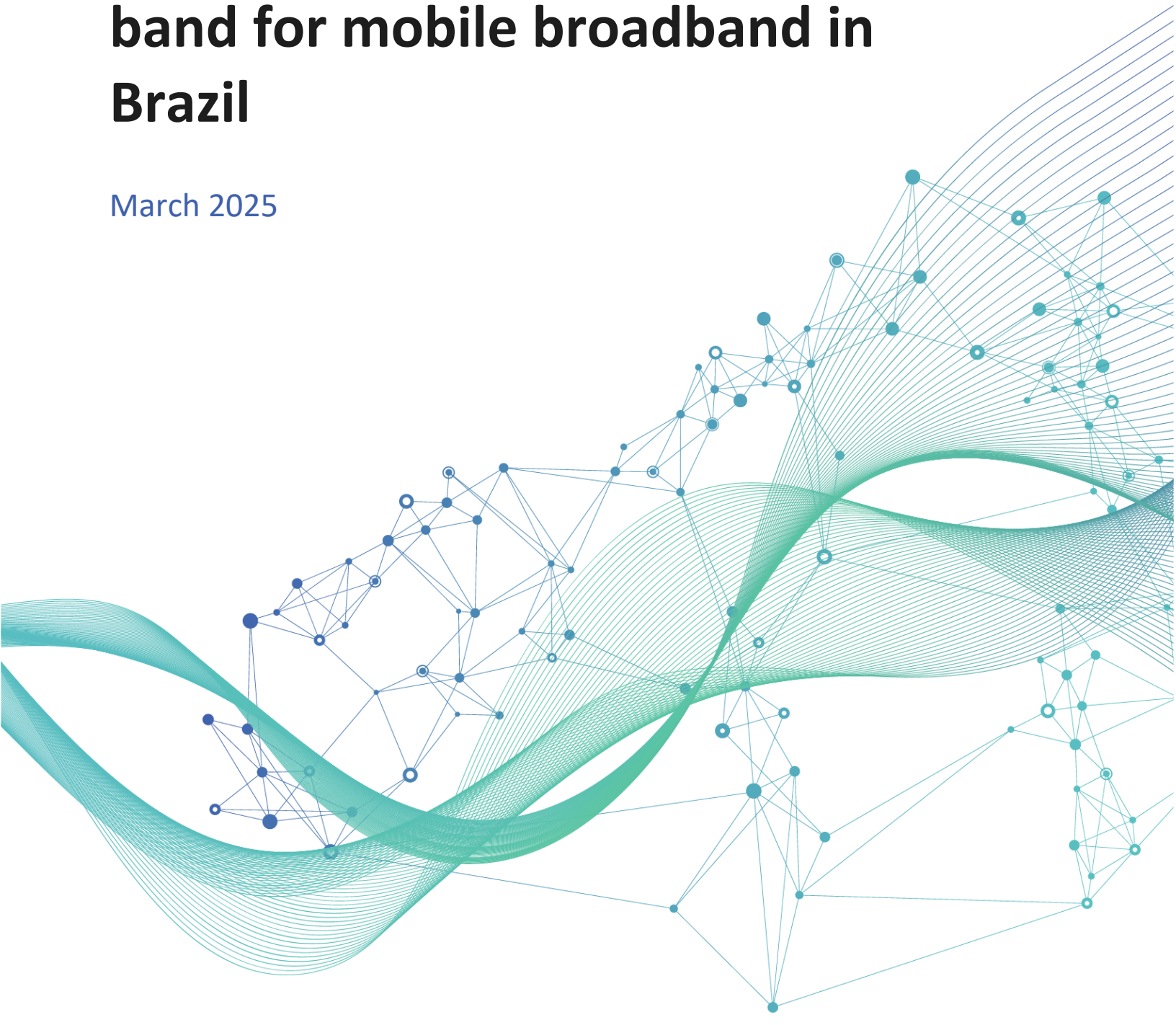
Reallocation of the 600 MHz band for mobile broadband in Brazil

March 2025



Acknowledgements

This report was drafted by TMG, a consulting firm specializing in the information and communication technologies (ICT) sector. For over 30 years, TMG has assisted public and private sector entities around the world on ICT policy and regulatory matters. Our team focuses on providing insight and developing strategies to assist clients on technology and market trends, the development mobile services; spectrum policy and management; broadband and ICT strategies; economic assessments and valuations, among other matters.

This report was commissioned by the GSMA, a global organisation unifying the mobile ecosystem to discover, develop and deliver innovation foundational to positive business environments and societal change. GSMA's vision is to unlock the full power of connectivity so that people, industry, and society thrive. Representing mobile operators and organisations across the mobile ecosystem and adjacent industries, the GSMA delivers for its members across three broad pillars: Connectivity for Good, Industry Services and Solutions, and Outreach. This activity includes advancing policy, tackling today's biggest societal challenges, underpinning the technology and interoperability that make mobile work, and providing the world's largest platform to convene the mobile ecosystem at the MWC and M360 series of events.

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Executive summary

1.1. Key results at a glance

- **Strategic importance of the 600 MHz band**: Crucial for enhancing 5G coverage and bridging the urban-rural digital divide. Low-frequency signals provide better indoor penetration and reduce 5G deployment costs in remote regions.
- **Phased reallocation strategy:**
    - **Category 1 (5,186 municipalities, of which 950 with 600 MHz already available):** Minimal regulatory intervention due to low or no TV usage in the 600 MHz band.
    - **Category 2 (298 municipalities):** Higher spectrum reorganisation needed, including multiprogramming and channel reassignments within UHF.
    - **Category 3 (86 major metropolitan areas):** High use requires advanced solutions—multiprogramming, VHF migration, and strategic channel consolidation.
- **TV 3.0 & 5G Broadcast opportunities**: Transition to TV 3.0 brings enhanced efficiency, but simultaneous reallocation requires coordinated stakeholder engagement. 5G Broadcast can be part of TV 3.0, reducing demand on traditional TV channels while improving spectrum use.
- **Robust regulatory framework**: A market-driven auction framework for 600 MHz, aligned with cost recovery, to encourage mobile operators and compensate broadcasters. Early and phased licensing to deploy services in cleared regions, with well-defined processes to address interference and channel migration.
- **International experience & best practices**: Lessons from Canada, Mexico, Saudi Arabia, and the United States underscore the value of stakeholder cooperation, careful planning, and mitigating broadcaster concerns early in the process.

1.2. Current landscape

Reallocating the 600 MHz band (614-698 MHz) from TV broadcasting to mobile broadband presents a promising route for Brazil to enhance its digital infrastructure and address growing demands for connectivity. This lower-frequency band is particularly valuable due to its superior signal propagation, which strengthens indoor coverage in urban areas and reduces deployment costs for extending 5G networks into remote regions. Although the 600 MHz band remains allocated to television broadcasting under Brazilian regulations, the International Telecommunication Union's World Radiocommunication Conferences (WRCs) have recognised it for mobile use in various countries. Several countries, including Canada, Mexico, Saudi Arabia, and the United States, are already well into the reallocation process, offering lessons that underscore the need for technical coordination, thoughtful planning, and stakeholder engagement.

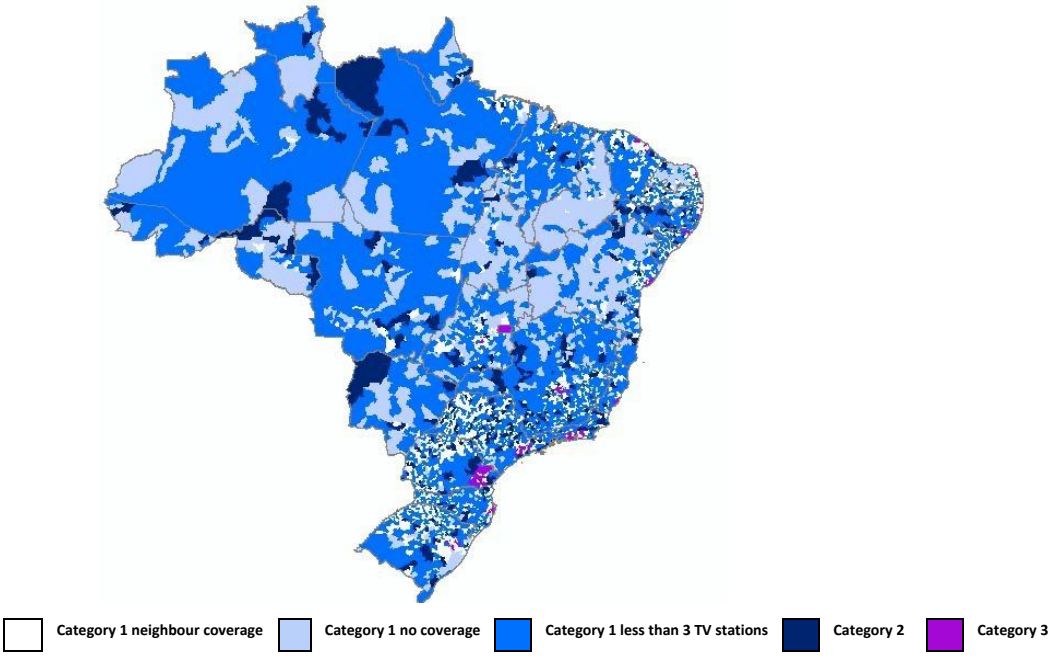
1.3. The 600 MHz band in Brazil

In Brazil, TV broadcasting use in the 600 MHz band varies considerably across municipalities. Major urban centres like São Paulo and Rio de Janeiro exhibit high levels of congestion, while many smaller areas have few or no TV stations operating in this frequency range. This disparity necessitates an adaptable strategy that addresses each municipality's unique circumstances. To simplify planning, the report groups

municipalities into three categories. The first category consists of areas where the 600 MHz band has little to no TV usage, making reallocation straightforward. The second category involves locations with moderate TV congestion, often requiring interventions such as sharing multiple channels within a single 6 MHz slot (multiprogramming). The third category covers large metropolitan areas with heavy spectrum use, necessitating advanced solutions such as VHF migration, consolidation of underused channels, and careful interference management.

- **Category 1 – spectrum available:** Comprising 2,754 municipalities with no assigned or planned TV channels in the 600 MHz band, out of which 950 of these lack any TV signal coverage in urban areas, allowing the 600 MHz band to be immediately allocated for mobile use. Another 2,432 municipalities with up to three active TV stations offer straightforward reallocation opportunities. These regions, mostly smaller towns, face minimal interference challenges, enabling a smooth transition.
- **Category 2 – higher spectrum reorganisation:** This category includes 298 mid-sized cities, with more than three licensed TV stations, requiring more extensive spectrum reorganisation. Multiprogramming, channel consolidation, and the reassignment of public broadcasters' channels to lower UHF bands can alleviate congestion. Technical analyses reveal available channels in the lower UHF band, and terrain-specific interference studies would support a detailed allocation plan.
- **Category 3 – high spectrum use:** Major metropolitan areas, including 86 cities like São Paulo and Rio de Janeiro, face the most complex challenges due to dense spectrum usage. Solutions involve reallocating channels to the VHF band, implementing multiprogramming, and consolidating channels with low utilisation or niche content. Voluntary agreements to switch off underused channels and adjustments for Special Subscription Television Service (TVA) channels further enhance spectrum efficiency.

Figure 1. Map with Brazilian municipalities per category of TV broadcasting occupation of the 600 MHz band



Source: TMG.

1.4. Technical and regulatory framework

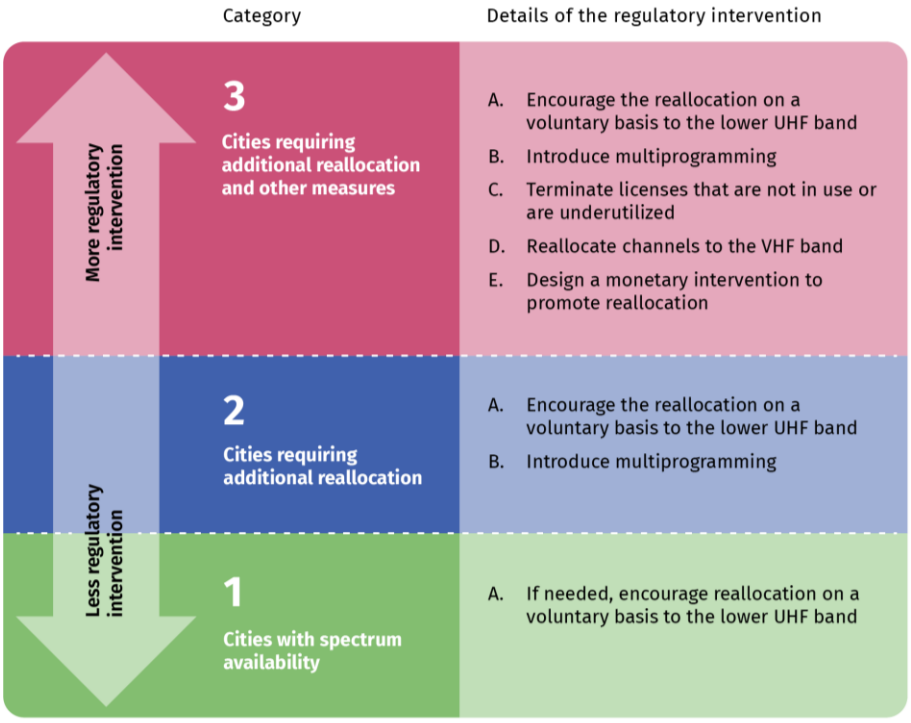
Despite the clear benefits of repurposing the 600 MHz band, Brazil needs to address the required actions on the technical and regulatory frameworks. High-density TV broadcasting assignments in urban areas create significant congestion, requiring careful analysis of interference contours and terrain-specific factors. Updating regulations to permit multiprogramming and potential channel reassignments—both within lower UHF frequencies and in the VHF band—becomes essential in congested cities.

