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Strategies, policies, regulations and methods of migration to and adoption of digital broadcasting implementation of new services

Output Report on ITU-D Question 2/1

Strategies, policies, regulations and methods of migration and adoption of digital broadcasting and implementation of new services

Study period 2018-2021

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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-17 in Buenos Aires in October 2017, agreed that for the period 2018-2021, Study Group 1 would deal with seven Questions within the overall scope of "enabling environment for the development of telecommunications/information and communication technologies."

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Executive summary

1 Introduction

The migration from analogue to digital broadcasting technologies has been completed in some countries, while others are in the process of completing the transition. The Final Report on ITU Telecommunication Development Sector (ITU-D) Study Group 1 Question 8/1 for the 2014-2017 study period[1] indicates that the transition results in a variety of strategies, plans and implementation actions that achieve a successful process to maximize the benefits. Those best practices, reflected in case studies, include actions to accelerate the transition and to narrow the digital divide by deploying new services; communication strategies for public awareness on digital broadcasting; and radio spectrum issues related to the analogue switch-off process, among other actions.

ITU-D has been playing a role in helping Member States evaluate the technical and economic issues involved in the transition from analogue to digital technologies and services. On these matters, ITU-D has been collaborating closely with both the ITU Radiocommunication (ITU-R) and the ITU Telecommunication Standardization (ITU-T) Sectors in order to avoid duplication.

Furthermore, the use of the digital dividend is an important issue, and continues to be widely debated by broadcasters and operators of telecommunication and other services operating in the same frequency bands. The role of the regulatory authorities in this regard is crucial to balancing the interests of users with the demands of growth in all branches of the industry.

Other issues to consider are the studies from other ITU Sectors, especially in the light of decisions taken at the World Radiocommunication Conference (Sharm el-Sheikh,2019) (WRC-19) on the use of the digital dividend in the future. In this regard, it is worth considering maintaining study topics related to technical and economic aspects involved in the transition from analogue to digital broadcasting.

Finally, another 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.

In this context, the present report discusses best practices for the transition to digital broadcasting, including television and sound, the use of the released spectrum (digital dividend), and new services and applications in broadcasting.

1 ITU-D SG1 Question 8/1 for the study period 2014-2017: Examination of strategies and methods of migration from analogue to digital terrestrial broadcasting and implementation of new services

2 Statement of the situation

ITU has been working over the past study periods on the important issue of transitioning from analogue to digital broadcasting. During this time, several important outputs where developed that are still relevant to the work of ITU-D Question 2/1.

As already stated, important material may be found in the *Final Report on Question 8/1 for the study period 2014-2017*.[2]

Another important reference for the transition to digital broadcasting is the *Digital Terrestrial Television Broadcasting Switchover Database* (DSO).[3] This database contains information on relevant events (e.g. workshops, frequency coordination meetings and seminars), publications (e.g. ITU-R and ITU-D documents, roadmaps and workshop presentations), websites (e.g. ITU-R and ITU-D, broadcasting organizations, GE06), contacts, and information sources (list of relevant surveys and questionnaires from ITU-D and ITU-R and other sources). Another important task of the DSO database is to gather key information from the countries regarding the digital switchover, such as year of the launch of digital television, digital terrestrial television (DTT) technology, status of the transition (ongoing, completed), among other information.

ITU is carrying out several activities related to digital broadcasting and its new technologies, services and applications. The importance of cooperation between ITU-D and ITU-R on the transition to digital broadcasting and usage of the digital dividend, and the discussions on the standardization of multimedia application frameworks, such as integrated broadcast-broadband (IBB) systems, ITU-T H.760 series, through cooperation between ITU-R and ITU-T, should also be highlighted.

2 ITU-D. Final Report on ITU-D Study Group 1 Question 8/1 for the study period 2014-2017. Examination of strategies and methods of migration from analogue to digital terrestrial broadcasting and implementation of new services. Geneva, 2017.

3 ITU. ITU-D. Spectrum and broadcasting. Status of transition to digital terrestrial television (DSO). Summary by country.

Abbreviations/acronyms

This table contains abbreviations/acronyms relating to international, regional or supranational bodies, instruments or texts, as well as technical and other terms used in this report.

Abbreviations/acronyms of national bodies, instruments or texts are explained in the text relating to the country concerned, and are thus not included in this table.

