around twenty years, in order to ensure that the investment is adequately remunerated. This concept of sunk costs is important for understanding and regulating the sector, especially in the case of customer migration and vacating bands occupied by users of satellite services, which represents the majority of a satellite operator's costs. In Brazil, the interested parties who took part in the tenders to receive rights to use orbital positions and their corresponding frequency bands had to meet certain regulatory and economic requirements and conditions. On the other hand, foreign satellite operators who have authorizations issued by other national administrations have invested in extensive coverage over Brazilian territory, despite being subject to coordination agreements that do not give them priority, reducing the coverage that could have been allocated to other markets, including cases in which investments in coverage are exclusively for Brazilian territory.

Therefore, the possible reallocation of bands to other services sterilizes or reduces the capacity to meet national demand and, consequently, the generation of revenue. Finally, it is important to note that ANATEL had no precedent for vacating bands previously earmarked forthe provision of telecommunications services through authorizations for the use of radio frequencies linked to satellite exploitation rights, which means that the agency has never faceda similar situation in terms of the facts and legal assumptions provided for in the General Telecommunications Law - LGT (Law 9.472 of 1997).

For its part, ANATEL, in the opinion of its Federal Attorney's Office (BRASIL, 2020),argues that the LGT is clear about its competence in the administration of the radio spectrum, and that the authority is responsible for assessing whether its use remains efficient and meets society's demands. In this sense, the LGT states:

Art. 127. The purpose of disciplining the operation of services under the private regimeshall be to enable compliance with the laws, especially those relating to telecommunications, the economic order and consumer rights, with the aim of guaranteeing:

III - efficient use of the radio spectrum;

Art. 157. The radio spectrum is a limited resource, constituting **a public asset**, administered by the Agency.

Art. 159. When allocating radio frequency bands, consideration shall be given to the rational and economic use of the spectrum, as well as existing assignments, distributionsand consignments, with the aim of avoiding harmful interference.

Sole paragraph. Harmful interference is considered to be any emission, radiation or induction that obstructs, seriously degrades or repeatedly interrupts telecommunication.Art. 160. The Agency shall regulate the efficient and appropriate use of the spectrum, and may **restrict the**

use of certain radio frequencies or bands, considering the public interest.

Sole paragraph. The use of radio frequencies will be subject to their compatibility withthe activity or service to be provided, particularly with regard to power, transmission range and the technique employed.

Art. 161. The destination of radio frequencies or bands may be modified at any time, aswell as changes in power or other technical characteristics, provided that the public interest or compliance with international conventions or treaties so dictates.

Sole paragraph. An adequate and reasonable deadline will be set for the change to take place.

Based on the LGT, therefore, ANATEL believes that re-evaluating the use of the bandsto be reallocated to 5G is within its duty to manage the spectrum, providing greater efficiency in its use. Thus, considering that the use of the 3,600 MHz to 3,700 MHz band by mobile systems will bring greater benefits, the modification of its destination falls within the Agency'slegal competence. It also argues that changing the allocation of the band will not mean the cessation of satellite services in the so-called C band, since operators will be able to reallocatetheir users to other frequencies.

It should be noted that according to ANATEL Ruling 63/2021, the expropriation of part of Band C only obliges ANATEL to reimburse the operators' customers and users of the services operated in the band for the costs incurred in migrating the Band. However, there wasno provision for compensating satellite operators, despite the blatant suppression of their right.This right derives from state authorization to operate satellites in accordance with articles 170 et seq. of the LGT, in line with the provisions of article 21, XI, of the Federal Constitution: to operate telecommunications services, directly or through authorization, concession or permission, under the terms of the law, which will provide for the organization of services, thecreation of a regulatory body and other institutional aspects.

In good legal practice, in the name of the public interest, ANATEL is carrying out a kind of "indirect expropriation" of the rights to use radio frequencies in this band. As a result of this expropriation, several operators are harmed, because the services provided via satellite involve three different categories: 1) the owners of the satellite infrastructure, who invest heavily in providing "satellite capacity"; 2) telecommunications service providers and broadcasters, who hire this capacity to offer their services to users; 3) the users of satellite telecommunications services themselves.