Another factor to be considered is the shift to TV 3.0, a next-generation digital television standard that promises improved audio-visual quality and interactive services. Broadcasters are concerned that switching to TV 3.0 will bring high transition costs, while mobile operators point to the pressing need for 5G coverage. There are also discussions about integrating 5G Broadcast technologies, which might free parts of the band but would require additional regulatory clarity.

1.5. Balancing regional needs and stakeholder interests

A phased reallocation approach offers a practical way of aligning local realities with the overarching goal of nationwide mobile coverage. In municipalities with minimal 600 MHz occupancy, mobile operators can begin rolling out services quickly after a light administrative procedure to migrate or consolidate any existing TV channels. Mid-sized cities with moderate congestion may need additional regulatory updates—such as allowing commercial broadcasters to share channels more liberally—and a thorough analysis to avoid interference. Densely populated metropolitan regions demand the most comprehensive solutions, from voluntary channel switch-offs to possible migrations into VHF frequencies.

Figure 2. Level of regulatory intervention in the 600 MHz band per city category



Source: TMG.

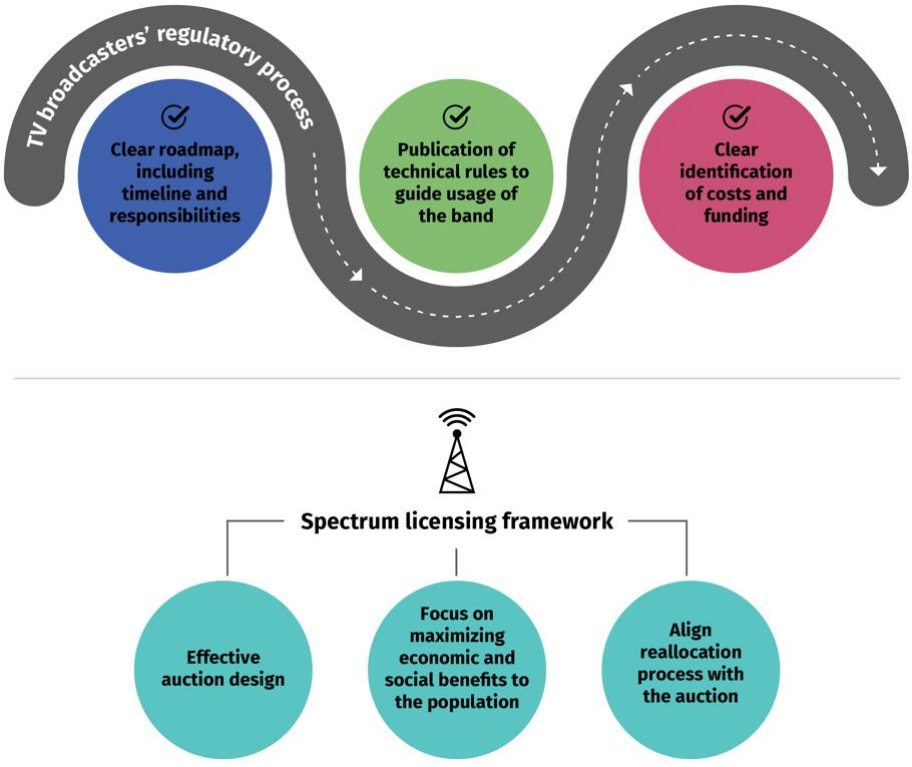
On the political and administrative side, effective collaboration between the Brazilian National Telecommunications Agency (Anatel) and the Ministry of Communications (MCom) is crucial. Ensuring a temporary freeze on new TV licences in the 600 MHz band will help prevent further spectrum saturation and simplify the transition. Equally important is a transparent system for compensating broadcasters who must relocate, funded by proceeds from a market-driven spectrum auction that is focused on cost recovery rather than inflated revenue targets.

1.6. Framework for auctioning the 600 MHz band

Designing an effective auction framework to license the 600 MHz band for mobile services requires balancing multiple aims:

1. **Equitable cost recovery**: Reserve prices should cover broadcasters' reallocation expenses while remaining low enough to encourage robust participation by mobile operators.
2. **Phased licensing**: Initiating the auction process before every municipality is cleared can accelerate 5G deployments in areas already free of TV stations, optimising spectrum use.
3. **Clear cost allocation**: Establishing an independent entity or fund to manage broadcaster reimbursement helps preserve transparency and fairness, minimising disputes among stakeholders.
4. **Flexible implementation**: The auction must allow operators to deploy services in phases, enabling a smooth rollout that progresses at the pace of broadcaster migration.

Figure 3. Regulatory process for TV broadcasting clearing and 600 MHz band assignment to mobile



Source: TMG.

1.7. Cost drivers and compensation mechanisms

Successful reallocation involves carefully planning for costs that vary substantially across regions. In category 1 and 2 cities, these expenses typically involve retuning existing equipment to channels below 600 MHz. Such retuning costs are relatively modest compared to earlier transitions from analogue to digital TV. In high-density urban centres (category 3), however, expenses can escalate quickly, especially if broadcasters must purchase entirely new VHF equipment or reorganise single-frequency networks. A targeted compensation mechanism can ensure that necessary funding is available to broadcasters without imposing excessive financial burdens on operators.

1.8. Recommendations

Reallocating the 600 MHz band holds significant promise for Brazil's connectivity goals, especially in light of surging data demands and the need for equitable digital access. The process is technically complex, though feasible, provided that policymakers adopt a flexible, region-specific approach supported by updated regulations. Embracing multiprogramming, exploring VHF reassignments where needed, and curtailing underused or special-interest channels will help release valuable spectrum for mobile services while maintaining robust TV broadcasting.

Close collaboration among Anatel, MCom, broadcasters, and mobile operators is vital. A phased, market-driven auction can promptly free up the 600 MHz band in lower-demand municipalities, expediting the expansion of 5G coverage while offering sufficient time for broadcasters in congested areas to transition. By balancing short-term spectrum relocation needs with long-term investments in TV 3.0 and 5G Broadcast, Brazil can lay the groundwork for a more inclusive, technology-forward digital environment that benefits consumers, businesses, and public institutions nationwide.

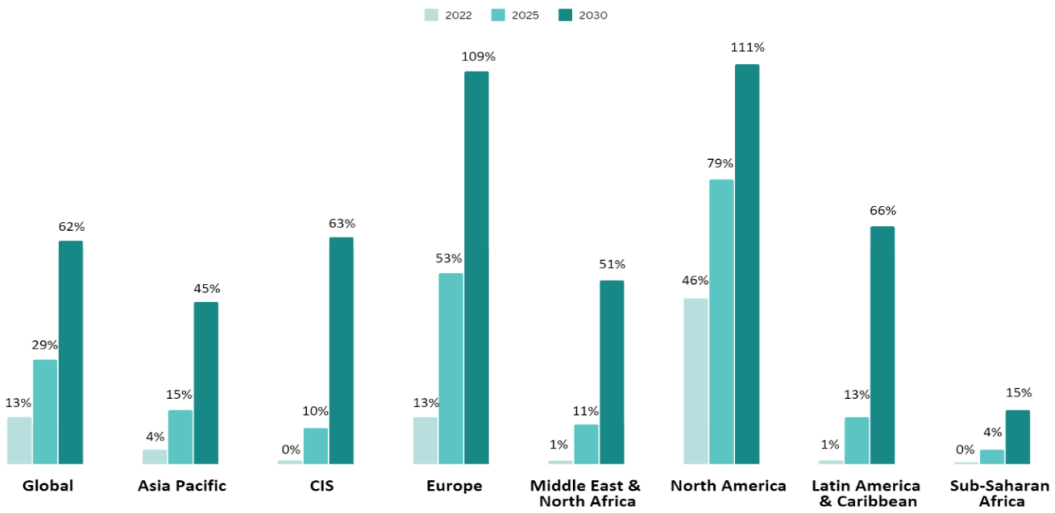
1. Introduction and background

This report presents a comprehensive analysis addressing the reallocation of the 614-698 MHz spectrum range, known as the 600 MHz band, for mobile broadband services in Brazil. As the demand for mobile connectivity continues to grow and the deployment of 5G networks expands, reallocating this spectrum from its current use in television (TV) broadcasting to terrestrial mobile service is crucial to extending broadband coverage, particularly in rural and underserved areas. This report explores the technical and regulatory challenges associated with the reallocation process, providing the necessary framework for an effective transition. The findings will guide stakeholders in navigating the complexities of spectrum reallocation while ensuring that both TV broadcasting and mobile services are efficiently supported.

1.1. The 600 MHz band is needed to deliver the vision of 5G

By 2030, projections suggest that there will be over 5 billion 5G connections globally.[1] To sustain this growth, governments and operators must ensure sufficient spectrum availability, particularly in rural areas and for indoor coverage in urban areas. One key strategy for achieving this is repurposing spectrum currently allocated to other services, including TV broadcasting, for mobile broadband services.

Figure 4. 5G market penetration by region, 2022–2030



Source: GSMA.

The 600 MHz band has emerged as a crucial asset for enhancing mobile network capacity and its use for mobile services would significantly improve 5G coverage and speeds. Benefiting critical infrastructure such as roads, ports, and mines, utilising the 600 MHz band for 5G can increase rural and deep-indoor 5G

[1] GSMA, Socio-Economic Benefits of 5G The Importance of Low-Band spectrum, March 2023, https://www.gsma.com/connectivity-for-good/spectrum/wp-content/uploads/2023/11/Socio-Economic-Benefits-of-Low-Band-Spectrum.pdf.

speeds by 30% to 50%, while reducing the costs of extending 5G coverage to remote areas by a third.[2] Furthermore, the 600 MHz band has been standardised by 3GPP into bands n71 and n105. Band n71, already widely supported by over 624 commercial devices, is being deployed globally, while band n105 is under consideration in several Asian countries, offering potential economies of scale due to its compatibility with band n71.[3]

In Brazil, reallocating the 600 MHz band is crucial for expanding 5G services, particularly in bridging the urban-rural digital divide. Currently assigned to TV broadcasting, this spectrum is managed by the Brazilian National Telecommunications Agency Anatel, with varying levels of usage across states. Densely populated regions like São Paulo and Rio de Janeiro face unique challenges due to the high concentration of TV channels, while most of the country faces a lesser use of the band. Recognised internationally for mobile use since the 2015 ITU World Radiocommunication Conference (WRC-15), the 600 MHz band's superior signal propagation makes it a valuable resource for enhancing connectivity. Thus, effective reallocation requires tailored technical and regulatory strategies to balance regional needs and manage coexistence with TV broadcasting services.

The 600 MHz band remains a valuable and cost-effective option for countries aiming to enhance mobile network capacity in indoor urban and rural areas, enabling them to provide improved services to critical infrastructure and accelerate 5G deployment.