Abbreviation	Term
ADSL	asymmetric digital subscriber line
AI	artificial intelligence
AIAV	advanced immersive audiovisual
AM	amplitude modulation
AR	augmented reality
ASMG	Arab Spectrum Management Group
ASO	analogue switch-off
ATSC	Advanced Television Systems Committee (Next Gen TV standard)
ATU	African Telecommunications Union
ATV	analogue television
BDT	Telecommunication Development Bureau
BEREC	Body of European Regulators for Electronic Communications
BML	broadcast markup language
BSDDIF	Black Sea Digital Dividend Implementation Forum
CDN	content delivery network
CDR	Convergent Digital Radio
CEA	Consumer Electronics Association
CEPT	European Conference of Postal and Telecommunications Administrations
CITEL	Inter-American Telecommunication Commission
COMTELCA	*Cómision Técnica Regional de Telecommunicaciones*
COVID-19	coronavirus disease 2019
CTU	Caribbean Telecommunications Union
DD1	first digital dividend
DD2	second digital dividend

(continued)

Abbreviation	Term
DRM	Digital Radio Mondiale
DSB	digital sound broadcasting
DSO	digital switchover
DTT	digital terrestrial television
DTTB	digital terrestrial television broadcasting
DTV	digital television
DVB	digital video broadcasting
EBU	European Broadcasting Union
EC	European Commission
EECC	European Electronic Communications Code
EPG	electronic programme guide
ESN	emergency services network
ETSI	European Telecommunications Standards Institute
EU	European Union
EWBS	Emergency Warning Broadcasting System
FDD	frequency-division duplexing
FM	frequency modulation
FTA	free-to-air
FTTH	fibre-to-the-home
G3ict	Global Initiative for Inclusive ICTs
GE06	Regional Agreement adopted by the Regional Radiocommunication Conference for planning of the digital terrestrial broadcasting service in parts of Regions 1 and 3, in the frequency bands 174-230 MHz and 470-862 MHz (Geneva, 2006) (RRC-06)
GSMA	Global System for Mobiles Association
HbbTV	hybrid broadcast broadband television
HD / HDTV	high definition / high-definition television
HDR	high dynamic range
HEVC	high-efficiency video coding
HF	high-frequency
HFR	high frame rate

(continued)

Abbreviation	Term
IBB	integrated broadcast-broadband
ICT	information and communication technology
IMT	International Mobile Telecommunications
IoT	Internet of Things
IPR	intellectual property rights
IPTV	Internet Protocol television
ISDB	Integrated Services Digital Broadcasting (standard)
ITU	International Telecommunication Unon
ITU-D	ITU Telecommunication Development Sector
ITU-R	ITU Radiocommunication Sector
ITU-T	ITU Telecommunication Standardization Sector
KPI	key performance indicator
LDC	least developed country
M&A	merger and acquisition
M2M	machine-to-machine
MBB	mobile broadband
MNO	mobile network operator
MPEG	Moving Picture Experts Group
MUX	multiplexes
MW	medium wave
NCL	nested context language
NEDDIF	North-East Digital Dividend Implementation Forum
NPV	net present value
NRA	national regulatory authority
OTA	over-the-air
OTT	over-the-top
PMSE	programme making and special events
PPDR	public protection and disaster relief
PSB	public sound broadcaster
PVR	personal video recorder

(continued)

Abbreviation	Term
QAM	quadrature amplitude modulation
QoE	quality of experience
RF	radio-frequency
RTT	round-trip time
SD / SDTV	standard definition / standard-definition television
SDGs	United Nations Sustainable Development Goals
SDL	supplemental downlink
SEDDIF	South-East Digital Dividend Implementation Forum
SFN	single frequency network
SI	service information
SLA	service-level agreement
STB	set-top box
SVC	scalable video coding
SW	short wave
TDD	time-division duplexing
TV	television
UHD /UHDTV	ultra-high definition / ultra-high-definition television
UHF	ultra-high frequency (band)
VAS	value-added service
VHF	very high frequency (band)
VoD	video on demand
VR	virtual reality
WCG	wide colour gamut
WEDDIP	West European Digital Dividend Implementation Platform
WRC	World Radiocommunication Conference

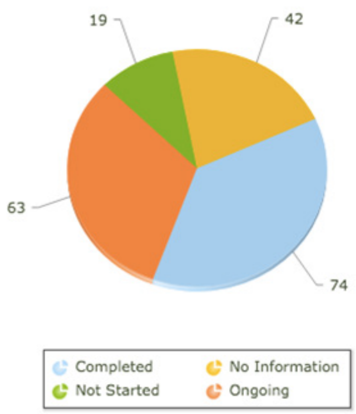
Chapter 1 – The digital television broadcasting transition

1.1 Current situation of digital terrestrial television

Digital television broadcasting has been in service for over a decade and corresponding technologies have now fully matured. The transition to digital terrestrial television (DTT) broadcasting has already started or even been finalized in many countries.

