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# Strategies, policies, regulations and methods of migration to and adoption of digital technologies for broadcasting, including to provide new services for various environments

Study period 2022-2025

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# Acknowledgments

The Study Groups of the ITU Telecommunication Development Sector (ITU-D) provide a neutral platform where experts from governments, industry, telecommunication organizations and academia from around the world gather to produce practical tools and resources to address development issues. To that end, the two ITU-D study groups are responsible for developing reports, guidelines and recommendations based on input received from the membership. Questions for study are decided every four years at the World Telecommunication Development Conference (WTDC). The ITU membership, assembled at WTDC-22 in Kigali in June 2022, agreed that for the period 2022-2025, Study Group 1 would deal with seven Questions within the overall scope of "Enabling environment for meaningful connectivity."

This report was prepared in response to Question 2/1: Strategies, policies, regulations and methods of migration to and adoption of digital technologies for broadcasting, including to provide new services for various environments, under the overall guidance and coordination of the management team of ITU-D Study Group 1 led by Ms Regina Fleur Assoumou-Bessou (Republic of Côte d'Ivoire), as Chair, supported by the following Vice-Chairs: Mr Ali Rasheed Hamad Al-Hamad (State of Kuwait), Mr Amah Vinyo Capo (Togolese Republic),Mr George Anthony Giannoumis (Norway), Mr Roberto Mitsuake Hirayama (Federative Republic of Brazil), Mr Sangwon Ko (Republic of Korea), Ms Umida Musaeva (Republic of Uzbekistan), Ms Caecilia Nyamutswa (Republic of Zimbabwe), Ms Memiko Otsuki (Japan), Ms Khayala Pashazade (Republic of Azerbaijan), Mr Sunil Singhal (Republic of India), and Mr Mehmet Alper Tekin (Republic of Türkiye).

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# Executive summary

This Final Report draws upon ongoing discussions on a new environment for content distribution services and technologies, taking into consideration that the migration to digital broadcasting technologies has been completed in some countries, while others are in the process of completing the transition; also that the relationship between different environments, notably broadcasting and broadband, demands interaction amongst various networks which deliver audiovisual content; and, last but not least, that the broadcasting arena is changing and the offers to users are evolving.

Therefore, the report investigates the implementation of new broadcasting technologies, services, systems, and applications in this new environment, which seems to be heading towards a global media strategy for service providers, not restricting service offers to the traditional broadcasting market, but also considering broadcasting as a key infrastructure for delivering innovative applications and services when combined with other networks and service platforms.

In that context, the report highlights recent developments of broadcasting systems, and the use of Internet protocol (IP) throughout the broadcasting chain, including the production, contribution, and transmission systems. Alongside that, the report presents an overview on the adoption of digital technologies in broadcasting, from two perspectives. First on the offerings by manufacturers of latest advancements in broadcasting technologies, and then in the form of benchmarking data on the adoption of those technologies by broadcasters by means of publicly available data.

The adoption of digital broadcasting for television and radio transitioning from analogue to digital, including spectrum management considerations and the use of the "digital dividend", is also a key element of the report. Best practices and experiences are presented and the needs of developing countries in that arena are clearly stated for the consideration of those planning and implementing the analogue to digital transition.

Building on the lessons learned and best practices from the experiences and case studies shared by contributors, the report presents some guidelines for stakeholders involved in adopting digital technologies within the broadcasting sector.

As an initial reflection, the report acknowledges that the context in which broadcasting services operate has changed dramatically in recent years, and that the need for their adaptation and evolution is clear. This understanding is shared by stakeholders across the broadcasting industry, including manufacturers, service providers, and regulators. It is also evident, from the findings of the report, that the adoption of digital technologies varies across regions, where they face specific challenges, including limited infrastructure and a lack of funding, and that the transition continues to be a significant issue.

The report also discusses the adoption of next-generation broadcasting systems (ATSC 3.0, 5G Broadcast, DVB-NIP, ISDB-T), with an emphasis on standardization to facilitate a more efficient transition to these systems. In the same vein, it is noted that developing countries face specific challenges, including costs and regulation, in harnessing the benefits such as interactivity, and content personalization, for consumers.

Finally, with these considerations in mind, the report suggests the following guidelines to be considered by stakeholders in the evolution of broadcasting services, stressing that:

- stakeholders (governments, regulators, industry actors, service providers and consumers/viewers) collectively make all the necessary efforts to conclude the transition to, and adoption of, digital technologies in television and radio services, and to complete the analogue broadcasting switch-off process;
- in the transition to, and adoption of, digital technologies for broadcasting, a strategy and roadmap be formally established and activities carried out on a basis of cooperation and collaboration amongst all the stakeholders;
- spectrum planning, including the usage of the digital dividend, be carefully carried out following best practices and international guidelines and standards;
- the audiovisual content distribution and consumption ecosystem be considered as a whole, as there may be interaction amongst several technologies (broadcast and broadband included) that are relevant to policymakers in creating an enabling environment for the provision of broadcasting services that meet consumers'/viewers' needs;
- subject to the sovereignty of each Member State, the regulatory and legal frameworks address new challenges and opportunities of digital broadcasting services, and contribute to a better user experience;
- any regulatory and legal discussion regarding audiovisual content distribution, including broadcasting, be carried out with full participation of all stakeholders in an open and participative regulatory and rulemaking process.

# Abbreviations and acronyms

| Abbreviation | Term |
|---|---|
| 2G / 3G / 4G / 5G / 6G | Second/Third/Fourth/Fifth/Sixth Generation mobile communications (see note 1 below) |
| AAC | advanced audio coding |
| AI | artificial intelligence |
| AR | augmented reality |
| ASO | analogue switch-off |
| ATSC | Advanced Television System Committee |
| AVC | audio and video coding |
| DASH | dynamic adaptive streaming over HTTP |
| DTT | digital terrestrial television |
| DVB | digital video broadcast |
| FeMBMS | further enhanced multimedia broadcast multicast service |
| HD | high definition |
| IBB | integrated broadcast-broadband |
| IP | Internet protocol |
| ISDB | integrated services digital broadcasting |
| ITU-D | ITU Development Sector |
| ITU-R | ITU Radiocommunication Sector |
| ITU-T | ITU Telecommunication Standardization Sector |
| MABR | multicast adaptive bit rate |
| ML | machine language |
| UHD | ultra-high definition |
| UHF | ultra-high frequency |
| VHF | very high frequency |
| VR | virtual reality |
| XR | extended reality |

Note:

1. While care was taken in this document to properly use and refer to the official definition of IMT-generations (see Resolution ITU-R 56, "*Naming for International Mobile Telecommunications*"), ITU Development Sector (ITU-D) would like to note that parts of this document contains material provided by the Membership which refers to the frequently used market names "xG": This material cannot necessarily be mapped to a specific IMT-generation, as the underlying criteria by the Membership is not known, but in general, IMT-2000, IMT-Advanced, IMT-2020 and IMT-2030 are known as 3G/4G/5G/6G, respectively. Furthermore, earlier available technologies such as global system for mobile communications (GSM), EDGE and general packet radio service (GPRS) are sometimes named 2G by the market and could be considered.

# Chapter 1 – Status of the adoption of digital technologies in broadcasting

The migration to digital broadcasting technologies has been completed in some countries, while others are in the process of completing the transition. In this context, the reports from the last study periods presented best practices that accelerate the transition and narrow the digital divide by deploying new services, communication strategies for public awareness on digital broadcasting, and considered radio spectrum issues related to the analogue switch-off process, among a number of case studies.

It is important to acknowledge the relationship between broadcasting and broadband environments, the necessity to treat broadcasting in a more general manner, and also to consider the relationship among the various networks which deliver audiovisual content.

The broadcasting arena is changing and the offers to users are evolving. New experiences in accessing audiovisual content are being provided, and one of the consequences of these new offers is that users now have access to much more than just the traditional media services/applications. They are instead starting to experience different ways of watching audiovisual content in their broadcast services.

To implement new broadcasting technologies, services, and applications in this new environment, which appears to be moving towards a global media strategy for service providers, while at the same time avoiding any restriction of service offers to the traditional broadcasting market, it is now becoming clear that consolidation, co-investment, and infrastructure sharing, are key trends being employed to reduce costs and allow massive investments in network deployment and content delivery.

It is beneficial then, to study broadcasting infrastructure as a key for delivering innovative applications and services when combined with other networks and service platforms. Additionally, it is important to consider these interactions from regulatory, economic, and technical perspectives, so as to leverage the strengths of each network for the benefit of the users, and to make available a more diverse range of services.

It is important to highlight that there have been developments in broadcasting systems using Internet protocol (IP) throughout the broadcasting chain, including in the production, contribution and transmission parts, and that the development of IP-based technologies in these parts is progressing quite quickly. Also notable are the innovations being implemented for broadcasting in the ultra-high frequency (UHF) band, and how they could lead to new forms of broadcasting services and applications.

The use of the "digital dividend" is another important issue and continues to be widely debated by broadcasters and operators of telecommunication and other services operating in the same frequency bands. Other important study topics concern spectrum planning matters related to the transition from analogue to digital broadcasting.

Finally, an important issue for the future of broadcasting is the emergence of new broadcasting technologies and standards that could be considered when developing countries are implementing the digital television transition. Traditional broadcasting services, with or without interaction with other platforms and networks, should also be considered.

This chapter provides an overview on the adoption of digital technologies in broadcasting. In section 1.1, the latest advances in broadcasting technologies proposed by manufacturers are discussed, while section 1.2 presents publicly available benchmarking data on the progress of adoption of those technologies by broadcasters.

## 1.1 Latest technologies proposed by manufacturers

The evolution of broadcasting is a topic of intense discussion in the International Telecommunications Union (ITU). ITU-R Report BS.2522.0 "A framework for the future of broadcasting", presents a collection of current and anticipated developments in broadcasting. The scope of the report is to present *"a framework for the future of broadcasting taking into account the expectations of end users and advances in broadcast programme production and delivery technologies. It aims to inform, assist, and guide the broadcasting industry, researchers, and regulators about future developments of systems, technologies and applications for broadcasting"*.

The report highlights some key aspects on future user experience, stating that "broadcast content and technology will offer a greater sense of reality. Together with additional options for media personalization and interaction, the bonds of a virtual community gathered around the same content will be substantially strengthened".

The report also presents and details trends in user experience, a major theme to leverage technologies and service offers that are useful for consumers. These user experience trends are grouped into the following seven categories:

- collective experience;
- personalized user experience;
- ubiquitous media consumption experience;
- digital assistant and ambient computing ecosystem experiences;
- accessible experiences;
- immersive experiences; and
- experiences that merge the physical world and the digital world.

The broadcasting industry is responding to these trends and the latest advancements in digital television broadcasting systems are in line with several of them and point to a more interactive, immersive, and richer user experience. The next generation of broadcast television technologies can offer improved video and audio quality (4K ultra high-definition video quality and theatre-like sound), improved mobile reception, and innovative new features to enhance and expand viewing experience, and more. Among those features allowing for new user experience use cases, there is the combination of functionalities and content from broadcast television and broadband, offering for example, the personalization of broadcasts with information and interactive features, so that users can access the content and features most relevant to themselves. These new services are possible due to the fact that next generation systems are based on Internet protocol (IP), enabling the combination of online and broadcast television.

The next generation broadcast television technology systems can also support enhanced mobile reception, so viewers access content on mobile devices over the air without having to rely on cellular data services, and the respective data usage and costs. Another expected feature is the enablement of emergency warnings, through the broadcasting system, with targeted public announcements that are interactive and mobile. Next generation broadcast television technologies, providing a snapshot of this potential include ATSC 3.0[1], 5G Broadcast[2], DVB-NIP[3], Advanced ISDB-T[4], and others. Some of the key features of each of these systems are highlighted in Annex 1 of this Report, and include but are not limited to:

- technology built on the same Internet protocol (IP) backbone as current popular streaming media platforms;
- the capability of advanced emergency alerting and informing;
- efficient free-to-air or zero-rated media content delivery;
- standalone terrestrial broadcast system based on IP over 5G infrastructure (5G broadcast);
- IP and HTML5 application environment (Advanced ISDB-T).

For more information on next generation broadcast television technology systems, please refer to chapter 2 of this Report and the web pages of the referred systems.

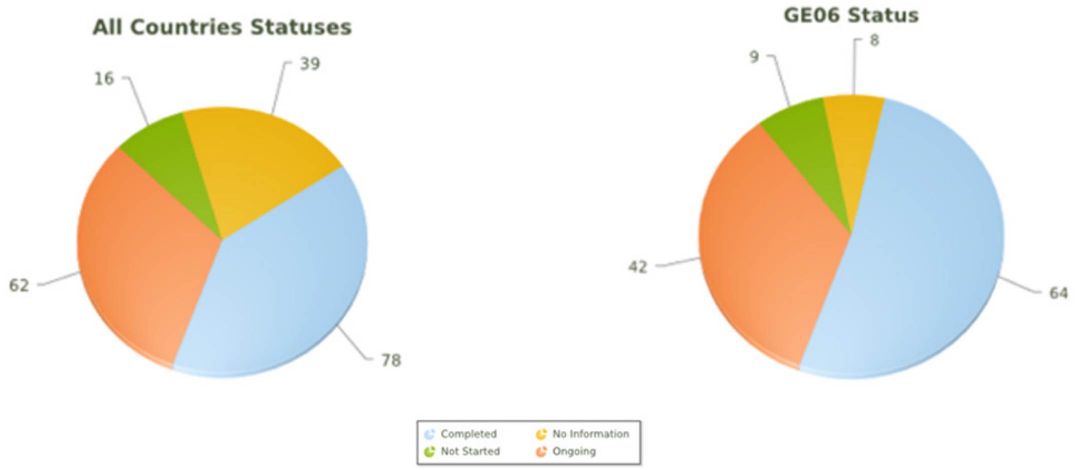
## 1.2 Benchmarking on the adoption of digital technologies in broadcasting

It is important to note that the evolution of IP digital broadcasting services is based on traditional digital broadcasting systems, and that the migration to a fully digital environment, is the start point for the delivery of new services. The continuous improvements in the adoption of digital technologies in broadcasting are being tracked by the International Telecommunication Union (ITU), and an important source of information on the adoption of digital broadcasting in general is the Digital Switchover Database, hosted by the ITU at https://www.itu.int/en/ITU-D/Spectrum-Broadcasting/DSO/Pages/default.aspx.

The Digital Switchover Database provides information on the status of the deployment of digital terrestrial television (DTT) worldwide, and since 2009, ITU Development Sector (ITU-D), have assisted States with the transition from analogue to digital broadcasting, bringing new opportunities to all stakeholders, from manufacturers to broadcasters and end-users. The status of the digital switchover transition is illustrated graphically in Figures 1 to 5. Figure 1 shows the digital switchover status (completed, ongoing, not started, or unknown), Figure 2, shows in terms of numbers of countries worldwide, the digital television year of launch and the analogue switch-off year. Figure 3 shows the numbers of first and second generation digital television systems adopted in countries worldwide. Figure 4 shows the evolution of codecs utilization. It can be seen that H.264/AVC use is declining while H.265/HEVC use is increasing. Finally Figure 5, shows streaming code types and their usage as a percentage worldwide.

1 https://www.atsc.org/nextgen-tv/
2 https://www.qualcomm.com/news/onq/2023/12/5g-broadcast-what-can-consumers-expect
3 https://dvb.org/?standard=native-ip-broadcasting
4 https://www.dibeg.org/advanced/

### Figure 1: Status of the digital switchover around the world and particularly for the countries of the GE06 Plan (DSO database, March 2025)




### Figure 2: Year of digital television launch and year of analogue switch-off (DSO database, March 2025)

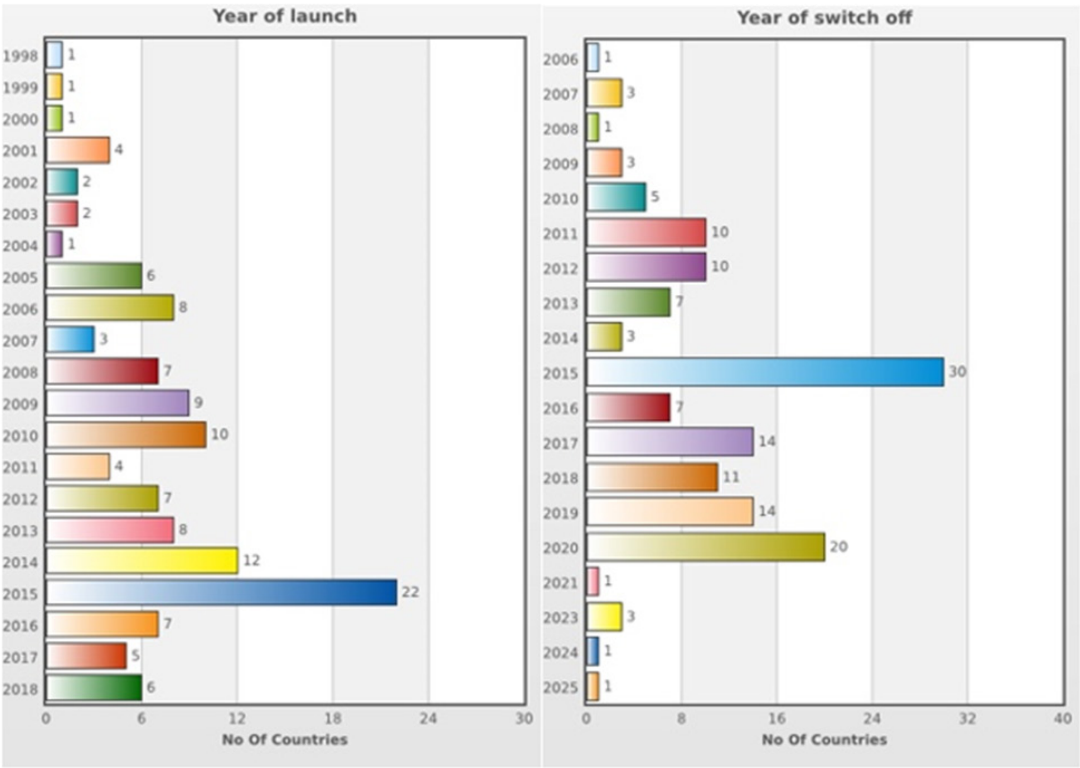


Figure 3: First and second generation digital television systems adoption (DSO database, March 2025)

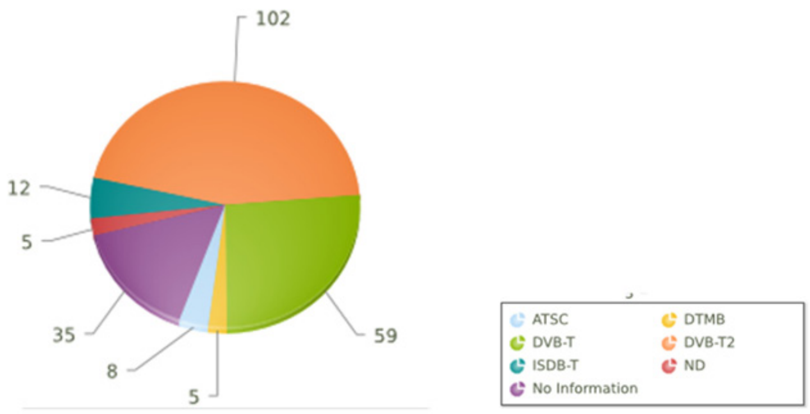



Figure 4: Evolution of codecs utilization (Source: Broadcast Transformation Report, 2024)

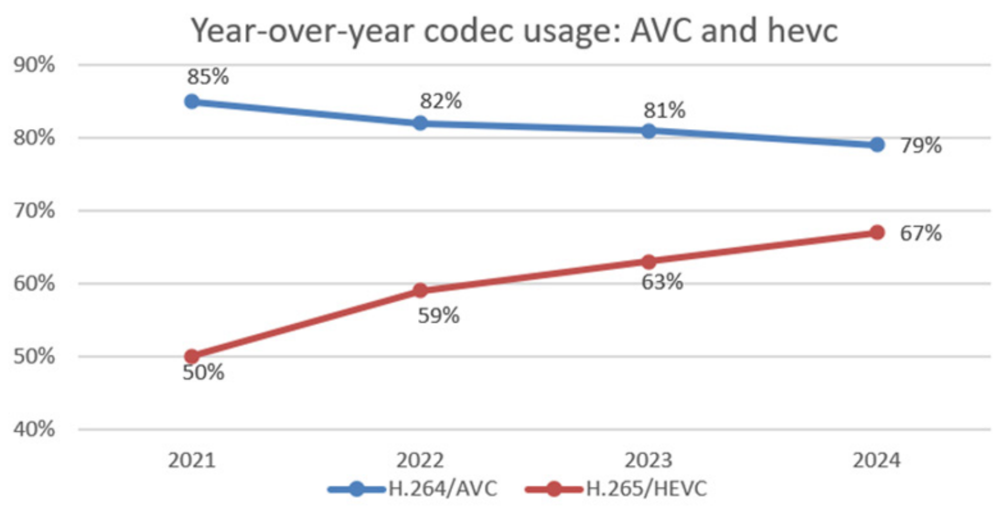
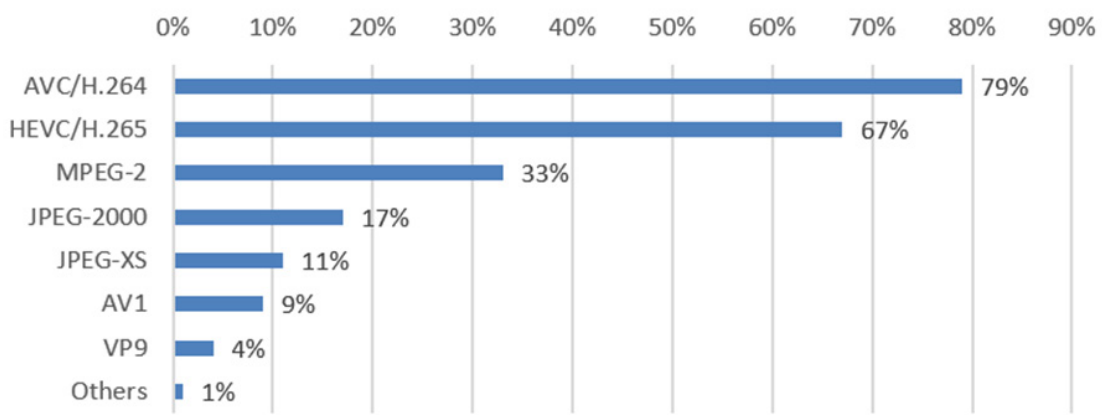



Figure 5: Streaming codes currently in use for live video



Digital television systems are evolving to next generation systems that include ATSC 3.0, 5G Broadcast, DVB-NIP (native IP broadcast system), Advanced ISDB-T, and others. The adoption information on these systems is of great relevance, and it is being followed closely by all stakeholders in the broadcasting industry. Information on the current deployments of some of these systems, is presented in the following reports:

- ATSC 3.0: EUA, Republic of Korea, Jamaica, and Trinidad and Tobago deployments information (Source: https://www.atsc.org/nextgen-tv/deployments/).
- 5G Broadcast trials in Europe: Austria, Republic of Croatia, Republic of Slovenia, Czech Republic, Finland, Spain, France, Italy, and Germany. (Source: https://broadcast-networks.eu/wp-content/uploads/5G-broadcast-trial-leaflet.pdf).
- Advanced ISDB-T: Japan (Source: https://www.dibeg.org/advanced/schedule-2/).

# Chapter 2 – Trends in new and emerging technologies for broadcasting services and related applications, including IP-based technologies

## 2.1 New broadcasting services and applications for consumers/ viewers

The panorama of services and applications provided to consumers/viewers of audiovisual content offers, has broadened significantly in the recent years. Today in addition to traditional broadcasters, there are now a multitude of different content distribution platforms, applications, and services.

It is important to evaluate the symbiotic relationship between traditional service providers and the new actors in the digital ecosystem. The Digital Economy Programme of the Russian Federation[5], aims at the development of human capital, a comfortable living environment and economic growth, by accelerating the introduction of digital technologies in the economy and social sphere, and the creation of conditions for high-tech businesses, increased national competitiveness in the global market, and improved quality of life for citizens.

The future of media technology will depend first and foremost on the relationship between the degree of benefit and the degree of disruption of new systems, services, and applications, as illustrated by Figure 6. Those technologies with high benefit and low disruption will be the first to be widely adopted. There are many steps to be climbed, and needs to be fulfilled before a new digital technology attains widespread use and the efficiency of the new technology is often not the only factor influencing adoption.

5 ITU-D Document https://www.itu.int/md/D22-SG01.RGQ-C-0117/ from Russian Federation

### Figure 6: Technology adoption (source: EBU[6])

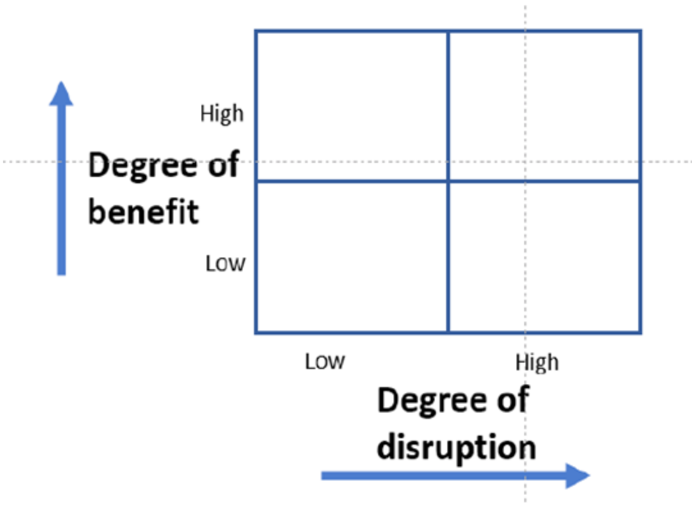
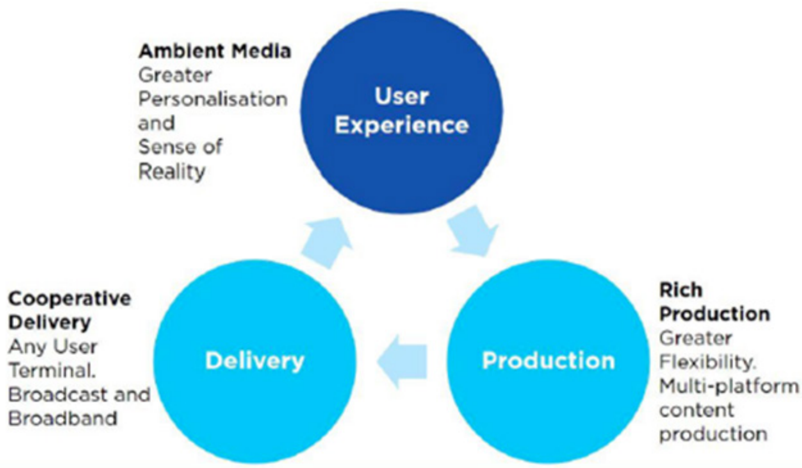



Figure 6 shows a method for judging if a system is going to succeed or fail, based on the following process:

- Examine the relationship between degrees of benefit and disruption.
- Examine if the means will be available to take all the steps needed to move from idea to widespread use.
- Examine if the system would be between 'too early' and 'too late'.
- Examine if the capacity is available to run the service.

To evaluate the current trends in new services and applications, therefore, it is important to evaluate the current and new technologies for audiovisual content delivery, and how they are evolving. The new services and applications using innovative technologies being implemented and offered currently to consumers involve three major areas: (i) user experience, (ii) cooperative delivery, and (iii) rich production. Figure 7 illustrates some of the potential applications in those areas.

### Figure 7: Major areas of innovation for new services and applications (source: EBU[7])

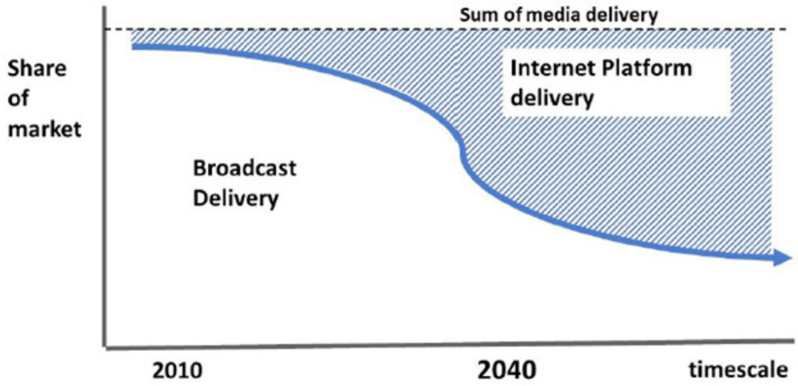



[6] Presentation of Dr David Wood at the ITU-D Question 2/1 Focus Session, available at https://www.itu.int/dms_pub/itu-d/oth/07/2e/D072E0000020018PDFE.pdf

[7] Id ibid.

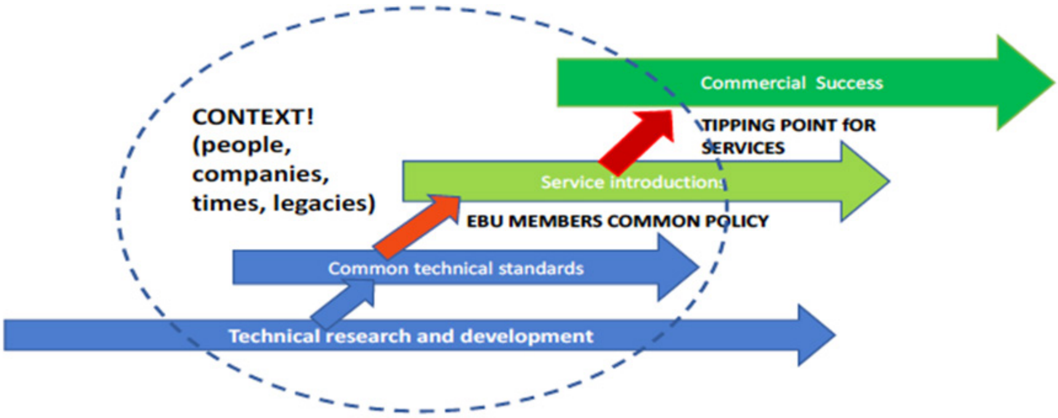
In the delivery arena, the broadcast and broadband platforms and networks co-exist and share the market in terms of media delivery. The actual content consumption by users seems to be increasing, however, new forms of delivery are now widely available and are shifting the pattern of consumption. Figure 8 shows the probable evolution of media delivery technology.

### Figure 8: Probable evolution of media delivery (source: EBU[8])




When evaluating available technologies, it is critical to understand what leads to a commercial success in terms of technological development. One of the most important considerations is standardization. Figure 9 illustrates the steps that a technology needs to undergo to progress from research and development to successful commercial implementation.

### Figure 9: Progression from R&D, to Common Policy, to Tipping point (source: EBU[9])




The following sections will address and evaluate current trends in terms of new services and applications for broadcasting, in the context of the new environment where broadcast and broadband delivery co-exist and complement one another. The contributions of both new services and applications for broadcasting, to a more diverse ecosystem benefitting increased consumer options, will also be considered.

[8] Id ibid.
[9] Id ibid.

### 2.1.1 Audiovisual content improvements, including ultra-high definition television (UHDTV) and latest trends

Some innovations in the audiovisual content arena are putting pressure on terminal devices. For example, HD/UHD digital terrestrial television (DTT) transmissions increase the demand for video for television sets, set-top boxes (STBs), cell phones, and tablets, etc. At the same time, other new services using virtual reality (VR) and/or augmented reality (AR) can further stress this scenario.

As an example, the case of People's Republic of China[10] can be highlighted, where, since 01 July 2022, new cable and satellite TV channels should have HD/UHD video resolutions, and the new satellite TV STBs should be HD/UHD smart STBs. As of 01 January 2023, Internet protocol television (IPTV) and cable TV new STBs should also be UHD STBs. It is expected that by the end of 2025, there will be a significant increase in penetration of HD/UHD STBs, what will lead to the shutdown IPTV SD channel signals.