1.2. International experiences on the 600 MHz band for mobile broadband

The ITU's World Radiocommunication Conferences (WRCs) play a pivotal role in global spectrum management by ensuring equitable access to frequencies, promoting efficient usage, and establishing conditions for coexistence between services. At WRC-15, the 600 MHz band was first identified for International Mobile Telecommunications (IMT) use, marking an important step toward global harmonisation. More recently, at WRC-23, additional countries adopted the band for IMT, with future WRCs expected to see even broader adoption. These decisions enable countries to transition the 600 MHz band from TV broadcasting to mobile broadband in a manner that suits their specific requirements, fostering greater international alignment. Countries that have identified the band for IMT include Bahrain, Bangladesh, Barbados, Belize, Canada, Colombia, Egypt, El Salvador, Guatemala, Iraq, Jamaica, Jordan, Kuwait, Lao P.D.R., Maldives, Micronesia, Mexico, New Zealand, Oman, Palestine, Qatar, Saudi Arabia, Solomon Islands, Syrian Arab Republic, Tuvalu, the Bahamas, the United Arab Emirates, the United States, and Viet Nam.[4]

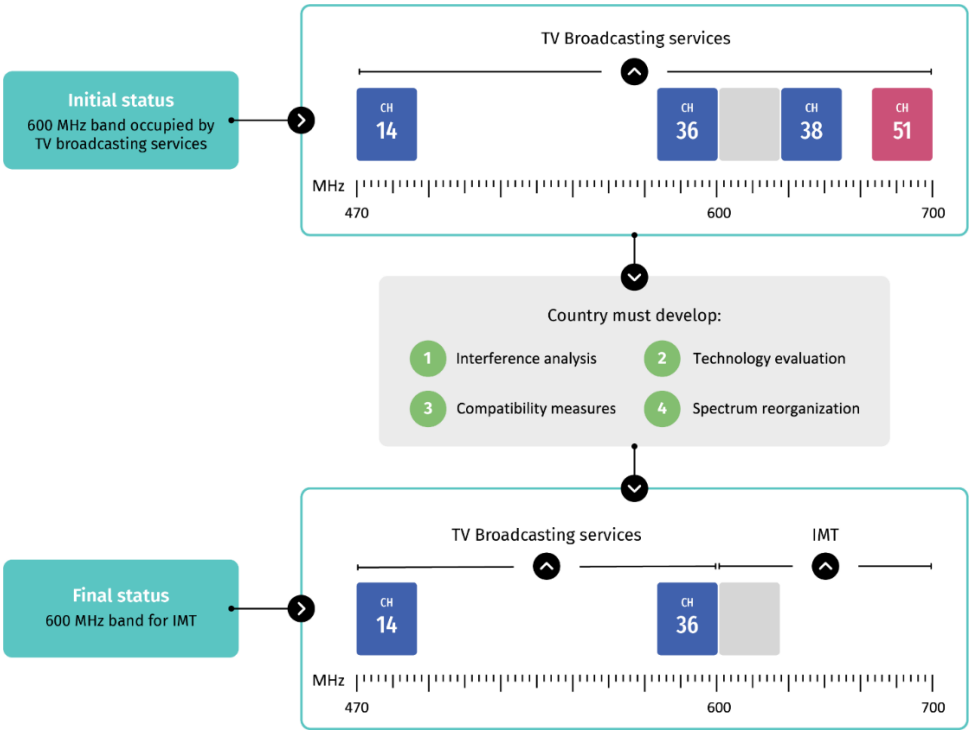
On a national level, countries like Canada, Mexico, Saudi Arabia, and the United States have already reallocated the 600 MHz band from TV broadcasting to mobile broadband, with Colombia and Costa Rica currently in progress. Though Mexico and Saudi Arabia have vacated the band, it has yet to be put in use. Decisions to reallocate are often driven by the need for additional spectrum to support broadband services, particularly in rural areas, and to lower deployment costs, which is particularly important for low- and middle-income countries. More details on different countries experiences are in Annex 1.

[2] GSMA, Spectrum Policy Trends 2023, February 2023, https://www.gsma.com/connectivity-for-good/spectrum/wp-content/uploads/2023/02/Spectrum-Policy-Trends-2023-1.pdf.
[3] GSA, 5G Device Ecosystem, July 2024, https://gsacom.com/paper/5g-devices-ecosystem-july-2024/.
[4] ITU, Radio Regulations, 2024 edition, https://www.itu.int/pub/R-REG-RR-2024.

1.2.1. General overview of the experiences in the reallocation of the 600 MHz band

To meet the growing demand for mobile broadband in frequency bands below 1 GHz, some countries have focused on reallocating the 600 MHz band from TV broadcasting to mobile services. This process requires thorough technical and regulatory analysis to ensure the band can be efficiently transitioned for mobile broadband use. Figure 5 outlines the key steps in this reallocation process.

Figure 5. Reallocation process of the 600 MHz band for mobile broadband



Source: TMG.

Each country takes a unique approach to reallocating the 600 MHz band, but the process generally includes technical assessments, regulatory and licensing reviews, and the development of a transition plan. In the United States, a spectrum incentive auction enabled licensees to voluntarily relinquish spectrum in exchange for a share of the auction proceeds. Conversely, in Saudi Arabia, where the 600 MHz band was sparsely used, the reallocation was achieved through a decision by the Communications, Space, and Technology Commission in collaboration with the broadcasting regulator, without the need for an incentive auction. Table 1 outlines key elements of these processes.

Table 1. Key elements of the reallocation process of the 600 MHz band in Canada, Mexico, Saudi Arabia, and the United States

	Canada	Mexico	Saudi Arabia	United States
Leading government entity	ISED	IFT	CST	FCC
Overall IMT spectrum targets	750 MHz of spectrum to commercial mobile services by the end of 2017	70 MHz of spectrum in the 600 MHz band for 5G mobile broadband	Improve access to more than 23 GHz of spectrum for a wide range of uses	Repurpose licensed spectrum in the 600 MHz band to commercial wireless operations

Reallocation timeline	2014-2019	2015-2018	2020-2023	2016-2017
Band users before reallocation	TV broadcasting, remote rural broadband systems (RRBS), low-power apparatus, television white space (TVWS) devices and wireless medical telemetry systems (WMTS), and radio astronomy service (RAS)	TV broadcasting	TV broadcasting. Limited usage: only 1% of all households viewed terrestrial broadcast signals (2021).	TV broadcasting
Amount of spectrum in 600 MHz for IMT	70 MHz	70 MHz	70 MHz	70 MHz

Source: TMG.

1.2.2. Lessons for Brazil from existing international experiences

International experience suggests that the success of the 600 MHz reallocation process depends on factors such as stakeholder collaboration, robust technical analysis, and effective interference management between mobile services and existing TV broadcasting. Countries with lower levels of 600 MHz band usage and strong cooperation among stakeholders encountered fewer challenges, while those with more complex spectrum use faced delays due to technical and regulatory hurdles.

Figure 6. Key lessons learned from other countries on the 600 MHz reallocation process

Canada

Coordination with neighbouring countries: Synchronised efforts with the United States reduced complexity and ensured sufficient spectrum in lower frequencies for both nations.

Effective management of relationships with broadcasters: The government established constructive engagement with TV broadcasters to facilitate the transition.

Spectrum availability for broadcasters: Canada ensured sufficient spectrum for existing over-the-air TV stations through coordination with the United States, allocation of guard bands, and guarantees for channels in the new allotment plan.

Mexico

Regulatory foresight and proactive planning: The regulator recognised the 600 MHz band for IMT use early and implemented forward-looking strategies to facilitate its reallocation.

Streamlined reallocation process: The suspension of new licences for TV broadcasting services in the band accelerated the transition, enabling a faster and more efficient reallocation.

Addressing demand challenges: Despite proactive measures, limited demand for the band highlighted the importance of aligning spectrum reallocation with market readiness.

Saudi Arabia

Minimal existing use of the 600 MHz band: The reallocation process was facilitated by the low utilisation of the band, with regulators proactively encouraging reduced future use.

Cross-sector regulatory coordination: Effective collaboration between broadcasting and telecommunications regulators ensured synchronised efforts, streamlining the reallocation process.

Addressing political resistance from TV broadcasters: Resistance was effectively managed through regulatory mechanisms, such as a spectrum incentive auction, enabling a smoother transition.

United States	**Evaluating process complexity and costs**: The auction process, while successful, proved administratively complex and costly, highlighting the importance of assessing these factors when selecting reallocation mechanisms.

Source: TMG.

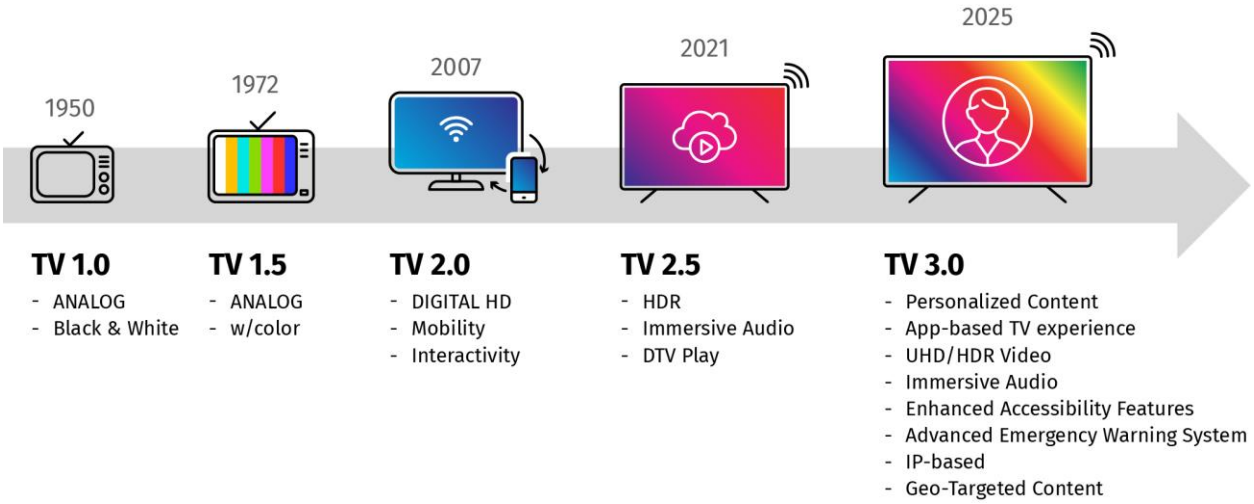
Successful reallocation processes are characterised by clear, coordinated efforts to address technical complexities, including interference mitigation and accommodating new technologies. Ensuring collaboration between broadcasters, regulators, and mobile operators is essential, as is aligning plans with neighbouring countries, particularly in border regions where spectrum use may overlap. For Brazil, lessons from these international experiences underline the importance of stakeholder coordination, technical planning, and regulatory adjustments, as shown in Figure 6.

Anatel's leadership will be crucial to streamlining the process, including working with the Ministry of Communications (MCom) in suspending new licences for TV broadcasting services in the band to facilitate a smoother transition, as it was the case with Mexico.

1.3. Opportunities with ongoing TV 3.0 and 5G Broadcast discussions in Brazil

The development of TV 3.0 standards is expected to improve TV broadcasting in Brazil, offering advancements over the current standard for digital television (ISDB-Tb). This new technology promises enhanced interactivity, accessibility, and personalisation, driven by artificial intelligence (AI), along with Ultra-High Definition (UHD) resolution and immersive audio.[5] Furthermore, the introduction of TV 3.0 provides an opportunity to reassess spectrum usage by TV broadcasting, potentially opening the door for more efficient use of the UHF band.[6]

Figure 7. TV broadcasting evolution in Brazil



Source: SBTVD.

[5] SBTVD Forum, TV 3.0 Project, September 2024, https://forumsbtvd.org.br/tv3_0/.
[6] Based on information provided by representatives from Anatel on September 26, 2024.

In 2023, the government established a framework for the evolution of the Brazilian Digital Terrestrial Television System (SBTVD), aiming to ensure spectrum availability for TV 3.0. It assigned responsibilities for different stakeholders in the ecosystem including Anatel, MCom, and the SBTVD Forum.[7] Following this directive, the SBTVD Forum recommended ATSC 3.0 as the transmission technology for TV 3.0 in Brazil.[8]

5G Broadcast plays a significant role in the TV 3.0 discussions, offering an alternative or complementary method for delivering TV content directly to mobile devices. Current considerations include integrating 5G Broadcast into broadcasters' existing channels or consolidating content from multiple broadcasters into a single channel, potentially utilising blocks within the guard band of the 600 MHz spectrum. This approach could reduce broadcasters' dependence on traditional spectrum allocations, enabling more efficient use of the band and freeing portions for mobile broadband services. While timelines for 5G Broadcast remain uncertain in Brazil, MCom has recently confirmed progress in the TV 3.0 process for fixed reception, with pilot tests scheduled in São Paulo and Brasília for 2025 and 2026, respectively, and an official launch anticipated by 2026.[9]

At the end of 2024, MCom announced a draft decree outlining key decisions, including the adoption of the ATSC 3.0 transmission standard, as recommended by the SBTVD Forum based on extensive field tests.[10] The decree also reserves the 300 MHz band to support TV 3.0 channel demands, signalling a shift in spectrum allocation policies. In line with this policy, in January 2025 Anatel amended the national frequency allocation table to include allocations to the broadcasting service in parts of the 300 MHz as a further step to implement TV 3.0 in Brazil.[11] Currently occupied by private services and the Armed Forces, the 300 MHz band will undergo channelisation under the oversight of Anatel to ensure seamless integration with the new standard. However, decisions on reallocating the 600 MHz band for mobile broadband remain pending.