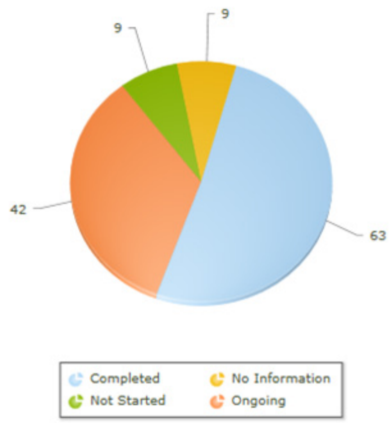
According to ITU figures on the status of the transition to DTT broadcasting, as at June 2020, 74 countries had completed the transition and in 63 countries the transition to DTT was ongoing. Considering the countries party to the GE06 Agreement, the transition had been completed in 63 of them and was ongoing in 42. The process of analogue switch-off is practically completed in Europe. The status of DTT is shown in **Figures 1a** and **1b**.

Figure 1a: All country status



Source: ITU.

Figure 1b: GE06 status



Source: ITU.

An overview of the digital switchover, including dates and an indication of the compression system applied for digital television in a number of countries is available in ITU.[1]

An overview of media consumption indicated that the importance of TV and radio as media is not decreasing: "*DTT will remain the pre-eminent television viewing platform in Europe for the foreseeable future. It provides viewers with significant benefits including universal coverage and free-to air services.*"[2]

The global COVID-19 pandemic proves that the value of media is growing, with linear TV regaining momentum during quarantine periods, attracting more viewers. FM and TV broadcasting are considered a primary source of critical information for the public in the event of disasters and emergencies. There is no doubt that the active response from broadcasters

[1] ITU. ITU-D. Spectrum and broadcasting. Status of transition to digital terrestrial television (DSO).

[2] Digital Television Action Group (DIGITAG) and Analysys Mason. Roadmap for the evolution of DTT – A bright future for TV. Geneva and London, 2014.

during the COVID-19 crisis has had a positive impact on our lives by (i) keeping us up to date with what's happening; (ii) keeping us entertained; (iii) rapidly adjusting their calendars and adapting operations and programming; (iv) tackling misinformation; and (v) preserving diversity of content. In addition, educational TV was adopted in many countries during the COVID-19 period to increase access to remote learning.[3,4]

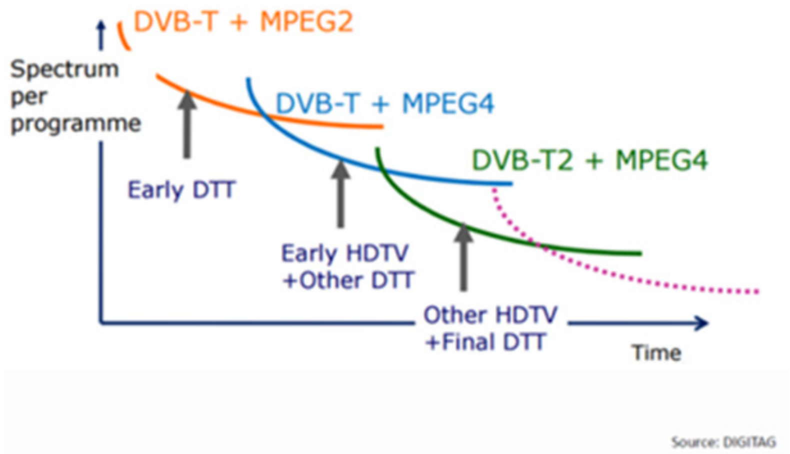
However, the DTT platform is currently jeopardized by the scarcity of radio-frequency spectrum. In addition to the allocation of the 800 MHz band to the mobile service worldwide at WRC-07, the re-allocation of the 700 MHz band reduced the total spectrum available for DTT by an average of 30 per cent (within the 470-790 MHz band). Yet, to remain competitive and sustain the adoption of new technologies, the DTT platform will require continued access to sufficient spectrum, especially during migration periods. A clear spectrum allocation is necessary to provide security and stability, promote innovation, and assure long-term investments for industry stakeholders and viewers.