These innovations in audiovisual content are key drivers for improved quality, and depict a constant trend in the evolution of content delivery. It is important therefore to assess the impacts of these innovations on both terminals and networks.

### 2.1.2 Augmented reality (AR) and virtual reality (VR), Edge computing, artificial intelligence (AI), and other emerging technologies in the context of content delivery

#### Augmented reality and virtual reality

Immersive experience technologies are fuelling a significant trend in content delivery. This section aims evaluate some of these emerging technologies, such as the augmented reality (AR) and virtual reality (VR) standards landscape, to give an overview of the topic and its relevance to innovative services such as those employed in the metaverse, in 5G use cases, and in content distribution platforms in general. Broadcasting services can take advantage of these technologies to provide new applications and services to viewers/consumers, responding to the demand for innovations that relate to new user experiences and the consumption of audiovisual content.

This Report refers to a paper published in the Kaleidoscope Academic Conference Proceedings for 2022[11], which presented a survey of extended reality (XR) standards, from a range of completed and ongoing work by standards developing organizations (SDOs), fora and consortia, dealing with technical aspects of XR, as a basis for considering those technologies.

Considering the definition proposed by ITU for XR as "*an environment containing real or virtual components or a combination thereof, where the variable X serves as a placeholder for any form of new environment*", the paper presents an extensive compilation of technical specifications addressing environments containing real or virtual components or a combination thereof,

[10] Presentation of Dr Luyu Zhao at the ITU-D Question 2/1 Focus Session, available at https://www.itu.int/dms_pub/itu-d/oth/07/2e/D072E0000020017PDFE.pdf.

[11] Makamara, G. and Adolph, M. A Survey of Extended Reality (XR) Standards. ITU Kaleidoscope Academic Conference Proceeding, pp. xxxi-xl, Accra, 2022. https://www.itu.int/dms_pub/itu-t/opb/proc/T-PROC-KALEI-2022-PDF-E.pdf (apud).

i.e., standards dealing with AR, mixed reality (MR), VR, and the metaverse, through a review of related literature, standardization documentation, and discussions.

In the work conducted, various SDOs were identified, including 3GPP[12], ETSI[13], ISO/IEC JTC 1 SC29[14], ITU and W3C[15]; as well as, consortia, fora, and trade organizations, including CTA[16], IDEA[17], Khronos Group, Metaverse Standards Forum, SVTA[18], and VRIF[19]; as well as research networks such as Qualinet. In addition to these entities, it can be noted that telecommunication, video coding, and streaming video standards associations are also involved in the discussions, which is an indication of the relevance of these technologies to audiovisual content distribution, and their related services and applications.

Additionally, the paper points out two main themes being explored in XR standardization work: "*(1) building capabilities for XR interoperability by establishing common understanding (standard terminology), identifying key system and user requirements (design guidelines and system standards), and developing compatible interfaces and data formats for XR services and applications; and (2) defining XR user experience requirements addressing accessibility and quality aspects*".

For the purpose of the current report, the second theme that defines XR user experience requirements, is of great relevance to the examination of trends and use cases being standardized, as this provides an understanding of the scope of the services and applications that can be offered. Trends, based on user experience requirements and use cases, identified below, are those most relevant to the study of new services and applications in the content distribution environment, including broadcasting:

- immersive teleconferencing and telepresence for remote terminals Use cases (3GPP TR 26.862);
- virtual reality (VR) media services over 3GPP (3GPP TR 26.928);
- AR, MR, and XR in 5G (3GPP TR 26.928 and TR 26.998);
- transport of immersive audiovisual content in IP-based broadcasting systems (ITU-R BT.2133);
- AR in smart television systems and services (ITU-T J.301, J.302);
- digital representation of cultural relics and artworks using AR (ITU-T F.740.2);
- immersive live experience services (ITU-T H.430.1, H.430.2, H.430.3, H.430.4, H.430.5);
- XR accessibility user requirements (W3C NOTE-xaur).

In conclusion, it is noted that several AR/MR/XR applications and service scenarios, including those through IP-based broadcasting systems and 5G mobile networks, have been standardized and will continue to evolve. The increase in data traffic, driven by various factors including the

[12] 3rd Generation Partnership Project (3GPP).
[13] European Telecommunications Standards Institute (ETSI).
[14] Joint Technical Committee (JTC 1) of International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC), is a consensus-based, voluntary international standards group for information technology. Subcommittee 29 (SC29) "Coding of audio, picture, multimedia and hypermedia information" comprises both, the Joint Photographic Experts Group (JPEG) and the Moving Picture Experts Group (MPEG).
[15] World Wide Web Consortium (W3C).
[16] Consumer Technology Association (CTA).
[17] Immersive Digital Experiences Alliance (IDEA).
[18] Streaming Video Technology Alliance (SVTA).
[19] Virtual Reality Industry Forum (VRIF).

COVID-19 pandemic, is necessitating a rapid and innovative adaptation of telecommunication infrastructure. The strategies outlined, including Edge computing, artificial intelligence (AI), next-generation networking, network virtualization, and the enhancement of core infrastructure, are crucial to ensuring high-quality service and to effectively meeting the growing demand.

As an example of the adoption of XR technologies, in Malaysia[20], VR and AR are revolutionizing content production by creating immersive environments that offer greater flexibility and creativity. The adoption of VR/AR virtual studios by local broadcasters has positioned the broadcasting industry of Malaysia at the forefront, offering viewers immersive experiences that set new standards for content quality and engagement. VR and AR virtual studios are now commonly used in various live programmes by local broadcasters.

## Edge computing

Edge computing is a relatively new concept and the American consulting and research company Gartner, and other experts, estimate that three-quarters of global data will be managed using Edge computing. This is another interesting use case, especially because 5G and Internet of things (IoT) services need things to move fast. Without Edge, it will not be possible for autonomous vehicles to be driven efficiently, and uploading of video over a 5G network will not be as fast as it could be.

One of the major advantages of Edge computing is its ability to significantly reduce the impact of latency on applications. This makes it possible to introduce new lower-latency applications and services on the network and improve the experience of existing applications, due in particular to 5G-related advancements.

The applications and services that customers want to use on Edge networks play a key role in driving revenue growth for telecommunication operators. However, in order to increase their revenue, it is essential that operators put in place appropriate systems and coordinate with stakeholders and technology partners.[21]

Studies are under way within ITU on this issue, in particular in ITU-T Study Group 11.[22]

As an example of the impact of these technologies, it is noted that the GSMA launched the Telco Edge Cloud (TEC) initiative two years ago, with 19 operators committing to design and develop a global Edge computing service based on the federation of the Edge infrastructure of multiple providers[23]. Several countries have adopted this technology, including China, which is ahead of the curve,[24] the Republic of South Africa[25] and a number of European countries.[26]

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[20] ITU-D https://www.itu.int/md/D22-SG01-C-0341/ from Malaysia.
[21] https://www.redhat.com/fr/topics/edge-computing/telecommunications (in French)
[22] https://www.itu.int/en/ITU-T/studygroups/2017-2020/11/Pages/q7.aspx
[23] https://www.gsma.com/solutions-and-impact/technologies/networks/latest-news/gsma-launches-new-whitepaper-telco-edge-cloud-value-achievements/
[24] https://techmonitor.ai/focus/what-chinas-lead-in-edge-computing-means-for-the-world
[25] https://seacom.co.za/news/why-is-edge-computing-the-next-big-thing-in-africa
[26] https://digital-strategy.ec.europa.eu/en/library/europes-potential-edge-computing-supporting-industrial-innovation-through-large-scale-pilots

### Artificial intelligence (AI)

AI can be used to optimize network management, predict traffic spikes and automate problem solving. AI algorithms can analyse data in real time to proactively adjust network resources, improve quality of service (QoS), and minimize outages.

| Advantages of AI network management | Examples |
|---|---|
| Proactive network management | – Vodafone uses AI to monitor and optimize its network in real time.[27]<br>– In France, Orange is deploying AI solutions to anticipate failures and optimize network performance.[28] |
| Reduced operational costs | |
| Improved user experience | |

### Networks of the future (5G and beyond)

5G networks and future networking technologies, such as 6G, offer higher bandwidth, lower latency and the ability to simultaneously connect a large number of devices. These technologies are essential to meet the growing demand for data and to support new bandwidth-intensive applications.

| Advantages of 5G networks and future networking technologies | Examples |
|---|---|
| Increased transmission speed | – SK Telecom in the Republic of Korea is deploying 5G networks to support smart cities and IoT applications.[29]<br>– In Japan NTT Docomo is experimenting with 6G for ultra-fast, low-latency applications.[30]<br>– Studies are under way within ITU on this issue, in particular in ITU-T Study Group 13.[31] |
| Lower latency | |
| Enhanced IoT management capability | |

### Network virtualization (SDN/NFV)

Network virtualization technologies, such as software-defined networking (SDN) and network function virtualization (NFV), allow for more flexible and dynamic network-resource management. They also facilitate the rapid deployment of new services and improve operational efficiency.

27 https://ch.zonebourse.com/cours/action/META-PLATFORMS-INC-10547141/actualite/Meta-et-Vodafone-optimisent-la-video-pour-ameliorer-l-efficacite-des-reseaux-47340829/ (in French)
28 https://newsroom.orange.com/orange-sassocie-a-la-plateforme-dia-reseau-augtera-pour-offrir-une-qualite-de-service-et-une-experience-client-optimales/ (in French)
29 https://www.lesechos.fr/monde/asie-pacifique/en-coree-dans-les-laboratoires-de-la-5g-1161409 (in French)
30 https://fleetinfo.info/le-japon-developpe-le-premier-appareil-6g-au-monde-20-fois-plus-rapide-que-la-5g/ (in French)
31 https://www.itu.int/en/ITU-T/studygroups/2022-2024/13/Pages/default.aspx

| Advantages of network virtualization technologies | Examples |
|---|---|
| Greater flexibility and agility | – In the Federal Republic of Germany, Deutsche Telekom is using SDN and NFV to enhance network efficiency.[32]<br>– In Spain, Telefónica is deploying SDN solutions to optimize network performance and flexibility.[33] |
| Lower network management costs | |
| Rapid deployment of new services | |

In Republic of the Congo[34], the COVID-19 pandemic has highlighted vulnerabilities in telecommunication infrastructure but has also acted as a catalyst for innovation and the adoption of complementary technological solutions. Countries have had to adapt their strategies to maintain connectivity and meet the growing demand for data, implementing various initiatives ranging from the expansion of 4G/5G networks to the use of community-wide satellite and Wi-Fi solutions. These actions demonstrate the resilience and adaptability displayed by some African countries in the face of unprecedented crisis.

### 2.1.3 Interactive applications and services, including broadcast and broadband content exchange

Next-generation television is poised to introduce innovative use cases, highlighting the vital role of multimedia applications in broadcasting services. These TV applications will allow broadcasters and their partners to leverage highly anticipated innovations, including personalized TV experiences, targeted advertising and programming, content recommendations, seamless OTA (over-the-air) to/from OTT (over-the-top) switching, immersive content provision, enhanced accessibility, sensory effects rendering, and novel interaction modalities.

As a result, multimedia TV applications are expected to transform from their traditional role as mere accessories for broadcasters into the central hub of all TV content control and consumption. This shift towards an "application-oriented television" is essential for enabling the proactive management of viewer profiles throughout their entire content consumption journey, shaping it into a personalized, immersive, and engaging experience. It can also make content delivery methods completely transparent to viewers, facilitating seamless integration with broadband content and services. Additionally, it redefines the conventional concept of TV channels. Overall, this approach aligns with the app-based user experiences commonly provided by smart devices. As an example of this new application-oriented television paradigm, note the under-study work and specification within the Brazilian TV 3.0 Project[35], of a new environment for accessing interactive applications. More information can be found in Annex 2 of this Report.

One very critical and relevant use case for new services and applications in broadcasting, is the accessibility of audiovisual content. One such use case is disaster alerting for deaf and hard-of-hearing persons. More than 90 per cent of deaf children are born into hearing families[36]. Unless the family learn sign language together, deaf children easily become isolated and may receive inadequate home education, despite this fact sign language education for such cases

32 https://www.juniper.net/fr/fr/customers/deutsche-telekom-case-study.html (in French)
33 https://www.telefonica.de/news/press-releases-telefonica-germany/2021/12/milestone-in-software-defined-networking-sdn-o2-telefonica-uses-new-standardized-sdn-interface-for-30000-microwave-links.html
34 ITU-D Document https://www.itu.int/md/D22-SG01-C-0291/ from Republic of Congo.
35 ITU-D Document https://www.itu.int/md/D22-SG01.RGQ-C-0239/ from Brazil.
36 ITU-D https://www.itu.int/md/D22-SG01-C-0153/ from Republic of Korea.

does not exist in most of countries. Disaster alerting systems have been built in most of countries through the use of open/closed captions on terrestrial and pay TV services, as well as through text type messaging to mobile phones. The problem is that more than half of deaf people have difficulty in understanding text, which means that most important information is not accessible to deaf persons with reading difficulties. Television equipment has evolved through connectivity and no matter what infrastructure type TVs or set-top-boxes are based on, most now comprise connectivity of some kind, through cable modems, direct IP communication by Internet service providers (ISPs/IPTVs), or low orbit satellite constellations, etc. However, connectivity is not often provided through terrestrial frequencies, under current traditional broadcasting systems, such as for example, digital video broadcasting (DVB) and ATSC. Consequently, in the United States, about 20 per cent of households with no broadband connectivity[37] are being provided, by the United States Government, with e-learning content through datacasting features of its next generation terrestrial television system (ATSC 3.0), in order to reduce education inequality issues.

Broadcasting applications can be beneficial in promoting inclusion, especially for those with specific needs. Another interesting case study from the Republic of Korea[38] shows how next generation broadcasting systems, such as ATSC 3.0, can contribute to a more inclusive and safe society, by delivering disaster alerting messages in text, as subtitles to TVs, STBs, and mobile phone screens. More information on this disaster alerting case can be found in Annex 3 of this Report, including information on the overall architectural concept of the platform for delivering the alerts.

## 2.2 Development of broadcasting systems using IP-based technologies

In this section, some advancements in broadcasting systems with the usage of IP-based technologies are highlighted, not only in distribution/delivery, but throughout the value-chain, from production, to content consumption, distribution, and delivery. This Report indicates some trends and refers to technologies that are being standardized and deployed in that context, as a snapshot of relevant experiences. Again, ITU-R Report BS.2522.0 "A framework for the future of broadcasting" is considered, as it acknowledges some important aspects, including the convergence of consumer and professional media-based broadcasting technology enabling new content creation, delivery and consumption opportunities; and the integration of IP technologies and cloud computing into broadcasting technologies enabling broadband access, and flexible and more efficient content creation and distribution.

The usage of IP-based technologies is critical to the advancement of broadcasting systems, with the potential of reshaping the traditional idea of broadcasting as it merges with gaming, streaming and content-based services, available through Internet-connected and smart devices that can be used in any location. This also reinforces the need to keep pace with trends that continue to influence the development of new media technologies and that play a role in shaping the future nature of society.

In a discussion of the development of broadcasting systems using IP-based technologies and networks, it is worth noting the benefits of broadcasting distribution, and considering why the usage of IP infrastructure in the context of broadcasting, can bring innovations and efficiency, as both environments, broadcast and broadband, can benefit from a converged service offer.

37 Id ibid.
38 Id ibid.

The first benefit is cost efficiency, as broadcasting services are characterized by fixed distribution costs, regardless of the audience size, and from the end-user perspective the costs of setting up satellite or terrestrial reception are low.

Another benefit is universal reach, as broadcasting services often offer full coverage of target markets, with a mix of terrestrial and satellite broadcasting services, compared with broadband networks, which can have high roll-out costs.

Finally, the service quality can be another benefit, as broadband networks get congested, broadcasting networks, either terrestrial or satellite, can enable an unimpaired viewing experience, being an efficient way for content consumption, and allowing for a mix of distribution methods by means of different platforms, as necessary, and as demanded by the users.

Historically, the development of broadcasting and broadband services led to parallel network infrastructure and ecosystems, where the receiver base and the content distribution platforms are duplicated to address users'/subscribers' consumption needs. The convergence of service offers in the context of content consumption, based on video-centric converged services, can build solutions for a true integration of broadcast and broadband.

In that sense, the development of IP-centric solutions to tackle the migration from traditional broadcasting to IP-based platforms could allow stakeholders to build a converged 5G/IP/broadcast ecosystem, introducing new opportunities for broadcasters and a new service experience for users. The main idea being to leverage existing broadband and broadcast infrastructures, complementing each other, and where one platform is not available the other can be used, and vice-versa.

As examples of IP-based broadcasting systems, DVB-NIP (DVB Native IP), 5G-Broadcast and ATSC 3.0 can be relevant. In the context of section 2.3 of this Report, some details of these next generation broadcasting systems are considered. Below, some considerations about the usage of IP in other parts of the value chain are presented.

### 2.2.1 IP-based and other emerging technologies throughout the broadcasting chain

Some trends can be identified with the usage of IP technologies in broadcasting. One such trend being the combination of delivery platforms in cooperative networks, for example, by applying broadcast systems in conjunction with the interactive capabilities of IP-based networks.

ITU-R Report BS.2522.0, on the future of broadcasting, also indicates that the future of media delivery lies in what may be termed a 'mixed media' delivery environment, as a sum of broadcast and IP delivery, with a balance appropriate to the needs of the public, the region, and the status and availability of technology development.

Additionally, the report mentions that the addition of technologies such as integrated broadcast broadband (IBB) allow broadcast and broadband networks to work together to efficiently deliver enhanced, personalized content to users. It is expected that such enhancements will continue, allowing the delivery of yet more advanced TV content formats in a cooperative way between broadcast and broadband networks.

Moreover, a future delivery framework must consider ways in which users will receive and interact with media. Future delivery systems will need to employ flexible and diverse technologies capable of realizing the developing user experience expectations, and of taking into account:

- user-driven trends for new delivery services;
- types of infrastructure changes in the adoption of new delivery systems; and
- coverage requirements of new delivery systems.

A combination of terrestrial broadcasting and Internet delivery, as indicated above, is a very effective way to meet the requirements arising from user-driven trends for new delivery services. The mixture of delivery networks will vary between markets, depending on various factors, including previous investments and availability of Internet connectivity, quality, and cost. Although the economics of each method will influence the eventual mixture of delivery networks used, other factors, such as regulatory requirements, will also have an influence.

Although, Internet delivery is an essential complement to terrestrial broadcast delivery, especially for enabling on-demand non-linear content consumption and the interactivity/personalization use cases, terrestrial broadcasting will still be necessary.

In media content production, IP-based technologies can also have an impact, and content will need to be produced with a greater sense of reality, personalization and interaction.

ITU-R Report BS.2522.0 points to some groups of future technology-driven innovations that are designed for media content production:

- software-based production;
- virtualized production;
- cloud-based production;
- complex media production;
- data-driven production;
- automated production through AI and machine learning (ML);
- immersive and accessible media production; and
- sustainable production.

A more detailed exploration of many of the concepts mentioned above can be found in Report ITU-R BT.2420 – *Collection of usage scenarios of advanced immersive sensory media systems,* and Report ITU-R BT.2447 – *Artificial intelligence systems for programme production and exchange*.

The experience of audiovisual IP content delivery is also an important aspect of the usage of IP in the broadcasting value chain. IPTV service offers in the Republic of Senegal[39], where some legal challenges related to audiovisual content rights, can be considered as an example. Despite the implementation of digital terrestrial television (DTT) in Senegal, its limited coverage and technical problems have spurred the adoption of Internet protocol television (IPTV), which uses the Internet to provide a variety of content. IPTV can open opportunities to piracy, (unauthorised acquisition, use, sharing or selling of copyrighted content) making it a threat to the income of legitimate operators and local content creators.

[39] ITU-D Document https://www.itu.int/md/D22-SG01-C-0363/ from Senegal.

While IPTV is legal under certain conditions, unauthorized IPTV, especially the services provided by distributors that are based abroad, can have economic consequences for the production of audiovisual content, not only at the national level, but also across the African continent. While there are regulatory measures to counter these negative impacts, the struggle against piracy via IPTV, can benefit from regional coordination and tougher measures to protect the audiovisual industry. While IPTV on a technical level provides great opportunities to access diverse content, its illegal use can pose a serious threat to the audiovisual industry. A concerted approach that involves regulators, authorized distributors, Internet service providers, content producers and the general public, creating an environment conducive to the legal and sustainable development of the audiovisual sector, can help address this phenomenon.

To increase the chances of successful outcomes, it is crucial to act at the community level, in particular within WAEMU[40] and ECOWAS[41] for the concerned African countries. The Member States of these organizations are invited to consider reforming their telecommunication and media laws to include specific provisions regarding IPTV and Internet-based content.

Collaboration with international technology companies could help identify and block illegal IPTV streams at source. Another form of usage of IP in the broadcasting value chain is found in Malaysia[42], with the shift to cloud-based solutions, which are enabling broadcasters to scale their operations more efficiently. Cloud broadcasting offers flexibility, cost savings, and the ability to adapt quickly to changing viewer demands. Some of the applications that have been adopted by local broadcasters are:

- **Media asset management system (MAMS)**: Leading broadcasters in Malaysia have transitioned to cloud-based MAMS, moving away from traditional file-based systems. This shift has made content management more reliable and reduced operational costs, enhancing the ability to store, manage, and distribute media assets efficiently.
- **Over-the-top (OTT) apps**: Cloud technology also underpins OTT apps widely used by Malaysian broadcasters. These OTT apps enable viewers to access content anytime, anywhere, furthering the reach of broadcasters in the digital age. For example, MYTV, as the content integrator for digital TV, has introduced its own OTT application "MYTV Mana Mana", aiming to become the main universal free-to-air (FTA) OTT platform in Malaysia.

It is also worth mentioning the usage of AI and machine learning (ML) in Malaysia and how these technologies are transforming the broadcasting industry by automating processes, enhancing content creation, and personalizing viewer experiences. These technologies are increasingly being used in content creation, distribution, and audience measurement:

- **AI for broadcasting**: While still in its early stages, Malaysian broadcasters are experimenting with AI, such as AI presenter for TV and AI DJ for radio programmes, and AI-driven content recommendations. RTM radio and several other radio broadcasters such as Fly FM and Hot FM, have pioneered the use of AI presenter/DJ in their programming.
- **Generative AI (Gen AI)**: Broadcasters in Malaysia are also exploring Gen AI for tasks such as automated captioning and journalism, although this technology is still in the experimental phase. To ensure ethical AI usage, the Malaysian Communications and Multimedia Commission (MCMC) is developing an AI Code of Ethics. This initiative aims to promote governance, prevent biases in AI models, ensure compliance with data privacy regulations, and build trust with audiences, making AI a more reliable tool in broadcasting.

[40] West African Economic and Monetary Union (WAEMU).
[41] Economic Community of West African States (ECOWAS).
[42] ITU-D Document https://www.itu.int/md/D22-SG01-C-0341/ from Malaysia.

## 2.3 Innovations for broadcasting in the UHF band, proposed new systems for broadcasting

It is important to consider current developments and studies aimed at evaluating what could be the future of broadcasting, in order to have a picture of what lies ahead in terms of new service scenarios and possibilities for those services.

The report ITU-R BT.2522-0[43] – "A framework for the future of broadcasting" serves as a reference to assess what could be the roadmap for innovations in broadcasting services. More information on the scope and general conclusions of the document can be found in Annex 4 of this Report.

In the context of the evolution of broadcasting systems, this section introduces some of the next generation systems and their main use cases and features.

### 2.3.1 5G Broadcast

In recent years, a new paradigm in broadcasting has emerged in the 5G ecosystem. 5G broadcast technology enables an unlimited number of users to be reached with a single data stream and without loss of quality. 5G Broadcast is based on the **LTE-based 5G terrestrial broadcast** standard (in short 5G Broadcast), developed by the Third Generation Partnership Project (3GPP).

3GPP has been developing standards for 5G Broadcast through several releases. 5G Broadcast was first introduced with **Release 14 (Q2/2017)** through LTE-based enhancements for broadcast and multicast, known as further enhanced multimedia broadcast multicast service (FeMBMS). This laid the groundwork for integrating broadcast capabilities within mobile networks. **Release 15 (2018)** marked the initial phase of 5G new radio (NR) standards, focusing on enhanced mobile broadband (eMBB). While primarily centred on unicast services, Release 15 also included foundational elements for supporting broadcast and multicast services in 5G. In 2020, **Release 16** brought significant enhancements to 5G NR, including support for NR multicast and broadcast services (NR-MBS). This release defined the specifications necessary for 5G networks to efficiently deliver broadcast content. **Release 17** of the 3GPP standards, finalized in 2022, brought significant enhancements to 5G broadcast capabilities and continued to develop and refine NR-MBS, building on the foundation laid in Release 16. This included enhancements to improve the efficiency and flexibility of delivering multicast and broadcast content over 5G networks. It also focused on supporting a wider range of use cases for 5G Broadcast, including live event streaming, software updates, emergency alerts, and other high-demand applications that benefit from efficient broadcast capabilities. More details on each of the releases, the overall architecture of 5G NR multicast broadcasting technology, the frequency bands used and other technical characteristics, as well as use cases, are presented in Annex 5 of this Report.

5G multicast broadcasting technology will have the following new features: (1) Ability to provide all-scenario and all-terminal broadcasting services and support general mobile devices; (2) Ability to provide effective support for services such as public safety, mission critical emergency communication, vehicle-to-everything (V2X) applications, IPv4/IPv6 multicast through transmission, IPTV, wire-based software upgrade, trunking communication and Internet of things; (3) Extensive flexibility, such as dynamic radio resource allocation between unicast and multicast transmissions, support for parallel transmission of the same video content with

43 https://www.itu.int/pub/R-REP-BT.2522

different video quality/resolution, changes in user mobility during content transmission, and support for specific multicast/broadcast transmission area.

Due to its 3GPP heritage, 5G Broadcast is primarily focused on mobility use cases (e.g., smartphones). However, 5G Broadcast does not require the network to support unicast, nor the device to have a SIM card or a cellular subscription for free-to-air broadcast reception. While unicast is not required, 5G Broadcast can be combined with unicast to deliver a fully hybrid, integrated user experience, leveraging the best aspects of unicast and broadcast technologies. In particular, the 5G Broadcast modem is designed to be hardware-compatible with existing cellular modem technologies and so does not require new hardware. In contrast to previous technologies, this hardware-compatibility is expected to significantly lower any barrier to the adoption of broadcast technologies in mainstream mobile devices.[44] A more detailed description of some use cases of 5G Broadcast can be found in Annex 6 of this Report.

In recent years, support for 5G broadcast across the broader mobile and broadcast ecosystem has grown significantly. This is exemplified by the more than 25 3GPP members who co-signed the Release 16 Work Item, which was subsequently completed in 2020. The 5G Multimedia Action Group (5G MAG) is a cross-industry organization established in 2019, and today has more than 40 active members across the media sector promoting the commercial adoption of 5G Broadcast. There are several 5G Broadcast trials that have been conducted, and new trials are being planned worldwide[45] which are rapidly setting the stage for virtually seamless, rich media, content delivery to our 5G devices.

In 2023, there were numerous demonstrations and small-scale trials in several countries including China, USA, Germany, France, Spain, Italy, Austria, Estonia and CzechRepublic. Other countries including India, Malaysia and Republic of Türkiye, are also studying 5G Broadcast. For an example of deployment, refer to the China case study, in Annex 6 of this Report.

As an example, in Malaysia, the adoption of 5G Broadcast is expected to have a transformative impact on broadcasting services. This will enable broadcasters to deliver high-definition content to a wider audience with minimal latency. Additionally, 5G Broadcast can serve as a complement to mobile networks by broadcasting text, audio, or video content, even in rural areas, without the need for data plans or subscriber identity module (SIM) cards. Moreover, 5G Broadcast can support an emergency alert warning system during crises, providing relevant government authority with the fastest platform to alert the public. From an infrastructure perspective, 5G Broadcast will require significant upgrades to existing broadcasting networks, although the rollout costs may be minimized by leveraging current digital terrestrial television (DTT) infrastructure in Malaysia.

Remote production, enabled by 5G new radio (NR), is transforming how live events are produced in Malaysia. With faster, more reliable, and lower-latency connections, 5G is essential for real-time broadcasting from remote locations. Currently, one national broadcaster and one private broadcaster have conducted trials of remote production via 5G NR in several live events such as sports events, general elections, etc. The use of 5G wireless cameras eliminates the need for an outside broadcast (OB) van, streamlining the setup process and making deployment easier.

Recently, Malaysia conducted another trial using 5G Advanced mode with the mmWave band during the opening ceremony of Sport (*Sukan Malaysia*, SUKMA) 2024 in Kuching, Sarawak,

44 ITU-D Document https://www.itu.int/md/D22-SG01.RGQ-C-0219/ from Qualcomm, Inc.
45 https://www.5g-mag.com/trials

Malaysia. This trial involved collaboration between mobile operators, along with the national broadcaster. This technology offers innovative ways to cover events with significantly reduced resources, lowering production costs while enhancing reliability.

### 2.3.2 ATSC3.0

In this section, the development of another of the next generation broadcasting systems, ATSC 3.0, developed by the Advanced Television Systems Committee, and some of its main functionalities and use cases, are considered.

ATSC 3.0 is a broadcasting system that enables broadcasters to also distribute data and media content, through the Internet using IP-based technologies. The broadcast of IP data offers a means to meet the growing demand for digital content offer solutions to close the digital divide, and provides innovations for the private and public sectors.

The rapid acceleration in demand for digital connectivity creates potential for broadcasters to create new business opportunities in the communications sector. The ability to broadcast high-quality video and IP data efficiently, offers an option to serve increasing consumer demand.

With full deployment of ATSC 3.0 in a country, it is expected that with a nationwide network in place it would have the capability to transmit IP-based content to the population, and especially those without access to highspeed broadband. Given that a vast majority of people, in developed and developing countries, can already receive broadcast TV signals today, next generation broadcasting systems have the potential to play a powerful role in bridging the digital divide.

ATSC 3.0 utilizes a one-to-many broadcasting distribution paradigm, where a single signal can be broadcast to a large number of users within each tower's coverage area. It is expected that ATSC 3.0 broadcasters will be able to enhance the live video content experience for their viewers, including delivery of Internet data, such as text, audio, video, or software, as well as advanced global positioning system (GPS) data, to their live video broadcast. ATSC 3.0 broadcasters' one-to-many network architecture will enable them to deliver content in a cost-effective way, when compared with traditional broadband networks, by leveraging established infrastructure to deliver content and data.

Some of the main functionalities of ATSC 3.0 include[46]:

- Content is broadcasted via TV high towers and single frequency networks (SFNs).
- Signals are networked via multiple frequency networks (MFNs).
- A data pipe that simultaneously transmits live and IP-based content.
- Delivery of content and data to devices with ATSC 3.0 receivers.
- Interactive solutions when receiver device applications converge with broadband.

Note: A detailed description of the functionalities and use cases can be found in Annex 7 of this Report.

ATSC 3.0 can allow the integration of broadband and broadcast services, providing a two-way communications channel for new use cases, such as interactive experiences, on-demand services, IoT, etc., using existing connectivity options.

[46] Deloitte. ATSC 3.0 white paper, 2022. Available at https://www2.deloitte.com/us/en/pages/consulting/articles/atsc3-benefits-and-applications.html. Access in September/2024.

In addition, some use cases, and applications possible with ATSC 3.0 include:

- Enhanced viewer experience.
- Targeted advertising.
- Spectrum-as-a-service: data offload, video streaming and edge caching.
- IoT connected cars.
- Remote learning.
- Advanced emergency alerting and informing.

## Examples of countries that have applied ATSC 3.0 technology

- **Brazil**: The final Phase 3 recommendations of the Brazilian Digital Terrestrial Television System (SBTVD) Forum were published on 22 July 2024, and forwarded to the Brazilian Ministry of Communications, which will study the recommendations for adoption as the country's TV 3.0 system, including ATSC 3.0 transmission technology.[47]
- **USA**: The Public Media Venture Group (PMVG), a business development consortium of 32 public stations, has launched NextGen broadcasting service on W35DZ-D, its low-power station located in Cookeville, Tennessee.[48] The regulator had adopted standards allowing the use of this technology from 2017.[49]
- **Canada**: Humber College has built its ATSC 3.0 laboratory.