The basic legal discussion is about recognizing the right to compensation, which derives, by analogy, from Article 5, XXIV, of the Federal Constitution: XXIV - the law will establish the procedure for expropriation for public necessity or utility, or for social interest, through fair and prior compensation in cash, except in the cases provided for in this Constitution. Expropriation is the procedure by which the Government compulsorily deprives someone of their property and acquires it, for compensation, based on a public interest. Fair compensation corresponds to the real and effective value of the expropriated property, i.e. the amount of which leaves the expropriated party absolutely free, without any damage to their assets (BANDEIRA DE MELLO,

2015, p. 889).

The issue here became the balance between the regulatory agency's discretion to dispose of the radio frequency spectrum, as provided for in the LGT, and the satellite operators' right to compensation, since by expropriating the spectrum, part of the investment made in thesatellites that use it is sterilized.

It is said that there is a need for analogical application because the radio spectrum is apublic asset of the Union (administered by ANATEL), according to art. 157 of Law 9.472/97. However, it is the object of a right of use granted for a fixed term and for a fee, which preventsthe withdrawal of this right without just and prior compensation. However, the opinion of ANATEL's public prosecutor, in item 215, states that, verbis: (...) "In fact, there are no grounds for the compensation to involve the amounts paid for the right of exploitation, since the exploitation of the satellite is not being totally prevented, and it is possible to use the satellite capacity in other ways." (BRASIL, 2020, p. 39).

One of the sources of interpretation is analogy, as stated in art. 4 of the LIDB (Law of Introduction to Brazilian Law). Thus, when analyzing an analogous case of the 5G auction in the United States, ANATEL's equivalent body, the Federal Communications Commission (FCC), has already recognized the need to provide fair compensation to satellite operators in relation to the clearing of bands for 5G. The FCC believes that the additional payment is due, considering the importance of implementing 5G for the country. In this way, ANATEL's interpretation differs from that of its US counterpart. This process, after negotiation with the satellite operators, resulted in compensation of more than US$ 9 billion to the satellite operatorsfor vacating the spectrum (SHEPARDSON, 2020), which helped provide a record collection inthe 5G auction of more than US$ 80 billion (JULIÃO, 2021).

FINAL CONSIDERATIONS

The implementation of 5G in Brazil represents a crucial step for technological progressand digital inclusion in the country. However, the transition to this new technology is not without its challenges.

Public policy plays a key role in facilitating the transition to 5G, ensuring that spectrumis allocated fairly and efficiently. The creation of an experimental regulatory environment, or 'sandbox', can be a valuable tool for testing new business models in a controlled setting, allowing the regulator to gather essential information for making informed decisions and adapting regulations to new technological realities. In addition, ANATEL, as a regulatory body, has a responsibility to ensure that spectrum allocation meets public interests, balancing the needs of both 5G and satellite services.

The regulatory challenge for allocating the frequency spectrum for 5G is complex, especially since the frequencies needed for 5G are in use by other systems, including satellite systems. This issue is particularly critical in relation to the C-band, which is currently used by communication satellites. This band is important because it offers greater capacity and greaterrange

in relation to the higher frequencies that will be used in 5G.

Public policies should include strategies for gradual spectrum reallocation, accompaniedby pilot studies and stakeholder consultations, as well as the implementation of an ongoingreview mechanism to assess the impact of these policies on all parties involved. The disputeover spectrum between telecommunications and satellite operators highlights the complexity ofthe regulatory landscape and the need for careful planning and well-structured public policies.The allocation of frequency spectrum for 5G requires a balance between the needs of different systems, including satellite systems, and the demand for frequency spectrum for 5G.Frequency spectrum is a finite and valuable resource, and must be managed carefully to ensurethat all stakeholders can meet their needs. In the case of satellite systems, it is necessary toensure that the reallocation of frequencies for 5G does not impair the ability of satellites toprovide critical services such as emergency communications, data transmission and locationservices. In addition, it is important to ensure that current holders of rights in these frequencysub-bands are adequately compensated for the costs of migrating to other frequencies. At firstglance, considering that ANATEL has determined a real expropriation (clearing) of thefrequencies in part of the band used by satellite operators (3.6 GHz to 3.7 GHz), which havealways been allocated and destined for satellite use, and in which satellite operators have madelarge investments, it is impossible to see how the lack of compensation to the operators affected by this decision can be normalized, to the fair extent of the deprivation imposed on them.