TV broadcasters have expressed concerns about the transition to TV 3.0, particularly regarding the feasibility of commercial deployment by 2026 and the likelihood that full implementation, including receiver requirements, will not occur before 2027. They highlight the financial challenges of transitioning to TV 3.0, clearing the 600 MHz band, and reserving spectrum for 5G Broadcast.[12] Organisations such as the Brazilian Association of TV and Radio Broadcasters (ABERT) advocate for protecting the 600 MHz band to support TV 3.0, citing opportunities like personalised advertising through its new model, while emphasising the high costs and tight timelines. Mobile operators, on the other hand, stress the need for

[7] Presidential Decree 11484, April 6, 2023, https://www.planalto.gov.br/ccivil_03/_ato2023-2026/2023/decreto/D11484.htm.
[8] MCom, Tecnologia de transmissão do sistema ATSC 3.0 será recomendada para a TV 3.0 no Brasil, July 2024, https://www.gov.br/mcom/pt-br/noticias/2024/julho/tecnologia-de-transmissao-do-sistema-atsc-3-0-sera-recomendada-para-a-tv-3-0-no-brasil.
[9] Tele síntese, TV 3.0: MCom confirma padrão norte-americano e faixa de 300 MHz, December 2024, https://www.telesintese.com.br/tv-3-0-mcom-confirma-padrao-norte-americano-e-faixa-de-300-mhz/.
[10] MCom, Ministério das Comunicações finaliza minuta do decreto da TV 3.0 e encaminha para Casa Civil, December 2024, https://www.gov.br/mcom/pt-br/noticias/2024/dezembro/ministerio-das-comunicacoes-finaliza-minuta-do-decreto-da-tv-3-0-e-encaminha-para-casa-civil.
[11] Anatel, Resolução 772/2025, Aprova o Plano de Atribuição, Destinação e Distribuição de Faixas de Frequências no Brasil - PDFF, promovendo as atribuições, destinações e condições específicas de uso de faixas de frequências nele dispostas, January 2025, https://informacoes.Anatel.gov.br/legislacao/resolucoes/2025/2001-resolucao-772.
[12] Based on information provided by representatives from the broadcasters on September 25, 2024.

clarity on TV 3.0 standards and their implications for mobile services. They call for a defined timeline and transparent policies for reallocating the 600 MHz band, warning that uncertainty could delay investments and slow the expansion of mobile broadband services.[13] These issues underscore the need for careful coordination to balance the interests of broadcasters and mobile operators.

Despite progress, challenges remain, particularly regarding regulatory alignment, funding for converters to assist low-income families in transitioning to TV 3.0 and defining clear policies for 600 MHz reallocation. By integrating 5G Broadcast into TV 3.0, Brazil could modernise broadcasting while optimising spectrum usage. This dual approach would enable TV broadcasters to release portions of the spectrum, facilitating its reallocation for mobile broadband and expanding network infrastructure in underserved regions.

The confirmed steps and pilots represent significant progress, but successful implementation will require continued coordination among stakeholders, clarity on spectrum policies, and financial support mechanisms to ensure a smooth transition to TV 3.0 and optimal use of the 600 MHz band. Special attention needs to be taken as MCom has and continues to license several TV channels to address previously unmet demand without any coordination with the 600 MHz band process.

1.4. Current context for the reallocation of the 600 MHz band in Brazil

The reallocation of the 600 MHz band in Brazil occurs within a favourable political alignment and offers a timely opportunity to enhance mobile broadband connectivity while aligning with public policies promoting digital inclusion and technological advancement. This spectrum is crucial for expanding 5G networks, particularly to improve rural coverage and indoor penetration in urban areas. The ongoing discussions on TV 3.0 present a unique chance to synchronise spectrum reorganisation with broadcasting advancements, ensuring more efficient use of the band. However, managing interference between mobile services and existing TV broadcasting, along with integrating new technologies such as TV 3.0 and 5G Broadcast, need to be managed properly.

A successful reallocation process will require a robust regulatory framework that facilitates the migration of TV broadcasters to alternative spectrum resources while efficiently assigning the 600 MHz band for mobile services. This includes updating regulations to enable multiprogramming, evaluating available spectrum in UHF and VHF bands, and designing a market-driven auction process. Balancing the interests of broadcasters and mobile operators, addressing public perception, and ensuring stakeholder collaboration are essential. Aligning these efforts with broader public policies and the ongoing TV 3.0 transition will create a coordinated and effective approach to spectrum management, benefiting all stakeholders.

This report explores these critical aspects, including the technical procedures necessary for cleaning the band, strategies for aligning with public policies, and the adoption of best practices in auction rules and requirements to maximise the benefits of reallocation for mobile services.

2. Spectrum reallocation of the 600 MHz band in Brazil

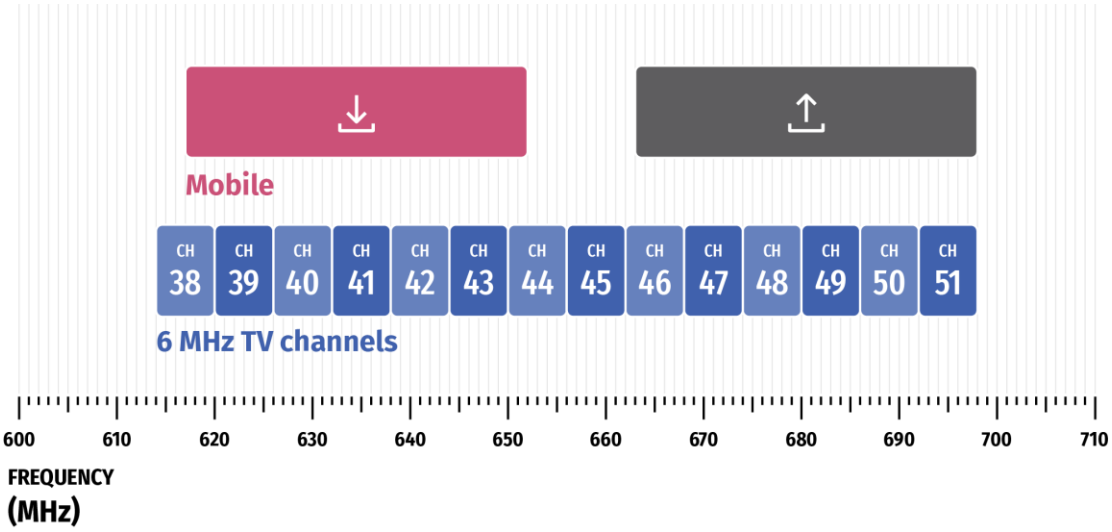
A critical step in reallocating the 600 MHz band for mobile broadband services in Brazil is evaluating the technical feasibility of reorganising existing TV broadcasting channels to free up the necessary spectrum. This requires the administration to analyse both current and future spectrum needs for TV broadcasting and mobile services. Understanding how TV broadcasting channels overlap with mobile broadband uplink

[13] Based on information provided by representatives from a mobile operator on October 7, 2024.

and downlink frequencies is key to determining where reallocation can occur without significant disruption.

Figure 8 illustrates which TV broadcasting channels overlap with the mobile service uplink and downlink in the 600 MHz band. The reallocation process should thus focus on TV broadcasting channels 38 to 51. Channel 45 falls completely within the mobile service's duplex gap which may be useful in the future for consideration of exclusive channels for mobile reception of TV broadcasting using 5G Broadcast technologies.

Figure 8. Identification of the affected TV broadcasting channels and mobile service duplexes in the 600 MHz band



Source: TMG.

The technical analysis focuses on key areas essential for the smooth reallocation of the 600 MHz band, as summarised in Figure 9. This includes interference analysis to prevent conflicts between mobile services and TV broadcasting, technology evaluation of future systems like TV 3.0 and 5G Broadcast, and compatibility measures to ensure both services can operate without interference. Additionally, spectrum reorganisation assesses how current TV channels can be efficiently reallocated to support mobile services.

Figure 9. Steps of the technical analysis for the reallocation of the 600 MHz band

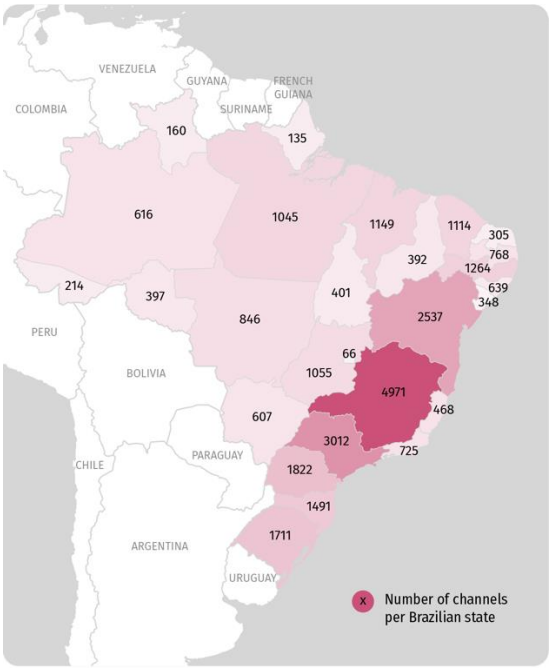
Interference analysis	Technology evaluation	Compatibility measures	Spectrum reorganisation
Essential to identify and mitigate any potential conflicts between mobile services and TV broadcasting, ensuring that both services can coexist without harmful interference	Assess the future adoption of technologies such as TV 3.0 and 5G Broadcast	Establish clear technical criteria that ensure both mobile and TV broadcasting services can operate concurrently without interference	Assessing the current usage of TV broadcasting channels and determining how they can be reallocated to accommodate mobile services, ensuring a smooth transition that minimises disruption to TV broadcasters and viewers

Source: TMG.

In Brazil, TV broadcasting in channels 38 to 51 has various occupation levels depending on the location. According to Anatel's database, there are a total of 28,258 TV channels in the country, of which 6,129 channels, or 22% of the total, have not yet been assigned.[14] As such, this analysis explores different reallocation scenarios, considering the variation in channel assignments across Brazilian cities, and proposes tailored solutions to ensure an effective transition of the 600 MHz band from TV broadcasting to mobile broadband services.

As shown in Figure 10, the distribution of TV channels in Brazil is heavily concentrated in more populous states like Minas Gerais, Rio de Janeiro, and São Paulo. The urban areas in these states face greater spectrum congestion due to the high number of licensed TV broadcasters, particularly in the lower part of the 600 MHz band. In contrast, many smaller or less populated municipalities have fewer TV channels assigned, allowing for more spectrum availability. This uneven distribution underscores the importance of adopting a flexible approach to spectrum reorganisation, ensuring regions with dense assignments are managed with detailed technical solutions, while less congested areas can more readily transition to support mobile broadband expansion.

Figure 10. Distribution of the total TV broadcasting planned and assigned channels per Brazilian state



Source: Anatel.

Brazil's reallocation of the 600 MHz band for mobile broadband services requires tailored approaches to address the diverse spectrum utilisation levels across its municipalities, as detailed in the following sections. This approach allows the regulator to adjust the reallocation plan to the specific needs of different areas, incorporating flexibility in terms of timelines, technical parameters, and reallocation strategies. For this analysis, cities are proposed to be categorised into three groups based on complexity and spectrum reorganisation needs:

[14] Anatel, Painéis de Dados > Outorga e Licenciamento > Estações de TV, FM e OM, October 25, 2024, https://informacoes.anatel.gov.br/paineis/radiodifusao .

- **Category 1 – spectrum available:** Comprising 2,754 municipalities with no assigned or planned TV channels in the 600 MHz band, out of which 950 of these lack any TV signal coverage in urban areas, allowing the 600 MHz band to be immediately allocated for mobile use. Another 2,432 municipalities with up to three active TV stations offer straightforward reallocation opportunities. These regions, mostly smaller towns, face minimal interference challenges, enabling a smooth transition.
- **Category 2 – higher spectrum reorganisation:** This category includes 298 mid-sized cities, with more than three licensed TV stations, requiring more extensive spectrum reorganisation. Multiprogramming, channel consolidation, and the reassignment of public broadcasters' channels to lower UHF bands can alleviate congestion. Technical analyses reveal available channels in the lower UHF band, and terrain-specific interference studies would support a detailed allocation plan.
- **Category 3 – high spectrum use:** Major metropolitan areas, including 86 cities like São Paulo and Rio de Janeiro, face the most complex challenges due to dense spectrum usage. Solutions involve reallocating channels to the VHF band, implementing multiprogramming, and consolidating channels with low utilisation or niche content. Voluntary agreements to switch off underused channels and adjustments for Special Subscription Television Service (TVA) channels can further enhance spectrum efficiency.

Together, these measures could reduce active broadcasting channels in urban areas, freeing up critical spectrum for mobile broadband while maintaining robust broadcasting services. By categorising cities according to these parameters, the reallocation process can be managed more efficiently, ensuring a smooth transition from TV broadcasting to mobile broadband services across Brazil. The full list of municipalities per each category is in Annex 3.