## Challenges and issues

As a new generation of digital terrestrial broadcasting standard, ATSC 3.0 technology poses many significant challenges and issues. The need for compatible broadcasting infrastructure, the large investment required for transition from previous standards, and the challenge of incorporation into existing technologies, in particular in the area of IP data compression and transmission, are the main challenges.

One of the primary issues is that of patents. A set of patents protects ATSC 3.0, which can make adoption of the standard costly due to associated royalties and licensing. This hinders access to many markets, in particular developing markets, such as in Africa, where financial resources to support such switchovers are limited. This has prompted LG, for example, to drop support for this technology in the production of its next line of televisions.[50]

## Example of adoption of ATSC 3.0 for UHD TV standard in Republic of Korea

In the Republic of Korea, the adoption of ATSC 3.0 for UHD TV standards marked a significant technological and regulatory advancement. The transition was driven by strong collaboration between Government and industry stakeholders. Key decisions included the allocation of 30 MHz spectrum in the 700 MHz band for UHD broadcast services, licensed to major broadcasters such as KBS, MBC, SBS, and EBS.

The policy plan set in December 2015, outlined a phased rollout, starting with simulcasting ATSC 1.0 and ATSC 3.0 in Seoul from 2017, expanding to major cities by 2021, and nationwide

[47] https://www.atsc.org/news/atsc-3-0-transmission-technology-unanimously-recommended-as-final-ingredient-for-brazils-tv-3-0-project
[48] https://www.atsc.org/news/tv-tech-pmvg-launches-nextgen-tv-station-in-cookeville-tenn/
[49] https://www.itu.int/dms_pub/itu-d/opb/stg/D-STG-SG01.02.2-2021-PDF-E.pdf
[50] https://www.theverge.com/2023/9/30/23897460/lg-drops-atsc-3-0-support-fcc-broadcast-tv

by 2027. The Government supported this with investments in R&D, incentives for technology development, and strategic initiatives to promote industry participation.

The Republic of Korea launched the world's first terrestrial 4K UHD service in May 2017, with KBS, MBC, and SBS broadcasting ATSC 3.0 signals. This milestone involved collaboration between broadcasters, manufacturers such as LG and Samsung (who produced ATSC 3.0-embedded TVs), and public agencies. The 2018 PyeongChang Olympics showcased these capabilities, highlighting advancements in 5G and mobile broadcasting using ATSC 3.0.

Overall, the adoption of ATSC 3.0 in Republic of Korea, demonstrated leadership in UHD broadcasting, leveraging technological innovation and strategic planning to establish a competitive edge in the global market.

### 2.3.3 DVB Native IP (DVB-NIP)

Continuing with the presentation of next generation systems, in this section DVB Native IP (DVB-NIP)[51] is considered. DVB-NIP is an end-to-end broadcasting system, that is based on IP, and uses the current family of European digital video broadcasting (DVB) standards as its building blocks, relying, as much as possible, on published DVB specifications, and complementing those where necessary. The DVB Native IP broadcasting system is built upon relevant DVB standards, such as:

- DVB-I service discovery and programme metadata;
- DVB-AVC (audio and video coding) for source media coding;
- DVB-DASH (dynamic adaptive streaming over HTTP) for stream formatting;
- DVB-MABR (multicast adaptive bit rate);
- DVB-GSE (generic stream encapsulation) – Logic link control;
- DVB-GSE (generic stream encapsulation) – Robust header compression;
- DVB-S2X (second generation satellite extensions) and DVB-S2 (second generation satellite) for satellite transport and delivery;
- DVB-T2 (second generation terrestrial) for terrestrial transport and delivery.

DVB Native IP[52] aims to facilitate the integration of over-the-top (OTT) and broadcasting technologies, into an IP media distribution system. With DVB-NIP and DVB-I, existing digital video broadcasting networks can be integrated as a part of the converged broadcast/broadband system, allowing for the integration of both platforms and networks, and the sourcing of content from both sides. Some of the features of the new system include:

- Leveraging of the existing infrastructure to connect legacy:
  - Existing infrastructure can be used to connect people in rural areas or to offer new services in public areas or transportation such as access to live stream and premium video on demand (PVOD) using legacy devices.
- Existing players can benefit from the integration with DVB-NIP, in both broadcast and broadband ecosystems:

[51] Reference: https://dvb.org/?standard=native-ip-broadcasting and standardization on DVB BlueBook A180r3 (Draft TS 103 876 V1.1.1).

[52] "Leveraging broadcast networks to broaden the reach of OTT services – an introduction of DVB Native IP". ITU workshop: The Future of Television for South Asia, Arab and Africa Regions, May 2023, Bangalore, India.

  - Satellite and terrestrial broadcasting service providers can stay relevant, using DVB NIP via satellite/terrestrial networks, and OTT service providers can scale down infrastructure costs and extend market reach.

- Stream without Internet:
  - Live OTT is served with broadcast quality regardless of the number of devices that are connected simultaneously.
- Help environmental sustainability:
  - As a broadcasting technology, the system is a sustainable way for IP services to reach millions of devices.
- Enable a 5G/IP/broadcast convergence:
  - "DVB-I over 5G" can enable a future combination with 5G broadcast (more appropriately 5G media streaming) for new devices that support 5G and in areas that may progressively offer 5G coverage.

DVB-NIP can offer new services and applications to users, and some of the new use cases that can be implemented by this new technology may include:

- Live TV enabled in poor connectivity and TV-less environments, with a mix of terrestrial and satellite transport technologies.
- Mobility: entertainment for captive audience in buses, railways, maritime deployments.
- Education: helping institutions to reach students in rural villages.
- Enablement of a converged media delivery ecosystem:
  - The same IP-based streams feed all screens:
    - Unified content distribution platforms.
    - Multiscreen and multiroom applications.
  - Standardized push video-on-demand (VOD);
  - Targeted advertising.

### 2.3.4 Other next-generation systems

Other systems are currently being developed to cope with the innovations that the audiovisual content market is undergoing. For example advancements are being discussed and planned for the digital terrestrial television system[53] adopted in Brazil, which has been denominated TV 3.0.

#### Process of discussions and adoption of TV 3.0 in Brazil

For its first generation digital terrestrial television system, after thorough testing and careful studies, the Government of Brazil adopted in June 2006, the ISDB-T standard, incorporating technological innovations that were deemed relevant, such as MPEG-4 AVC (H.264) video coding, MPEG-4 AAC audio coding, an appropriate closed caption character set for Brazilian Portuguese, and a new middleware for interactive applications (Ginga, H.761).

[53] Brazil adopted the Brazilian Digital Television System (SBTVD), which is based on the Japanese system, ISDB-T, with other innovations included.

The SBTVD Forum[54] developed the first SBTVD standards, that were published in 2007, allowing the official opening of transmissions in that same year. Since then, the standards have been continuously revised and updated by the Forum. The technological innovations proposed by Brazil were incorporated into the integrated services digital broadcasting – terrestrial (ISDB-T) standard, which is currently adopted by 20 countries.

Following the take up of the deployment, and the innovations incorporated and planned to be included to the digital television standards and systems, the SBTVD established the TV3.0 Project, aiming at incorporating those latest evolutions into the Brazilian digital television system. The discussions for the adoption of TV 3.0 in Brazil underwent a phased process that involved a call for proposals (CfP) on enabling technologies, testing and evaluation, and field tests. More information can be found in Annex 8 of this Report.

Additional information on the TV 3.0 candidate technologies and evaluations done can be found in Annex 9 of this Report.

An end-to-end demonstration of TV 3.0, integrating all its system components, was planned for August 2024. TV 3.0 is expected to launch in 2025. Further information can be obtained at https://forumsbtvd.org.br/tv3_0/.

## 2.4 National experiences on strategies for the introduction of new technologies, emerging services, and capabilities, and their impact in broadcasting

Within the European Union, policymakers and regulators recognized a significant shift in viewing habits, particularly among younger generations, where traditional TV is increasingly being replaced by mobile devices. The rise of new content formats, such as user-generated videos, has elevated the role of video-on-demand services, and video-sharing platforms, impacting the market for traditional broadcasters. These new technologies have created new market dynamics and affected business models within broadcasting.

In response to these new market dynamics, the European Union introduced a major regulatory innovation by incorporating video-sharing platforms into the regulatory framework. This shift was formalized in 2018, with the inclusion of video-sharing platforms (VSPs) under the scope of the European Union Audio-Visual Media Services Directive (AVMSD) which now governs EU-wide coordination of national legislation on all audiovisual media, traditional TV broadcasts, and video on-demand services.[55]

As a result, the regulation at the European Union level, is therefore limited to audiovisual media services (linear TV programmes and video distribution via Internet) as well as video sharing platform services. The adoption of the Digital Services Package by the European Union, which includes two acts, namely the Digital Services Act and the Digital Markets Act, demonstrates that regulations that apply to the broadcasting sector should respond to technological innovations, such as in this case, the adoption of new and emerging technologies and should evolve with them. In many cases, this will require additional resources and a convergent regulatory approach for the responsible institutions.

[54] Brazilian Digital Television System Forum, https://forumsbtvd.org.br.
[55] https://digital-strategy.ec.europa.eu/en/policies/audiovisual-and-media-services

In order to address these developments, in 2021, the European Commission adopted the "Shaping Europe's digital future"[56] strategy through a programme of reforms and policies and by adopting the so-called Digital Services Package consisting of two acts: Digital Service Act (DSA) and Digital Market Act (DMA), which both address evolutions posed by the emergence of new digital services that have affected broadcasting.

The aim of these legislative acts is to update and modernize the existing rules for the regulation of digital services in Europe. The two main goals of the Digital Services Package are to protect digital services users and ensure that their fundamental rights are respected; and secondly, to establish a level playing field in the digital ecosystem to promote innovation and competitiveness. Detailed information can be found in Annex 10 of this Report.

As an example of the implementation of the new regulatory framework at the European Union level, the case study of **Bosnia and Herzegovina** is presented in Annex 10 of this Report, and is summarized below:

As elsewhere in the world, digital technologies have radically affected the way content is delivered, produced, distributed, and consumed. The number of Internet users is constantly increasing (according to the RAK Annual Report of the Communications Regulatory Agency (CRA) for 2021, Internet penetration has reached almost 96 per cent). The use of online sources of information is also increasing. According to the research of media habits of adults in Bosnia and Herzegovina from 2022, nine out of ten adults use Internet, while eight out of ten use social networks. For most adults, television is still the main source of information regarding the news from the country and worldwide (78 per cent), followed by social networks (52 per cent) and online information portals (45 per cent). Video exchange platforms are used by 42 per cent of adults. A significant percentage of adults (35 per cent) state that they were exposed to potentially harmful content in the media and the ICT environment, whereby 'hate speech' is at the top of the list (48 per cent).[57]

In order to address these developments, in May 2023, the CRA Council adopted a set of by-laws aligned with the revised AVMSD from 2018, thus expending the scope of regulation to video-sharing platforms.

The new regulations include a **Rule on provision of audiovisual media services,** and a **Rule on video-sharing platform services**, as well as two codes, a **Code on programme content** and a **Code on commercial communications**. These regulations serve as an example of how Bosnia and Herzegovina has updated their national regulations in response to the new market dynamics that affect broadcasters.

The regulatory authority regularly engaged with other stakeholders and conducted new research during this process. In response to growing public concerns, and to better understand its legal mandate for regulation of online media (other than audiovisual), the CRA has been promoting the need for the country to implement a systematic approach, based on cooperation between various stakeholders that have a role in the online media ecosystem. To this end, a study was produced under the auspices of the JUFREX Project (Freedom of Expression and Freedom of the Media in South-East Europe), implemented by the Council of Europe, mapping relevant

[56] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/shaping-europes-digital-future_en
[57] https://rm.coe.int/mil-media-habits-bos-nova-verzija/1680a845ff

local stakeholders (institutions such as the election authority, a self-regulatory body for online media, CSOs, and professional associations) and assessing their capacities and readiness to take on this joint responsibility. The Study entitled **Mapping of European co-regulatory practices for combating harmful online content – the context in Bosnia and Herzegovina and the search for efficient models of media coregulation**[58], was published in December 2022. In the months following, all identified stakeholders were brought together in order to reach an agreement on the establishment and functioning of a cooperation platform, as well as on the potential formalization of such cooperation, following the recommendations provided by the Study.

Furthermore, with the support of the Open Society Foundations-Western Balkans, the Study **Future of the Western Balkans in Digital Europe**[59] was developed in order to elaborate the readiness of Western Balkan countries for the harmonization of their national regulations with the European Union Digital Services Act.

### 2.4.1 Regulatory, economic, and technical aspects

Over the past few years, digitalization has become an integral part of our lives and influences the way we live and interact. Technological development has contributed to the emergence of new, innovative products and services for end users. These innovations have had disruptive effects on many economic sectors impacting consumers, businesses, and policymakers. This has raised concerns about competition issues in some instances, as well as the question of how to update the relevant laws and regulations, to respond to the new reality created in part by these new and emerging technologies.

An example of such innovations, is the convergence of fixed, mobile and media networks, that made it possible for new entrants to provide innovative services, impacting traditional value chains of telecommunication and media business models, including the broadcasting sector.[60], [61], [62]

### 2.4.2 Influences in the broadcasting services

The European Union Digital Service Package presents the new set of rules that regulates the digital ecosystem. This serves as an example of how countries have been updating their regulations in response to the emergence of new technologies and how they might affect broadcasting services, as these regulations serve as an enabling environment for the evolving digital landscape.

By updating their regulations, policymakers can support fair competition an protect user interests in an increasingly online-oriented media ecosystem. These legislative frameworks establish clear rules on transparency requirements, ensuring that broadcasting services operate responsibly in the digital sphere. Ultimately, updating the regulatory framework in a responsive

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[58] https://www.coe.int/en/web/freedom-expression/-/towards-the-co-regulation-of-harmful-online-content-in-bosnia-and-herzegovina
[59] https://metamorphosis.org.mk/en/izdanija_arhiva/towards-a-feasible-implementation-of-the-digital-services-act-in-the-western-balkans/
[60] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/shaping-europes-digital-future_en
[61] Regulation (EU) 2022/2065 of the European Parliament and of the Council of 19 October 2022 on a Single Market For Digital Services and amending Directive 2000/31/EC, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022R2065&qid=1666857835014
[62] https://digital-markets-act.ec.europa.eu/index_en

and inclusive manner can help create an enabling environment that upholds the integrity and longevity of broadcasting services in the ever-changing digital realm. Detailed information on the European Union Digital Service Package can be found in Annex 10 of this Report.

# Chapter 3 – Migration to digital broadcasting

## 3.1 Digital television transition

It is recognized that one of the key challenges for the implementation of the migration towards digital technologies is the need for coordination among the stakeholders during the definition of policies and regulations, and project implementation, as was stated by Kingdom of Bhutan, in its submission regarding strategies for the deployment of broadband in the country[63]. This section will address some of the key issues related to the migration to digital television broadcasting, including planning and coordination efforts.

Another important aspect is the establishment of national strategies and roadmaps for the implementation of the digital switchover. As an example, the case of Republic of Cameroon[64] can be cited, where the institution-level action on the migration to digital broadcasting took place in two stages. The first was to **elaborate the strategy**, with the creation of a steering committee[65] and the elaboration of the strategy document. The next stage was to **implement the strategy**, with the creation of the implementation body[66].

From the experiences of countries that implemented strategies for the migration to, and adoption of, digital broadcasting, some relevant issues and best practices can be identified. The following sections will address these issues, indicating case studies relevant for each of the components of an overall strategy, including:

- National strategy;
- Policy and regulatory framework;
- Establishment of methods of migration to digital terrestrial television (DTT);
- Implementation of the strategy;
- Availability of DTT receivers to low-income populations.

### 3.1.1 Relevant issues and best practices

#### *a) National strategy*

For a successful transition to digital broadcasting, it is important to adopt and closely follow a national strategy document guiding the implementation of all the activities involved in the digital switchover and the analogue broadcasting switch-off.

63 ITU-D Document https://www.itu.int/md/D22-SG01-C-0048/ from Bhutan.
64 ITU-D Document https://www.itu.int/md/D22-SG01.RGQ-C-0014/ from Cameroon.
65 Digital Broadcasting Switchover committee (CAM-DBS) established by government order no. 222/CAB/PM of 24 September 2009.
66 Digital Broadcasting Migration Implementation Body (CAM-DTV) by order No. 122/CAB/PM of 30 August 2012.

As an example, consider the case of Cameroon[67], where in 2012, the Government adopted a **national strategy document** for the **migration from analogue to digital broadcasting**. This document comprised four major parts:

- general information on the migration;
- review and analysis of broadcasting in the country;
- the current vision for the digital TV landscape in Cameroon;
- the machinery of migration implementation.

The national migration strategy comprises some 40 projects organized into six segments:

- institutional and legal projects;
- economic and financial issues;
- technical projects;
- projects relating to development of broadcasting content;
- projects for development of human resources and competencies;
- projects for building awareness on migration among policymakers and the general public.

The process that was undertaken by Cameroon to establish its national strategy, serves as a useful example, and is described in Annex 11 of this Report. Additionally, the main stages of the migration process in Cameroon are described in Annex 12 of this Report.

Republic of Guinea[68] has also embarked on a project aimed at deploying digital terrestrial television (DTT) throughout its territory. This project responds to a strategic need to modernize and optimize the frequency spectrum, while offering a better quality of service to the population. After several years of delay and planning efforts, Guinea now aims to accelerate the digital transition to take advantage of the technical and economic benefits it provides.

The transition from analogue to digital broadcasting in Guinea is crucial for the country's development, with a view to modernizing infrastructure, optimizing radio spectrum use, and providing better services. The digital terrestrial television (DTT) project seeks to address issues including interference and inefficient spectrum use, and so connect Guinea more effectively to the digital world.

The case study of Guinea raises some important aspects, which are recommended to be taken into consideration, when formulating the overall strategy for the migration.

### Republic of Guinea case study

The Government of Guinea made an initial 15 per cent payment for the DTT project, but additional funding from donors is required to meet the 30 per cent payment needed for the official launch. Efforts are being undertaken to secure the necessary finances and so avoid further delays.

Funding is crucial for the implementation, and it is recommended to be considered in the national strategy set-up from the start.

[67] ITU-D Document https://www.itu.int/md/D22-SG01.RGQ-C-0014/ from Cameroon
[68] ITU-D Document https://www.itu.int/md/D22-SG01-C-0451/ from Guinea

**– Frequency allocation and spectrum planning**

Regarding frequency allocation for digital broadcasting, although the implementation partner has proposed the necessary channels, some TV and FM frequencies are already in use by other operators. The French Post and Telecommunications Regulatory Authority (ARPT), in collaboration with the Government of Guinea, has taken steps to free up these frequencies, but a formal request for their allocation must still be submitted, and processes followed.

From the example of Guinea, it can be seen that a thorough planning of the spectrum allocation and refarming activities should be carried out in order to establish clearly the necessary steps to be considered in the implementation phase.

**– Other challenges and next steps**

One challenge faced by the project is that of a fixed budget limitation, which may create gaps in coverage and prevent sufficient transmission support, particularly with regard to optical fibre for connecting broadcasting sites. There is also a lack of rehabilitation of old analogue sites that could expand coverage. The next steps will include finalizing missing documents, securing frequency allocation, and completing the legal framework for regulatory compliance. All of these steps, which are clearly identified by the Government of Guinea, are also of key importance in the overall migration strategy.

It is important to note that the Guinea implementation case has evolved, and an update on how the stakeholders managed the issues discussed here, can be found in Annex 13 of this Report.

### *b) Policy and regulatory framework*

Another good practice is to formalize the strategy in the nation's policy and regulatory framework related to the migration to digital broadcasting. In the strategy formalizing process, a crucial aspect to be considered is the establishment of incentives for stakeholders in order to gain their support. A well-defined policy must be put in place in order to create a clear legal framework. Only subsequently to the creation of a clear legal framework, can all relevant legal instruments can be implemented.

Firstly, strategic objectives need to be established. The strategy is recommended to:

- create all vital requirements for the migration to digital terrestrial television (DTT);
- stop analogue broadcasting in all UHF bands;
- allow new licences to be allocated for other services, such as mobile telephony, that will use other portions of the released spectrum (digital dividend);
- include all stakeholders operating at the time of the migration to DTT.

Secondly, the strategy must take into account the transition from analogue broadcasting to DTT.

Finally, the policy must make plans for a mechanism for identifying potential gaps in the existing legislation that could be used to bypass broadcasting provisions. These gaps will need to be corrected in the new legal instruments[69].

### c) *Establishment of methods of migration to DTT*

In order for the implementation to be effective and efficient, it is essential to provide for a transition period during which analogue and digital services must coexist. During this period, the necessary tools for operation must be made available.

The transition period should allow for the quickest possible migration over to DTT because the simultaneous use of analogue and digital services could cause service disruptions. One option, as chosen by Republic of Madagascar, is to begin with the transition at regional level before moving to the national level[70].

From a general perspective, the migration to DTT is inevitable. The institution of a transition policy and the establishment of an enabling legal environment will greatly contribute to the achievement of this objective. Once these elements are in place, the actual transition can begin with the simultaneous use of analogue and digital services.

As was the case in Madagascar, the financing of the transition is another critical issue, and the search for donors and the organization of financial assistance cannot be relegated to second place.

### d) *Implementation of the strategy*

From the case studies submitted and referred to above, some best practices related to strategy implementation can be established:

*Technical aspects:*

- Experimental projects can be useful;
- Recruitment of strategic partners to construct the technical infrastructure for digital broadcasting can be important;
- Identifying of funding sources is critical;
- Data collection for a complete survey of the existing broadcasting infrastructure country-wide is key;
- A public information campaign to build awareness of the importance of migration to DTT and its challenges is very important, including seminars organized in different regions;

[69] In the case of Madagascar, the transition to DTT was prepared by Act No. 2020-006 amending the Media Communication Code (Act No. 2016-029). Under new article 126, "national coverage shall be granted to all public and private media subject to their conversion to DTT transmission mode and the relevant legislation. Their specifications shall establish the authorized means of transmission and broadcasting. Private radio and television stations may choose between seven topics, namely, education, information, sport, entertainment, art and culture, economy and music. One licence shall correspond to one topic. Licences for each topic shall be allocated through a call for tender." The referred article allows all public and private media channels with DTT transmission capability to broadcast throughout the country. In order to regulate the new DTT transmission mode, the Government of Madagascar is currently drafting a bill that will set out all of the rules and conditions for the operation of DTT.

[70] The town of Nosy Be was chosen as a pilot city in 2015 in order to enable a smoother transition. Currently, two private operators offer digital terrestrial television in some other towns in the country.

- Revision of frequency plans in the ultra-high frequency (UHF) and very high frequency (VHF) bands, with an increase of the planned spectrum resource capacity in those bands, is critical;
- Development of scenarios for migration to DTT, taking into account the costs and objectives of coverage of the national territory, is fundamental.

*Content-related aspects:*

- It is important to consider the preparation and creation of content (TV programmes).

*Human resources aspects:*

- Upgrading the competencies of selected personnel in administration and public bodies involved in the migration process is key.

### *d.1) Coordination in the implementation process*

Another important element in successfully conducting the digital switchover is the coordination amongst stakeholders. One case study of particular interest is that of Brazil. The governance of the transition from analogue to digital television in Brazil[71] was established by a series of normative instruments published by the Government with the focus on establishing a cooperative and collaborative effort towards the goal of the digital switchover[72].

In this context, the Brazilian digital terrestrial television system (SBTVD) Forum was created by Decree, to advise the Government of Brazil, regarding policies and technical issues related to the approval of technical innovations, specifications, development, and implementations of the SBTVD. The SBTVD Forum is composed of representatives of the broadcasting, academia, transmission, reception, and software industry sectors, and includes the participation of Government representatives as non-voting members.

Alongside with the SBTVD Forum, to oversee the process and conduct the actions planned jointly by all stakeholders, a third-party entity was established to implement the tasks included in the National Strategy, tasks which included among others:

- a mandatory communication campaign about the analogue transmissions switch-off, including advertisements, news programmes and social mobilization events;
- distribution of a digital terrestrial television broadcasting (DTTB) readiness kit (STB, antenna and accessories) for low-income families;
- provision of a website and a 24/7 toll-free call-centre to support the affected population in the process;
- execution of household surveys to verify the fulfilment of the analogue switch-off conditions;
- repacking of TV channels to release the 700 MHz band; and
- mitigation of possible interference from international mobile telecommunication (IMT) into TV receiving systems.

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71 In June 2006, the Brazilian government adopted, by means of Decree 5820/2006, the ISDB-T system as a base for the Digital Terrestrial Television (DTT) transmissions. On 2 December 2007, the official system launch date, the Brazilian DTT system initiated commercial operations in the city of São Paulo, and since then the deployment is being carried out successfully.

72 For further information please refer to the Chapter 1, sections 1.3.2, 1.4.3.3, and the Annex 2, of the Final Report of ITU-D Question 2/1, for the period 2017-2021, available at https://www.itu.int/hub/publication/D-STG-SG01.02.2-2021/

Malasia provides another example[73] of the transition from analogue to digital television, which marked a significant milestone in the nation's broadcasting evolution. The Government of Malasia took charge of ensuring a smooth transition from analogue TV to digital TV for free-to-air (FTA) TV stations. The initiative was further supported by the appointment of a Special Purpose Vehicle which acts as the common integrated infrastructure provider (CIIP) to oversee the construction and management of the DTT infrastructure. The DTT migration aimed to modernise FTA TV broadcasting, providing higher efficiency and enhanced viewer experience. A direct-to-home (DTH) solution was deployed to complement DTT coverage in remote areas.

Malaysia had successfully completed the analogue switch-off (ASO), transitioning entirely to digital broadcasting in 2019. This achievement laid the foundation for a modernised, accessible television infrastructure that reaches both urban and rural areas. This has enhanced the nation's broadcasting capabilities, ensuring a more inclusive and future-ready television service. The number of FTA TV channels has increased to 15 digital TV channels and 17 radio channels on the DTT platform, improving public access to information and entertainment across the nation.

#### *d.2) Analogue switch-off (ASO) strategy*

The analogue switch-off strategy is another critical issue in the implementation phase. There are several options, that were tackled in the Final Report of ITU-D Question 2/1, for the period 2017-2021[74], including a one-shot and a phased-approach.

As an example of the phased-approach, the case study from Brazil can be considered, where Brazil divided its ASO into two phases. In the first phase of ASO, the capital and other major cities and towns shut-down their analogue transmissions to allow for the operation of the fourth generation IMT advanced system in the 700 MHz band (698-806 MHz), and in the second phase, the switchover in all locations where analogue TV was still in operation[75] was completed.

To be able to accomplish the first phase, there was a replanning and reallocation of TV channels from the 700 MHz band down to the VHF band (channels 7 to 13) and of the remaining UHF band (channels 14 to 51) in Brazil.

For the second phase, a Government programme, **Digitaliza Brasil** (Digitize Brazil), was established, which utilized funds, provided by the 700 MHz band auction, that remained from the original allocation for the first phase[76].

The analogue switch-off (ASO) strategy in Brazil was successful, with the transition to digital TV broadcasting having no significant impact on the free-to-air terrestrial TV audience. This success is particularly important for Brazil, where the majority of the population relies on free-to-air television for audiovisual content consumption. The digital switchover had several positive outcomes, including a boost to the national industry (covering set-top boxes, TVs, receiving antennas, digital TV transmitters, and transmission antennas), and a renewed public interest in free-to-air terrestrial television. Key lessons from the ASO strategy in Brazil include the importance of cooperation and collaboration among stakeholders, with the operational implementation of planned actions by a third party. Consumer awareness and involvement were crucial for smooth

73 ITU-D Document https://www.itu.int/md/D22-SG01-C-0340/ from Malaysia.
74 Available at https://www.itu.int/hub/publication/D-STG-SG01.02.2-2021/
75 The first phase was implemented between 2016 and 2018, and the second one started 2021 and is planned to finish December 2023.
76 The total amount of funds reserved for the second phase of the Brazilian ASO strategy is approximately R$ 850 million (around U$ 160 million).

implementation, supported by the decision to include digital television (DTV) converter boxes in all TV sets sold in the retail market, in a gradual and phased manner. Providing necessary equipment, such as DTV converter boxes and antennas, for free to low-income populations also contributed significantly to the transition. Local actor involvement facilitated the switchover, underscoring the importance of community engagement. For countries with vast geographical territories, a long-term ASO plan is advisable, including considerations such as maintaining analogue transmissions on a secondary basis in small municipalities to stimulate the migration to digital in these areas. More information on the **Digitaliza Brasil** (Digitize Brazil) Programme can be found in Annex 14 of this Report.

### *e) Availability of DTT receivers to low-income populations*

Another issue to consider is the availability of DTT receivers to low-income populations. This matter was considered in the Final Report of ITU-D Question 2/1 for the 2017-2021 study period, available at https://www.itu.int/hub/publication/D-STG-SG01.02.2-2021/, and other similar initiatives should also be examined.

In the case of Brazil[77], the 5G auction in 2021, for mobile broadband with 5G technology, had important implications for the broadcasting market in the country. Due to interference in the transmissions of satellite broadcasting services by 5G networks in one of the frequency bands (3.5 GHz), it was decided that a migration from the existing satellite broadcasting technologies would be necessary. This involved the digitalization of a receiver's base from analogue to digital satellite broadcasting.

One of the provisions of the 5G auction proceedings involved the acquisition of equipment for low-income families that would cover their migration from analogue to digital satellite broadcasting service with funds raised by the auction.

Specifically, the decision was made to migrate from the existing C band satellite systems, using the 3.5 GHz band to another band, called the Ku band. This involved an estimated 20.7 million homes that received television programming using satellite broadcasting. 17 million of those homes were receiving free-to-air satellite channels and the rest were on paid subscription TV offers.

Of the total number of free-to-air television homes, 8.3 million were families registered in state social welfare programmes and their migration was funded through the 5G auction. Another 9.2 million homes will have to change their equipment, with the installation of a kit that costs around BRL 250 (approximately USD 50).

The benefits of this initiative, based on the 5G auction provisions, include:

- Extending broadcasting coverage to remote and isolated areas;
- Fund management by a third-party entity;
- Acquisition of reception equipment for 8.3 million families who have benefited from state social welfare benefits. It is estimated that this concerns 20.7 million households that receive television via satellite broadcasting, including 17 million in the form of satellite channels.

[77] More information in section 4.1 of this Final Report

More information on the implementation of the migration of satellite stations and the delivery of equipment to users can be found in Annex 15 of this Report.

### 3.1.2 Needs of developing countries in terms of the digital broadcasting migration

Though many countries have completed the digital switchover process, there remain a significant number where the process is still on-going, and the varied specific needs of these countries must be considered in the context of adoption and migration to digital broadcasting.

This section addresses specific case studies attempting to grasp a diversity of views from different countries in different stages of the transition. The needs of some of these countries are summarized below and fully detailed in Annex 16 of this Report.

A consideration of specific needs identified by case studies from the Argentine Republic, Bosnia and Herzegovina, the Federative Republic of Brazil, the Republic of Côte d'Ivoire, the Republic of Guinea, and Republic of Senegal, concerning the digital switchover process, is critical. Among those needs identified by this Report are the following:

- Connectivity and infrastructure development;
- Improvement of the territory coverage by DTT and the conclusion of the digital switchover process;
- Combinations of other technologies, such as direct to home (DTH) satellite offers, in addition to terrestrial broadcasting offers to cover territories;
- Integrated decoder options, including DTT, satellite and Internet service offers;
- Mobile television services (smartphones and tablets);
- An enabling environment to foster more content and diversity of programmes, including local and regional environments;
- Evolution of the digital television offer with new services and capabilities;
- Video-on-demand and catch-up TV offers;
- Enabling environments for the implementation and migration to technologies for broadcasting including, OTT, digital platforms, and video sharing platforms;
- Special attention, on the regulatory response to the new broadcasting landscape and the change of consumers habits;
- Improved communication and easier acquisition of free DTT;
- Inclusion of the most vulnerable populations;
- Capacity building needs;
- Funding needs.