In addition to this issue, other questions were raised about the proposed allocation of spectrum for 5G, such as the lack of alignment with the International Telecommunications Union, which does not identify this band for 5G, and the Brazilian government had not taken aposition in favor of including this band at the last World Radiocommunication Conference (CMR-2019). There were no studies at the time the Public Consultation was launched and the concern was that 5G services could interfere with the reception of satellite stations, as there wasno definition of the filters that would be used to protect stations from interference, nor was therea guard band separating the two services. In this case, it comes back to the question of the RIA,which should have been carried out beforehand and in great detail, in order to address all the possible impacts and their respective solutions.

It is clear that in order to resolve these regulatory issues, it is necessary to involve the regulatory authorities and all the affected entities, in this case satellite operators, telecommunications service providers and others involved in the sector. It is important to havea collaborative approach to ensure that spectrum allocation is managed in a fair and balanced way, meeting the needs of all stakeholders.

In this way, other regulatory challenges that permeated the 5G auction process in Brazil are listed, which may be the subject of future analysis, according to Mateus Adami and others (ADAMI; PEREIRA DA SILVA NETO, 2021).

1) Fair competition: it is important to ensure that all companies have a level playingfield to compete in the 5G market. Regulation needs to be clear and balanced to avoid market distortions and ensure fair competition. In addition, regulators need to ensure that all interested parties, including incumbent operators and new entrants, have the chance to acquire the spectrum needed

to deploy 5G networks. Regulators may also need to consider issues such as coverage obligations and licensing conditions to ensure that spectrum is used efficiently and effectively.

2) Security: 5G is a highly advanced technology and it is therefore important to ensure that security measures are adequate and effective. The regulator needs to take measuresto guarantee the security of the network and users' data.

3) Investment: the deployment of 5G requires major investments in infrastructure and technology. The regulator needs to create incentives for companies to invest in 5G and ensure that the investments are profitable in the long term. In the case of Brazil, a non-revenuemodel was chosen, with part of the investment converted into coverage obligations for both 5Gand 4G technology.

The implementation of 5G in Brazil, with all its promises of technological and social transformation, has faced complex and multidimensional regulatory challenges, especially in the allocation of frequency spectrum. This issue, particularly critical in relation to the C-band,has required a delicate balance between the needs of existing communications systems, including satellite services, and the emerging demand for 5G spectrum. The regulatory disputedescribed in this article, especially with the satellite sector, highlighted the complexity of reallocating valuable resources in an environment where every spectrum counts. ANATEL, faced with this challenging scenario, adopted an approach that, while not giving in to claims for compensation for previous investments, ultimately covered the costs of customer migrationand interference mitigation, striving to balance the needs of all stakeholders, a crucial step for the advancement of 5G in Brazil. These measures demonstrate a commitment to mitigating theimpacts of spectrum reallocation, reflecting the importance of a continuous dialog between thegovernment, regulators and stakeholders.

It is important to recognize that although 5G technology brings numerous benefits, it does not fully replace the capabilities of satellite services, especially in remote regions where terrestrial infrastructure is limited. Therefore, a balanced approach is needed to ensure that both technologies can coexist and complement each other, contributing to digital inclusion and the country's socio-economic development.

By embracing the future with the implementation of 5G, Brazil has the opportunity to lead the digital transformation in Latin America, promoting sustainable and inclusive development that benefits all citizens. Against this backdrop, Brazil's journey towards 5G reflects a careful dance between innovation and responsibility, between the new horizon that 5G opens up and reverence for the contributions of established systems. As the country movesforward, with its eyes firmly on the future, but with the wisdom to appreciate and resolve the complexities of the present, it establishes itself not only as a global player in the digital age, butas an example of balanced progress. Ultimately, Brazil stands at the forefront of a new era, proving that even the most intractable challenges are mere stepping stones on the road to a connected and limitless future.

In conclusion, the implementation of 5G in Brazil should be seen as an opportunity for innovation and the modernization of the telecommunications sector, but also as a challenge that requires strategic planning and robust public policies. The combination of technologies and the adoption of a flexible and responsive regulatory approach are essential to ensure that the benefits

of 5G are fully realized, promoting a more connected and inclusive society.

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