2.1. Spectrum reorganisation process

2.1.1. Coverage and interference analysis

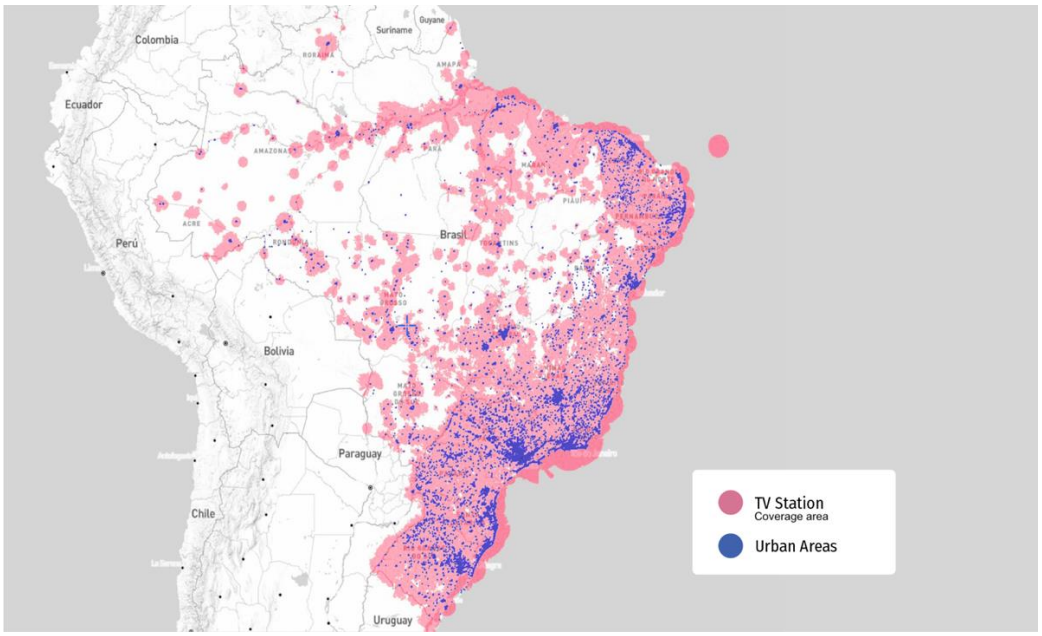
As Brazil proceeds with the reallocation of the 600 MHz band, a thorough analysis of potential interference between mobile services and existing TV broadcasting stations is a crucial first step. In some cases, geographic and technical factors enable the coexistence of both services without significant disruption, such as when the interference areas of TV stations and mobile base stations do not overlap. However, when conflicts do arise, targeted mitigation strategies are necessary to maintain the operation of both services prior completing the reallocation of TV channels.

The simulation depicted in Figure 11 highlights the coverage areas of TV channels 38 to 51, providing a clear view of regions in Brazil where the 600 MHz band may already be available for mobile services and others where TV channel reallocation will be necessary. The areas in red represent TV broadcasting coverage achieving a minimum field strength of 51 dB(µV/m), which is generally suitable for outdoor

antenna reception in alignment with the requirements in Brazil.[15] The figure includes all TV stations, and their respective technical characteristics, as listed in Anatel's database and takes account of terrain, using the same analytical tools employed by the regulator when assessing requests for new TV channels.[16] This ensures an accurate depiction of current coverage and helps identify regions for spectrum reallocation.

Where coexistence is not feasible, a staggered approach to implementation is recommended. This would involve deploying mobile services in phases, aligned with the phased clearance of TV broadcasting stations from the 600 MHz band in different regions. Such a strategy allows for the progressive rollout of mobile networks while ensuring that TV broadcasting services are not unduly disrupted. By adopting these measures, Brazil can ensure a smooth and balanced reallocation process, minimising interference and addressing the needs of both TV broadcasters and mobile operators.

Figure 11. Coverage areas of TV Stations operating on channels 38 to 51 in Brazil



Source: TMG based on Anatel database.[17]

2.1.2. Category 1 – spectrum available

Table 2. Types of municipalities in category 1 by existing TV broadcasting use of the 600 MHz

	Number of municipalities

[15] Anatel, Ato 9751, Requisitos Técnicos de Condições de Uso de Radiofrequências para os Serviços de Radiodifusão de Sons e Imagens e de Retransmissão de Televisão, July 6, 2022, Annex Table 1, https://informacoes.ANATEL.gov.br/legislacao/atos-de-requisitos-tecnicos-de-gestao-do-espectro/2022/1688-ato-9751.
[16] Spectrum-E, Technical Analysis Module, https://public.spectrum.center/se/public/technical-analysis.
[17] Anatel, Planos Básicos de Distribuição de Canais, August 2024, https://www.gov.br/ANATEL/pt-br/regulado/radiodifusao/planos-basicos-de-distribuicao-de-canais.

Category 1 municipalities	5186
Up to 3 TV stations	2,432
No TV station	2,754 (950 no coverage)

Source: TMG.

Brazil has a total of 5,570 municipalities,[18] with 7,697 TV broadcasting stations either authorised or planned in channels 38 to 51.[19] Out of this total, an analysis of Anatel's database indicates that there are 2,816 municipalities where there is at least one TV station in the 600 MHz band. The remaining 2,754 municipalities do not have assigned or planned TV stations in the band.[20] Furthermore, from these 2,754 municipalities there are 950 municipalities — representing 17% of the total — which are not fully covered by any existing TV broadcasting stations in this frequency range. In these cities, urban areas do not receive signals from any neighbouring TV stations, as shown in Figure 11. In such locations, the 600 MHz band can be immediately used for mobile services without the need for reallocation of existing TV channels. However, these are generally smaller markets that may not create sufficient economic incentives for mobile and TV broadcasters to invest in service deployment, potentially affecting the business case for new coverage in these regions. Separate consideration should be given to the other 1,804 cities without a TV station that do receive signals from neighbouring locations.

Additionally, there are 2,432 municipalities with a maximum of three TV broadcasting stations licensed to operate out of the 14 possible channels available between 38 and 51. In these cases, spectrum reallocation is expected to be relatively straightforward due to the limited number of active broadcasters. This simplifies the process of conducting spectrum studies and minimises the complexity of interference management. Consequently, these areas present significant potential for early reallocation, offering a smoother transition to mobile services with minimal technical challenges. Table 2 summarises the types of municipalities in category 1.

One example of a municipality with only a few licensed TV broadcasting stations is Água Boa, in the state of Mato Grosso, where channel 39 is planned, and channels 40 and 49 are already licensed. Technical studies undertaken for this report, which evaluated interference contours and service areas of existing TV stations, identified several additional channels available below the 600 MHz band (including channels 15, 17, 19, 23, 24, 25, 26, 27, 29, 30, 31, 33, 34, and 36). Another example of municipality with tree licensed TV stations in the band is Baturité, in the state of Ceará, where channels 10, 27, 36 would be available for a reallocation process. These additional channels provide viable options for migrating TV stations currently using the 600 MHz band to lower UHF channels, ensuring minimal disruption to broadcasting services during the reallocation process.

[18] IBGE, Divisão Territorial Brasileira, 2022, https://www.ibge.gov.br/geociencias/organizacao-do-territorio/estrutura-territorial/23701-divisao-territorial-brasileira.html?=&t=downloads.
[19] Anatel, Painéis de Dados > Outorga e Licenciamento > Estações de TV, FM e OM, October, 25 2024, https://informacoes.ANATEL.gov.br/paineis/outorga-e-licenciamento/estacoes-de-tv-fm-e-om.
[20] Anatel, Planos Básicos de Distribuição de Canais, August 2024, https://www.gov.br/ANATEL/pt-br/regulado/radiodifusao/planos-basicos-de-distribuicao-de-canais.

2.1.2.1. Ongoing digitalization efforts

The introduction of new TV broadcasting channels under the *Digitaliza Brasil* project further complicates the reallocation process for cities under this category. This MCom programme aims to complete the digitalisation of TV broadcasting services in over 1,650 municipalities that still rely solely on analogue signals. It also includes the installation of digital retransmission equipment and the distribution of TV converters to low-income families.[21] It is important that the initiatives of this program be coordinated with the public policies related to the 600 MHz band, as the new licences being issued for TV broadcasting may affect the reallocation process for category 1 municipalities.

Based on the analysis above, for most of the municipalities in this category the availability of alternative frequencies allows for a relatively straightforward transition, enabling the reallocation of the 600 MHz band for mobile services without significantly affecting TV broadcasting stations. These alternative frequencies, primarily in the lower UHF, ensure that existing TV services can continue uninterrupted while freeing up valuable spectrum for mobile broadband expansion.

2.1.3. Category 2 – higher spectrum reorganisation

Table 3. Types of municipalities in category 2 by existing TV broadcasting use of the 600 MHz

	Number of municipalities
Mid-sized municipalities with more than 3 TV stations	298

Source: TMG.

This second category includes mid-sized municipalities and some state capitals with more than three licensed TV broadcasting stations in the 600 MHz band, leading to greater difficulty in reallocation. There are a total of 298 cities in this category. Additionally, many of these municipalities have channels operated by government entities such as the Brazilian Communication Company (EBC), House of Representatives (TV Câmara), and the Federal Senate (TV Senado), potentially adding further complexity the process of spectrum reallocation.

2.1.3.1. Implementing multiprogramming to reduce spectrum congestion

The spectrum reallocation in these cities requires more detailed analysis, and in some cases, there may not be an option to leverage channels below 600 MHz to migrate existing TV broadcasting stations. This requires consideration of other options, including grouping channels into multiprogramming arrangements, to maximise spectrum efficiency. Multiprogramming allows for the broadcasting of multiple TV contents on a single 6 MHz channel, reducing the number of separate channels required.

Various approaches could be considered to identify channels for multiprogramming. For example, channels with similar thematic content, such as those focusing on specific religious programming or government programming, could be grouped together, ensuring separation where necessary to reflect distinct audience segments. Additionally, TV programming belonging to the same media group could be consolidated on a single channel to optimise spectrum use. In some cases, exclusive channels could be maintained for broadcasters with larger audiences or unique programming requirements, ensuring that

[21] MCom, Programa Digitaliza Brasil, October 2024, https://www.gov.br/mcom/pt-br/acesso-a-informacao/acoes-e-programas/programas-projetos-acoes-obras-e-atividades/digitaliza-brasil-1.

their content remains available while maximising the efficiency of the spectrum. These solutions aim to ensure spectrum efficiency while maintaining content diversity.

2.1.3.2. Technical assessment of selected category 2 cities

A spectrum analysis tool was employed to assess the interference contours and service areas of the existing TV stations in this category of cities. The findings show that some TV channels can be used for reallocation in select cities as described in Table 4.

Table 4. Examples of TV channels available below 600 MHz to support the reallocation process in selected category 2 cities

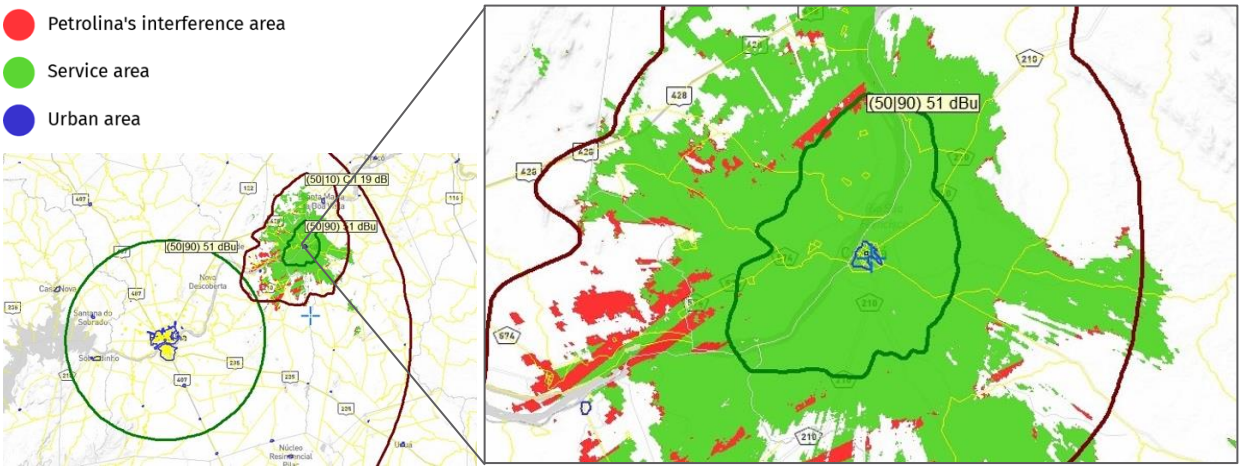
State	City	Channel Class	Channels available below 600 MHz
Acre	Rio Branco	Class A	7, 8, 9, 10, 20, 29, 31
Amapá	Macapá	Class A	8, 9, 10, 11, 12, 14, 15, 21, 22, 23, 24, 25, 26, 30, 31, 33
Amazonas	Manaus	Class A	8, 10, 13, 23
Bahia	Luís Eduardo Magalhães	Class B	8, 9, 14, 17, 22, 27, 28, 32, 34, 35
Goiás	Rio Verde	Class C	15, 21
Mato Grosso	Cuiabá	Class A	14, 17, 19, 22, 25, 29, 33
Mato Grosso do Sul	Campo Grande	Class A	11, 12, 23, 26, 29, 36
Minas Gerais	Uberlândia	Class B	10, 11, 15, 16, 18
Pará	Belém	Class A	7, 13, 14, 17, 29
Paraná	Umuarama	Class B	8, 12, 13, 27, 32
Pernambuco	Petrolina	Class B	7, 8, 10, 11, 12, 13, 32, 34, 36
Piauí	Teresina	Class A	10, 15, 25, 30
Rio Grande do Norte	Mossoró	Class B	9, 11, 13, 15, 28, 30, 36
Rondônia	Porto Velho	Class A	8, 9, 10, 11, 12, 13, 18, 19, 24, 25, 27, 29, 33
Roraima	Boa Vista	Class A	10, 11, 12, 13, 14, 18, 20, 21, 27, 28, 31, 32, 33
Tocantins	Palmas	Class A	19, 31, 33

Source: TMG.

The reallocation process for cities in this category must address several TV channels assigned to government entities and ensure a detailed review of all licensed channels in conjunction with multiprogramming. This approach is necessary to free up the 600 MHz band for mobile services while maintaining the integrity of TV broadcasting operations in these mid-sized cities.