### 3.1.3 Costs of implementation to relevant stakeholders

The costs involved in the implementation are a relevant aspect of the overall strategy to migrate to digital broadcasting. Following up on the costing data gathered in Final Report of ITU-D Question 2/1 for the 2017-2021 study period, available at https://www.itu.int/hub/publication/D-STG-SG01.02.2-2021/, it is worth mentioning any updates on costing data, especially that provided by developing countries.

One such case is that of Guinea[78], whose case study addressed the level of progress of the digital transition, from analogue to digital television, after a 15 year delay in the process. The intention of Guinea is to advance in the migration in order to harvest the benefits of new technologies, while at the same time, freeing up frequency bands that can be reused. The case study also highlights the willingness of the Government of Guinea to carry out the project that has been set up for this purpose, and identifies the shortcomings of the project, which covers only 15 sites of the country's 33 prefectures, with digital terrestrial television. Consequently, the proposal also includes satellite broadcasting for the densification of the DTT network provided for by the project.

Note that the total cost of the project was estimated at EUR 66 million, which will be financed to the limit of 85 per cent by external sources[79] based on a loan. The other 15 per cent will be supported by the Guinean Government through the countries' banking system.

**Level of implementation of the project**

In the implementation of the project, the following actions were taken:

a) The creation by presidential decree of a Monitoring and Coordination Committee for the digital migration process;

b) The signing of a commercial contract with a technical operator;

c) Site visit with the technical operator;

d) Evaluation of the offer sent by the partner.

### 3.1.4 Lessons learned from implementation of the process

#### Brazil

The experience of the first phase of implementation of the analogue switch-off (ASO) strategy was a success, as the analogue switch-off had no significant impact on the free-to-air terrestrial TV audience. This was of particular importance to Brazil, as the vast majority of the population relies on free-to-air television. Other consequences of the digital switchover include a positive impact on the national industry (STBs, TVs, receiving antennas, digital TV transmitters, transmission antennas, etc.) and a renewed public interest in free-to-air terrestrial television.

Other aspects that were important in the first phase of the ASO strategy in Brazil included:

- Importance of cooperation and collaboration amongst all the stakeholders, in the case of Brazil through a third-party that implemented the planned actions;
- Importance of consumer awareness and involvement for a smooth ASO implementation;
- A key contribution to the smooth digital switchover was the decision to provide DTV converter boxes in all TV sets sold in the retail market, in a gradual and phased manner;
- Another key decision was to provide the necessary equipment, including DTV converter boxes, antennas, etc., as needed, to low-income population free of charge;
- Involvement of local actors facilitated the digital switchover, and was a key finding that motivated some of the actions planned for the second phase.

[78] ITU-D Document https://www.itu.int/md/D22-SG01-C-0250/ from Guinea.
[79] Banque Publique d'Investissement de France (BPI France) and the General Directorate of the French Treasury.

### Bosnia and Herzegovina

- Even though policymakers were key for adopting the strategic framework and the strategic decisions, the role of the regulator proved to be crucial in overcoming challenges. In Bosnia and Herzegovina, the regulator acted as the initiator and a partner in almost all the activities of the process. The regulator decided to take actions to protect end users, stimulate industry, and accord with international agreements.
- Regardless of any delays in the transition to digital terrestrial television, the regulator can always act within its competencies to move forward and even lead the process.
- The importance of a regional context, especially in cases of frequency interference, is a significant factor in the success of the process. The regulatory authority must maintain good communication and collaboration with regional partners, to ensure that international agreements are fully implemented.
- Even though serious backlogs in the process, and delays compared with other European countries, threatened to endanger end user access and the industry, cable and IPTV sectors have since experienced significant growth, and citizens have not been deprived of services. The penetration of cable distribution amounts to 45 per cent of total TV subscribers, with IPTV amounting to 39 per cent, and DTH to 16 per cent of total subscribers. The availability of TV signal including programme diversity and media pluralism has always remained at a satisfactory level. It can be concluded then, that despite a delay, the process of introduction of digital terrestrial broadcasting in Bosnia and Herzegovina has been a success and is almost completed.

### Cameroon

The Cameroon process of migration from analogue to digital broadcasting currently faces several difficulties of a general nature:

- the problem of the division of responsibilities in the conduct of the migration process;
- the fact that the project is burdened by the need to take into account issues associated with radio production, TV production and radio broadcasting, as part of the rehabilitation of the public broadcaster 'CRTV';
- the repeated modifications that the project has undergone in response to a variety of demands; and
- funding difficulties.

## 3.2 Digital radio transition

### 3.2.1 Relevant issues and best practices, including the use of VHF band III for DAB or DTT

As is the case for a digital television transition, a digital radio broadcasting migration also involves planning and coordination. The case of Brazil provides an example of such a digital radio broadcasting migration. Discussions about the adoption of digital radio began in Brazil in 2007, and the National Telecommunications Agency (Anatel), the telecommunications regulator, and the Ministry of Communications (Mcom) started coordinated testing with the broadcast industry, of high definition (HD) radio and digital rights management (DRM) systems.

In Brazil, the general consensus was that the tests had to be directed to in band on channel (IBOC) systems, which use the same band as analogue systems. This was because the interested parties felt at the time that these were easier and cheaper to deploy (they could be activated with the same physical structure as analogue stations using adjacent channels). Additionally, it was the view of the Ministry of Communications and Brazilian Radio and TV Stations Association (ABERT)[80] that the systems were recommended to be deployed in both FM and AM and would have minimal financial impact on broadcasters.

Recently, discussions have been held to allocate spectrum that could allow simulcast transmissions on both digital and analogue radio systems. However, the deployment of digital radio in Brazil is still under discussion, because analogue radio is still very popular and consequently some initiatives to expand the usage of the FM band, which has a better service quality, were carried out. In Annex 17, the Brazilian experience is briefly introduced as a case study, including information on the migration of AM stations to the FM band, and the extension of the FM band to include more channels.

More information on digital radio transition and adoption is presented in Chapter 4, section 4.2.7, of the Final Report of ITU-D Question 2/1 for the 2017-2021 study period, available at https://www.itu.int/hub/publication/D-STG-SG01.02.2-2021/. Below some important references on the adoption of digital radio technologies are summarized.

#### 3.2.1.1 Digital radio technologies adoption

The adoption of digital radio technologies varies from country to country. Norway stands out as the sole country to have fully transitioned to digital audio broadcasting (DAB) technology in national radio broadcasting, discontinuing FM transmissions.

Other countries, such as Hungary, Portugal, Ireland, and Romania, have introduced DAB+, but after several years' experience, they ceased DAB broadcasting and shut down the receiver network.

Other nations maintain both analogue FM and digital DAB systems, with the two coexisting rather than replacing one another. Consequently, most countries operate DAB and FM concurrently, with some stations expanding their coverage areas across different networks.

Some countries have official DAB+ multiplexes, and there are 30 of them across the world, while in 28 countries, DAB+ exists as a pilot project.[81] Population coverage percentages of DAB+ signals in European Union countries are high, ranging from 42 per cent in France at the bottom of the European Union table, to Italy at 86 per cent, Germany at 98 per cent, the United Kingdom at 97 per cent, or Denmark at the top of the table with 99.9 per cent (data from WorldDAB).

The future of digital audio broadcasting (DAB) presents both opportunities and challenges, especially in the face of competition from other radio platforms and streaming services. As FM radio remains one of the last analogue technologies, its limitations are necessitating a shift to digital platforms. Younger audiences often view traditional radio as outdated, favouring alternatives such as YouTube, Spotify, and podcasts. However, fully transitioning to streaming services faces obstacles such as limited mobile network coverage, high data costs, and capacity issues. Policymakers should consider several factors for DAB implementation: its growing adoption due to superior sound quality and additional features, the influence of regulatory support and content diversity on user interest, and potential innovations such as interactive features and smart device integration. Despite competition, the strengths of DAB in broadcast

[80] ABERT – Associação Brasileira de Emissoras de Rádio e TV (Brazilian Radio and TV Stations Association).
[81] https://www.worlddab.org/countries

reliability, spectrum efficiency, and localized content can help it remain relevant. The future of DAB in developing countries will depend on economic development, technological advancements, regulatory support, and evolving user preferences.

In Annex 17 of this Report, more information is presented on the adoption DAB and DAB+ in Bosnia and Herzegovina, Norway, and Senegal.

### 3.2.1.2 Next generation radio and audio systems

In this section, some examples of evolutions in radio and audio broadcasting are presented. The intent of these new systems is to leverage the features of Internet applications into radio systems, including more robust and innovative content, and the usage artificial intelligence (AI) in production, multicast, and IP delivery.

The cases presented concern NextGen FM, a new term that refers to the future generation of FM broadcasting, which seeks to modernize and enhance the experience of traditional FM radio by incorporating advanced digital technologies.[82] Examples, that are briefly detailed below include, (i) HD radio evolution in the USA, (ii) visual radio and podcasting, and (iii) media over IP (MoIP) applications in Malaysia.

#### HD radio in the United States

Over the years, HD radio architecture has seen technical advancements that have stabilized signal multiplexing and delivery, improved bandwidth management and incorporated enhanced features. Most enhancements stem from a more robust end-to-end platform powered by an increasingly software-defined architecture.[83]

HD radio is a technology that allows radio stations to broadcast digitally in CD-like sound quality. It also enables stations to multicast additional channels on a single frequency. This means more options for listeners with HD-capable radios, and more options for stations to explore new and innovative content.

As an example, Minnesota Public Radio is now broadcasting all three of its services, MPR News, YourClassical MPR and The Current®, on HD radio in several communities throughout the state.[84] ITU conducted several studies on HD radio in 2020.[85]

#### Visual radio and podcasting in Malaysia

Visual radio enhances traditional audio broadcasts by adding visual elements, creating a more engaging experience for listeners. The national broadcaster station and many others have adapted a visual radio element into their content creation. Visual radio integrates visuals with audio broadcasts, providing a richer experience. This can include live video feeds of the radio studio, synchronized graphics, text, and interactive elements. A high quality camera and video system was installed in the radio studio with AI camera control capabilities to help to facilitate content creation. Visual radio content for the Malaysia national broadcaster station contributes content to news and sports channels with full HD video programmes and interaction between

82 https://www.gatesair.com/fr/solutions/hd-radio (in French)
83 Id ibid.
84 https://www.mpr.org/listen/hd-radio
85 https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-BS.2482-2020-PDF-E.pdf

radio and TV studios. High bandwidth network connections are required to provide the services with full HD video for digital video broadcasting – second generation terrestrial (DVBT-2) transmission through online and social media platforms.

Commercial channels and a number of community radio stations utilise the visual radio and podcast creation podcast program. The content is normally streamed via social media platforms and published in the cloud as podcasts. Visuals make radio broadcasting more engaging and can attract a wider audience. Listeners can interact with the broadcast through quizzes, polls, and social media. Visual radio can open new revenue streams through advertisements. Content regulatory elements and guidelines might need to be implemented to make sure this medium is not abused and used to cause discomfort to society and communities.

## Media over IP application in Malaysia

Media over IP (MoIP) technologies have been implemented for radio broadcasting upgrades in Malaysia. The national broadcaster and some commercial radio stations adopted AES-67 audio over IP (AoIP) technology for the audio network in their infrastructure to make signal management more efficient.

34 public radio broadcasting channels under the national broadcaster use a fixed IP network for station-to-station content contribution for news, centralized content, and inter-regional programming.

AoIP mobile codec uses 4G/5G mobile networks to send programmes back to the radio studio for outside broadcasting using low latency codecs such as Opus, HE-AAC, and APT-X via a mobile network provided by the telecommunication mobile operator. Network slicing technology via 5G will make the network more reliable and help to overcome network congestion issues via the telecommunication network during broadcasting events.

Studio to transmitter link (STL) utilizes IP technology with fixed networks to send a signal from the radio studio to the FM transmitter site using AoIP codec to send the signal long distance without compromising the quality of the audio. IP technology is used not only to contribute and distribute the signal, but also to monitor and control the broadcasting equipment that is installed remotely from the radio studio control room. FM transmitter equipment that is installed, can be controlled with remote access via mobile and fixed networks. Data collected from the remote site can be stored in cloud-based storage for future analysis and to assist in preventive maintenance work.

# Chapter 4 – Relevant issues and best practices on spectrum planning related to migration to digital broadcasting

## 4.1 National experience on solving spectrum planning and interference mitigation issues

The development of a State is inextricably intertwined with the development of the technology sector, with respect to digital broadcasting technologies. The problem with older broadcasting technologies is that they place limitations on airwave use and the number of channels, and restrict spectrum use, in addition to creating interference in adjacent frequency bands. The use of digital broadcasting provides a durable solution to these problems. Currently, digital broadcasting technologies are widely available, but many countries still remain that want to adopt digital broadcasting fully in order to enjoy all its benefits. People see such technologies as a resource to connect, inform and entertain themselves.

Challenges related to the optimal use of spectrum for broadcasting services, including spectrum planning and migration, and to the usage of the digital dividend, are considered in the following sections.

### 4.1.1 Spectrum planning and the migration to digital broadcasting

As pointed out by Cameroon[86], a new frequency plan has been adopted by the international community in the context of the Geneva-06 agreement[87], along with an agreement on the following migration deadlines: **17 June 2015** for the **470-862 MHz bands (bands IV/V)** and **17 June 2020** for the **174-230 MHz band (band III)**. Upon conclusion of the work, ITU recommended that ITU Member States set up structures for the elaboration of national strategies for the migration from analogue to digital broadcasting. The international deadlines mark the point at which analogue broadcasting services are no longer protected against digital broadcasting services.

The decision to migrate from analogue to digital is the result of several factors:

- advances in communication technology;
- strong demand for radio spectrum;
- the shift towards digital television, driven by its economic, social and cultural impact;
- specifically, for radio, digitization is happening at a slower pace in developing countries, due to a lack of digital radio receivers and the continued popularity of frequency

86 ITU-D Document https://www.itu.int/md/D22-SG01.RGQ-C-0014/ from Cameroon.
87 References: Final Acts of the Regional Radio Conference (RRC-06) (Geneva, 2006) (itu.int) and itu.int/en/ITU-R/terrestrial/workshops/SRME-19/Documents/Workshop/GE06-Agreement-and-etools.pdf#:~:text=GE06 Agreement%3A General Aspects Adopted by the Regional,in Geneva Entry into force%3A 17 June 2007

modulation (FM) technology, which provides a satisfactory listening experience at a modest cost to those equipped with FM radios.

An important case regarding the GE-06 agreement and the coordination of spectrum usage between neighbouring countries is the case of Bosnia and Herzegovina, that has accepted the agreement which stipulated the complete termination of analogue television and transition to digital terrestrial broadcasting by 17 June 2015[88].

In joint efforts of all relevant stakeholders, including the Government, Ministry and the regulator, Bosnia and Herzegovina adopted the main strategic documents and appointed the key institutions with defined responsibilities for the process. In line with its competencies, the regulator also set necessary preconditions by adopting the relevant sub-legislation and released the frequency bands for digital broadcasting. In total nine digital allotments were defined in each multiplex covering the entire territory of the country. Following the best practices in other countries, the first step was the digitalization of public broadcasting, which would have expanded to the commercial sector later in the process. However, due to the complex political circumstances in the country, the project has been lagging for years.

The first phase of the digitalization process regarding public broadcasting services was not completed. Because of the complexity of the structure of the national public broadcasting services, the problem occurred when the public broadcasters failed to establish a joint legal entity to manage the public broadcasting multiplex. Because of the resulting delay, the country faced problems with neighbouring countries that had completed their digitalization process and advanced in the usage of released frequency spectrum (digital dividend) for 5G roll-out. The neighbouring administrations sent requests to Bosnia and Herzegovina to turn off the analogue signal in the border areas due to interference.

Nevertheless, the regulator decided to take actions in line with its competencies and to proceed with allocating multiplex for commercial broadcasting. A new public call was announced, and the commercial sector expressed great interest in joining the multiplex. As a result, commercial multiplex is now fully operational covering 50 to 80 per cent of the territory of the country, and providing services to 20 TV stations that entered the multiplex and that are now broadcasting via the digital terrestrial signal, most of them with national coverage. Recently, a regional call for digital broadcasting was announced and TV stations have expressed interest. Regarding the multiplex for a public broadcasting service, the process is still ongoing.

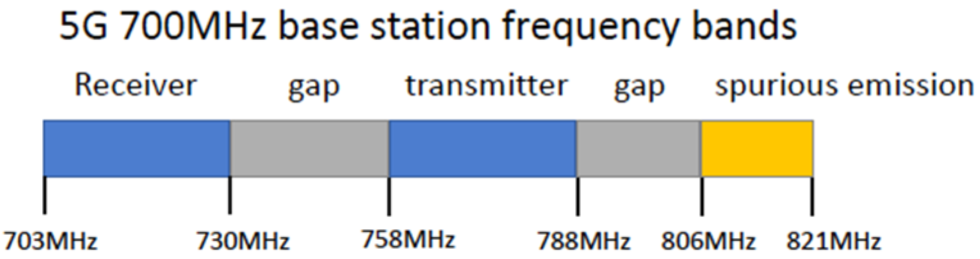
Another relevant case to highlight is the adjustment of the frequency spectrum of broadcasting services in China[89]. The following re-farming initiatives were carried out in that country:

- 702-798 MHz frequency band was removed from broadcasting service and assigned to 5G mobile communication.
- 703-743/758 798 MHz frequency bands are used by frequency division duplexing (FDD) mobile communication system.
- The television channels previously in the 702-798 MHz frequency band were migrated to lower frequency bands.
- Some of the lower frequency bands used after migration for television channels include 187 MHz, 482 MHz, 554 MHz, 634 MHz, and 690 MHz.

[88] ITU-D Document https://www.itu.int/md/D22-SG01.RGQ-C-0214/ from Bosnia and Herzegovina.
[89] ITU-D Document https://www.itu.int/md/D22-SG01.RGQ-C-0229/ from China Institute of Communications.

Figure 10 illustrates how the 700 MHz digital dividend frequency band is being used for 5G services in China.

Figure 10: Base station frequency bands in the digital dividend used for 5G services in China




As shown in the table below, some implementations of combined 5G transmissions in both 700 MHz and 4.9GHz bands are available in base stations, mainly to benefit from the coverage differences in specific bands.

Table 4.1: Coverage differences in specific bands

| Radius of coverage (single base station)/km by frequency band | Urban area | Countryside |
|---|---|---|
| 700 MHz | 1.34 | 4.66 |
| 2.6 GHz | 0.82 | 2.03 |
| 3.5 GHz | 0.72 | 1.85 |
| 4.9 GHz | 0.61 | 1.55 |

In another noteworthy case Argentina[90] aimed at enhancing the efficient use of spectrum resources, an essential factor in achieving sovereign policy objectives (additional information can be found in Annex 18). The policy adopted by the State in the administration and management of the radio frequency spectrum, not only defines the provision of telecommunications services, but also impacts companies that develop services and solutions relying on this resource, even if they are not necessarily licensed for information and communication technology (ICT) services. The future of innovation in production processes is tied to the advancement and promotion of high-capacity wireless network deployment, a key element in boosting the productive matrix of the nation.

### 4.1.2 National experiences on interference mitigation

The aim of this section, comprising national experiences use cases, is to illustrate strategies used by some countries to address the mitigation of interference in the usage of the digital dividend frequency bands.

90 ITU-D Document https://www.itu.int/md/D22-SG01-C-0184/ from Argentina.

## Brazil

One example of policies implemented to mitigate interference comes from Brazil[91]. This case highlights the satellite broadcasting policy adopted to extend the coverage of television broadcasting to remote and rural areas, as well as to suburban areas, that were without optimal digital terrestrial television coverage. The initiative was also targeted at overcoming a problem of interference experienced by satellite broadcasting services in the C band using the 3.5 GHz band, as this same 3.5 GHz band is also used by the 5G networks of neighbouring countries/stations.

The solution that was found was to migrate existing satellite broadcasting technologies in the C-band, to another frequency band, the Ku-band. This migration has led to the need to provide appropriate digital receivers to low-income populations but has also promoted the extension of digital satellite broadcasting coverage in these areas.

In addition to the main objective of avoiding interferences to satellite broadcasting services, other specific objectives were, to allow the use of 5G in the 3.5 GHz frequency band, and to facilitate the migration of existing analogue satellite services to a digital broadcasting service, free from interference.

More information can be found in Annexes 15 and 18 of this Report.

## Bosnia and Herzegovina

In Bosnia and Herzegovina[92], the transition from analogue to digital broadcasting services began in 2006 with the aim of complying with the Geneva Agreement GE-06, wherein each country is required to comply with ratified international agreements and take immediate steps to eliminate interference from television channels that no longer have the right to broadcast analogue signals.

Bosnia and Herzegovina defined 17 June 2015 as the end of the transition period, and also aimed to benefit from an efficient use of the frequency range and to offer citizens a better quality of television broadcasting with advanced services.

Unfortunately, the project was delayed, and this delay led to interferences from the systems of neighbouring countries that had completed their digitization process and advanced in the introduction of new technologies, especially for the 5G deployment. Croatia filed a complaint against Bosnia and Herzegovina in April 2021, regarding interference in the 700 MHz frequency range (attributed to 5G technology) coming from analogue broadcasting in Bosnia and Herzegovina.

Annex 18 provides details of the strategies implemented to cope with the complaint from Croatia against Bosnia and Herzegovina, and to eliminate interference from television channels in mobile communications. It can be noted that, following implementation of several measures, the programming of 26 television stations, the subject of the complaint from Croatia, were also included in the offer of almost all the cable operators in Bosnia and Herzegovina, with coverage of up to 90% of all households in the country. This facilitated the analogue switch-off, and mitigated the interference caused by those channels, which were reallocated.

91 ITU-D Document https://www.itu.int/md/D22-SG01-C-0143/ from Brazil.
92 ITU-D Document https://www.itu.int/md/D22-SG01-C-0201/ from Bosnia and Herzegovina.

Bosnia and Herzegovina were able to react quickly by implementing several actions, including the granting of multiplexes for commercial broadcasting. As a result, there are now two fully operational multiplex operators in Bosnia and Herzegovina: MUX A for public broadcasting and MUX D for commercial broadcasting.

In its proceedings, the regulator for Bosnia and Herzegovina informed the competent institutions and licensees of the complaint received from Croatia. In this regard, meetings were held with representatives of broadcasters, during which a schedule for the shutdown of the analogue signal was set, from 01 July to 31 December 2021. It should be noted that 171 transmitters from 26 television stations throughout the country were affected by the shutdown of analogue broadcasting.

### Senegal, Gambia, Guinea, Guinea-Bissau, Mali, Mauritania, and Cabo Verde

Interference is a major problem for radiocommunications because it interferes with signal transmission. The broadcasting services in the VHF/UHF bands, which are a significant user of the radio spectrum in the West Africa region, are increasingly confronted with interference issues arising from the rapid technological evolution which has created an increasing demand for spectrum in these bands.

The proliferation of broadcasting stations has increased the interference, not only between the broadcasting stations themselves, but also with other radiocommunication services.

In addition, the end of simulcast (transmissions on both digital and analogue radiocommunication systems) has not yet come into effect in all West African countries. This could lead to interference between neighbouring countries. Indeed, some countries have already deployed 4G mobile networks in some digital dividend frequency bands, while analogue TV continues to operate in others.

### West Africa subregional approach to mitigating interference

With a view to interference prevention and management, Republic of Senegal, Republic of the Gambia, Republic of Guinea, Republic of Guinea-Bissau, Republic of Mali, Islamic Republic of Mauritania, and Republic of Cabo Verde, adopted in August 2009, a Coordination Framework agreement for coordination and sharing of frequencies at border zones with the participation of 21 telecommunication operators.

The main objectives of this agreement are to:

- harmonize the use of frequencies in neighbouring countries;
- guard against harmful interference in border zones;
- propose provisions for frequency sharing and coordination in specific frequency bands.

Note: The border zone/coordination zone is the area adjacent to the border of two countries, 15 km deep inside each country.

This agreement has been updated on several occasions, between 2013 and 2020.

The legal and regulatory framework of the Coordination Framework document refers to Article 6 of the RR "Special agreements". The agreement is composed of five general provisions and seven technical annexes.

In practice, the coordination procedure is based exclusively on the principle of equitable access to frequency resources. In addition to the overall framework provided by the coordination document, bilateral agreements were signed with bordering countries providing details on trunking channels and emission thresholds.

Channels have since been defined and allocated to countries in the different border areas, and this new plan is being implemented by the national operators.

Monitoring missions are carried out annually, and in response to complaints. These monitoring missions provide an opportunity to verify compliance with the allocated channels, as well as compliance with the set emission thresholds. For example, Senegal and Mauritania regularly carry out joint monitoring missions to verify the effectiveness of the bilateral agreement and to take corrective measures if necessary.

There are many interference issues in border areas, especially for mobile communication services. The framework document and the bilateral agreements focus, at this stage, mainly on mobile communication services rather than broadcasting, as the development of DTT in the countries of the West Africa subregion is not yet sufficiently advanced.

However, this established framework may contribute to the resolution and prevention of future interference conflicts related to the widespread deployment of DTT at different rates. More detailed information is presented in Annex 18 of this Report.

## 4.2 Digital dividend usage updates based on current national experiences

The usage of the digital dividend is a key objective in the implementation of the migration to digital broadcasting, as it allows the usage of the same amount of spectrum to provide more services, including mobile and broadcast services.

This section aims at compiling best practices on the strategies for usage of the digital dividend frequency bands, based on national experiences and at complementing the information provided in the Final Reports of the ITU-D Question 2/1 for the previous study periods.

A new context is added with the processing of the digital dividend frequency band 1 and band 2 in regions such as Europe, and its implications on planning and reallocation of stations, among other aspects. The following section addresses those considerations.

### 4.2.1 Processing of digital dividend band 1 and band 2

#### Italy case study

The first case detailed is that of Italy[93]. The approach of Italy to the release of the 700 MHz frequency band and the reorganization of digital terrestrial television (DTT) followed coordinated European-level discussions and strategic national planning. A key component of the transition involved mitigating interference with neighbouring countries and refarming frequency bands to accommodate channels previously using the 700 MHz band.

[93] ITU-D Question 2/1 Focus Session April2-24, AGCOM, Italy https://www.itu.int/dms_pub/itu-d/oth/07/31/D07310000010005PDFE.pdf.

To facilitate the reallocation, several technical measures were implemented:

- Exclusive use of coordinated frequencies assigned to Italy.
- Extensive deployment of single frequency networks (SFN).
- Adoption of efficient coding techniques, including high efficiency video coding (HEVC).
- Reassignment of nationwide and local/regional multiplexes.

The regulatory framework played a crucial role, with Decision no. 129/19/CONS mandating the progressive migration of national and local DTT operators to sub-700 MHz frequencies. Specific policies included:

- Differentiated approaches for national and local operators, with market exit mechanisms for local broadcasters.
- Cost-refunding mechanisms to support the transition from DVB-T to DVB-T2.
- Compensation for local operators withdrawing spectrum usage rights.
- Conversion of DVB-T spectrum rights into DVB-T2 transmission capacity.

A competitive procedure was later introduced for auctioning additional spectrum made available by reallocating local broadcasting capacity (Decision no. 564/20/CONS).

### Key lessons learned

- The reorganization had a significant effect on the broadcasting sector, requiring substantial investments from both operators and the state.
- Due to high DTT penetration in Italy, a large number of households required migration support.
- DVB-T2 spectrum rights were assigned in 2019 for a ten-year period, with full migration to DVB-T2 expected from 2024.
- In the transitional period, reduced national and local networks (from 20 to 12) are operating in DVB-T, resulting in a shortage of transmission capacity.
- Increasing demand for high-quality video services (HD/UHD) has further constrained available bandwidth.
- The shift from a vertically integrated to a horizontal entry model in local broadcasting is still being assessed.
- Despite ongoing technological transitions, DTT remains the primary TV distribution platform in Italy.

This case study highlights the importance of coordinated planning, regulatory frameworks, and financial support mechanisms in managing frequency reallocation and ensuring minimal disruption to broadcasting services. Detailed information on the Italian case study can be found in Annex 19 of this Report.

### Brazil case study

In 2013, Brazil approved the allocation of the 700 MHz band to fixed and mobile services to provide voice and data communications[94].

[94] Anatel Resolution no. 757, November 8, 2022. Available at: https://informacoes.anatel.gov.br/legislacao/resolucoes/2022/1760-resolucao-757.

An auction established three national bands of 10 + 10 MHz and another band of the same size for certain regions. For the second round of the auction, the remaining spectrum needed to be sold in smaller chunks of 5 + 5 MHz.

Currently, the 700 MHz band is completely freed-up and ready to be used by mobile services all over Brazil. More information can be found in Annex 19 of this Report.

### South Africa case study

Finally, the case of South Africa, a country that continues to experience growing demand for spectrum due to the significant increase in broadband traffic. The shortage of radio frequency spectrum allocated for international mobile telecommunications (IMT) imposes constraints and challenges on the provision of broadband services.

To address bandwidth deficiency in South Africa, the regulatory authority proposed the simultaneous licensing of the IMT700, IMT800, IMT2600 and IMT3500 spectrum bands, as these bands have been identified worldwide for IMT services. These bands complement each other in the sense that they fulfil the requirements for capacity and coverage which make them suitable for rural and urban areas, and for bridging the digital divide, and the disparities between urban and rural access to broadband networks.

The regulatory authority successfully concluded the licensing of the high-demand radio frequency spectrum auction on 17 March 2022[95], including the digital dividend frequency bands.

[95] The auction for IMT bands in South Africa involved six qualified bidders, i.e. Cell C, Liquid Intelligent Technologies, MTN, Rain Networks, Telkom and Vodacom. The revenue collected from this auction totals more than R14.4 billion, which has gone to the national public treasury. Nonetheless, the allocation of the high-demand spectrum will speed up the roll-out of new technologies, such as fifth generation (5G) technology, reduce the cost of mobile data and ensure greater Internet connectivity.

# Chapter 5 – Conclusions and lessons learned from national experiences

After analysing different cases and experiences on aspects of the strategies, policies, regulations and methods of migration to, and adoption of, digital technologies for broadcasting, and for the provision of new services for various environments, it is now time to assess some of the lessons learned and to establish recommendations and guidelines, that may serve as useful references, for current and future implementations of traditional and innovative broadcasting services and applications.

This chapter aims to provide conclusions and lessons learned from national experiences shared through contributions to this Final Report. It also compiles best practices related to strategies, policies, regulations, and methods for migrating to, and adopting, digital broadcasting technologies, including the provision of new services in various environments. Additionally, it recommends specific topics for ITU Member States to consider in the planning, regulation, deployment, and implementation of digital broadcasting technologies.

## 5.1 Lessons learned from national experiences and case studies

This section compiles identified lessons learned and considers best practices related to the topics of this Final Report. To that end, it examines areas such as next-generation broadcasting systems, new and emerging technologies and applications for broadcasting, the adoption of digital technologies, particularly for television and radio, and the use of spectrum.

Firstly, in the context of next generation broadcasting systems and the future of broadcasting in general, some new functionalities and innovations need to be considered for future proof broadcasting solutions and services, as emphasized by the ITU-R Report BT.2522-0[96] – "A framework for the future of broadcasting". Having said that, the referred report indicated the following concepts to be considered:

- the concept that user expectations are driving changes in areas of:
  - how media is created, delivered and consumed;
  - services and personalized options accessible on any device, at any location, at any time;
  - desire for communal and shared media consumption;
  - increasingly immersive content presented according to personal preferences.
- the concept that broadcasters must meet future user demands and compete using technologies that assist and automate creation and exchange, accelerating the shift to cloud based virtual production; and
- the concept that media is delivered as a combination of platforms and end user devices, with the implication that:
  - flexible production technologies and common standards are vital;

[96] https://www.itu.int/pub/R-REP-BT.2522

- terrestrial broadcasting remains essential and must keep evolving, distributing new media production formats and enabling new user experiences;
- terrestrial broadcasting can be combined with Internet delivery to offer effective and efficient solutions.