1.2 Relevant issues and best practices in respect of the transition to digital broadcasting, including analogue-to-digital and digital-to-digital

1.2.1 The evolution of digital terrestrial television

Core DTT technologies available today offer broadcasters and consumers increased choice and quality. Channel formats are improving and evolving the quality of the video experience (SDTV, HDTV and UHDTV). Encoding standards are offering greater gains in capacity (MPEG-2, MPEG4 and HEVC). The next generation of broadcast transmission standards (DVB-T2) is available, increasing the capacity to offer new services.

Figure 2: Technology transition



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[3] See also: ITU Public Webinar on Broadcasting services for COVID-19 response, organized by the ITU-D study groups on 3 July 2020.

[4] Another example of the use of broadcasting services for remote learning in response to the COVID-19 pandemic is *satellite connectivity*, which is ideal for broadcasting essential educational channels as it is the most reliable and cost-effective way to reach millions of people across a wide area, thereby ensuring that vulnerable communities, wherever they are, have access to critical news and information, through either free-to-air (FTA) free-to-view (FTV) or pay-TV platforms. See ITU-D SG1 Document SG1RGQ/364 from SES World Skies.

The successful future development of DTT depends on the efforts of broadcasters and relevant authorities to introduce advanced technologies, such as DVB-T2/MPEG4 or HEVC to ensure continuity of DTT broadcasting in the remaining part of UHF band (470-694 MHz) while keeping or enhancing the existing DTT broadcasting capacity. This leads to the need for additional DTT channels in this part of the UHF band, taking into account advanced DTT technologies.

DTT content was mainly standard-definition (SD), with an increasing number of channels available in high-definition (HD) and ultra-high-definition (UHD). MPEG-2 is the predominant encoding standard, although many countries have established MPEG-4 ecosystems in which the majority of new consumer equipment is MPEG-4 compatible.

On the other hand, 4K and 8K standards are sensitive for the spectrum resources on account of the increase in net bit rates. Transition to a more efficient coding protocol, i.e. HEVC, and higher modulation types, e.g. 64 QAM and 256 QAM, is required in order to handle increased traffic capacity for higher screen resolutions. Currently, with 4K (DVB-T2 and HEVC) a typical 8 MHz frequency channel will be sufficient for one video programme. With 8K and large home flat panels, however, an 8 MHz channel is no longer sufficient if we consider that transmission efficiency in data rates converge to the Shannon limit (see **Figure 3**). For this reason, many administrations, especially in countries where most users are receiving television by terrestrial broadcasting, should be careful in allocating additional UHF bands to the mobile service.

1.2.2 DTT market developments[5]

In each country there are a number of important market factors that determine the future roadmap for the adoption of DTT technologies, such as the level of DTT penetration, the degree of competition from other TV distribution platforms, the penetration and usage of different consumer devices and the consumption and usage of linear and non-linear TV.[6]

The TV market is becoming more competitive due to different TV platforms. DTT is evolving from a model based purely on linear TV services, standard TV sets and set-top boxes (STB), to a model providing non-linear services, as well as mobile TV services to devices such as smartphones and tablets. In this way, the DTT platform is adapting to the growth of changing viewing trends and the rise in viewing on new devices. It also shows how the key players in the market influence the different parts of the DTT ecosystem. In response to changing market trends, demands and needs, the DTT platform remains agile and ready to respond to the market. DTT is transitioning from being a purely linear model to one that can provide non-linear services available on all types of devices.

[5] Digital Television Action Group (DIGITAG) and Analysys Mason (op. cit.)
[6] *Non-linear services*: The end user determines the audiovisual content and when this content is to be played. A commonly known service in this category is video-on-demand (VoD). Non-linear services also include time-shifting of content. Time-shifting enables the content to be viewed at the viewer's convenience. It can include pausing and rewinding linear television services (i.e. live television) as well as playback of content after the initial broadcast. See: ITU. Regional initiatives – Asia and the Pacific. **Interactive Multimedia Services in Asia-Pacific: trends and insights**. Geneva, 2015.