In addition, a more detailed point-to-point analysis of interference and coverage that takes terrain into account is necessary for municipalities where high-power TV stations have interference zones extending over 200 km. This significantly complicates the process of identifying additional available channels and must be factored into any future channel reallocation efforts. For instance, in the city of Petrolina, located in the state of Pernambuco, initial assessments indicated that channel 15 could not be utilised due to an existing station in the nearby city of Curaçá, in the state of Bahia. However, a more granular analysis considering the terrain between the two cities using the same tool as Anatel did not determine actual interference in Curaçá's urban area from the TV station in Petrolina, as illustrated in Figure 12. This demonstrates the importance of detailed terrain-based evaluations in determining channel viability and avoiding unnecessary limitations on channel reallocation for a future reallocation process of the 600 MHz band in Brazil.

Figure 12. Contours of TV stations on Channel 15, including Petrolina's interference area into Curaçá, service area, and urban area



Source: TMG based on Anatel database.

2.1.4. Category 3 – high spectrum use

Table 5. Types of municipalities in category 3 by existing TV broadcasting use of the 600 MHz

	Number of municipalities
Major metropolitan areas	86

Source: TMG.

This category includes major metropolitan areas, primarily state capitals, characterised by higher spectrum usage and requiring more comprehensive measures for the reallocation of the 600 MHz band. These cities, with numerous licensed TV broadcasting stations, present significant challenges due to high spectrum congestion and complex interference scenarios. A total of 86 cities falls within this category, necessitating advanced technical solutions and detailed analysis to facilitate an efficient transition of the 600 MHz band to mobile broadband services while maintaining broadcast continuity.

2.1.4.1. Reallocation of channels to the VHF band

Given the dense spectrum usage in these areas, a key element of the reallocation process will involve the reassigning from TV channels from the 600 MHz band to the VHF band. Although VHF channels are less commonly used in these cities, there remains significant potential for reallocation, as seen in the São Paulo area, where only channels 8, 10, and 12 are used for TV stations in Barueri, São Caetano, and Guarulhos, respectively. The seven remaining VHF channels in this band could be used in the reallocation process but would require regulatory changes, as per the current MCom directive they are reserved only for government TV broadcasters.[22] This presents an opportunity to explore more flexible and innovative solutions for spectrum management in Brazil.

[22] Portaria de Consolidação GM/MCom nº 1, Consolidação de normas ministeriais de radiodifusão, June 1, 2023, Art. 411, https://www.in.gov.br/en/web/dou/-/portaria-de-consolidacao-gm/mcom-n-1-de-1-de-junho-de-2023-*-487937728.

2.1.4.2. Using multiprogramming to address congestion

In addition to reallocating channels to VHF, the use of multiprogramming is a critical strategy for optimising spectrum use. Similarly to the use of VHF, the flexible use of multiprogramming would require regulatory updates as discussed in section 2.1.3.1.. Multiprogramming would be implemented following similar rules as those discussed for category 2 cities to ensure both spectrum efficiency and content diversity.

2.1.4.3. Voluntary switch off channels

Another possible solution could be switching off certain channels with low utilisation or those operated by niche broadcasters. In the case of São Paulo, for example, channels with limited audience reach, or specialised content, could be voluntarily reassigned or consolidated. For instance, one example involves a broadcaster currently operating on channel 14 in São Caetano, part of the metropolitan area of São Paulo, as well as on channel 44, in the central area of São Paulo (Paulista Avenue). If one of these two channels are switched off, the remaining one could be moved to channel 13 in the VHF band, freeing up the 600 MHz band while still maintaining the broadcaster's service. This approach, done on a voluntary basis, would not only optimise spectrum use but also facilitate the broader reallocation strategy, addressing potentially underused channels without disrupting essential services.

2.1.4.4. Addressing Special Subscription Television Service (TVA)

The Special Subscription Television Service (TVA) was originally intended to provide subscription-based pay TV but never achieved widespread success. Instead, many TVA channels have been repurposed as de facto free-to-air broadcasters, particularly in state capitals, leading to regulatory challenges. These channels now function similarly to traditional broadcasting services without adhering to their original licensing purpose. The reallocation of the 600 MHz band offers an opportunity to address this issue. Reassessing the TVA channels, by either integrating them into the standard broadcasting framework or reallocating them, would free up additional spectrum in major cities. While this would require regulatory updates, it could greatly streamline the spectrum reallocation process and ensure more efficient use of resources.

Case study: São Paulo and Rio de Janeiro

In both São Paulo and Rio de Janeiro, reassigning the 600 MHz band involves a multifaceted set of strategies designed to ease spectrum congestion in densely populated environments while allowing for mobile broadband expansion. In Rio de Janeiro, the city's mountainous terrain has led certain broadcasters to operate multiple 6 MHz channels—often in single frequency network (SFN) configurations—to reach all corners of the city. Through consolidation or multiprogramming (two programmes in one 6 MHz channel), broadcasters can maintain sufficient coverage without occupying as many discrete channels. Such actions free valuable portions of the 600 MHz band, which can then be repurposed for advanced mobile services, particularly 5G.

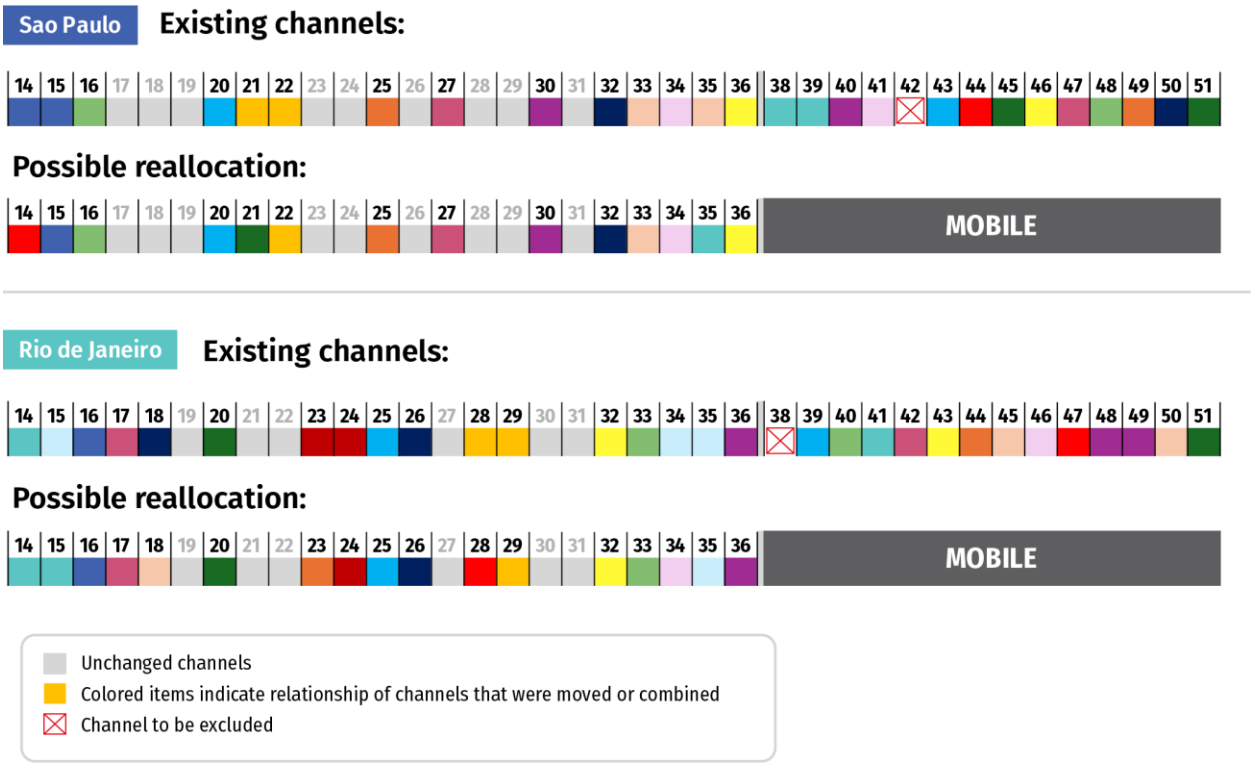
São Paulo faces comparable challenges but offers unique opportunities for reallocating channels to the VHF band, where fewer stations are currently active. Outside of channels 8, 10, and 12 (assigned to Barueri, São Caetano, and Guarulhos), seven VHF channels remain unused as they are currently reserved solely for public stations. Allowing commercial broadcasters to move into those underused VHF slots could substantially reduce 600 MHz congestion. At the same time, multiprogramming provides an option to share channels among different services, ensuring diverse content remains available while minimising the total number of 6 MHz assignments. This arrangement is particularly

effective for thematically related or co-owned broadcasters, and can be fine-tuned to preserve popular, large-audience programmes on standalone channels.

A further step involves identifying low-audience or niche channels that can be voluntarily switched off, consolidated, or migrated to VHF. In São Paulo, for example, a broadcaster currently operating on channel 14 in São Caetano and channel 44 near Paulista Avenue in central São Paulo could move both programmes to channel 13 in the VHF band. Not only would this merge underutilised frequencies, but it would also pave the way for redeploying 600 MHz channels for mobile use. When pursued together—reassignment to VHF, multiprogramming, and strategic channel consolidation—these measures have the potential to cut the total number of active broadcasting channels by up to 30–40% in urban areas with high demand. While such reorganisation demands regulatory updates, extensive interference analysis, and cooperation among broadcasters, regulators, and mobile operators, it offers a practical blueprint for achieving a more balanced and future-proof spectrum environment in Brazil's most populous cities.

These targeted modifications would effectively release the 600 MHz band for mobile broadband expansion while preserving robust broadcast coverage, as shown in the example in Figure 13.

Figure 13. Examples of possible reallocation of TV channels in São Paulo and Rio de Janeiro metropolitan areas



Source: TMG.

2.2. Compatibility measures

Establishing a set of clear technical conditions is essential to ensure coexistence of mobile and TV broadcasting services during a phased transition of the 600 MHz band in Brazil. This phased process will gradually allow the use of the 600 MHz band for mobile service by region, as TV broadcasting channels

are progressively reassigned. As certain regions complete the reallocation of TV channels, mobile services can begin operating in those areas while the process continues in others.

One key mitigation measure in this phased approach involves defining separation distances, which establish minimum distances between mobile and TV broadcasting stations to prevent signal interference. For mobile base stations, protective actions such as adjusting antenna direction, implementing shielding, and applying filters can effectively minimise interference with nearby TV stations. Similarly, TV stations may need to modify antenna positioning and adjust power output to reduce their impact on neighbouring mobile networks. This careful coordination ensures a smooth transition as the reallocation process moves forward across different regions.

Based on technical studies of interference and service areas for both mobile and TV broadcasting services, it is possible to determine the appropriate distances between systems to ensure interference-free operation. Annex 2 provides a detailed assessment of potential interference scenarios and measures. For example, as shown in Table 6, a mobile base station could affect a TV station within a 13-kilometre radius, while the TV station's service area extends up to 39 kilometres. Conversely, broadcasting signals from a TV station could interfere with mobile operations within a 70-kilometre radius, while the mobile base station service area is around 12 kilometres.

Table 6. Examples of separation distances between mobile and TV broadcasting stations

Interference Scenario	Interference Contour	Service Area Contour
Mobile into broadcasting	13 km (from mobile base station)	39 km (from TV station)
Broadcasting into mobile	70 km (from TV station)	12 km (from mobile base station)

Source: TMG.

Furthermore, adequate consideration should be given to the different power levels associated with the TV broadcasting authorisations in Brazil, thus adjusting these distances accordingly.[23]

Table 7. Classification of digital television channels in Brazil based on maximum characteristics

Class	Channels	Max ERP	Max Protected Contour Distance
Special	7-13	16 kW	65.6 km
	14-46	80 kW	58.0 km
	47-51	100 kW	58.0 km
A	7-13	1.6 kW	47.9 km
	14-51	8 kW	42.5 km
B	7-13	0.16 kW	32.3 km
	14-51	0.8 kW	29.1 km
C	7-13	0.016 kW	20.2 km
	14-51	0.08 kW	18.1 km

Source: Anatel.

[23] Anatel, Ato 9751, Requisitos Técnicos de Condições de Uso de Radiofrequências para os Serviços de Radiodifusão de Sons e Imagens e de Retransmissão de Televisão, July 6, 2022, Annex Table 2, https://informacoes.ANATEL.gov.br/legislacao/atos-de-requisitos-tecnicos-de-gestao-do-espectro/2022/1688-ato-9751.

The separation distances outlined serve as a reference for managing interference during the phased reallocation of the 600 MHz band in Brazil and may be adjusted based on specific regional conditions. Clearly defining these distances is crucial to ensure a smooth transition, enabling mobile services to roll out without disrupting, or being disrupted by, existing TV broadcasting operations in neighbouring areas. Geographic characteristics and the technical specifications of stations will influence these distances, with earlier-transitioning regions required to implement protective measures to prevent interference with adjacent areas still operating TV broadcasting services. This approach ensures effective coexistence of mobile and TV broadcasting services while minimising disruptions during the transition.