The concept that user experience with content delivery platforms, and their impact on the broadcasting industry, as well as the adaptation of broadcasters' service offerings, (not only due to competing technologies but also through collaboration between the broadcasting and broadband environments), is key to the future of broadcasting and to evolving ways of consuming content through these services. Regarding the new user experiences, some important considerations should also be taken into account, including:

- the vital role of multimedia applications in broadcasting services;
- the importance of leveraging of innovations from other content distribution platforms in broadcasting TV applications; and
- the demand for personalized TV experiences, targeted advertising and programming, content recommendations, seamless over-the-air (OTA) to/from over-the-top (OTT) switching, immersive content provision, enhanced accessibility, sensory effects rendering, and novel interaction modalities, among others.

Other important aspects to be considered in the new broadcasting environment are the regulatory implications of other media services, especially those provided through the Internet. The following aspects can be highlighted:

- monitoring of the audiovisual distribution market in line with national regulations is relevant;
- regulations contribute to an enabling environment for the evolving digital landscape and its relationship with broadcasting services;
- ensuring, as much as possible, fair competition, and the protection of user interests in an increasingly online-oriented media ecosystem, is key for all the stakeholders, including the broadcasting industry;
- a regulatory framework that establishes clear rules, for example, on transparency requirements, ensuring that broadcasting services operate responsibly in the digital sphere, in line with the national regulatory framework, is important;
- compliance with an encompassing regulatory framework, that upholds the integrity and longevity of broadcasting services in the ever-changing digital realm, is fundamental.

Furthermore, in this compilation of best practices and lessons learned, the transition from analogue to digital broadcasting is also considered. It is worth highlighting that the transition to, and the adoption of, digital technologies in broadcasting, begins with the migration from analogue to digital, and so opening to a multitude of new services, functionalities, and capabilities. Therefore, concluding the migration process is crucial for many countries that are still undergoing the digital switchover. Additionally, it is important to recollect the lessons learned and best practices in that regard, which include the following:

- Elaborate a strategy to migrate from analogue to digital broadcasting, involving all the activities in the digital switchover and analogue switch-off, and implement said strategy in a collaborative and collective way, including through the establishment of a steering committee that is open to all stakeholders;
- An established policy and regulatory frameworks are critical to formalize the digital switchover strategy, and to provide guidance to the whole process, including for spectrum planning and the usage of the digital dividend;

- Establishing methods of migration to digital broadcasting, including on how the analogue and digital services will co-exist, and how the analogue service will be phased out (analogue switch-off), is critical for an effective and efficient implementation;
- Considering technical, content-related, human resources, and consumer aspects in the implementation is fundamental;
- Coordination amongst the stakeholders is critical for the implementation process;
- Considering ways to include low-income and more vulnerable elements of the population, for example, in the availability of receivers, and in the communication strategies employed, is fundamental for successful implementation;
- Considering the specific needs of each country concerning the digital switchover process is critical. Among such specific needs identified by this Report, are the following:
  - Connectivity and infrastructure development in the country;
  - Improvement of the territory coverage by DTT and the conclusion of the digital switchover process;
  - Combinations of other technologies, such as direct to home (DTH) satellite offers, in addition to terrestrial broadcasting to cover the territory;
  - Integrated decoder options, including DTT, satellite and Internet service offers;
  - Mobile television services (smartphones and tablets);
  - An enabling environment to foster more content and diversity of programmes, including local and regional programmes;
  - Evolution of the digital television offer with new services and capabilities;
  - Video on demand (VoD) and catch-up TV offers;
  - Enabling environments for the implementation and migration to technologies for broadcasting including over-the-top (OTT), digital platforms, and video sharing platforms;
  - Special attention should be given to the regulatory response to the new broadcasting landscape and the changes in consumers habits;
  - Improved communication and easier acquisition of free DTT;
  - Inclusion of the most vulnerable populations;
  - Capacity building needs;
  - Funding needs.

In relation to the analogue switch-off (ASO), the following lessons learned were also identified:

- The importance of cooperation and collaboration amongst all the stakeholders;
- The importance of consumer awareness and involvement for a smooth ASO implementation;
- For a smooth digital switchover, consider embarking DTV converter boxes in all TV sets sold in the retail market, in a gradual and phased manner;
- Provide the necessary equipment, including DTV converter boxes, antennas, etc., as needed, to low-income population, free of charge;
- The involvement of local actors to facilitate the digital switchover.

Finally, it is important to consider the lessons learned in terms of spectrum planning and the usage of the digital dividend frequency bands, where the following aspects were identified:

- The importance of negotiations on frequency allocation plans in the international sphere, for example the GE-06 Agreement;
- Considering spectrum planning issues related to the digital switchover process is critical;
- Evaluating ways to mitigate interference from other services using the freed-up bands with the analogue switch-off remains critically relevant;
- Addressing the needs for the allocation of frequency bands to broadband services, notwithstanding the needs of broadcasting services, is also critical.

## 5.2 Conclusions and guidelines

Building on the lessons learned and best practices from the experiences and case studies shared by contributors in the previous section, guidelines are presented in this section for stakeholders involved in adopting digital technologies within the broadcasting sector.

As an initial reflection, it is important to acknowledge that the context in which broadcasting services operate has changed dramatically in recent years, and the need for their adaptation and evolution is clear. This understanding is shared by stakeholders across the broadcasting industry, including manufacturers, service providers, and regulators.

It is also evident that the adoption of digital technologies varies across regions, such as in some parts of the Americas, Africa, and Asia and the Pacific, as these areas face specific challenges, including limited infrastructure and a lack of funding.

Furthermore, it is worth considering, in future work, the discussion of adopting next-generation broadcasting systems (ATSC 3.0, 5G Broadcast, DVB-NIP, ISDB-T), with an emphasis on standardization to facilitate a more efficient transition to these systems. In the same vein, it can be noted that developing countries face specific challenges, including costs and regulation, in harnessing the benefits for consumers, such as interactivity and content personalization.

To conclude, an analysis of emerging innovations, such as content tailored to personal preferences and the use of artificial intelligence, could enhance the Report in the next study period and offer valuable insights into the development of digital broadcasting.

Bearing that in mind, the following guidelines are suggested to be considered by stakeholders in the evolution of broadcasting services:

- Stakeholders (governments, regulators, industry, service providers and consumers/viewers) collectively make all the necessary efforts to conclude the transition to, and adoption of, digital technologies in television and radio services, and switch-off analogue broadcasting;
- In the transition to, and adoption of, digital technologies for broadcasting, a strategy and roadmap should be formally established and its activities should be carried out on the basis of cooperation and collaboration amongst all the stakeholders;
- Spectrum planning, including the usage of the digital dividend, should be carefully carried out following best practices and international guidelines and standards;
- The audiovisual content distribution and consumption ecosystem is considered as a whole, as there may be interaction amongst several technologies (broadcast and broadband

included) that are relevant to policymakers in creating an enabling environment for the provision of broadcasting services that meet consumers'/viewers' needs;

- Subject to the sovereignty of each member state, the regulatory and legal frameworks address new challenges and opportunities of digital broadcasting services, and contribute to a better user experience;
- Any regulatory and legal discussion regarding audiovisual content distribution, including broadcasting, is carried out with full participation of all stakeholders in an open and participative regulatory and rulemaking process.

# Annex 1 – Main features of next generation broadcast systems

**ATSC 3.0**[97]: A next generation terrestrial broadcast system that is designed to improve the television viewing experience with higher audio and video quality, improved compression efficiency, robust transmission for reception on both fixed and mobile devices, and more accessibility, personalization and interactivity. The ATSC 3.0 standard is defined in a suite of more than 20 standards and companion recommended practices. Key features of ATSC 3.0 include:

- Built on the same Internet protocol backbone as today's popular streaming media platforms;
- Designed to bring together over-the-air (OTA) with over-the-top (OTT) content;
- Delivers better video quality and immersive audio to viewers;
- Provides the capability of 'advanced emergency alerting and informing';
- Easily adaptable for future technologies.

**5G Broadcast**[98]: A terrestrial broadcast standard completed in 2020 as part of the 3GPP Release 16 specifications, that enhanced features of the initial enhanced TV (enTV) standard of 3GPP Release 14. 5G Broadcast has been endorsed as a standalone terrestrial broadcast system, with all the characteristics of a broadcast technology, via the ETSI TS103 720 technical specification, and most recently by ITU-R where it is defined as a worldwide standard within the ultra-high frequency (UHF) band. Key features of 5G Broadcast include:

- Efficient free-to-air or zero-rated media content delivery;
- Robust emergency notification for public safety;
- Enhanced venue casting at sporting events and concerts;
- Standalone terrestrial broadcast system based on IP over 5G infrastructure.

**DVB-NIP**[99]: An end-to-end native IP broadcast system for digital video broadcast (DVB) bearers. It relies as much as possible on existing DVB specifications, and complements those where necessary. The native IP broadcast system is built upon DVB-I for service discovery and programme metadata, DVB-AVC and DVB-DASH for source coding and stream formatting and DVB-MABR, DVB-GSE and the physical layer specifications DVB-S2X, DVB-S2 and DVB-T2 for transport. DVB-NIP facilitates the integration of over-the-top (OTT) and broadcast technologies into an IP media distribution solution.

**Advanced ISDB-T**[100]: The next iteration of integrated services digital broadcasting - terrestrial (ISDB-T), Advanced ISDB-T will enable an offering beyond the existing audio, video and

97 https://www.atsc.org/nextgen-tv/
98 https://www.qualcomm.com/news/onq/2023/12/5g-broadcast-what-can-consumers-expect
99 https://dvb.org/?standard=native-ip-broadcasting
100 https://www.dibeg.org/advanced/

multimedia services, and will enable provision of UltraHD based service on both broadcast and integrated broadcast-broadband (IBB) systems. Key features include:

- Capability of varied and flexible service provisioning with high efficiency;
- Emergency warning notification;
- Interactive UltraHD streaming;
- IP and HTML5 application environment;
- Over-the-air 2×2 multi-input multi-output (MIMO) transmission.

# Annex 2 – Application-oriented television paradigm

The TV 3.0 project in Brazil[101] is actively engaged in meticulous research and specification of the application-oriented television paradigm. Employing a rigorous scientific methodology, the investigation extends beyond the exploration of state-of-the-art approaches to encompass the prototyping of each component within the application-oriented TV architecture. These prototypes undergo thorough assessments for viability and performance. Furthermore, they are subjected to evaluations by focal groups, providing valuable insights and opinions on the novel experiences introduced. This iterative process allows researchers to refine concepts, and even to replace certain lines of thinking with new ones.

Application-oriented television represents a paradigm shift, where the entry point for TV content consumption moves from selecting a broadcaster's channel to selecting a broadcaster's application. This means that from the beginning of a TV viewer's journey, an application can proactively manage viewer profiles (with their consent), which is essential for delivering personalized and engaging TV experiences that broadcasters can leverage. While this new paradigm offers numerous advantages, it also raises concerns about potentially compromising some of the existing fair, convenient, and well-established broadcasting experiences.

The application-oriented television paradigm requires several basic functionalities. These include adaptations to channel scanning to address performance issues, the instantiation and installation of broadcasters' applications, and the management of application metadata. A dedicated user interface is needed for listing installed broadcasters' applications, and these applications must be able to handle all OTA/OTT multimedia content. There should be support for quick application switching, allowing broadcasters to use sequences of small applications instead of a single complex one. Additionally, the paradigm necessitates TV content metadata, new possibilities for the electronic programme guide (EPG) in OTA/OTT, and the introduction of an electronic content guide (ECG).

Based on the Brazilian experience, it is proposed that the concept needs to consider a general architecture for application-oriented television in a technology-agnostic way, including some relevant architecture components, that may include:

- Persistent media player: Media player that needs to ensure continuous presentation of selected content during application switches, with the player's lifecycle not tied to a specific application, allowing applications to freely modify the player state and its media source;
- Broadcaster's bootstrap application: Application that is automatically instantiated and installed for each identified service (entry point for a specific TV service, and launching when the viewer selects the corresponding icon on the application catalogue user interface);
- Legacy broadcasting system support;

[101] https://www.itu.int/md/D22-SG01.RGQ-C-0239/en

- Broadcaster's additional applications: Other applications to provide next-generation TV experiences, such as access to personalized experiences based on recommendations, dynamic programming, targeted advertisements, and so on;
- Viewer profiles: From the application catalogue user interface, viewers could create their profiles once on a specific device, with the flexibility to use this profile across multiple broadcasters at their discretion;
- Application catalogue: Dedicated TV-exclusive section within a device, designed to display all bootstrap applications installed following a scan or rescan process. Additionally, it offers access to other broadcasters' applications and modules such as the EPG and the ECG;
- EPG module: The electronic programme guide (EPG) is a familiar user interface found in existing broadcasting systems, presenting programming in a timeline format;
- ECG module: The electronic content guide (ECG) is a recognizable user interface commonly seen in current IPTV services, used to display a content catalogue available in video-on-demand (VoD) services, and characterized by its non-linear nature.

# Annex 3 – Disaster alerting information in Republic of Korea

The Ministry of science and ICT of the Republic of Korea operates a nationwide emergency disaster alerting system. This system aggregates all disaster information and sends it to the broadcaster with CAP format* and the broadcaster will automatically show the text in subtitles.

*CAP example:<identifier>KR.T7-20230416</Identifier><sender>mmdip@mictr</..><event>Flooding </..>..

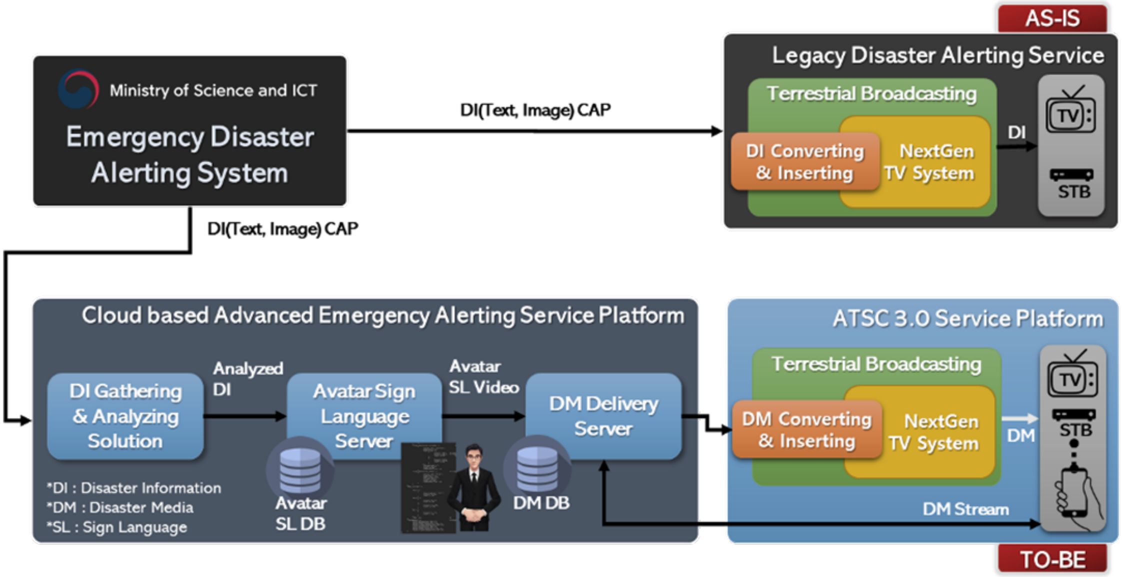
Figure A.3.1: Accessible disaster alerting system with avatar sign language


As captions (text only information) are not fully accessible by deaf people, the Republic of Korea consortium is developing a new system based on the latest terrestrial standard specification of ATSC 3.0 where IP communication for avatar signing is possible.

The project also covers pay TV set-top-boxes and smart phones so that deaf citizens can always have accessibility to any disaster information.

Figure A.3.1 shows the current system where the text and image are directly delivered by terrestrial and push streams to STBs and televisions. Figure A.3.2 shows the new system where the disaster information (DI) is converted to disaster media (DM) formats including avatar signing, and transmitted with a terrestrial signal. The disaster media stream can be directly streamed to mobile phones with a text message and link.

## Figure A.3.2: Accessible disaster alerting system




The system is now under development, not only for the Republic of Korea public broadcaster, but also for some public broadcasters in the United States, where the same terrestrial specification is deployed. The pilot broadcasting was scheduled for the end of 2023 on Jeju Island in the Republic of Korea, with nationwide deployment in 2025.

As the latest European Union digital terrestrial standard specification also includes IP communication, the system can be implemented in more countries.

# Annex 4 – Overall scope and general conclusions of Report ITU-R BT.2522-0 – A framework for the future of broadcasting

The objective of the framework for the future of broadcasting is to evaluate the changing landscape of media and audience expectation, evaluating the potential of mergers of medias, such as gaming, social media, traditional media, etc., and the rapid and accelerating media technology development competition.

The Report delves into the following aspects:

- User experience trends, broken down into seven key trends: collective; personalized; ubiquitous media consumption; digital assistant; accessible; immersive; and merging physical and digital worlds.
- Production challenges, broken down into eight key trends: software based; virtualized; cloud based; complex media; data driven; automation through AI/ML; immersive and accessible; and sustainable broadcast delivery.
- Opportunities and challenges to realizing user and production trends through a combination of terrestrial broadcasting and Internet delivery.

The conclusions of the Report include:

- The notion that user expectations are driving changes in:
  - how media is created, delivered and consumed;
  - services and personalized options accessible on any device, at any location, at any time;
  - desire for communal and shared media consumption;
  - increasingly immersive content presented according to personal preferences.
- The notion that broadcasters must meet future user demands and compete using technologies that assist and automate creation and exchange, accelerating the shift to cloud based virtual production.
- The notion of media delivery as a combination of platforms and end user devices, wherein:
  - flexible production technologies and common standards are vital;
  - terrestrial broadcasting remains essential and must keep evolving, distributing new media production formats, and enabling new user experiences;
  - terrestrial broadcasting combined with Internet delivery offers effective and efficient solutions.

# Annex 5 – Architecture, frequencies, and features of selected releases of 5G broadcasting

This annex presents additional information regarding the architecture, assigned frequencies, and main features of selected releases of 5G Broadcast, as specified by the 3GPP consortium, as well as, a more detailed description of use cases.

Release 16 5G Broadcast technology can provide an independent broadcasting service, which does not rely on a mobile communication network. It is similar to conventional terrestrial digital television broadcasting services. R16 5G Broadcast technology can be used for high-power large-tower transmission, supports single-frequency networks, and achieves large-scale continuous coverage of radio and television. The architecture of R16 5G Broadcast technology and the frequency bands, are shown in Figure A.5.1.

Release 17 5G new radio (NR) multicast and broadcasting technology supports point-to-multipoint, multicast and broadcast functions by extending the functions of the 5G core network and wireless network. In essence, this technology adds two multicast and broadcast communication modes to the mobile communication network. Consequently, the mobile communication network has more transmission modes to choose from in a one-to-many transmission of 'common data' scenario, and so can aggregate traffic and improve efficiency. Common data is not limited to video content, but can also be data in application scenarios, such as data in Internet of vehicles (IoV) and Internet of things (IoT) scenarios.

Essentially, R16 5G Broadcast, is a one-way broadcast technology, which supports high-power tower deployment and a large-scale single-frequency network. It can be used to form a radio and television network independent of the mobile communication network, and can form a 5G radio and television network by transforming the exciter, and multiplexing most of the radio and television station resources. 5G radio and television technology could be considered as essentially a new generation of terrestrial digital television technology, which is suitable for the deployment of radio and television operators in the radio and television industry. R17 5G NR multicast broadcasting is a functional extension of the 5G mobile communication network, which can realize a multicast broadcast communication mode. It can dynamically configure to provide a multicast broadcasting service when needed, or to release resources to provide mobile communication and mobile Internet services, when multicast broadcasting service is not needed. This flexibility facilitates mobile operators to provide regional and temporary multicast broadcasting services.

### Figure A.5.1: Architectures of R16 5G Broadcast technology and R17 5G NR (New Radio) multicast broadcasting technology. (a) R16 5G Broadcast technology (b) R17 5G NR (New Radio) multicast broadcasting technology


(a) (b)

### Table A.5.1: Frequency bands of R16 5G Broadcast technology

| R16 5G Broadcast bands | Uplink | Downlink | Duplex type |
|---|---|---|---|
| **B107** | N/A | 612~652 MHz | Standalone Downlink Only |
| **B108** | N/A | 470~698 MHz | Standalone Downlink Only |

### Table A.5.2: Features of R16 5G Broadcast technology

| Classification | Features |
|---|---|
| **Frequency band** | Support for the standalone downlink only (SDO) frequency band types. |
| | Support for B107 and B108 bands on the UHF broadcast television bands. |
| **Channel resource** | Support for 6 MHz/7 MHz/8 MHz channel bandwidth. |
| | Almost 100% of the resources are available for broadcast service hosting. |
| **Network access** | Free to acceptance (FTA), no SIM card required, no mobile carrier contract required. |
| | Receive only mode (ROM), suitable for terminals other than mobile phones, such as televisions. |
| **Mobility** | Up to 250 km/h (theoretical). |
| **Network deployment** | Base station spacing greater than 100 km (theoretical), low cost, wide coverage. |
| | Support for broadcast single frequency network, efficient use of spectrum resources. |
| | It supports independent networking and does not rely on mobile communication networks. |

### Table A.5.3: R17 5G NR multicast broadcasting technology frequency band allocation example related to China Broadnet (See Annex 6 for more information)

| R17 5G NR multicast broadcasting bands | Uplink | Downlink | Duplex type |
|---|---|---|---|
| **703-733 MHz/758-788 MHz** | 703~733 MHz | 758~788 MHz | FDD |

### Table A.5.4: Features of R17 5G NR multicast broadcasting technology

| Classification | Features |
|---|---|
| **Frequency band** | 703-733 MHz/758-788 MHz, frequency division duplex |
| **Channel resource** | Support for 5 MHz/10 MHz/5 MHz/20 MHz/25 MHz/30 MHz channel bandwidth; Communications, multicast and broadcast share the channel resources. |
| | Channel resources are dynamically scheduled according to the requirements of two-way communication and multicast broadcasting services, and multicast broadcasting can only work in the pre-configured frequency range. |
| **Network access** | Multicast requires SIM card and access authentication, and does not FTA or ROM. |
| | For broadcast, standard project file does not support FTA and ROM, but technically they can be realized by pre-configuration of the information needed for receiving broadcast in terminal. The feasibility of the real-life operating conditions for the preconfigured method need to be verified. |
| **Mobility** | Multicast can support mobile switch. |
| | For broadcasting, the validity and business continuity of the preconfigured method needs to be verified in the event of mobile switching |
| **Network deployment** | Base station spacing is generally several hundred metres, it cannot support low-cost, wide coverage for broadcast television |
| | It does not support broadcast single-frequency networks and cannot be deployed nearby for the same frequency networks |
| | It is built on mobile communication networks and does not support independent multicast broadcast networks |

## 5G Broadcast new use cases

Beyond the technology benefits, 5G Broadcast can also enable many attractive new use cases that bring value to consumers. Some of these new use cases outlined below[102]:

- **Efficient free-to-air or zero-rated media content delivery**: An example of this could be from a livestream of a soccer match or a presidential debate. When this content is watched simultaneously by a large number of viewers over unicast cellular connections, it creates a huge burden on the network, reducing quality of service and increasing delivery costs for network operators. With 5G Broadcast, live content can be delivered to thousands or even millions of users, without the same data being sent individually to each user as is the case when using unicast.
- **Robust emergency notification for public safety**: During public emergencies and disaster events such as earthquakes, wildfires, floods and tornados, a smartphone can become a life-saving device if it is robustly connected. In a scenario where the cellular network becomes disabled due to structural damage (e.g., in the case of an earthquake), public authorities could still use the broadcast infrastructure to communicate with smartphones that support broadcast services. This is because the high-tower broadcasting sites are more physically resilient. This is a priority for many public safety agencies, and 5G Broadcast has become a prime candidate to enable services that can facilitate invaluable direct communications (e.g., sending of emergency information and lifesaving instructions) with those who need it the most.
- **Enhanced venue casting at sporting events or concerts**: Events such as motorsports racing, the Olympic games, football matches, and large festivals pose a real challenge for mobile operators as large numbers of users in close proximity, will share nearby limited network resources such as nearby cellular towers, simultaneously. For such scenarios, 5G Broadcast could fill a much-needed role in ensuring all users in the area can smoothly stream high-definition video content from the event, without overloading the cellular towers in the area.

102 For more details, refer to [5G Broadcast: What can consumers expect? | Qualcomm]

# Annex 6 – 5G Broadcast implementation in China

In December 2023, it was announced through the China Mobile and China Broadnet co-construction and sharing initiative, that China Broadnet has now co-constructed more than 600 000 5G base stations, becoming the world's largest 700 MHz 5G network with nationwide coverage[103]. At the same time, China Broadnet has promoted 929 network access terminals to support the 700 MHz frequency band. This makes 700 MHz the main 5G frequency band fully supported by the global industry chain. Mainstream manufacturers have completed software adaptation of more than 630 mobile phone models within 6 months of the opening of the China Broadnet 5G network, covering the principal mobile phone models of mainstream brands of the past four years. Mobile phone models adapted to the China Broadnet 700 MHz 5G network currently comprise more than 90 per cent of the country's 1.2 billion stock of mobile terminals. In addition, China Broadnet has essentially completed the national network testing and optimization. There are currently over 20 million China Broadnet 5G users in China.

China Broadnet cooperated with Chinese manufacturing companies to implement, by 19 December 2023, the 5G NR broadcasting end-to-end service network, based on the 3GPP R17 standard. This enables mobile phones equipped with 5G chips to receive 5G broadcast. The jointly constructed 5G NR broadcasting 700 MHz band end-to-end service network, covers many functions such as basic broadcasting services, concurrent broadcasting and unicast, card-free broadcast reception, and emergency broadcasting. After verification, the results were declared to meet the 3GPP standard protocol process and performance expectations.

Figure A.6.1 shows an image from the 2022 Beijing Olympic Winter Games, where 5G NR broadcast successfully provided video signals for 9 different mobile phone models from different manufacturers.

### Figure A.6.1: 5G NR broadcast successfully provides 9 different video signals for 9 mobile phone models in the 2022 Beijing Olympic Winter Games

[103] Note: The 700 MHz band here is specifically 703-733 MHz/758-788 MHz band.

The 5G NR multicast and broadcast services (NR-MBS) prototype system test was completed in Beijing by China Broadnet (3GPP R17 5G MBS). China Broadnet and its industry chain partners, used the commercial 5G NR network and universal 5G smart terminals, to develop the world's first 5G NR MBS end-to-end prototype test system. Using this system, field tests of 5G NR multicast broadcast, including cellular deployment, and TV high tower deployment, were carried out. The field testing has mainly been for the unidirectional broadcast service of the non-connected terminal, and subsequent testing will be carried out for the multicast service of the connected terminal.

Concerning cellular deployment, the base stations are installed according to conventional cellular communication base stations, and for TV high tower deployment, base stations are installed in TV high towers. There are several test routes in the cellular deployment testing scenario and in the high tower deployment testing scenario, and all test routes are in dense urban areas.

The results show the coverage ranges of cellular deployment and high tower deployment. Tests on the business continuity of cellular deployment and tests on high-speed movement and high tower terminal deployment is also being carried out. High-power high tower transmission sites, which broadcast the signals to the terminal devices.

# Annex 7 – Detailed functionalities, use cases and available terminals for ATSC 3.0

Some of the main functionalities of ATSC 3.0 include[104]:

- **Content is broadcasted via TV high towers and SFNs**

Broadcast TV towers deliver TV content and IP data through over-the-air signals to receiver devices within a coverage area. To ensure uniform coverage and service, single frequency networks (SFNs) can be used to reinforce signals in areas where signals are weaker.

- **Signals are networked via MFNs**

Utilizing multiple frequency networks (MFNs) on overlapping ATSC 3.0 signals can create a mesh network among TV broadcasters. Handoff integrated in MFNs enables IP-based content to be transferred from one signal to another, extending the distribution reach beyond a single market.

- **A data pipe that simultaneously transmits live and IP-based content**

ATSC 3.0 can deliver a variety of content with a single TV channel, for example, broadcast TV, on-screen interactive applications, and software updates. The standard can allow a single television channel to be divided into multiple "physical layer pipes" enabling a broadcaster to optimize certain content for mobile reception, while transmitting other content at higher bitrates for traditional television reception.

- **Delivering content and data to devices with ATSC 3.0 receivers**

Broadcast video and IP content is delivered to consumers through ATSC 3.0 receivers connected to an over-the-air antenna, including smart TVs with built-in receivers, stand-alone tuners, and home gateways. ATSC 3.0 chips can also be included in mobile phones, tablets, connected cars, and other Internet of things (IoT) devices making it possible to broadcast to devices beyond televisions.

- **Interactive solutions when receiver device applications converge with broadband**

ATSC 3.0 can allow the integration of broadband and broadcast services, providing a two-way communications channel for new use cases, such as interactive experiences, on-demand services, IoT, etc., using existing connectivity options.

In addition, some use cases and applications possible with ATSC 3.0 include:

- **Enhanced viewer experience**: ATSC.3.0 can deliver more content, and interactive experiences, with enhanced video quality using 4K and high-dynamic range (HDR) with immersive sound. It can allow viewers to select from multiple live feeds.

[104] Deloitte. ATSC 3.0 white paper, 2022. Available at https://www2.deloitte.com/us/en/pages/consulting/articles/atsc3-benefits-and-applications.html. Access in September/2024

- **Targeted advertising**: Accessing household data, broadcasters will be able to deliver more relevant, targeted advertising, increasing the value of their audience reach for advertisers, using customized and creative audience-targeting.
- **Spectrum-as-a-service**:
  - Data offload: Broadcasters can sell data capacity to companies seeking to download data to consumers at scale, creating synergistic partnerships between broadcasters and broadband providers.
  - Video streaming and edge caching: Third-parties will be able to develop applications to transmit video streaming over the air in a one-to-many fashion. This is a more economical method of transporting large amounts of data and making it available locally on demand by caching the content on the edge of the network.
- **IoT - Connected cars**: IoT devices with ATSC 3.0 chips send and receive essential data via broadcast signals to and from many devices, including those on the move. This use case can be a cost-effective alternative to broadband, using broadcasters' one-to-many infrastructure. Specific use cases can include transmitting in-vehicle entertainment, vehicle software updates, and sending data to autonomous long-haul trucking fleets.
- **Remote learning**: ATSC 3.0 can improve the quality of distance learning services, enhancing live educational experiences for students by delivering a combination of live instruction and interactive content. The interactive experiences can integrate live TV content with mobile devices, and broadcaster applications with connectivity solutions, to deliver virtual educational services to students.
- **Advanced emergency alerting and informing**: In times of crisis, the one-to-many broadcast architecture allows for resiliency, being an alternative to broadband networks. With the increasing prevalence of hurricanes, wildfires, and other extreme weather events, TV datacasting capability can help by supporting the emergency alert systems, and for communications and services of communities during power outages and destructive events, including those in rural and underserved areas.