1.2.3 Transition scenarios

1.2.3.1 Transition from analogue to digital

Example 1a: Countries under the GE06 Agreement (DVB standard)

For countries that have not yet started their transition to DTT, it seems logical that they should immediately introduce DVB-T2. DVB-T2 has already started as a regular service in some countries. Equipment is now available mass market and is often incorporated in TV sets and personal video recorders (PVRs). In the Arab States region and sub-Saharan Africa, DVB-T2 has been selected (except Botswana, with ISDB-T).

It is expected that a simulcast period similar to that required for the transition from analogue TV to DVB-T will be needed for transitions. For the simulcast period, additional spectrum would be required for the parallel transmission of TV services. The required amount of spectrum will depend heavily on the introduction strategy adopted for DVB-T2.

The simulcast situation is eased in the case of transition from analogue to DVB-T2, as this technology can accommodate more individual programmes in a multiplex and so a smaller number of multiplexes may be required. This will reduce the cost involved in the simulcast period and alleviate the difficulty of finding spectrum for the simulcast.

Example 1b: Case study – United States (ATSC standard)

The analogue-to-digital transition was a technological event unprecedented in scale in the United States broadcast television industry, touching nearly every household directly or indirectly.

In 1996, the United States Federal Communications Commission (FCC) adopted the ATSC standard for DTV. Subsequently, a number of steps were taken to facilitate the transition. In 1997, the FCC adopted a DTV Table of Allotments and related service rules. In addition, Congress granted each full-power broadcaster a second 6 MHz channel and temporary licence that allowed them to build a digital station while maintaining their analogue TV operations. The broadcasters were allowed to transmit via analogue signals over one channel and via digital signals over the other channel; when the transition was complete, they were required to relinquish one of the channels.[7]

The FCC issued the appropriate licences and adopted mandatory dates by which broadcasters would have to complete the transition to DTV. The conversion was planned to occur on a phased-in basis according to market size and network. Stations in the top 10 markets were required to complete the transition first, followed by markets ranked 11-30, followed by all other full-power commercial stations, and then finally non-commercial stations.[8] Transition deadlines ranged from 1999-2003, and were later relaxed by Congress based on circumstances in a given market. Congress also codified the FCC-determined deadline of 2006 for the full digital switch, at which time stations would have to relinquish one of the channels and cease analogue

[7] James Prieger and James Miller. (2010). The Broadcasters' Transition Date Roulette: Strategic Aspects of the DTV Transition. Pepperdine University, School of Public Policy Working Papers. Paper 7. p. 460
[8] Ibid. p. 463.

broadcasting. Congress subsequently extended this deadline to February 18, 2009 and then finally fixed the deadline at June 12, 2009.[9]

In the meantime, as the transition to digital proceeded through the nation, the FCC in 2002 required manufacturers to include a digital receiver tuner in new TV sets. Later, analogue television sets that continued to be sold were required to have a warning label indicating that it would require an analogue-to-digital converter box. All converter boxes were required to comply with standards set by the FCC.

To gain experience in a complete switch to digital in advance of the 2009 statutory deadline, the FCC conducted a trial in a local market. The first test market to cease analogue transmission and switch to a digital signal was performed in 2008 in Wilmington, North Carolina, at that time the 135th largest market in the United States.[10] The test provided the FCC with insight into ways to address and correct transition and reception problems in advance of the full nationwide switch to digital. Wilmington was one of the few cities that was technically able to make the full digital switch ahead of the transition deadline and, with its flat terrain and all TV stations using UHF channels, proved to be a good place for early testing. Only 7 per cent of viewers were affected by the loss of analogue broadcasts, and to address this problem, on 7 November 2008 FCC permitted those digital TV stations with coverage gaps or that needed to extend their coverage to use a distributed transmission system (DTS).

The last full-power television station in the United States ceased over-the-air transmission of analogue programming on 12 June 2009, marking the culmination of more than 20 years of technical collaboration and 10 years of complex regulatory decisions. Today, all full-power stations in the United States transmit only DTV.[11]

Example 1c: Case study – countries in Latin America (ISDB-Tb standard)[12]

ISDB-T international is the technical standard for digital television broadcasting currently being used in Argentina, Bolivia (Plurinational State of), Botswana, Brazil, Chile, Costa Rica, Ecuador, El Salvador, Honduras, Nicaragua, Paraguay, Peru, Philippines, Uruguay and Venezuela. In Brazil, for example, the first commercial operation was launched in December 2007, in São Paulo.