3. Regulatory aspects for the 600 MHz band in Brazil

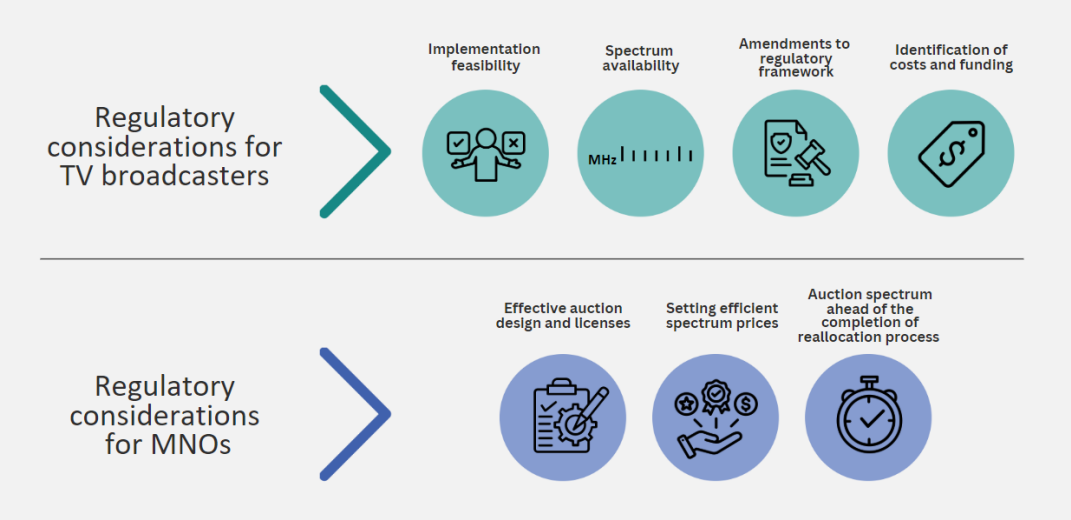
The reallocation of the 600 MHz band in Brazil requires a robust regulatory framework to address the dual objectives of transitioning TV broadcasters to alternative spectrum resources and efficiently licensing the band for mobile broadband services. These two interrelated components are essential to ensuring the smooth transition of the 600 MHz band while maintaining the continuity of broadcasting services and meeting the growing demand for mobile connectivity. The migration of TV broadcasters involves technical assessments to identify suitable spectrum in the UHF and VHF bands, regulatory updates to enable multiprogramming and other innovative solutions, and stakeholder engagement to address the operational and financial impacts of reallocation. Simultaneously, licensing the band for mobile services requires a market-driven approach, focusing on an efficient auction design, cost recovery mechanisms, and timely assignments to facilitate rapid deployment of mobile networks.

A successful regulatory framework must incorporate lessons learned from Brazil's previous spectrum reallocation efforts and international best practices. It should prioritise flexibility to address varying regional conditions, establish clear timelines and milestones, and ensure fairness and transparency in all processes. The framework should also align with broader public policy objectives, including digital inclusion and technological advancement, while considering the economic and technical challenges faced by broadcasters and mobile operators.

3.1. Lessons learned from previous assignment processes

Lessons learned from Brazilian and international spectrum assignment processes suggest that Anatel consider certain key elements, as shown in Figure 14.

Figure 14. Considerations for the reallocation of the 600 MHz band



Source: TMG.

For the successful relocation of TV broadcasters, the regulatory framework should:

1. assess feasibility of the process, including conducting consultations and sharing information with relevant stakeholders to guide the process;
2. analyse spectrum availability in the UHF band and, if needed, to reallocate TV broadcasters in the VHF band;
3. amend current regulations that may limit the transition; and
4. clearly identify costs of the process and sources of funding.

To ensure efficient assignments of freed-up spectrum for mobile broadband, the regulatory framework should:

1. ensure an effective and market-driven auction design;
2. establish reserve prices aimed at recovering costs of the reallocation process and promoting digital connectivity; and
3. implement the auction process ahead of the full completion of the reallocation of TV broadcast stations to enable the prompt launch of mobile services in the band.

Thus, Anatel should consolidate (1) the process to migrate TV broadcasters; and (2) the framework to license the band for mobile broadband under a migration plan for the band. This plan will set clear and transparent guidelines for spectrum management, including for its allocation, reassignment, and its transition from TV broadcasters to mobile services, providing certainty for stakeholders involved in the process and promoting a smooth and organized transition. A migration plan for the 600 MHz band should consider the following elements:

- Publish regulation to approve the allocation, destination, and conditions of use of radio frequencies in the band;
- define spectrum block configuration;
- create an implementation group to conduct the migration. The group could be formed by Anatel, mobile licensees, and TV broadcasters;
- design and conduct spectrum auction; and
- ensure international coordination.

3.2. Proposed framework to reallocate TV broadcasters

The regulatory framework to reallocate the 600 MHz band should consider three interrelated factors:

1. the current level of occupation of the band in each geographic area;
2. the need to amend existing regulations to implement the reallocation mechanism; and
3. the reduction of reallocation costs.

The output of these factors may require different approaches to the process in different parts of the country and will provide Anatel with inputs to develop regulatory solutions tailored to the needs of stakeholders and challenges of the process.

Reallocation of TV broadcasters must distinguish between the three categories of cities proposed in the spectrum reorganisation. This will lead to an incremental design of regulatory actions and options to achieve the goals of the broader reallocation process. As complexity increases, regulatory options and solutions should provide practical and effective responses to secure the dual objectives of ensuring TV broadcasting service continuity at the lowest possible cost.

The level of regulatory intervention will depend on the extent to which the spectrum is currently used: lower use will lead to limited regulatory intervention while higher use will result in more complex regulatory solutions. As summarized in Figure 15, the result will likely be minimal interventions in cities in category 1, intermediate intervention in categories 2, and higher intervention in category 3 cities.

Figure 15. Framework to reallocate spectrum to TV broadcasters based on three categories

	Category 1 Spectrum available	Category 2 Higher spectrum reorganisation	Category 3 High spectrum use
Implementation feasibility	• Low use of 600 MHz band • Minimal regulatory intervention to achieve reallocation within the UHF band	• Medium use of 600 MHz band • Intermediate regulatory intervention to achieve reallocation within the UHF band, including introducing multiprogramming	• High use of 600 MHz band • High regulatory intervention to achieve reallocation, including multiprogramming and possible migration to VHF bands
Spectrum availability	• Sufficient availability in channels 14-36	• Potential for insufficient availability in channels 14-36	• Insufficient spectrum in channels 14-36 likely
Amendments to regulatory framework	• Not needed	• Update regulations to allow commercial stations multiprogramming	• Update regulations to allow commercial stations multiprogramming • Amend rules to permit the use of VHF frequencies by commercial broadcasters
Identification of costs and funding	• Retuning equipment	• Retuning equipment	• Costs associated with new equipment in case TV broadcasters reallocate to the VHF band

Source: TMG.

Category 1 includes smaller cities with low use in the 600 MHz band. Because sufficient spectrum will be available in channels 14-36 to migrate existing TV broadcast stations, Anatel's regulatory intervention is expected to be minimal. The reallocation can be made administratively with limited changes to existing licences. In consultation with industry and government stakeholders, Anatel should set up a schedule to implement the process, creating a set of milestones and incentives for TV broadcasters to migrate and reimburse migration costs. For this category of cities, no amendments are expected to existing TV broadcasting regulations as these currently allow for the proposed regulatory actions. Relatedly, reallocation costs should be relatively low, limited mostly to retuning existing equipment (See section 3.4).

Category 2 includes mid-size cities with higher use in the 600 MHz band. As a result, spectrum availability in channels 14-36 may be insufficient to individually reallocate all existing TV stations in every city. Anatel should thus consider a two-stage process to reallocate this band. During the first stage, existing TV broadcasters would have the option to voluntarily relocate within the lower part of the UHF band or to surrender their licences if they do not plan on continuing to provide service. Similarly, Anatel should consider, in consultation with MCom, revoking existing licences that are not in use. Depending on first-stage results, Anatel should then assess whether sufficient channels are available to migrate TV broadcasters within the UHF band in each city. If sufficient spectrum exists, then Anatel would proceed to administratively award the spectrum following the approach outlined for category 1 cities.

If insufficient spectrum exists to accommodate all TV broadcasters in a specific city, Anatel would move to a second stage in the process. To minimise reallocation costs, this stage would seek amending existing regulations to allow more flexibility for commercial stations to engage in multiprogramming in the UHF band. Currently, the decree which governs multiprogramming imposes limitations on commercial broadcasters, allowing only partnerships with government entities for content of that is in the public interest.[24] Updating these regulations to allow commercial stations to engage in multiprogramming freely would enable more efficient spectrum use, as multiple broadcasters could share a single UHF channel without compromising service continuity and quality. Such changes would require MCom to redefine the criteria for channel allocation and multiprogramming to align with the broader policy objectives of freeing up the 600 MHz band. This two-stage approach ensures that TV broadcasters continue operating in the UHF band, avoiding the need to replace network equipment. This reduces reallocation costs to mostly retuning of equipment, similar to category 1 cities.

Category 3 includes the largest cities in Brazil, with the highest use in the 600 MHz band. The complex radio frequency environment in these cities requires the highest potential regulatory intervention from Anatel. In consultation with key stakeholders, the regulatory framework should offer TV broadcasters options to facilitate the reallocation process, ensuring flexibility and a balanced approach that considers the needs of all relevant stakeholders. As with category 2 cities, the reallocation of TV broadcasters in the 600 MHz band should follow a two-stage process. During the first stage of this, TV broadcasters would be allowed to voluntarily relocate to the lower part of the UHF band or surrender their licences. Anatel should then assess whether to revoke such licences that are not in use.

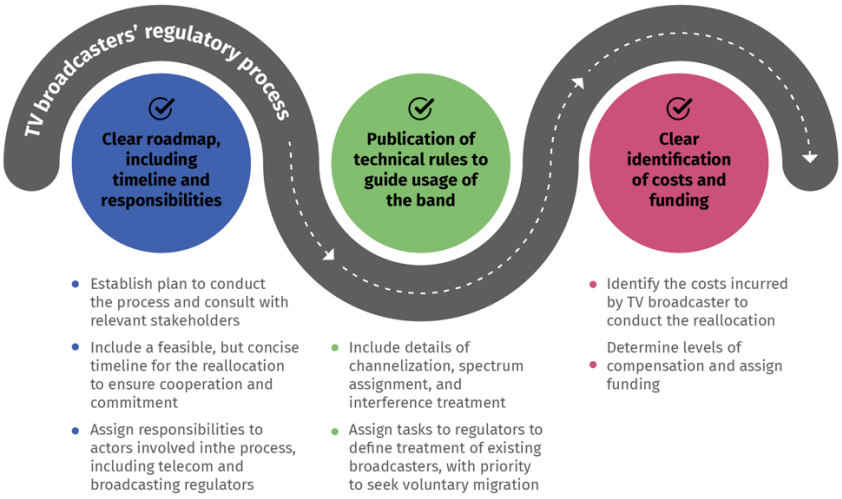
In a second stage, Anatel should determine whether sufficient channels are available to migrate TV broadcasters within the UHF band and whether allowing multiprogramming could be an efficient mechanism to accommodate TV broadcasters. Regulatory changes in relation to multiprogramming would

[24] Presidential Decree 12051, June 11, 2024, https://www.planalto.gov.br/ccivil_03/_ato2023-2026/2024/decreto/d12051.htm.

be required as discussed for category 2 cities. If these regulatory options are insufficient to achieve the reallocation process goals, Anatel could subsequently consider migrating TV broadcasters to the VHF band to ensure service continuity. This last option will depend on multiple stakeholder engagement and further regulatory changes, as current regulations under the *Digitaliza Brasil* project restrict the use of VHF channels exclusively to public TV stations.[25] Changes to these rules will be needed to permit commercial broadcaster use of VHF channels. Such amendments would provide Anatel greater flexibility in reassigning channels, particularly in highly congested areas.

Reallocating broadcasters to VHF channels has important cost implications and should be viewed as a last-resort option. While the VHF band offers a technically feasible alternative for accommodating displaced broadcasters, it requires equipment changes due to incompatibilities, in turn driving higher reallocation costs.

Figure 16. Regulatory considerations for TV broadcasting



Source: TMG.

3.3. Proposed framework for the assignment of the 600 MHz band to mobile

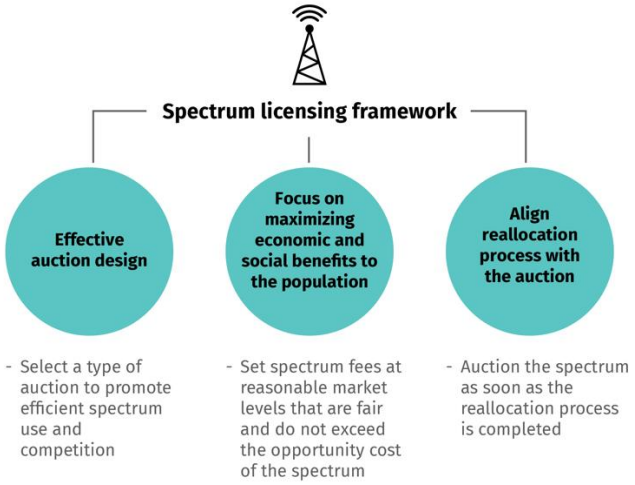
The second component of the reallocation process is to adopt an efficient framework to assign the 600 MHz band for mobile broadband. To do so, Anatel should:

1. establish an efficient auction design and licences;
2. ensure that spectrum prices focus on cost recovery and promoting digital connectivity; and
3. auction the spectrum ahead of the completion of the reallocation process. The following section provide recommendations to achieve these objectives.