**Examples of commercially available television sets incorporating ATSC 3.0 technology**

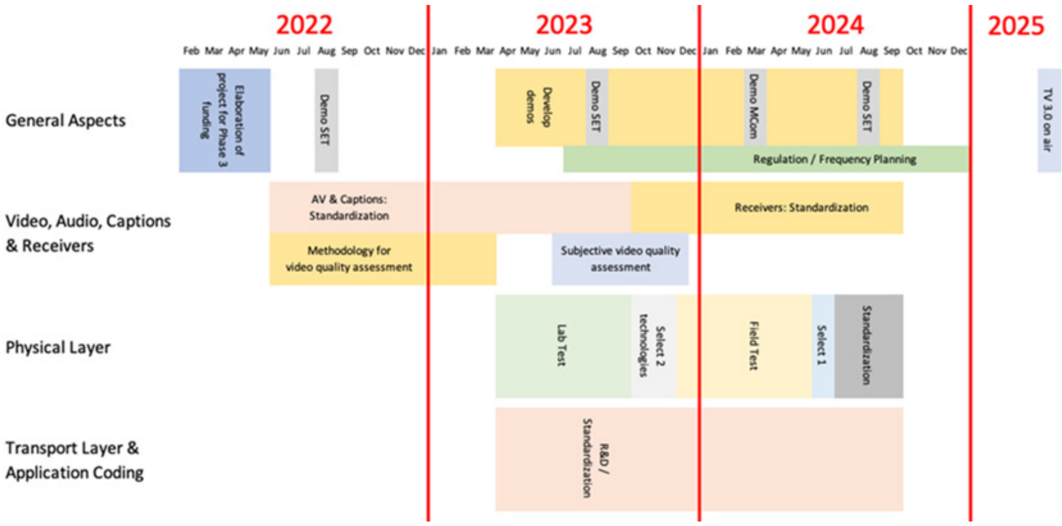
- **Sony**: Sony Bravia XR A95L OLED[105]
- **Samsung**: Samsung S95C[106]
- **LG**: LG OLED[107]

[105] https://www.rtings.com/tv/reviews/sony/a95l-oled
[106] https://www.kitele.com/fr/tv-samsung-qe55s95c (in French)
[107] https://www.tomsguide.com/best-picks/best-tvs-with-atsc-30-tuners

# Annex 8 – Progress report on Phase 3 of the TV 3.0 Project in Brazil

The Phase 3 schedule of the TV 3.0 Project in Brazil experienced some minor adjustments, as illustrated in Figure A.8.

## Figure A.8: Phase 3 progress report




The Brazilian digital terrestrial television system (SBTVD) Forum, is working cooperatively with a group of Brazilian universities, funded by the Ministry of Communications through the National Education and Research Network (*Rede Nacional de Ensino e Pesquis*). From April 2023 to September 2024 this cooperative work comprised:

- performing complementary tests for the selection of the physical layer technology (laboratory and field tests), among the current candidate technologies (Advanced ISDB-T, ATSC 3.0 and 5G Broadcast);
- developing the necessary adaptations and extensions to the ROUTE/DASH transport layer specification alongside a reference mux/demux implementation;
- performing a subjective assessment of the quality of TV 3.0 video coding technologies (VVC and LCEVC) for the determination of the required bitrate;
- developing adaptations and extensions to DTV play for TV 3.0 application coding alongside an integrated development environment (IDE) and a test suite;
- finalizing technical standards, operational guidelines and conformance testing for TV 3.0; and
- developing end-to-end system demonstrations.

Approximately 90 researchers from 7 Universities in Brazil participated in research for Phase 3 of the TV 3.0 Project. Research areas included:

- Application coding – R&D;
- Video coding – Subjective quality assessment;
- Transport layer – R&D;
- Physical layer – Laboratory tests;
- Physical layer – Field tests.

# Annex 9 – Call for proposals (CfP) concerning system components for the TV 3.0 Project in Brazil

The Brazilian digital terrestrial television system (SBTVD) Forum, issued a call for proposals (CfP) for the TV 3.0 Project in July 2020, targeting 6 system components: 1) over-the-air physical layer system component, 2) transport layer system component, 3) video coding system component, 4) audio coding system component, 5) captions system component, and 6) application coding system component. The CfP deadline was extended, exclusively for the application coding system component, to March 2021. For the remaining 5 system components there were 24 candidate technologies, and these technologies are listed in Table A.9.1.

The SBTVD Forum also released Phase 2 of the TV 3.0 CfP. Phase 2 targeted testing and evaluation to compare the proposals of candidate technologies, and included reception performance, video coding quality, and laboratory tests to select two physical layer technologies for final field tests.

The reports of Phase 2 testing and evaluation are available on the SBTVD Forum website, along with the selected technologies for each system component, a consideration of the test results, and market and intellectual property aspects of the candidate technologies. Reports of the testing and evaluation from Phase 2 of the TV 3.0 Project and technologies selected, are presented in Table A.9.2.

For the reception performance and to assist with the definition of the minimum required field strength for indoor reception of the candidate technologies, the SBTVD Forum also released a Call for Prototypes for multi-input multi-output (MIMO) indoor antennas (Phase 3).

The TV 3.0 Project, through the SBTVD discussion process, is expected to issue new technical specifications for video coding, audio coding, captions, transport layer and application coding, to reflect the new evolutions selected. Alongside with that, after the field tests referred to above, the related technical specification will also be drafted and issued.

Following the establishment of the TV3.0 Project by the SBTVD Forum, the Government of Brazil encompassed the activity in a formal public policy enacted in April 2023, by Presidential Decree No. 11 484/2023, which provides the guidelines for the evolution of the Brazilian digital terrestrial television system (SBTVD) and for ensuring the availability of radio frequency spectrum for its deployment[108].

The TV3.0 Project formal policy establishes that the next-generation digital terrestrial television broadcasting (DTTB) system in Brazil, to be called TV 3.0, shall have the following characteristics:

- audiovisual quality superior to that of the first-generation Brazilian DTTB system;
- fixed reception, with external and internal antenna, and mobile reception;

[108] Available at http://www.planalto.gov.br/ccivil_03/_ato2023-2026/2023/decreto/D11484.htm.

- integration between contents transmitted by the broadcasting service and over the Internet;
- app-based user interface;
- content segmentation according to viewers' geographic location;
- customization of content according to viewers' preferences;
- optimized use of the radio frequency spectrum destined for terrestrial television broadcasting; and
- new forms of access to cultural, educational, artistic, and informative contents.

The TV3.0 Project formal policy states that the Ministry of Communications will support the SBTVD Forum so that the studies related to the technological innovations that may comprise TV 3.0 are completed by 31 December 2024, including the technical requirements for the receivers that will allow the adaptation from the current digital television technology to TV 3.0.

It determines that the National Telecommunications Agency (Anatel) shall conduct studies on the frequency planning of TV 3.0 until 31 December 2024, and promote actions to ensure:

- regulatory stability, through the availability of frequency bands necessary for the evolution of terrestrial television broadcasting; and
- implementation of digital terrestrial television in Brazil and its technological evolution.

Finally, TV3.0 Project formal policy states that the Ministry of Communications will constitute and coordinate a working group to propose regulations for TV 3.0, with the participation of representatives from the National Telecommunications Agency (Anatel), the Ministry of Science, Technology and Innovation, the Ministry of Finance, the SBTVD Forum and entities representing the broadcasting sector. The deadline for the completion of activities by the working group is 31 December 2024.

### A.9.1 Candidate technologies for TV 3.0 Phase 1 CfP

| Component | Candidate technology | Proponents |
|---|---|---|
| **Over-the-air physical layer** | Advanced ISDB-T | DiBEG |
| | ATSC 3.0 | ETRI |
| | | ATSC |
| | 5G Broadcast / EnTV | Qualcomm / Rohde & Schwarz GmbH |
| | DTMB-A | DTNEL |
| **Transport layer** | ROUTE/DASH | ATSC |
| | SMT | DTNEL |
| | | NERC DTV |
| | OTT-B | OTT-Broadcast Consortium |
| | MMT | DiBEG |
| | | ATSC |

(continued)

| Component | Candidate technology | Proponents |
|---|---|---|
| **Video coding** | VVC | DiBEG |
| | | InterDigital / Ateme / Fraunhofer HHI |
| | HEVC / SHVC | ATSC |
| | AVS3 | DTNEL |
| | LCEVC | V-Nova |
| | | Phase / Harmonic |
| | Dynamic resolution encoding | Phase / Harmonic |
| | SL-HDR (1/2/3) | InterDigital / Philips |
| | | ATSC |
| | SMPTE ST 2094-10 (Dolby Vision) | Dolby |
| | | ATSC |
| | SMPTE ST 2094-40 (HDR10+) | Samsung |
| | V3C (V-PCC / MIV) | InterDigital / Philips / Harmonic / Phase |
| | ATSC 3.0 AEA | ATSC |
| **Audio coding** | AC-4 | ATSC |
| | | Dolby |
| | AVSA | DTNEL |
| | MPEG-H Audio | DiBEG |
| | | Ateme / Fraunhofer IIS |
| | | ATSC |
| **Captions** | IMSC1 | ATSC |
| | ARIB-TTML | DiBEG |
| | Captions | DTNEL |

### A.9.2 Reports of the testing and evaluation from TV3.0 Phase 2 and technologies selected

| Component | Report issued by the SBTVD Forum |
|---|---|
| Physical layer – Lab tests | https://forumsbtvd.org.br/wp-content/uploads/2021/12/SBTVD-TV_3_0-PL-Lab-Report.pdf |
| Physical layer – Field tests | https://forumsbtvd.org.br/wp-content/uploads/2021/12/SBTVD-TV_3_0-PL-Field-Report.pdf |
| Transport layer | https://forumsbtvd.org.br/wp-content/uploads/2021/12/SBTVD-TV_3_0-TL-Report.pdf |
| Video coding | https://forumsbtvd.org.br/wp-content/uploads/2021/12/SBTVD-TV_3_0-VC-Report.pdf |
| Audio coding | https://forumsbtvd.org.br/wp-content/uploads/2021/12/SBTVD-TV_3_0-AC-Report.pdf |
| Captions | https://forumsbtvd.org.br/wp-content/uploads/2021/12/SBTVD-TV_3_0-CC-Report.pdf |
| Application coding | https://forumsbtvd.org.br/wp-content/uploads/2021/12/SBTVD-TV_3_0-AP-Report.pdf |

Technologies recommended as per the testing and evaluation performed, and other considerations, subject to final adoption by the SBTVD Forum. More information can be found in document 6/210[109], A Brazilian Contribution to the ITU-R SG6.

109 https://www.itu.int/md/R19-SG06-C-0210/en

# Annex 10 – European Union digital services regulatory framework

## A.10.1 Digital Services Act

The Digital Services Act (DSA)[110] is a new set of rules which imposes clear obligations on digital services providers that act as online intermediaries, and that are able to transmit or store content of third-parties, and thus connect consumers with goods, services, advertisers and content providers. The DSA addresses platform practices in terms of content management and distribution.

The DSA aims at creating a safer online environment and an improved protection of users and their fundamental rights by establishing:

- the regulatory framework for the handling of illegal and potentially harmful content, products or services offered online;
- a transparency and accountability framework for online platforms;
- a system for oversight and enforcement.

The DSA applies to three categories of intermediary services:

- "Mere conduit" services that provide access to, or the transmission of, information over a communication network (e.g., Internet access providers, Internet exchange points, virtual private networks, domain name registries, and voice over IP);
- "Caching" services that provide for the automatic, intermediate, and temporary storage of information, as it is transmitted over such networks, in order to improve the efficiency of that data exchange (e.g., content delivery networks or reverse proxies);
- "Hosting" services that provide for the permanent storage of information provided by, and at the request of, a user. This category includes online platforms which disseminate information to the public, such as online marketplaces, app stores, collaborative economy platforms, and social media platforms.

The obligations placed on different service providers are proportionate to their role, size and impact in the online ecosystem. Whereas the first two categories that provide network infrastructure and are more technical in nature, are subject to a basic tier of rules, "hosting" services and in particular online platforms, have additional obligations that reflect their role in making user-provided information available to a potentially unlimited number of users. The most detailed and stringent set of rules is reserved for the so-called very large online platforms (VLOPs) and very large online search engines (VLOSEs), platforms which reach at least 45 million users in the European Union.

The DSA requires companies to take a more active role in monitoring and responding to issues such as disinformation campaigns, harmful content, or hate speech and applies financial penalties if platforms are in breach. These fines can be up to 6 per cent of the company's

110 Regulation (EU) 2022/2065 of the European Parliament and of the Council of 19 October 2022 on a Single Market For Digital Services and amending Directive 2000/31/EC, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022R2065&qid=1666857835014

worldwide annual turnover from the concerned intermediary service and, ultimately, a ban on operating in the European Union single market for repeat serious offenders, can be imposed.

The Digital Services Act entered into force on 16 November 2022. On 25 April 2023, the European Commission designated 17 VLOPs and two VLOSEs as platforms reaching at least 45 million monthly active users.

The platforms have been designated based on the user data that they were obliged to publish by 17 February 2023. Following their designation, the application of the DSA set of rules applies within four months of the designation. The DSA set of rules includes: more user empowerment, strong protection of minors, more diligent content moderation, less disinformation, and more transparency and accountability.

The implementation of the Digital Services Act across European Union countries involves the designation of **digital service coordinators (DSCs)** as national regulatory authorities responsible for overseeing compliance with the DSA and ensuring its proper enforcement. The situation across the European Union varies, since each Member State is allowed to designate one or more institutions as the DSC, based on their existing regulatory frameworks. The DSC role can be assigned to either a single regulatory authority, or split between multiple institutions, depending on a country's approach.

In several European Union countries, the national regulators for electronic communications have been designated as the DSC, due to their experience in handling digital infrastructure, and the intersection between telecommunications and digital services. Broadcasting regulators, who already have oversight over audiovisual media services, have also been designated in several member states. This decision leverages the existing roles that broadcasting regulators have in monitoring and regulating content distribution, such as their work with video-on-demand services. Other possible solutions for DSCs include institutions such as consumer protection authorities of newly established hybrid authorities.

### A.10.2 Digital Market Act

The Digital Market Act (DMA)[111] focuses on the role of platforms as "gatekeepers" between businesses and consumers.

The two main objectives of the Digital Market Act are:

- to ensure contestability in the digital sector by promoting competition among digital platforms;
- to ensure fairness for business users depending on gatekeepers for providing their products and services.

The Digital Market Act set *ex ante* prohibitions and obligations that will be applied to companies designated by the European Commission as "gatekeepers". This "gatekeeper" designation is applied to providers of one or more core platform services (CPS), that are considered as having significant intermediation power.

111 https://digital-markets-act.ec.europa.eu/index_en

Article 2 of the DMA lists core platform services (CPS) as follows:

a) online intermediation services;
b) online search engines;
c) online social networking services;
d) video-sharing platform services;
e) number-independent interpersonal communications services;
f) operating systems;
g) web browsers;
h) virtual assistants;
i) cloud computing services;
j) online advertising services, including any advertising networks, advertising exchanges and any other advertising intermediation services, provided by an undertaking that provides any of the core platform services listed in points (a) to (i).

The Digital Market Act provides an asymmetrical regulation, meaning its obligations can be applied only to certain CPS providers, that can be designated as gatekeepers, for one or several core platform services.

The DMA proposes that the designation or identification as a gatekeeper is applied on the basis of three cumulative criteria:

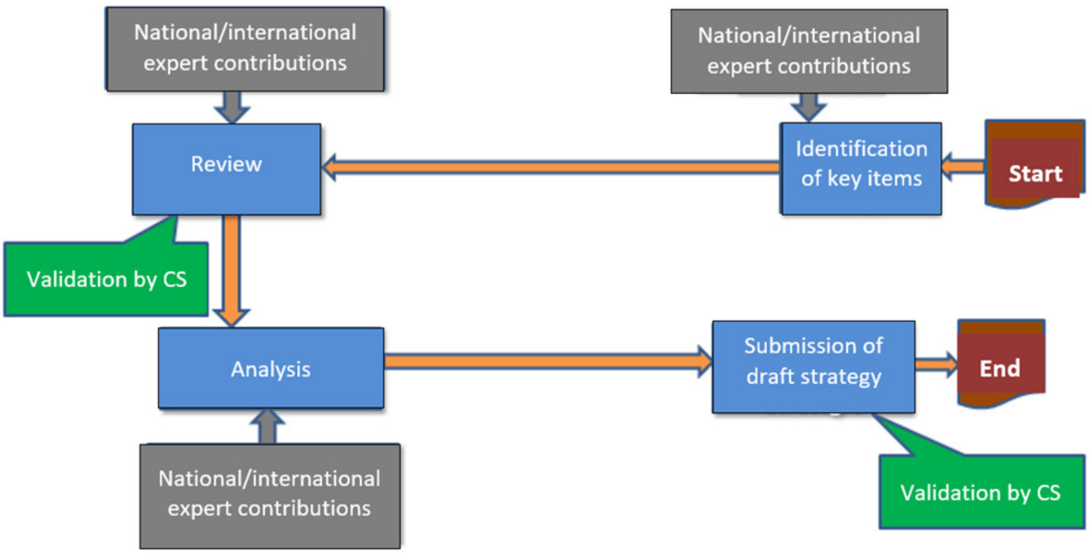
a) Significant impact on the internal market;
b) Operates a core platform service which serves as an important gateway for business users to reach end users; and
c) Enjoys an entrenched and durable position in its operations, or that it is foreseeable that it will enjoy such a position in the near future.

The DMA entered into force on 1 November 2022, and the application began as of 2 May 2023.

Following the 45-day review process, on 6 September 2023, the European Commission designated a number of platforms as gatekeepers. Gatekeepers then have six months to ensure full compliance with the DMA obligations for each of their designated core platform services.

# Annex 11 – Methodology for elaboration of the strategy for the digital broadcasting transition in Cameroon

Figure A.11: Workflow of digital broadcasting transition strategy




## A.11.1 Strategic directions

The strategy covers a number of directions, set out below:

### Institutional and regulatory

- Respect of Cameroon's commitments to the international institutions (2006 Geneva Agreement and related conferences);
- Creation of a legal and regulatory framework (regulatory authority, fund to support production, determination of the legal regimes, separation of creation and broadcasting functions, a body charged with archival of broadcast work).

### Technical

The principal planned technical characteristics are as follows:

- Coverage of the population: 85 per cent by DTT;
- Frequency band at the start: band 3;
- Standard: DVB-T2;
- Video coding: MPEG-4 AVC (MPEG-4 AVC or H.264);

- Audio coding: HE AAC;
- DTT backbone within Cameroon: national public operators' networks with CRTV for broadcasting and CAMTEL for transmission. To be augmented by satellite.

## Content development

- Industrialize content production;
- Establish production obligations and broadcast quotas;
- Promote and protect local cultures;
- Foster the creation of a market for programmes;
- Archive production nation-wide.

## Human resources development

- Personnel training: technical and artistic professions, broadcast support professions (legal, sales, advertising, etc.);
- Train-the-trainer schemes;
- Strengthening of the training platforms, sharing.

## Economic and financial

- Construction of a DTT network that will be a good fit for the requirements of the new digital economy;
- A new economic model for television based on the creation of digital value-added services;
- Creation of a broadcasting development fund.

## Communication

- Establish communication strategies to involve all stakeholders and inform the population.

# Annex 12 – Principal stages of the migration process at the national level in Cameroon

## A.12.1 From a migration strategy to the implementation of DTT switchover projects

At the national level, a prerequisite for implementation of the migration to digital broadcasting, was a complex of administrative, technical and legal measures, defined in a specially created strategy document.

The Prime Minister and Head of Government, in a participative and inclusive approach involving all the concerned players, issued **order No.222/CAB/PM of 24 September 2009** establishing a **national supervisory body, the Cameroon Digital Broadcasting Switchover Committee (CAM-DBS).** The main task of the committee was to prepare for the Government a proposal on a national strategy for the switchover to digital broadcasting, by producing a review and an analysis of the current state of national broadcasting, under all of its aspects. On 24 September 2012, the Government adopted a **national strategy document for the migration from analogue to digital broadcasting** (known by the French acronym **DSMN**). To implement the various projects that emerged from the national strategy document, by an order of the Prime Minister and Head of Government in 2012, the CAM-DBS committee was recast into a new project structure called **Cameroon Digital Television Project (CAM-DTV).** This committee had two working bodies: a steering committee (***Comité de pilotage*, COPIL**), chaired by the secretary general to the Prime Minister and assisted by the Minister of Communications as vice-chair; and a technical operational unit (***Unité technique opérationnelle*, UTO**) made up of experts from the different administrations involved in the switchover process.

## A.12.2 The migration to DTT in Cameroon with the technical rehabilitation of CRTV and an experimental DTT project at CRTV

On the authority of the President of the Republic, a contract for the technical rehabilitation of Cameroon Radio and Television (CRTV) was awarded in November 2012, after the tender dossier had been cleared by the office of the President. Further negotiations resulted in a commercial contract, between the Government of Cameroon, represented by the Minister of Communication, and the contractor, being signed in December 2014. This in turn made it possible effectively to begin implementation of the project in the cities of Douala and Yaoundé at the following sites:

- The Yaoundé earth station (Mballa II), where the multiplexing platform, the head-end and their power equipment are installed;
- The Yaoundé broadcasting station (Mbankolo), where the DTT transmitters are installed, along with their power equipment;
- The Douala broadcasting station (Logbessou), where all facilities have been completed, including the rebuilding of a 200-metre high pylon.

After a further revision to the terms in 2017, a new contract for the technical rehabilitation of CRTV was signed, with the objective of setting up a joint venture with the contractor. That approach was subsequently rejected by the office of the President. Currently, the search for funding is being pursued within the framework of a public-private partnership (PPP). Previously, the Ministry of Communication and CRTV had elaborated and sought funds to implement an experimental DTT project in two cities, Yaoundé and Douala. The purpose of the project was to allow CRTV and the State to obtain a better appreciation of the constraints and realities of DTT before deploying the technology country-wide. The delay in identifying funding sources for the project meant that the contract was signed just one year before the deadline set by ITU for migration. Implementation of the contract, the execution period for which was four months, made the actual official launch of DTT at Yaoundé and Douala possible in July 2015, with a multiplex of 12 television channels available free to analogue television sets equipped with a special decoder or directly to DVBT-2/MPEG4-capable digital television sets.

## A.12.3 Current situation in Cameroon

Technical aspects:

- The experimental DTT project is operational, with a 12-channel multiplex and two equipped DTT broadcasting centres (Yaoundé and Douala);
- Preparation of terms of reference relating to the recruitment of a strategic partner to construct the technical infrastructure for digital broadcasting in Cameroon;
- The technical partner has been chosen and has commenced certain work lots;
- Funding is being negotiated;
- An office has been chosen to provide support to the contract principal;
- A dossier being prepared for the call for proposals (CfP) for a prime contractor;
- Data is being collected for a complete survey of the existing broadcasting infrastructure country-wide;
- A public information campaign is in progress to build awareness of the importance of migration and its challenges. Seminars have been organized in different regions;
- Revision of frequency plans in the UHF and VHF bands with an increase of the planned spectrum resource capacity in those bands;
- Development of scenarios for migration to DTT, taking into account the costs and objectives of coverage of the national territory (minimum of 60 per cent, corresponding to the current coverage by analogue television).

Content-related aspects: Preparation and creation of the first digital DTT package in Cameroon (12 TV channels currently broadcasting in Yaoundé and Douala) with eight local and four foreign channels.

Human resources aspects: Upgrading of the competencies of selected personnel in administration and public bodies involved in the migration process. Two training sessions on terrestrial digital broadcasting have been held in Yaoundé.

### A.12.4 Forthcoming activities and outlook

**On the institutional and legal front**, the regulatory framework will be further finalized with the elaboration of subsidiary texts for law no. 2015/007 of 20 April 2015, on broadcasting. **On the technical front**, now that the installation of head-end equipment at the CRTV headquarters in Yaoundé-Mballa II and the broadcasting centre at Yaoundé-Mbankolo has been completed, the deployment of equipment for the experimental DTT solution will continue in other cities, along with the progressive digitalization of the other broadcasting centres throughout the country. **After phase 1 of the contract for rehabilitation of CRTV**, implementation of the project will continue at other locations, as indicated above. It will take into account all of the business activities affected, in particular: radio production, TV production, the information system, audio/video transmission, radio and DTT broadcasting, and commercial services for the distribution of decoders.

# Annex 13 – Digital broadcasting television migration strategy and implementation in Guinea

## A.13.1 Background

The development of a country is intertwined with the development of the telecommunications sector, especially in terms of digital technologies for broadcasting. The problem with analogue in this area is that it limits the use of radio spectrum, not to mention the interference that it is subject to, and the interference it causes even in the adjacent frequency bands. The use of digital broadcasting provides a lasting solution to these problems. Today, digital technologies for broadcasting have been widely developed. People see these types of technologies as a resource that allows them to connect, inform and entertain themselves. Like many countries, Guinea also aspires to the effective adoption of digital broadcasting to benefit from all of its associated advantages.

## A.13.2 Latest information on the transition to digital broadcasting in Guinea

The transition to DTT began in Guinea in 2008. The initial involvement from the private sector was followed by the State in 2015, with a total coverage rate of 3.37 per cent. Nine licences were awarded, four of these to TV promoters, and five to broadcasters. The technology standards currently being employed are MPEG-2, and MPEG-4/ SD, as well as HD/DVB-T, DVB-T2 and DVB-S2 and the main transmission media are radio beam, cable and satellite.

The Government of Guinea recently restarted the project to migrate from analogue to digital broadcasting nationwide. This project will comprise:

- the construction of 15 sites throughout Guinea (one in the capital and the other 14 in the interior of the country) and five regional studios (Kindia, Boké, Kankan, Labé and Nzérékoré);
- two mobile studios are also planned, as well as mobile production vehicles for live events;
- a national service centre;
- a digital archive centre;
- a number of reception kits;
- a staff training programme;
- the construction in Koloma (Conakry) of a DRC+3 building to house the network supervision centre, the Lower Guinea maintenance centre, the multiviewers, the offices and meeting room, and the local project management unit;
- the modernisation of the RTG public broadcaster studios in Conakry (Koloma and Boulbinet);
- the distribution of TV services to all sites via satellite (Ku-band);
- the broadcasting of public services programmes via satellite in DTH (Ku-band).

The total cost of the project is projected to be EUR 66 million, which will be 85 per cent financed by the Public Investment Bank of France (BPI France) and the General Directorate of the French Treasury on the basis of a loan. The remaining 15 per cent will be supported by the Government or Guinea through the ECOBANK which is a primary bank of the country.

The projected duration of the project is 24 months, from the effective start date of the project, which also depends on funding.

### A.13.3 Project delivery level

As part of the implementation of the project, the following actions were taken:

a) The creation, by presidential decree, of a Monitoring and Coordination Committee for the digital migration process. This committee is composed of:

   - The Minister in charge of communication and information, Chairman of the Committee;
   - The Deputy Head of administration and control of major projects and Government procurement (ACGP.MP), Rapporteur.

   Committee members:

   - The Minister in charge of telecommunication or his representative;
   - The Minister in charge of finance or his representative.

b) In March 2022, a commercial contract with the technical operator was signed. The technical operator chosen by the Government to carry out the project was the Thomson Broadcast group.

c) In July 2022, the official site visit was carried out with the technical operator.

d) An evaluation of the offer was sent by the Thomson Broadcast partner.

### A.13.4 Deficiencies noted in the partners offer

To implement the recommendations of the presidential decree, a Technical Commission, a Legal Commission and a Communication and Audiovisual Content Commission were established.

As part of their activities, these Commissions were asked to evaluate the offer from the technical partner. Following their assessment, the following deficiencies were identified:

- The evaluation of the offer of the technical partner was requested at a time when the budget for the realization of the project was already fixed. This could either lead to either a blockage in the implementation of the project, or to the failure of the objective which is to attain DTT coverage of the territory;
- The sites planned to cover the country are insufficient because there are 33 Prefectures in Guinea;
- The lack of sufficient transmission medium support (optical fibre) provided for the connection of broadcasting sites to the national backbone at each of the Prefectures. Such a connection would allow interconnection between the sites, and so allow additional transport of the signal from the production studios to the head of the RTG public broadcaster studios in Conakry;
- The failure to support the other fourteen sites (former analogue sites that could be rehabilitated for DTT) by the project.

Please note that the evaluation of the offer from the partner is ongoing at the level of the various commissions.

# Annex 14 – Digitize Brazil Programme – ASO strategy Phase II

It is useful to consider the example the analogue switch-off (ASO) strategy implemented by Brazil, as the strategy of 'phased analogue switch-off' implemented in the case of Brazil, has been chosen by a significant number of other countries. The Brazil case study can therefore serve as an example for the evaluation of a phased analogue switch-off (ASO) strategy. Brazil divided the ASO into Phase I and Phase II. In Phase I, all Brazilian capitals and other major cities shut-down their analogue transmissions to allow for the operation of a Fourth Generation IMT advanced system operating in the 700 MHz band (698-806 MHz). In Phase II the switchover was completed in all locations where analogue TV was still in operation[112].

In order to accomplish Phase I, all TV channels from the 700 MHz band, down to the VHF band (channels 7 to 13) and the remaining UHF band (channels 14 to 51) were subject to replanning and reallocation.

By January 2019, 1 379 municipalities, comprising 129.6 million people, had completed the analogue switch-off, including all state capitals, metropolitan areas, and other areas, corresponding to 62.6 per cent of the Brazilian population. The analogue switch-off was required, in order to release the 700 MHz band, and this was successfully accomplished in Phase I of the phased ASO strategy.

For Phase II of the phased ASO strategy, a Government programme, **Digitaliza Brasil** (Digitize Brazil) was established utilizing funds remaining from the 700 MHz band auction, after the initial funds allocation utilized for Phase I[113].

Phase II comprised 2 896 municipalities, some of these municipalities had partially digitized transmissions, while others (1 639 municipalities) had analogue TV only. These remaining municipalities were the target of the **Digitaliza Brasil** programme. The objective of the **Digitaliza Brasil** programme was the completion of the transition to digital terrestrial television by December 2023, the final deadline for the analogue switch-off (ASO).

The population in these areas will not receive set-top-boxes and antennas, and their analogue switch-off is not conditioned to household surveys, as it is expected, based on the previously mentioned projection, that they will naturally and progressively migrate from analogue to digital TV as the currently existing analogue TV sets stop receiving transmissions.

Two main courses of action are planned for the programme:

- Continue the distribution of DTV reception kits to low-income families, where deemed necessary; and
- Digitize stations in analogue-only locations.

112 The fisrt phase was implemented between 2016 and 2018, and the second one started 2021 and is planned to finish December 2023.

113 The total amount of funds reserved for the second phase of the Brazilian ASO strategy is approximately R$ 850 million (around U$ 160 million).

For the first course of action, preliminary estimates are that 4.2 million DTV kits will be distributed (in addition to the 12 million that were distributed in the first phase of the ASO. The second course of action involves acquiring and installing DTV transmitters for the analogue broadcasters, as well as bearing the costs with regulatory demands (mainly taxes and engineering labour).

A standardized transmission assembly will be used as a reference for the deployment of stations in each of the municipalities, which can be modified to meet local conditions. The equipment will allow sharing of common infrastructure, such as combiners, transmission lines, towers, and antennas between up to eight DTV broadcasters' channels, and reducing equipment, deployment, energy, and maintenance costs. A maximum transmitter power of 50W will be provided for each channel.

The infrastructure will be maintained under the municipal administration premises and will be operated by local broadcasters. Both municipal administrations and broadcasters will undergo a selection process to complete requirements established by the programme. Qualified broadcasters are to deploy the necessary equipment at their own expense. On the other hand, the existing infrastructure (sites, housing, towers, antennas, etc.) can be used on a shared basis by incoming broadcasters, greatly reducing total deployment costs. Additionally, municipalities bear electricity costs, reducing operational expenditures.

The analogue switch-off (ASO) strategy in Brazil was successful, with the transition to digital TV broadcasting having no significant impact on the free-to-air terrestrial TV audience. This success is particularly important for Brazil, where the majority of the population relies on free-to-air television for audiovisual content consumption. The digital switchover had several positive outcomes, including a boost to the national industry (covering set-top boxes, TVs, receiving antennas, digital TV transmitters, and transmission antennas) and a renewed public interest in free-to-air terrestrial television. Key lessons from the ASO strategy in Brazil include the importance of cooperation and collaboration among stakeholders, with the operationalization of planned actions by a third-party. Consumer awareness and involvement were crucial for smooth implementation, supported by the decision to include DTV converter boxes in all TV sets sold in the retail market in a gradual and phased manner. Providing necessary equipment, such as DTV converter boxes and antennas, for free to low-income populations, also contributed significantly to the transition. Local actor involvement facilitated the switchover, underscoring the importance of community engagement. For countries with vast geographical territories, a long-term ASO plan is advisable, with considerations such as maintaining analogue transmissions on a secondary basis in small municipalities to stimulate the migration to digital in these areas.

# Annex 15 – Analogue to digital satellite broadcasting migration in Brazil

The task of migrating to satellite broadcasting free-to-air services involved the distribution of receiver kits for low-income families and the installation of the new equipment. To achieve this, a third-party entity was created, in a similar way to that employed during the digital terrestrial television switchover to 700 MHz band for 4G, which involved the creation of a governance structure to monitor the process. Among other activities, this third-party entity implemented the relocation of analogue television stations to other parts of the spectrum, to allow for the usage of the 700 MHz digital dividend band. More information can be found in the Final Report of Question 2/1 for the 2017-2021 study period.

A monitoring group (GAISPI) for the implementation of solutions to interference problems in the 3 625 to 3 700 MHz band was constituted, as was the 3.5 GHz band managing entity (EAF – Siga Antenado). This entity is fully operational and provided a communication plan to produce information on the necessary procedures enabling each family to claim their kit or request its installation. More information can be found at https://sigaantenado.com.br/.

The migration process is planned to continue until 2025, and consequently a simulcast period with concurrent transmissions in the current band (C band) and the new band (Ku band), will be followed by the shutdown of the C band transmissions. Only those homes that either received kits, or who have purchased the new devices will be able to continue watching satellite TV.

The equipment that composes the kits, the acquisition and distribution costs, and the scheduling of activities are responsibilities of GAISPI and the EAF. Initially, 16 types of antennas were identified, of these eight were of low noise block-down converter feedhorn (LNBF) type, which are satellite-to-TV signal converters used in satellite dishes, and the remaining eight comprised candidate receivers to compose the kits.

Sensibilization and information campaigns were also amongst the responsibilities of both GAISPI and the EAF. These campaigns were carried out to update the registration of land stations of the fixed satellite service operating in the C band, both for data correction, such as geographic coordinates, and for the creation of new records, mainly from receiving stations. Receiving stations are under no obligation to register with the National Telecommunications Agency (Anatel), but in order to be entitled to protection against interference, broadcasting stations must be registered.

Based on the register of available stations, it is considered that it may be necessary to install filters in the 1 340 fixed satellite service (FSS) earth stations in the state capitals. In addition, another 229 stations that currently operate in the extended C band (range from 3 625 to 3 700 MHz) will need to vacate the band, as if they fail to do so, they will be subject to interference caused by 5G transmissions at 3.5 GHz.

## Status of the migration process

GAISPI continues to participate in deliberations to free-up cities for 5G usage, including on the management of interference, and the distribution and installation of satellite broadcasting kits. Within the scope of the GAISPI group, it was decided that all municipalities that are part of the metropolitan area of all State capitals, the Federal District, and cities influenced by municipalities of more than 500 000 inhabitants, would migrate first, followed by a migration schedule for the remaining regions.

This decision was motivated by the logistical gains to be obtained in the process of distribution and installation of reception kits, as well as by a better use of migration communications. In this way, GAISPI sought efficiency gains in the migration process and the best use of the financial resources contributed to the group.

It is important to emphasize that the implementation of all of the necessary actions to allow for 5G usage in a particular municipality, does not mean that the 3.5 GHz band will necessarily be available for immediate use. The migration progress in each city enables the GAISPI to evaluate, and make decisions on, the 3.5 GHz band availability, and on the possible anticipation of the release of the C band in other cities, provided that actions to mitigate interference in the fixed satellite service (FSS) receiving stations, are also completed.

As of August 2023, 1 712 municipalities, having completed the migration actions to mitigate interferences in satellite broadcasting services, were deemed ready, and have been permitted to provide 5G services. Further information and updated dashboard data can be found at https://informacoes.anatel.gov.br/paineis/espectro-e-orbita/gaispi-liberacao-e-planejamento-3-5-ghz.

## Objectives of the public policy strategy

The main objectives of the current public policy strategy were two-fold, first, to allow for the usage of the 5G in the 3.5 GHz frequency band, and second, to allow the migration of the existing satellite services to a more advanced and interference-free digital broadcasting service.

Both actions are strategic to the Brazil context, as Brazil is a country large in territorial area that needs to rely on satellite services to extend coverage, both for broadcasting and for other services, including broadband Internet.

# Annex 16 –Digital broadcasting needs in developing countries

## A.16.1 Argentina

The role of information and communication technology (ICT) was reinforced during the Covid-19 pandemic, when connectivity became essential for citizens to continue with their jobs, education, communication and entertainment. Today without ICT, people risk being excluded from the digital economy. Providing connectivity to all of Argentina, involves thinking about various specific strategies that are integrated into a general strategy.

Through the Conectar Plan, the Government of Argentina have worked to deliver connectivity infrastructure to remote areas, so that every citizen can utilize digital technologies and take advantage of their full potential. Regarding the Conectar Plan, it stands out as a lesson learned, in that the Conectar Plan is a public policy sustained over time, and that transcends the different administrations that succeeded each other in the National Executive Branch. In this sense, the connectivity policy that is reflected in the Conectar Plan is a continuation of the various initiatives implemented by the National Government since 2010, when the Argentina Conectada Plan was formulated.

The adoption of a tailored approach for each region of the country, with due consideration of specific singularities, involved providing a digital solution to fit the needs of each region, and providing satellite or optical fibre solutions according to the specific characteristics of each region. For remote areas, satellite connectivity proved an effective solution to connect small towns and cities where the deployment of optical fibre would be difficult. One of the lessons learned from this experience is that it is important to diversify investments in connectivity technology to effectively connect the unconnected and to strategically allocate public resources.

In Argentina, the Conectar Plan, implemented by Arsat, a state state-owned telecommunications company, has contributed also to the transition from analogue to digital broadcasting through an open digital terrestrial television platform, called Open Digital Television (TDA), that constitutes a state policy that began in 2009, with the selection of the integrated services digital broadcasting – terrestrial (ISDB-T) standard. The Conectar Plan also comprises updating and recovering of all transmission stations, the renewal of the transmission platform to improve image quality, and strengthening of equipment to avoid transmission outages.

## A.16.2 Côte d'Ivoire

The status of the digital terrestrial television (DTT) transition in Côte d'Ivoire is outlined in this section. A steering body was established in 2017, and DTT was officially launched 2019, followed by the launch of the campaign to switch off analogue television in Abidjan in 2021, and the cessation of transmissions with the old RTI antennas in the same year.

Côte d'Ivoire has been able to meet economic, social, and institutional challenges for the deployment of DTT, including Government investment of approximately XOF 30 billion. The national objective of switching off analogue transmissions before the end of December 2021, has been complied with.

State of needs in terms of digital broadcasting:

- According to the provisional results of a survey on DTT penetration from 2022, the adoption by households in Côte d'Ivoire of this technology remains a major challenge. Four major axes summarize the needs of the populations in this area:
- Improved content and diversity of programmes[114].
- Improved communication and easier acquisition of free DTT[115].
- Targeting of the most vulnerable populations[116].
- The conquest of new markets[117].

## A.16.3 Guinea

The status of the DTT transition in Guinea is outlined in this section. Private broadcasters began transmissions in 2008, while transmission by the public broadcaster began in 2015, which allowed for the coverage of part of the Greater Conakry region and other areas. Licences were granted to four TV broadcasters and five cable distributors, and the digital dividends in both cases were released.

State of needs in terms of digital broadcasting:

- Improvement of the territory coverage by DTT[118].
- Capacity building needs[119].
- No current needs for new services and applications[120].

114 It would be appropriate to increase the number of free-to-air channels available on the free DTT offer. Households without free DTT subscribers, particularly in urban areas, present the number of free DTT channels as an obstacle to its acquisition. An improvement in the diversity of programmes served by DTT is required. The analysis reveals that the improvement points of free DTT according to households are, among other things, the programming for youth and for early childhood, the programming of television series (africaines or "novelas") and sporting events.

115 Even though the overall awareness of DTT is very high, around 72.6 per cent, DTT offer has not yet entered the daily lives of the households surveyed. Only 4.4 per cent of households surveyed cite free DTT as a television offer, and only 1.2 per cent for Pay DTT. It is important to intensify communication on free DTT, in particular via television. It would be possible to broadcast commercials on the 7 channels already present simultaneously on free and pay DTT, or even on other popular satellite channels. Beyond that, an intensive campaign on social networks, for example with the intervention of influential personalities, could make it possible to increase market share. It would also be possible to present DTT as an additional offer to the offers that are already present in households. It will, therefore, be necessary to insist on DTT's uninterrupted character. Finally, it is important to facilitate the acquisition of DTT kits by households. Although this was not the main objective, the survey showed that only 33.5 per cent of the 50 households surveyed had a DTT point-of-sale in their immediate surroundings. Like the points-of-sale for satellite offers, or mobile money offers in telecommunications, it would be necessary to significantly increase the number of points-of-sale per household living area.

116 Analysis of the determinants of DTT makes it possible to understand that socio-economic categories of households (income level, housing amenities) and these categories serve as excellent explanatory factors for the adoption of free DTT. It would be interesting to carry out sustained local awareness campaigns in the geographical areas with the most poor or vulnerable households.

117 An intense promotion of DTT kits in collective public places such as hospitals, restaurants, and hotels would make it possible to anchor DTT in the daily lives of households.

118 The country needs technical and financial assistance to densify the network that will be deployed by the current DTT migration project in place, financed jointly by the development and investment banks of France (BPI France) and the CEDEAO (BIDC). The 15 sites and the two multiplexes planned by the referred project are insufficient to cover the 33 prefectures with the DTT network.

119 The country needs support in terms of capacity building in the audiovisual field, especially the personnel of all the stakeholders, including the regulator, the ministries involved, as well as the staff of radio and TV broadcasters. The country also needs support for the development of legal texts in the matter.

120 The needs relating to the evolution of audiovisual technology for the country are, for the moment, future innovations, since digital technology is not yet very developed in the country.

According to the Guinea case study[121], the digital terrestrial television (DTT) project comprises 15 sites. Given that the country has 33 Prefectures, the 15 sites planned by this project will not cover all the territory. To achieve the objective of covering the rest of the country, Guinea must find ways to provide reception kits to families living in areas not covered by DTT.

More information on the overall strategy and implementation progress can be found in Annex 13 of this Final Report.

## A.16.4 Senegal

The status of the DTT transition in Senegal is outlined in this section. A national strategy was established following concertation among all stakeholders. This national strategy comprised technical, economic, legal, and audiovisual dimensions. The implementation began in 2014. After the creation of the Senegal Broadcasting Company (TDS), as sole operator responsible for carrying out the distribution activity, and for the technical and commercial operation of the DTT infrastructure. The national strategy implementation currently comprises 23 sites spread across the country. These 23 sites cover most of the national territory with 31 transmitters (including four transmitters in the capital and two in each of the bigger cities. Dakar, the capital, has 80 channels on four multiplexes) and following the switch-off of some of the analogue broadcasting of TV channels, a coverage of approximately 70 per cent of the demographic is ensured.

State of needs in terms of digital broadcasting:

- A direct to home (DTH) satellite offer, in addition to terrestrial broadcasting to cover the territory.
- Integrated decoder options, including DTT, satellite and Internet service offers.
- Mobile television services (smartphones and tablets).
- Video-on-demand and catch-up TV offers.
- Interactive and transactional programmes, such as banking, games, and education programmes.
- Access to more regional and local content.
- Thematic television channels, such as the "Télé Ecole" school/education channel that was established during the COVID crisis.

## A.16.5 Brazil

The status of the DTT transition in Brazil is outlined in this section. A DTT standard was adopted in 2006 and initial transmissions began in 2007. Between 2016 and 2018, analogue transmissions were switched-off in all state capitals and other major cities to allow for a Fourth Generation IMT advanced system operating in the 700 MHz band. Since 2021, a new phase is being carried out to complete the digital switchover in all locations where analogue TV is still in operation. A deadline was set for the end of 2023, based on a projection of the expected lifespan of existing household analogue TV sets[122].

121 ITU-D Document https://www.itu.int/md/D22-SG01-C-0250/ from Guinea.

122 In the first phase, 1 379 municipalities, comprising 129.6 million people, completed the analogue switch-off, including all state capitals, metropolitan areas, and other areas where the analogue switch off was required to clear the 700 MHz band, corresponding to 62.6 per cent of the Brazilian population. The second phase comprised 2 896 municipalities, some of these already having partially digitized transmissions, and others having analogue TV only (1 639 municipalities).

State of needs in terms of digital broadcasting:

- Completion of the digital switchover and shutdown of the last remaining analogue TV stations in remote areas and municipalities.
- Evolution of the digital television offer with the development of the TV3.0 standard[123].

## A.16.6 Bosnia and Herzegovina:

The status of the DTT transition in Bosnia and Herzegovina is outlined in this section. In 2007, the Broadcasting Sector Policy was established, followed in 2009, by the strategy for transition from analogue to digital terrestrial broadcasting and by Rule 90/2018 on the provision of electronic communications network management services in digital terrestrial broadcasting. Transmissions started with the implementation of both public and commercial broadcasting multiplexes, the latter successfully implemented by 2021.

State of needs in terms of digital broadcasting:

- Complete the process of transition to digital terrestrial broadcasting;
- Implement new services, such as OTT, digital platforms, video sharing platforms. Special attention to be paid to the regulatory response to the new broadcasting landscape, and to the changes in consumers habits;
- Adaptation to the European Union regulatory provisions, such as the Digital Service Act (DSA), and the Digital Market Act (DMA), and due attention to the discussions on the Fair Share initiative by the European Telecommunications Network Operators Association (ETNO).

[123] Following the take-up of the deployment and the innovations incorporated and planned to be included to the digital television standards and systems, the SBTVD established the TV3.0 Project, aimed at incorporating the latest evolutions into the Brazil digital television system, including personalized content, app-based TV experience, UHD/HDR video, immersive audio, enhanced accessibility features, advanced emergency warning system, IP-based technologies and frequency reuse.

# Annex 17 – Case studies of digital radio broadcasting implementations

## A.17.1 Brazil case study

As is the case for a digital television transition, a digital radio broadcasting migration also involves planning and coordination. One example of such a migration was implemented in Brazil. Discussions about the adoption of digital radio began in 2007, and the National Telecommunications Agency (Anatel), the telecommunications regulator, and the Ministry of Communications (MCom) began coordinated testing, with the broadcast industry, of HD radio and digital rights management (DRM) systems. In 2010, the Brazilian Digital Radio System (SBRD)[124] was instituted through Ordinance No. 290/2010, which defined the usage of the digital radio system for MW and FM.

In 2012, with the objective of assisting in the implementation of digital technology into the audio broadcasting system, the Digital Radio Advisory Council[125] was established to advise the Minister in the implementation planning of the Brazilian Digital Radio System (SBRD).

The Digital Radio Advisory Council was made up of representatives of civil society, of Federal Government, including Anatel and the Ministry, of the broadcasting sector (commercial, educational, community and public actors), of industry (reception, transmission and audiovisual actors), of academic institutions; and of advertisers. The Ministry of Communications was in charge of the coordination of the council. Council sub-groups were also created:

- CCRD1: A thematic commission addressing policy;
- CCRD2: A thematic committee addressing technological innovation;
- CCRD3: A thematic committee addressing test analysis and monitoring.

In Brazil, the general consensus was that the tests had to be directed to in band on channel (IBOC) systems, which use the same band as analogue systems. This was because the interested parties felt at the time that IBOC systems were easier and cheaper to deploy as they could be activated with the same physical structure as analogue stations using adjacent channels. Additionally, it was the view of the Ministry and ABERT (Associação Brasileira de Emissoras de Rádio e TV) that the systems were recommended to be deployed in both FM and AM and would have minimal financial impact on broadcasters.

Recently, discussions have been underway to allocate spectrum that could allow simulcast transmissions on both digital and analogue radio systems. However, the deployment of digital radio in Brazil remains under discussion, and one of the reasons for this is that analogue radio is still very popular, and consequently some initiatives were carried out to expand the usage of the FM band, which has a better service quality. This case study is presented below.

[124] SBRD – Sistema Brasileiro de Rádio Digital, in Portuguese.

[125] CCRD – Comitê Consultivo do Rádio Digital, in Portuguese.

## Broadcasting transition – AM-FM migration in Brazil

The adaptation of authorizations for amplitude modulation (AM) radio service stations, operating in medium wave (MW) radio licences, to migrate to frequency modulation (FM) radio service stations, is a successful example of public policy employed to prioritize small radio stations in Brazil.

The migration aimed to strengthen both the broadcasting sector, and small AM radio stations in Brazil, impacted by the abandonment of audiences in face of increased interference and noise, especially in urban areas. The migration of the AM radio services to FM radio services allowed improved audio and transmission quality, in addition to enabling the transmission of programming onto mobile phones, with an immediate increase in audiences and revenues. Currently, of the 1 781 AM radio station authorizations, approximately 1 720 stations have requested the migration to FM.

## Extended FM range

To meet the spectrum requirements for migration, the Brazilian National Telecommunications Agency (Anatel) made available channels in the currently allocated band for FM radio (88-108 MHz). However, it was found to be technically unfeasible to include new channels in some high-spectrum occupancy regions. Consequently, in 2019, Anatel completed a revision of its technical regulations for audio broadcasting to extend the FM band down to 76 MHz, thus adding 60 new channels. The extended FM band (76-88 MHz) in Brazil will be entirely available after the analogue TV switch-off, foreseen to be completed by the end of 2023.

In 2021, the MERCOSUR (Southern Common Market) administrations achieved consensus on establishing the technical parameters for coordinating FM channels within the extended FM band (76-88 MHz). These parameters included protection ratios, which were determined based on sharing studies conducted by the Brazil administration, encompassing both analogue TV and FM stations. The approval of these technical parameters paved the way for commencing frequency coordination procedures among the administrations of the MERCOSUR Member States.

In 2022, Brazil led discussions within the Inter-American Telecommunication Commission (CITEL) to develop Recommendation PCC.II/REC. 66 (XXXIX-22), which recommends that CITEL Member States evaluate the use of the extended FM frequency band (76-88 MHz) for the provision of FM audio broadcasting services. The Recommendation also states the importance of administrations establishing bilateral or multilateral frequency coordination agreements in the extended FM band, in order to guarantee interference-free operation, and that administrations should consider taking actions to facilitate the production of receivers capable of tuning into stations in the 76-108 MHz band.

## Milestones of the migration

- In May 2010, the National Telecommunications Agency published a study on the technical feasibility of migrating from AM radio to the FM band, using television channels 5 and 6 in Santa Catarina State;
- After discussions with broadcasters, on 07 November 2013, the migration decree, Decree No. 8.139/2013 was published;

- On 12 March 2014, the Ministry of Communications published an ordinance that regulated the migration of AM radio to the FM band (Ordinance No. 127/2014);
- On 25 August 2014, the Ministry of Communications issued the first authorizations for the radio migration, followed by Ordinance No. 6 467/2014 which defined the prices for migrating from AM to FM radio, published on 24 November 2015;
- On 23 May 2017, the Ministry of Science, Technology, Innovations and Communications regulated how the medium wave channels would fall back to the Brazil's Federal Government (Ordinance No. 2771/17);
- On 25 January 2018, Decree 9.270/2018 opened a new period of 180 days for the remaining broadcasters to present the request for migration from AM radio service to FM;
- In February 2020, Anatel published Resolution 721/220 which included technical parameters to extend the FM band to 76-88 MHz;
- In October 2021, the Mercosur Sub-Working Group no. 1 "Communications" approved the revision of the technical rules that are applied for frequency coordination of FM audio broadcasting stations in border zones to include the FM extended band (Resolution 47/2011); and
- In April 2022, the Inter-American Telecommunication Commission (CITEL) published Recommendation PCC.II/REC. 66 (XXXIX-22), which recommends that CITEL Member States evaluate the use of the 76-88 MHz frequency band for the provision of FM audio broadcasting services.

### Objectives of the public policy

The migration from AM to FM, aimed at increasing audio and transmission quality for small radio stations throughout Brazil. However, other objectives were also achieved with this policy, including reinvigorating the FM market and increasing content availability and competition.

FM technology has proven to be still attractive to the broadcasting industry in Brazil, which was not the case for AM radio stations which became less attractive due to interference. With the migration from AM to FM, several new radio stations could be included in the radio station range of many urban areas, adding increased options and a more diverse programming set, which is beneficial for the public.

Another important achievement is the more efficient use of spectrum, delivered through the use of television channels 5 and 6 that were released following the analogue television switch-off (ASO), enabling effective service delivery with radio broadcasting. New usages are also under discussion, such as use of the same spectrum freed by the ASO to speed up the transition from analogue to digital radio broadcasting in Brazil, with the possibility of allocating simulcast channels, as was the case for television. However, this option is still under discussion in Brazil.

For more information on digital radio transition and adoption, refer to Chapter 4, section 4.2.7, of the Final Report on ITU-D Question 2/1 for the 2017-2021 study period, available at https://www.itu.int/hub/publication/D-STG-SG01.02.2-2021/.

## A.17.2 DAB and DAB+ technologies adoption

The level of adoption of digital radio varies from country to country. Norway stands out as the sole country to have discontinued FM transmissions and fully transitioned to digital audio broadcasting (DAB) technology in national radio broadcasting.

A number of countries such as Hungary, Portugal, Ireland, and Romania introduced DAB+, but after several years' experience, they each ceased DAB broadcasting and shut down the receiver network.

Other countries maintain both analogue FM and DAB systems, with the two coexisting rather than replacing one another. In most countries DAB and FM operate concurrently, with some stations expanding their coverage areas across different networks.

Some countries have official DAB+ multiplexes, and there are 30 of these worldwide, while in 28 countries, DAB+ exists as a pilot project.[126]

Population coverage percentages of DAB+ signals in European Union countries are high, ranging from 42 per cent in France at the bottom of the European Union table, to Italy at 86 per cent, Germany at 98 per cent, the United Kingdom at 97 per cent, and Denmark at the top of the table with 99.9 per cent (data from WorldDAB).

In the case of Bosnia and Herzegovina[127], the regulator for electronic communications began the process of introducing digital radio by issuing a public call for a DAB multiplex with specified conditions regarding coverage and deadlines to provide the services. However, as is the case in many other countries, Bosnia and Herzegovina is considering the profitability of this investment, and the real level of interest among users and radio broadcasters for this form of broadcasting, given that current estimates suggest that a relatively low number of citizens own DAB receivers. For this reason it is anticipated that the simultaneous broadcast of FM and DAB radio will persist into the foreseeable future.

The future of digital audio broadcasting (DAB) presents both opportunities and challenges, especially in the face of competition from other radio platforms and streaming services. As FM radio remains one of the last remaining analogue technologies, its limitations necessitate a shift to digital platforms. Younger audiences often view traditional radio as outdated, favouring alternatives such as YouTube, Spotify, and podcasts. However, fully transitioning to streaming services faces obstacles such as limited mobile network coverage, high data costs, and capacity issues. Policymakers should consider several factors when deciding upon DAB implementation, including its growing rate of adoption due to the superior sound quality and additional features of DAB, the influence of regulatory support and the influence of content diversity on user interest, as well as potential innovations such as interactive features, and smart device integration. Despite competition, the strengths of DAB in terms of broadcast reliability, spectrum efficiency, and localized content can help it to remain relevant. The future of DAB in developing countries will depend on economic development, technological advancements, regulatory support, and evolving user preferences.

### *i) DAB+ in Norway*

Despite the switchover from traditional FM to DAB+ digital radio in Norway in 2017,[128] the initiative can be seen as an effort towards a form of NextGen FM.

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126 https://www.worlddab.org/countries

127 ITU-D Document https://www.itu.int/md/D22-SG01.RGQ-C-0214/ from Bosnia and Herzegovina.

128 https://insight.npaconseil.com/techno-equipements/lexemple-reussi-de-la-transition-vers-la-radio-numerique-en-norvege/ (in French)

DAB+ offers better sound quality, increased channel capacity, and increasingly efficient data services. The components of NextGen FM could be inspired by successful switchovers in other countries.[129]

ITU has been studying this topic.[130]

### Hybrid radio

A hybrid radio is a device that allows you to receive broadcasts from radio stations via:

- digital audio broadcasting (DAB) or HD FM broadcasting, and/or
- Internet (IP) streams.

The purpose of a hybrid radio is to provide a seamless broadcast service anywhere. When one transmission method becomes unavailable or weak, it is superseded by another.

The beauty of using a hybrid radio in an automotive context is that connection to the radio station can be maintained despite changing conditions.

For example, during a long-distance drive, a listener may travel out of the range of the FM signal of a station. If the vehicle is equipped with a hybrid radio, the hybrid radio will find another way of receiving that station and select it automatically, so that the listener can continue listening without interruption.[131]

According to the European Broadcasting Union "*The introduction of digital and hybrid services can reinstate and fortify the role of radio as the backbone of audio consumption in the years to come*."[132]

#### *ii) DAB+ in Senegal*

Within the framework of the development of broadcasting services in Senegal and following the adoption of DAB/DAB+ standards by the international community, Senegal launched a pilot project for digital terrestrial radio (DTR). This pilot project began in May 2022, in Dakar, with broadcast tests on channels 10A and 10C.

Faced with the saturation of the FM band in some regions, Senegal undertook this DTR pilot project using the DAB+ standard to explore alternatives to frequency modulation (FM) broadcasting and to meet the growing needs of radio promoters.

DAB+ is a digital broadcasting technology that allows more stations to be broadcasted on the same frequency channel through digital compression, thus providing audio quality that is superior to that of analogue FM. In addition, the DAB platform provides access to rich multimedia content (text, images, video), and is more energy efficient, contributing to its reputation as a 'green' technology. By reducing the number of transmitters required, DAB+ also reduces non-ionizing electromagnetic radiation.

129 https://www.tecnonews.info/tecnonewsworld/norway_makes_history_with_radio_s_first_digital_switchover
130 https://www.itu.int/en/ITU-R/terrestrial/workshops/SRME-19/Documents/Workshop/SRME-19-DigitalRadio.pdf
131 https://developers.radioplayer.org/use-cases/hybrid/
132 https://tech.ebu.ch/groups/radio

### Digital terrestrial radio pilot project objectives

Senegal officially launched the pilot project on 10 May 2024, with the following objectives to:

- decongest the FM band;
- respond to the shortage of frequencies;
- promote technological innovation;
- solve interference problems;
- promote test coverage, quality of service (QoS), and user experience (QoE);
- analyse the costs and availability of receivers;
- study the CAPEX and OPEX per station.

For the evaluation of this experimental phase, a measurement protocol was defined, including coverage mapping, key performance indicators (KPIs), evaluation of receivers (portable, fixed, DAB+ USB sticks), field measurements and benchmarking with international standards.

### Selection of radios

The criteria for selecting the radios for this experiment are based on:

- the status of radio stations (public, community, commercial, foreign);
- geographical proximity (Dakar, regions);
- collection media (encoder/decoder, Internet streaming, satellite);
- recording techniques (mono, stereo).

A total of 32 radio stations were selected to participate in the pilot phase.

### DAB+ station coverage

The stream of each radio programme is transmitted at a bit rate of 64 Kbit/s with EEP3-A protection level. The field tests, carried out using a SANGEAN receiver, made it possible to capture 32 flows along the Kayar-Toubab Dialaw axis in the direction of Dakar.

During the last quarter, a quality of service (QoS) monitoring plan was developed, using the Audemat FM/DAB+ MC-6 tool, in order to exhaustively map the signals received over the entire Dakar region.

### Implementation schedule

In terms of the implementation schedule, the following steps are considered:

- Drafting and signing of a protocol between the regulatory authority and the national broadcasting company. This protocol must define the objectives of the pilot project by specifying a matrix of responsibilities between the stakeholders.
- Overall evaluation of the pilot project: A complete analysis of the results obtained, highlighting performance indicators such as:
    - The benefit/cost ratio of infrastructure.
    - The benefit/cost ratio of receiver kits.

– Consultation between stakeholders: The establishment of a national committee to coordinate efforts and ensure synergy in the implementation of the project.
– Recommendations on the business model and next steps:
  - Development of recommendations on the business model to be adopted.
  - Definition of the next steps, with a key decision to be made between scaling up ("Go") or a paradigm shift ("Not Go"), depending on the results obtained.

– National policy and strategy:
  - Definition of a national strategy aimed at diversifying the offer of services.
  - Promotion of social inclusion and territorial equity to ensure that digital broadcasting is accessible to all segments of the population, including in the most remote areas of the country.

These steps are intended to ensure an efficient transition to digital broadcasting, while taking into account the specific features and national priorities for the development of audiovisual services.

## Status of implementation

This pilot project is an opportunity to present the technical details of the solution, including a collection network (32 channels), a head-end (32 encoder/decoders), a distribution network (two + one transmitters each of 600 W) and a supervision system (two computers with software).

In terms of receiving terminals, 99 fixed receivers, 99 mobile receivers, 99 handheld receivers and 99 DAB+ USB keys were acquired. This equipment was distributed to institutional players, radio publishers, training institutes, and the general public in order to conduct qualitative and quantitative tests.

Unfortunately, these types of receivers are only available in specialist technical equipment stores. In addition, most cars are not yet equipped with DAB+ receivers to switch between digital radio and FM signals via a selector.

For this reason, many countries maintain both analogue and digital FM DAB+ systems, with the two co-existing, rather than replacing each other. As a result, most countries are simultaneously operating DAB+ and FM, with some stations extending their coverage areas across different networks.

In accordance with Article 4 of the Geneva 06 Agreement, Senegal has initiated international coordination for the notification of frequencies to ITU, with a view to their publication and recording in the ITU international register.

Senegal is the first West African country to be tested for DAB+ since June 2022.

In terms of steering, it is crucial to re-examine the importance of technical coordination, the organization of test broadcasts, the introduction of DAB multiplexes, opportunities for programme enrichment, parallel FM/DAB broadcasting, regulatory adjustments, and equipment adaptation in the automotive industry.

To this end, a dedicated national committee should be set up to deal with these issues properly, in order to avoid the pitfalls encountered previously in the implementation of digital terrestrial radio (DTR).

## General guidelines

The future of digital terrestrial broadcasting (DTB) in Senegal presents both opportunities and challenges, particularly in the face of the rise of streaming platforms. The optimization of the FM band is essential in order to compensate for the current saturation, and to accommodate new services.

FM radio broadcasting is one of the last remaining analogue technologies still in use in the current digital era. In Africa, the saturation of the FM spectrum limits the available space for new programmes and services, necessitating the development of new digital radio platforms.

While many alternatives such as YouTube, Spotify, Deezer, and various podcasts offer options for listening to music and audio content, it is pertinent to wonder about the future of radio in its traditional form.

It has been noted that the transition to streaming-only services faces several challenges, including insufficient coverage with new generations of mobile networks, high costs associated with using mobile data, and capacity limitations.

For a successful implementation of DTR, the following recommendations are proposed:

- **Adoption**: Encourage the adoption of DTR because of its sound quality, diversity of available stations and additional capabilities.
- **Market dynamics**: Foster high user engagement through regulatory support and diversity of content.
- **Innovation and interactivity**: Integrate innovations to improve the user experience, such as personalized content recommendations.
- **Internet connectivity**: Consider the transition to digital platforms, while taking into account the challenges of network coverage and mobile data costs.
- The success of DTR depends on regulatory support, innovation in content, and user preferences. To this end, Senegal could consider creating a **national committee** responsible for defining strategies for migrating to digital technologies and promoting their adoption.

In short, the future of DAB+ will depend on such factors as economic development, technological advances, regulatory support, content innovation, and user preferences.

Despite competition from other platforms, digital terrestrial radio (DTR) can leverage its strengths in terms of delivery reliability, spectrum efficiency, and localized content to remain a relevant and attractive choice for radio enthusiasts.

# Annex 18 – Case studies of spectrum planning for digital broadcasting, including interference mitigation

## A.18.1 Spectrum monitoring in Argentina

The policy adopted by Argentina for the administration and management of the radio frequency spectrum not only defines the provision of telecommunications services, but also impacts companies that develop services and solutions relying on this resource, even if they are not necessarily licensed for information and communication technology (ICT) services. The future of innovation in production processes is tied to the advancement and promotion of high-capacity wireless network deployment, a key element in boosting the productive matrix of the nation.