The following sections provide recommendations to achieve these objectives.

[25] Ministério das Comunicações, Digitaliza Brasil, June 2, 2023, https://www.gov.br/mcom/pt-br/acesso-a-informacao/acoes-e-programas/programas-projetos-acoes-obras-e-atividades/digitaliza-brasil-1.

Figure 17. Regulatory considerations for the assignment of the 600 MHz to mobile services



Source: TMG.

3.3.1. Efficient auction design and licences

Governments assign spectrum through various mechanisms, including competitive auctions, administrative assignments, or hybrid approaches. The choice depends on policy objectives, market conditions and services, and expected level of demand for the spectrum, among other factors.

The 600 MHz band has the potential to complement current spectrum holdings to expand 5G services and bridge the digital divide in Brazil. Given the anticipated interest of mobile operators in the 600 MHz band and the need to reimburse TV broadcasters' reallocation costs, Anatel should implement market-based mechanisms to achieve an efficient assignment. Notably, Anatel can leverage its proven track record in organizing spectrum tenders to ensure efficient assignments in the 600 MHz band. A competitive auction, adapted from those used to assign the 700 MHz band and more recently the 3.5 GHz bands, could be implemented to assign spectrum in the 600 MHz band.

Auction design, however, should not include spectrum set asides that may limit the amount of spectrum made available and increase the price of spectrum. Such measures have proven ineffective to promote viable entry into the Brazilian market, as demonstrated in the recent 5G auction conducted by Anatel, where set-asides attracted limited interest and failed to encourage new entrants capable of competing with established operators. In addition, assignments should be made for a period of 20 years with a presumption of renewal in a manner consistent with recent 5G assignments made by Anatel.

3.3.2. Setting efficient spectrum prices

Brazil's primary objective for the 600 MHz auction should be to maximise the economic and social benefits derived from the efficient use of the radio spectrum. This includes expanding access to mobile broadband services, which has the potential to significantly enhance digital connectivity across the country. To achieve this, Anatel must consider the costs associated with reallocating TV broadcasters and design a process that prioritises broadband development over the pursuit of high spectrum fees or excessive auction revenues.

Focusing on affordability is critical, as imposing high financial barriers to entry could reduce spectrum demand or discourage network investment. Such outcomes would undermine the socio-economic

benefits of reallocating the 600 MHz band, particularly its role in improving broadband penetration in underserved areas. By adopting an auction design that balances cost recovery with promoting digital inclusion, Anatel can ensure that the reallocation of the 600 MHz band delivers meaningful and widespread connectivity improvements.

Reserve prices for the 600 MHz auction should reflect the actual costs of transitioning TV broadcasters, ensuring they are based on a transparent assessment of reallocation expenses. While prices can consider policy objectives, these should be clearly offset or discounted to prevent unnecessary inflation. To promote broad participation and efficient spectrum use, reserve prices must exclude unrelated government program costs and adhere to the principle of cost minimisation, focusing solely on enabling an effective transition to mobile broadband services.

Consistent with Anatel practice, the auction rules should establish an entity tasked with efficiently managing the reallocation process.[26] This will facilitate stakeholder engagement, promote transparent disbursement of funds and streamline the implementation of the complex process of migrating existing users of the band. In addition, a claw-back mechanism should be incorporated into the auction rules in case Anatel overestimates the migration costs. If auction receipts exceed the actual migration costs, any excess funds should be either reimbursed to bidders or credited towards bidders' regulatory payments or fees. The combination of these mechanisms will ensure spectrum prices reflect market conditions and incentivize participation in the reallocation process.

3.3.3. Auction the spectrum based on a phased reallocation process

To expedite use of the 600 MHz band for mobile broadband, especially in small and medium-sized cities, Anatel should initiate the auction while the migration is ongoing. By establishing a band clearance timeline and milestones in the auction rules and other sector regulations, Anatel would ensure transparency and certainty in the assignment process for mobile services. This should incentivise participation in the auction and facilitate faster roll-out of 5G services using the 600 MHz band.

3.4. Expected cost drivers of the reallocation process

Reallocating the 600 MHz band involves transitioning TV broadcasters from their current spectrum assignments to lower UHF channels (14-36) to free up the band for mobile broadband services. The costs associated with this process vary significantly across the three categories of cities, reflecting the complexity and specific requirements of each scenario.

For category 1 and 2 cities, which comprise most Brazilian municipalities, the reallocation process is relatively straightforward. Broadcasters in these regions will primarily require equipment retuning to operate on new channels. This involves site visits, technical adjustments, and testing, with minimal disruption. The costs in these areas are expected to be low, as no new broadcasting equipment is required. This contrasts with the earlier 700 MHz reallocation process, where the transition from analogue to digital broadcasting necessitated substantial investment in new equipment, significantly driving up costs.

In category 3 cities, characterised by higher spectrum use and more complex interference scenarios, the costs are more substantial. Reallocation in these areas may require broadcasters to migrate to the VHF band, which involves purchasing new equipment such as antennas, modifying transmission towers,

[26] Anatel, Grupo de Implantação do Processo de Redistribuição e Digitalização de Canais de TV e RTV – GIRED, https://www.ANATEL.gov.br/Portal/verificaDocumentos/documento.asp?numeroPublicacao=323816

conducting detailed frequency coordination, and potentially setting up temporary facilities to avoid service interruptions during the transition. These additional technical requirements reflect the higher costs associated with reallocating spectrum in densely populated urban areas.

To ensure a fair and transparent process, Anatel should conduct a detailed cost analysis to determine the compensation needed for broadcasters. This compensation should cover all reasonable expenses incurred during the reallocation process, such as equipment retuning or replacement, installation work, and frequency coordination. Establishing a special fund, as done for the 700 MHz reallocation in Brazil and similar processes in the United Kingdom and the United States,[27] can help reimburse broadcasters effectively and maintain stakeholder confidence. Additionally, any revenue generated from the 600 MHz auction should be dedicated exclusively to covering reallocation costs. The government must avoid diverting these funds to other projects, as this could inflate auction reserve prices and discourage mobile operators from participating, potentially undermining the broader goal of expanding mobile broadband services.

To ensure a smooth transition, compensation mechanisms must be developed to fairly allocate funds to broadcasters for their incurred costs. These mechanisms should include a detailed analysis of financial requirements, the assignment of funds, and the design of efficient reimbursement procedures. Figure 18 summarises these cost categories and highlights their relevance to the reallocation process.

Figure 18. Cost-drivers for the reallocation process of the 600 MHz band in Brazil

Costs of equipment upgrades and channel reassignment	Compensation mechanisms
Reallocation design and implementation	Detailed cost analysis for the reallocation
Installation or retuning of existing transmitters	Determine the level of compensation required
Installation of new antennas	Assign required funds
Use existing transmission lines or install new ones	Design procedures to conduct the compensation
Modification or rebuilding of towers	
Installation of interim facilities	
Conduct testing	
Professional services (if applicable): engineers, lawyers, and consultants	
Special cases: guard against interference	
Other expenses: local permits, disposal costs, equipment delivery and handling charges, equipment storage, notify users of channel change	

Source: TMG based on FCC.

3.5. Political and financial considerations

The reallocation and auction of the 600 MHz band in Brazil necessitate effective coordination among key stakeholders, including the national government, TV broadcasters, and telecommunications service providers. Each group has distinct interests and priorities concerning the use of the 600 MHz band, making it critical to establish mechanisms that balance these competing interests. A well-coordinated framework is essential to ensure that the spectrum is allocated efficiently while maintaining the confidence and support of all stakeholders involved.

[27] FCC, Reimbursement, https://www.fcc.gov/about-fcc/fcc-initiatives/incentive-auctions/reimbursement#:~:text=The%20Spectrum%20Act%20appropriated%20%241.75,%22MVPDs%22)%20that%20incurred%20costs.

The ongoing discussions around TV 3.0 provide a timely opportunity to align the reallocation of the 600 MHz band with advancements in broadcasting technology. Both processes share overlapping regulatory considerations, such as the need to reorganise existing channels and implement updated technical standards. However, it is imperative to separate these processes in terms of financial and political decision-making. Conflating the costs of TV 3.0 deployment with the reallocation of the 600 MHz band risks introducing unnecessary complexities, heightening political sensitivities, and delaying progress. Auction proceeds from the 600 MHz band should not be used to fund the TV 3.0 transition, as this would inflate spectrum costs, reduce operator participation, and potentially limit network investment.

Instead, the reallocation process should be managed independently, focusing on creating a structured and efficient transition for mobile broadband expansion. This independent approach allows Brazil to reorganise the 600 MHz band without compromising the broader objectives of digital inclusion and technological modernisation. By addressing regulatory requirements for both processes in parallel but distinctively, Brazil can simultaneously enhance mobile broadband services and modernise its broadcasting infrastructure, ensuring that financial resources and political efforts are directed effectively to maximise socio-economic benefits.

4. Conclusions

The reallocation of the 600 MHz band from television broadcasting to mobile broadband in Brazil offers a practical solution to meet the rising demand for connectivity, particularly for expanding mobile services and improving rural coverage. However, the transition involves significant technical, regulatory, and economic challenges that must be carefully navigated to ensure the continued provision of broadcasting services while enabling the development of mobile broadband infrastructure.

A key technical challenge is the reorganisation of digital TV broadcasting channels in preparation for the adoption of TV 3.0, a new standard that promises greater interactivity, efficiency, and user experience. Trials for TV 3.0 are planned for 2025, with commercial deployment expected in 2026 or later. This transition is complicated by broadcasters' requests to maintain dual allocations in the 600 MHz band and lower UHF bands, creating additional spectrum congestion in high-demand states like Minas Gerais and São Paulo.

Despite this, the technical studies in this report have outlined actionable solutions for reorganisation, including channel consolidation, shared channels, multiprogramming, and reallocating certain channels to the VHF band. These strategies, applied successfully in metropolitan areas like São Paulo and Rio de Janeiro, demonstrate the feasibility of spectrum reorganisation even in highly congested regions.

The following recommendations should be considered to address the different steps of the reallocation process:

1. **Develop a phased, flexible timeline:** Establish a structured yet adaptable timeline that balances independently the implementation of TV 3.0 with the gradual release of the 600 MHz band. This timeline should provide flexibility for delays in regulatory approvals and technological deployments, ensuring alignment between broadcasters and mobile operators.
2. **Freeze licensing of new TV stations in the 600 MHz band:** To avoid further spectrum congestion, MCom should temporarily halt the issuance of new licences for TV stations in this band. This measure will facilitate smoother reallocation by reducing the need to accommodate new players during the transition.

3. **Incorporate economic incentives:** Addressing the financial burden on broadcasters for relocating channels will require targeted economic incentives. A well-structured auction should include mechanisms to compensate broadcasters for equipment upgrades, channel migration, and service continuity. Incentives should also encourage mobile operators to invest in rural areas, where lower population densities may reduce immediate profitability.
4. **Strengthen technical coordination and conduct interference analysis:** A comprehensive technical framework should manage interference between mobile and TV broadcasting services. This includes defining minimum separation distances, adjusting antenna parameters, and optimising channel assignments. In congested areas, shared channels and multiprogramming must be deployed to maximise spectrum efficiency.
5. **Reassess TVA channel usage:** Many TVA channels, originally licensed for subscription TV, now function as free-to-air broadcasters, creating regulatory inconsistencies. Reevaluating their role and incorporating them into the broader reallocation plan will free up additional spectrum, particularly in urban areas with high demand.
6. **Enhance stakeholder collaboration:** Close cooperation between MCom, Anatel, TV broadcasters, and mobile operators is essential. Regular stakeholder consultations, data-sharing, and collaborative technical studies will help align priorities and resolve challenges efficiently. This coordinated effort will ensure the reallocation process is transparent and inclusive.
7. **Address the costs of assigning the band for mobile services:** Reserve prices for the 600 MHz band auction should be carefully calibrated to reflect the actual costs of reallocation, such as compensating broadcasters, while avoiding inflated fees that could deter mobile operators from participating. The auction process must prioritise affordable access to spectrum, enabling investment in network deployment, especially in underserved rural areas. Any surplus revenue from the auction should be reinvested in enhancing digital connectivity, ensuring long-term socio-economic benefits.

By addressing these technical and regulatory challenges, Brazil can unlock the potential of the 600 MHz band for mobile broadband while safeguarding the interests of the broadcasting sector. Effective reallocation will support the expansion of digital inclusion, enhance connectivity in underserved areas, and position Brazil as a leader in the global digital economy. Strategic planning, technological innovation, and regulatory alignment will be key to achieving these objectives.

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