Within the ICT sector, the spectrum is one of the most relevant resources for the provision of mobile telecommunications services. The management of spectrum resources in Argentina has gone through different phases throughout history, depending on the socio-economic and productive model proposed by each government administration. These phases ranged from extraction and concessions to private entities (both national and foreign), to models of public exploitation.

However, in 2021, Argentina introduced a domestically developed platform for the technical verification of electromagnetic emissions in the radio frequency spectrum. This reversed the previous logic, where spectrum management was carried out by international third-parties, or through technological solutions provided by foreign companies, thus concluding the cycle of sovereignty over the management of the natural resource initiated in 2004.

The recently acquired technological solution, called the iSpectrum App, is entirely local and the result of collaborative efforts between the public and private sectors, which flourished thanks to policies promoting the development of the knowledge economy.

The iSpectrum App is a flexible solution that simplifies and automates radio frequency spectrum monitoring activities. Currently focused on terrestrial services with minimal connectivity and hardware requirements, it has the ability to control and manage equipment independently of the manufacturer, including digital receivers, measuring equipment, and peripheral accessories such as uninterruptible power supply (UPS), global positioning system (GPS), antenna switches, routers, and PCs, among others. These features facilitated the deployment, adaptation, reuse, and capacity expansion of existing equipment in the national technical emission verification system (SNCTE) of the communications regulatory authority. Work is currently underway to incorporate the monitoring of satellite services, coverage planning (4G/5G/FM/DTT/satellite), signal localization, and automated measurements using unmanned aerial vehicle (UAV) systems.

Argentina has made progress in solving historical problems such as the technological obsolescence of its radio emissions verification system, and its dependence on the global oligopoly of hardware manufacturers. It has also addressed current challenges, such as the lack of foreign exchange to acquire international goods and services, operational difficulties in having highly qualified human capital, and long-term projections, positioning itself with its capabilities at the forefront of mobile technology evolution.

The Government of Argentina considered the effective and efficient use of public resources by deciding to nationalize the management of the radio frequency spectrum in 2004, with the aim of prioritizing the development of individuals and society. In this way, the public value chain is promoted, creating opportunities for local companies and workers, that can serve as a model for other countries.

### A.18.2 Interference mitigation strategies in Brazil

An example of policies implemented to mitigate interference is that of Brazil[133]. This case study highlights the satellite broadcasting policy adopted in Brazil to extend the coverage of television broadcasting to remote and rural areas, as well as suburban areas without optimal digital terrestrial television (DTT) coverage. The initiative was also targeted at solving the problem of interference caused by the 5G networks of neighbouring countries/stations using the 3.5 GHz frequency band, to satellite broadcasting services in the C band using the same band (3.5 GHz).

The solution that was proposed was to migrate existing satellite broadcasting technologies in the C-band, to another frequency band, the Ku-band. This led to the need to provide appropriate digital receivers to low-income populations and has also promoted the extension of digital satellite broadcasting coverage in these areas.

In addition to the main objective of avoiding interferences, other specific objectives include, to allow the use of 5G in the 3.5 GHz frequency band and, to facilitate the migration of existing analogue satellite services to a digital broadcasting service exempt from interference.

As part of the transition to digital satellite broadcasting, two entities were created. One for monitoring the implementation of solutions to interference problems in the frequency band 3 625-3 700 MHz (GAISPI[134]), and the other for the management of the 3.5 GHz band (EAF – Siga Antenado[135]). These entities are operational and have created communication channels to inform beneficiaries of reception kits about the procedures to obtain and install the reception kits. Both entities, GAISPI and EAF, are responsible for the equipment included in the kits, the acquisition and distribution costs, and the scheduling of activities.

The migration process is expected to continue until 2025, and so there will be a simulcast period of transmissions in the current band (C-band) and in the new band (Ku-band), followed by the discontinuation of transmissions in the C-band. After the end of the simulcast period, only households that have received kits or purchased new devices will be able to continue watching satellite TV in digital.

The GAISPI and EAF entities are also responsible for organizing awareness and information campaigns to update the registration of terrestrial stations of the fixed-satellite service operating in the C band, both for the correction of data, such as geographical coordinates, and for the creation of new listings, mainly from reception stations. More information can be found in Annex 15 of this Final Report.

133 ITU-D Document [https://www.itu.int/md/D22-SG01-C-0143/](https://www.itu.int/md/D22-SG01-C-0143/) from Brazil.
134 GAISPI - Monitoring Group for the Implementation of Solutions to Interference Problems in the Frequency range of 3,625 to 3,700 MHz.
135 3.5 GHz Band Administering Entity (EAF).

### A.18.3 Case study on eliminating harmful interference in Bosnia and Herzegovina

In Bosnia and Herzegovina[136], the transition from analogue to digital broadcasting services began in 2006, with the aim not only of complying with the Geneva Agreement GE-06, which defined 17 June 2015, as the end of the transition period, but also to benefit from an efficient use of the frequency range and to offer a better quality of television broadcasting with advanced services to its citizens.

Unfortunately, the project was delayed, leading to interference with neighbouring countries that have completed their digitization process and advanced in the introduction of new technologies, especially for 5G deployment.

According to the frequency allocation plan, the UHF and VHF spectrum is divided into respective groups of very high frequency (VHF) and ultra-high frequency (UHF) channels: VHF 5-12 channels (used by public broadcasters) and UHF 21-69 channels (for all broadcasters). The UHF TV channels frequencies band should be reassigned from broadcasting to mobile services (digital dividend) and is further divided into 3 blocks of channels, as follows:

| | | |
|---|---|---|
| 21-48 | 49-60 | 61-69 |

Each country is required to comply with ratified international agreements and take immediate steps to eliminate interference from television channels that no longer have the right to broadcast analogue signals. This was the case when Croatia filed a complaint against Bosnia and Herzegovina in April 2021, regarding interference in the 700 MHz frequency range (attributed to 5G technology) from analogue broadcasting in Bosnia and Herzegovina.

Bosnia and Herzegovina quickly reacted by implementing several actions, including the granting of multiplexes for commercial broadcasting. In its proceedings, the Bosnia regulator informed the competent institutions and licensees of the request received from Croatia. In this regard, meetings were held with representatives of broadcasters, during which a schedule for the shutdown of the analogue signal was set, from 01 July to 31 December 2021. It should be noted that 171 transmitters from 26 television stations throughout the country were affected by the shutdown of analogue broadcasting.

At the time of receipt of the application from Croatia, Bosnia and Herzegovina had only one multiplex (MUX A) in operation, intended for public service broadcasting, with a capacity of 19.9 Mbit/s, due to technical limitations imposed by the DVB-T technology.

It was clear that under existing conditions it was possible to broadcast six TV program streams (three public HD 720p HD programmes, at 4 Mbit/s each and 12 Mbit/s total, and three commercial SD programmes, at 2 Mbit/s each and 6 Mbps total) in each region. Through further analysis, it was confirmed that, under the existing conditions, and given the available multiplexes in each region, it was not possible to broadcast the 26 program streams affected by the analogue shutdown in compliance with the complaint received, without compromising the operation of public broadcasting services.

[136] ITU-D Document https://www.itu.int/md/D22-SG01-C-0201/ from Bosnia and Herzegovina.

In view of this and the fact that MUX A was allocated to public broadcasting services, it was requested that commercial television stations should contact public broadcasting services, to negotiate entry into MUX A in accordance with available technical capacity, explicitly emphasizing that consent would be given for any agreement reached. In the meantime, the process of setting up the multiplex for commercial television channels began, and this multiplex is now fully operational. As a result, there are now two fully operational multiplex operators in Bosnia and Herzegovina: MUX A for public broadcasting and MUX D for commercial broadcasting.

In addition, it can be noted that the programming of the 26 television channels, the subject of the application from Croatia, was also included in the offer of almost all cable operators in Bosnia and Herzegovina, with coverage of up to 90 per cent of all households in the country, a fact that facilitated the analogue switch-off.

## A.18.4 Interference mitigation policies in Senegal

Interference is a major problem for radiocommunications because it interferes with signal transmission. The broadcasting service in the VHF/UHF bands, which is a significant user of the radio spectrum in West Africa, is increasingly confronted with interference issues arising from the rapid technological evolution which has created an increasing demand for spectrum in these bands.

The proliferation of broadcasting stations has increased the volume of harmful interference, not only between the broadcasting stations themselves, but also with other radiocommunication services.

In addition, the ending of simulcast has not yet been effected in all West African countries. This could lead to interference between neighbouring countries. Indeed, some countries have already deployed 4G mobile networks in some digital dividend frequency bands, while analogue TV continues to operate in others.

According to the Radio Regulations (RR) of the International Telecommunication Union (ITU), there are three types of interference:

- Permissible interference: Observed or predicted interference that meets the interference levels and quantitative sharing criteria set out in the Regulations, or in ITU-R Recommendations or in special agreements, the possibility of which is provided for in the Regulations (RR Article 1.167).
- Accepted interference: Interference, greater than that defined as permissible, which has been agreed upon between two or more administrations without prejudice to other administrations (RR Article 1.168).
- Harmful interference: Interference which endangers the functioning of a radio-navigation service, or of other safety services, or seriously degrades, obstructs, or repeatedly interrupts the functioning of a radiocommunication service operating in accordance with the Radio Regulations (RR Article 1.169).

Interference is regularly reported by administrations, the main causes of which are:

- Unauthorized transmissions.
- Lack of coordination: Harmful interference caused by the use of uncoordinated frequencies.
- Failure to comply with technical operating characteristics: transmission power, frequency tolerances, antenna orientation.

- Unnecessary transmissions: Harmful interference caused by the transmission of superfluous signals.

This issue of interference is crucial, and is the subject of ongoing study by ITU and administrations.

## Subregional approach to mitigating interference

Within the framework of interference prevention and management, Senegal, Gambia, Guinea, Guinea-Bissau, Mali, Mauritania, and Cabo Verde adopted in August 2009, a Coordination Framework document for coordination and sharing of frequencies at borders with the participation of 21 telecommunication operators.

The main objectives of this coordination framework agreement are to:

- harmonize the use of frequencies in neighbouring countries;
- guard against harmful interference in border areas; and to
- propose provisions for frequency sharing and coordination in specific frequency bands.

Note: The border zone/coordination zone is the area adjacent to the border of two countries, 15 km deep inside each country.

The Coordination Framework document was updated at several meetings between 2013 and 2020.

The legal and regulatory framework of the Coordination Framework document refers to Article 6 of the "RR special agreements". The document is composed of five general provisions and seven technical annexes.

- In practice, the coordination procedure is based exclusively on the principle of equitable access to frequency resources. In addition to the overall framework provided by the coordination framework document, bilateral agreements were signed with bordering countries providing further details on trunking channels and emission thresholds.

Thus, channels have been defined and allocated to countries in the different border areas, and this new plan is being implemented by the national operators.

Monitoring missions are carried out in response to complaints or annually. Monitoring missions provide an opportunity to verify compliance with the allocated channels as well as compliance with the emission thresholds set. For example, Senegal and Mauritania regularly carry out joint monitoring missions to verify the effectiveness of the bilateral agreement and take corrective measures if necessary.

There are many interference issues in border areas, especially for mobile communication services. The coordination framework document and the bilateral agreements focus, at this stage, mainly on these services rather than on broadcasting. The development of DTT in the countries of this subregion is not yet sufficiently advanced.

However, this established coordination framework may contribute to the resolution and prevention of future interference conflicts related to the widespread deployment of DTT at different rates.

# Annex 19 – Case studies of digital dividend usage

## A.19.1 Italy case study

This case study considers the approach taken by Italy, following discussions at European level, concerning the release of the 700 MHz frequency band and the reorganisation of digital terrestrial television. Figure A.19.1 shows the approach taken by Italy in the release the 700 MHz frequency band. Coordination at the European level and thorough planning were key components in the approach of Italy.

Figure A.19.1: Release of the 700 MHz frequency band in Italy

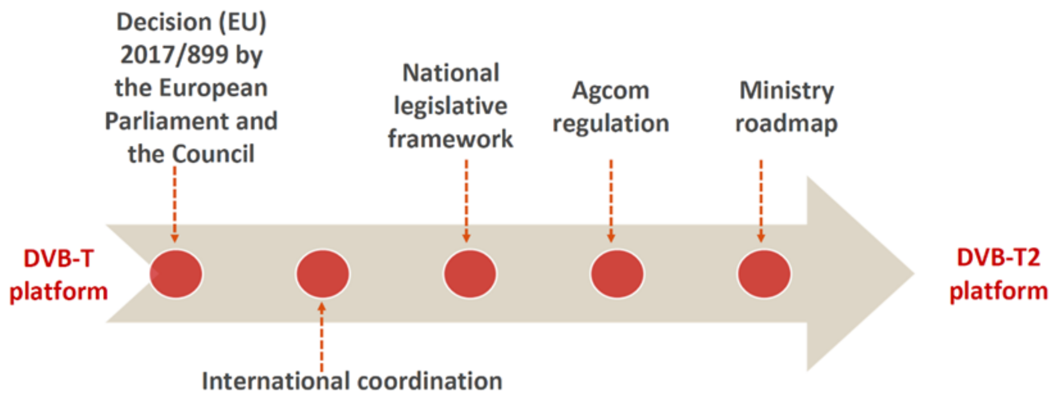



Figure A.19.2: Roadmap for DTT move from 700 MHz to lower frequency bands

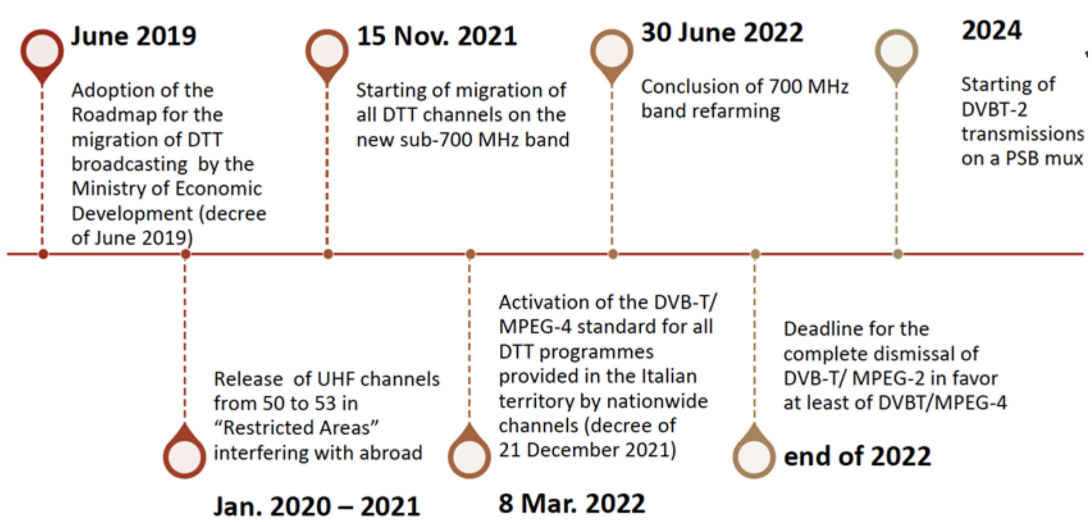
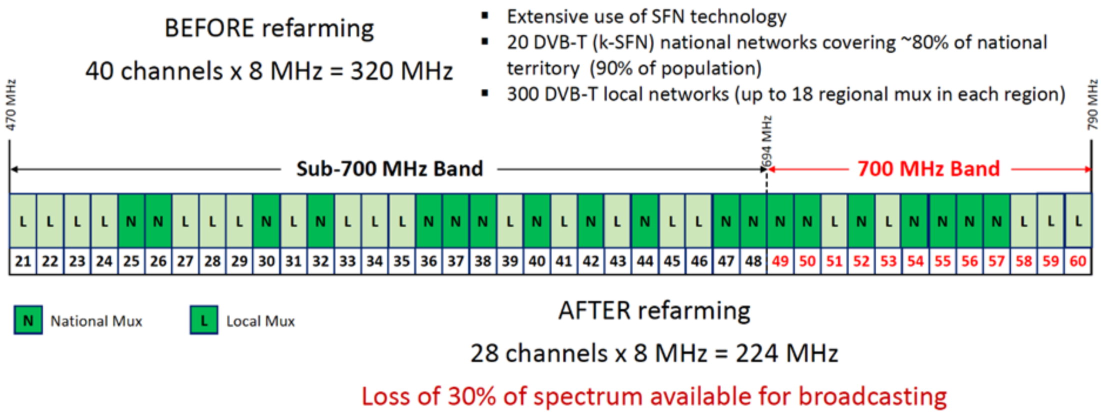


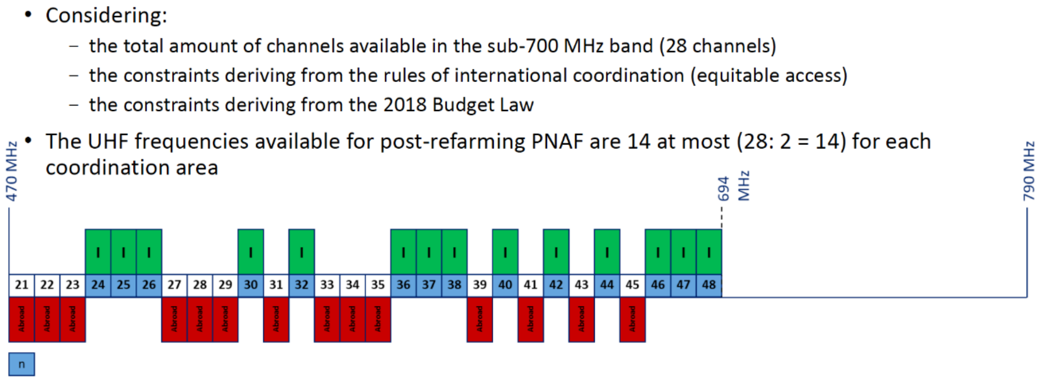

Figure A.19.2 shows the roadmap for the migration of DTT from the 700 MHz band to lower frequency bands allowing for the use of mobile services providing voice and data communications in the 700 MHz band.

An important task that needed to be accomplished was the mitigating of interferences with neighbouring countries and the refarming the frequency bands to accommodate the channels in the 700 MHz. Figure A.19.3 shows the impact in terms of the number of channels available after this refarming exercise.

## Figure A.19.3: Impacts on frequency allocation after the release of the 700 MHz band




- Before the refarming of the 700 MHz band.




- After the refarming of the 700 MHz band.

In order to make possible the reallocation of stations a series of actions were planned and implemented:

- Exclusive use of coordinated frequencies assigned to Italy;
- Extensive use of single frequency networks (SFNs);
- Adoption of the most efficient coding techniques (such as high efficiency video coding) and transmission standards;
- Assignment of nationwide and local/regional multiplexes.

Another key aspect to the success of the replanning was the policy and regulatory actions taken (Decision no. 129/19/CONS approved 18 April 2019), such as:

- National and local DTT operators had to progressively release frequencies in the 700 MHz band, migrating to the sub-700 MHz band.
- Different policy approaches at national and local level, since market exit mechanisms were envisaged only for the local sector:

- Cost refunding mechanism for the change of technologies from DVB-T to DVB-T2 for the national TV broadcasting company;
- Compensation mechanism for the withdrawal of the usage rights for the local operators;
- Rules establishing the conversion of existing DVB-T spectrum usage rights into rights of use of transmission capacity of the national DVB-T2 MUX and awarding of spectrum to operators.

The funding scheme is presented in the table below:

| Entities | 2020 | 2021 | 2022 |
|---|---|---|---|
| National broadcasters | EUR 24.1 million | EUR 24.1 million | EUR 228.1 million |
| Local broadcasters | EUR 230.3 million | EUR 73.9 million | |

An aspect which is worth highlighting is the competitive procedure for auctioning additional spectrum made available following the removal of the reservation of transmission capacity in favour of local broadcasting (Decision no. 564/20/CONS).

Some of the lessons learned from the overall replanning and reallocation exercise include:

- The reorganization process of broadcasting following the release of the 700 MHz band had a significant impact on the entire broadcasting sector.
- A number of investments were made by operators and by the State to manage the transition, due to the high DTT penetration in the country and the large number of DTT households that needed to be migrated.
- DVB-T2 rights of use of spectrum with a ten-year duration, were assigned to network operators starting from 2019.
- The full transition to DVB-T2 was expected to start from 2024.
- During the transitional period, local and national networks (reduced from 20 to 12 networks) operated in DVB-T. This resulted in a shortage of capacity available to audiovisual media service providers.
- The requests for high quality video services (in UHD or HD formats) made bandwidth availability even more critical.
- The full transition to the next stage of DTT technology (DVB-T2, MPEG4/HEVC, HDTV/UHDTV (4k) is ongoing but the TV renovation cycle needs to be completed.
- The impact of reorganization on local broadcasting, moving from a vertical integration model to a horizontal entry model, is yet to be assessed.
- Currently and for the foreseeable future DTT is the main TV distribution platform in Italy.

## A.19.2 Brazil case study

In 2013, Brazil approved the reallocation of the 700 MHz band to fixed and mobile services to provide voice and data communications[137].

The band allocation was established to comply with frequency division duplexing (FDD), and the band was divided into nine 5 + 5 MHz sub-bands. The use of time division duplexing (TDD)

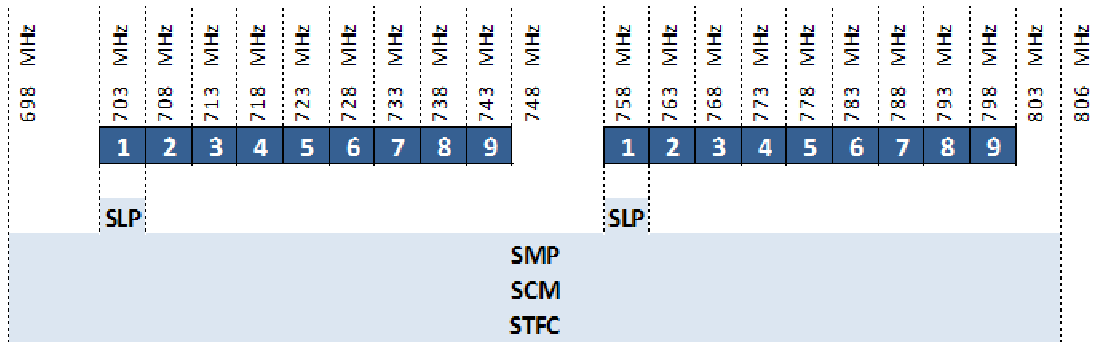
[137] Anatel Resolution no. 757, November 8, 2022. Available at: https://informacoes.anatel.gov.br/legislacao/resolucoes/2022/1760-resolucao-757

could be authorized on these sub-bands, if technically feasible. Finally, it was decided that the first 5 + 5 MHz sub-band would not be used for 4G services, so this sub-band was consequently allocated for public safety applications. The allocation of the 700 MHz band is shown in Figure A.19.4.

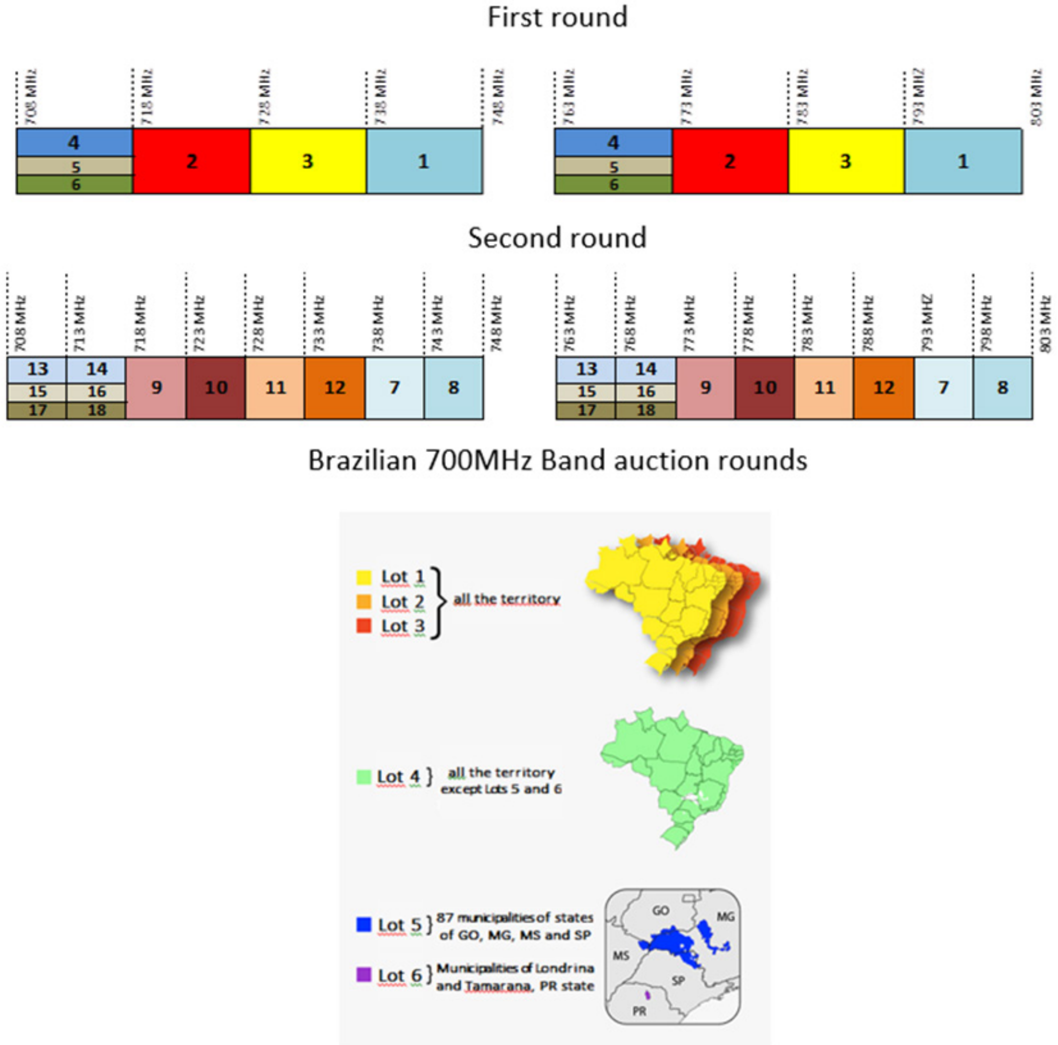
To ensure fair competition, a spectrum cap of 10 + 10 MHz was also established for the first round of the auction. For any remaining spectrum, the cap could be increased to 20 + 20 MHz for the second round of the auction. For small cities, the spectrum cap could also be increased to optimize investments, for example with the usage of shared infrastructure between all companies that bought the rights for the spectrum in those cities.

The auction established three national bands of 10 + 10 MHz, and one band of the same size for specific regions. For the second round, the remaining spectrum needed to be sold in smaller chunks of 5 + 5 MHz. Figure A.19.5 shows the 700 MHz band auction areas and the auction method employed.

## Figure A.19.4: Frequency allocation of the 700 MHz band in Brazil



### Figure A.19.5: Brazilian 700 MHz band auction areas




Currently, the 700 MHz band is completely freed-up and ready to be used by mobile services all over Brazil.

# Annex 20 – Question 2/1 Lessons learned

| Web | Received | Source | Title |
|---|---|---|---|
| 1/364 | 2024-09-20 | Senegal | Digital dividend and prospects for the development of broadcasting in Africa |

1. Adopt single frequency network (SFN) configuration instead of multi-frequency network (MFN) configuration to maximize the efficient use of frequencies.
2. Allocate part of the revenues generated by the sale of 4G and 5G licences to financing the transition to DTT and audiovisual content production, taking into account that these frequencies were originally intended for broadcasting.
3. To encourage the participation of broadcasters in the work of ITU, particularly World Radiocommunication Conferences (WRCs), in order to defend the interests of broadcasting in frequency management.

| Web | Received | Source | Title |
|---|---|---|---|
| 1/337 | 2024-09-18 | Korea (Rep. of) | Migration from DTV to UHD TV – Enhancing viewers' experience for OTA media content delivery |

- Government support, in the form of policies, incentives, and spectrum allocation, plays a key role in enabling the adoption of new technology.
- Collaboration among broadcasters, manufacturers, and other stakeholders ensures that the technology is deployed efficiently.
- A focus on both consumer education and high-quality content can increase public awareness and accelerate the adoption of new broadcasting standards.

| Web | Received | Source | Title |
|---|---|---|---|
| 1/201 | 2023-10-09 | Bosnia and Herzegovina | Analogue TV interference in the 700 MHz band |

Delay in the process of the transition from analogue to digital broadcasting inevitably causes interference problems with neighbouring countries who have completed their digitalization process and advanced in the introduction of new technologies. Every country is obligated to comply with ratified international agreements and take immediate steps to eliminate interference from TV stations that no longer have the right to broadcast uninterrupted analogue signals.

In the case of Bosnia and Herzegovina, even though the Ministry of Communications and Transport had the main responsibility for carrying out the process of digitalization, the regulatory agency played the crucial role as an initiator and a partner in almost all activities of this process. It is of utmost importance that the regulator acts in accordance with its legal responsibilities and competencies laid down by the law to remove obstacles for industry growth and to ensure the country respects ratified international agreements.

| Web | Received | Source | Title |
|---|---|---|---|
| 1/153 +Ann.1 | 2023-09-07 | Korea (Republic of) | Case studies utilizing TV platform to enable inclusive communication |

Through two projects, it has been proved that TV is one of the most impactful platforms for delivering social values to deaf people. The two projects, funded by Government, are just starting point, as AI-based sign language translation technology is still in early stage. There was a proof of concept (PoC) project by two leading TV manufacturers to implement avatar sign language on their user guide. As the technology evolves, we can expect all contents on TV to be automatically translated into avatar sign language. To make this happen, there should be strong support from Government on AI training datasets (parallel corpus of sign language and spoken language) and on an effective translation engine.

| Web | Received | Source | Title |
|---|---|---|---|
| 1/48 | 2022-10-13 | Bhutan (Kingdom of) | Strategies: Deployment of broadband in Bhutan |

In order to operate and manage the network, it is necessary to involve stakeholders in ensuring reliable and available service anytime.

Government needs to provide subsidies/incentives to telecommunication operators in development of ICT Infrastructures.

Government developed infrastructure (fibre-optic network) and leased to telecommunication operators and a demand aggregation project reduced tariffs to make it affordable for communities.

| Web | Received | Source | Title |
|---|---|---|---|
| SG1RGQ/115 | 2023-04-25 | South Africa (Republic of) | Sharing experience from South Africa on the licensing process for international mobile telecommunications (IMT) in respect of the provision of mobile broadband wireless access services for urban and rural areas using the complementary bands, IMT700, IMT800, IMT2600 AND IMT3500 |

- The auction is a significant milestone that could lead to lower communication costs, expanded network reach to rural and outlying areas, improved network quality and enhanced competition.
- The regulatory authority has social obligations for telecommunications operators to connect 18 520 schools, 5 731 clinics and hospitals, 8 241 traditional authority offices, 949 libraries and a number of government services centres.
- While the revenue collected from the auction will go to the public treasury to support national priorities, the allocation of the high-demand spectrum will speed up the roll-out of new technologies, such as fifth-generation (5G) mobile, reduce the cost of mobile data and ensure greater Internet connectivity.
- The allocation of the spectrum will also enable the roll-out of 5G networks, which will accelerate the process towards universal connectivity, and the deployment of the digital technologies and services that are driving the fourth industrial revolution.

| Web | Received | Source | Title |
|---|---|---|---|
| SG1RGQ/14 (Rev.1) | 2023-02-20 | Cameroon (Republic of) | Update on the process of migration from analogue to digital broadcasting and outlook |

**Lessons learned and suggested best-practices (if appropriate):**

In Cameroon the process of migration from analogue to digital broadcasting currently faces several difficulties of a general nature:

- the problem of the division of responsibilities in the conduct of the migration process;
- the fact that the project is burdened by the need to take into account issues associated with radio production, TV production, and radio broadcasting as part of the rehabilitation of CRTV;
- the repeated modifications that the project has undergone in response to a variety of demands;
- funding difficulties.

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