ISDB-T International is also called ISDB-Tb[13] (ISDB-T Japanese standard, Brazilian version) and basically differs from original ISDB-T by using H.264/MPEG-4 AVC as a video-compression standard (ISDB-T uses H.262/MPEG-2 Part 2); a presentation rate of 30 frames per second even in portable devices (ISDB-T, One-Seg, uses 15 frames/s for portable devices); and powerful interaction using middleware Ginga, composed by Ginga-NCL and Ginga-J modules (ISDB-T uses BML).

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9 The FCC extended the 17 February 2009 deadline for an additional 30 days to permit "nightlighting". During this period, analogue stations could continue to broadcast and inform unprepared viewers about the DTV transition and to broadcast during emergency situations such as severe weather. Approximately 120 full service stations briefly maintained their analogue "nightlight" service.

10 FCC to Test Transition to Digital TV in N.C. *The Washington Post* (Kim Hart, 8 May 2008).

11 The digital conversion deadline for low-power Class A translator stations is 1 September 2015. See for example: FCC (United States). Consumer guides. DTV Transition and LPTV – Class A – Translator Stations. Last updated 14 September 2017.

12 Wikipedia. ISDB-T International.

13 In January 2009, the Brazilian-Japanese study group for digital TV finished and published a specification document joining the Japanese ISDB-T with the Brazilian SBTVD, resulting in a specification now called *ISDB-T International*. ISDB-T International is the system that is proposed by Japan and Brazil for use in other countries in South America and around the world. See: ITU-R. Recommendations ITU-R BT.1306, ITU-R BT.1699 and ITU-T H.761.

The implementation of the ISDB-Tb standard in most countries in the Americas region brought several benefits to the population, especially social benefits of digital inclusion through DTV and quality of image, sound and robustness of ISDB-T system as well as mobility and interaction.

Countries that have adopted ISDB-Tb:

- Brazil: First commercial operation was launched on 7 December 2007, in São Paulo; several regions have switched off.
- Peru: On 23 April 2009.The decision was taken based on recommendations by the Multi-sectional Commission to assess the most appropriate standard for the country. Service started on 30 March 2010, and the deployment of the standard started in October 2010. The Peruvian Government announced that the analogue switch-off will be gradual, starting in 2020, in the Lima Metropolitan Area, and finishing after 2030. They also announced that entry-level receivers (for standard definition only) would cost around USD 20.
- Argentina: On 28 August 2009, and service started on 28 April 2010.
- Chile: On 14 September 2009, and experimental services started in June 2010.
- Venezuela: On 6 October 2009, and trials started 20 February 2013 in 13 cities.
- Ecuador: On 26 March 2010, and transmissions by Tc Mi Canal on 8 May 2013.
- Costa Rica: On 25 May 2010, and trial transmissions on Channel 13 from Irazú Volcano on 19 March 2012; official transmissions started on 1 May 2014.
- Paraguay: On 1 June 2010, and experimental broadcasting started from Asunción area on 15 August 2011.
- Philippines: On 11 June 2010.
- Bolivia (Plurinational State of): On 5 July 2010, and start of trial transmissions from June 2011 in La Paz, Cochabamba and Santa Cruz. Official transmissions started on 14 May 2012.
- Nicaragua: On 10 August 2010.
- Uruguay: On 27 December 2010, trial transmissions from September 2011 for seven months, and state-owned channel starts trial transmission in August 2012.
- Maldives: On 19 October 2011, associated with earthquake early warning for tsunamis, and the first country with 8 MHz channel bandwidth.
- Botswana: On 26 February 2013, the first of the African countries to do so, and Botswana Television (BTV) officially started digital TV broadcasting on 29 July 2013.
- Guatemala: On 30 May 2013.
- Honduras: On 12 September 2013.
- Sri Lanka: On 20 May 2014.
- El Salvador: On 19 January 2017.

From the experience of these countries so far, some lessons learned are reflected in section 1.6 of this report, but it is worth highlighting the importance of stakeholder engagement, including viewers, involving them in the decision-making process and clearly communicating all key milestones. It is also fundamental that receivers be available to the low-income population.

1.2.3.2 Transition from digital to digital

Example 2a: DVB-T to DVB-T2

Most countries in the Europe region have completed their digital switchover (DSO) with DVB-T as the main broadcast transmission standard. Markets around Europe are migrating or planning their migration to DVB-T2. DVB-T2 is not backward compatible with DVB-T, so an abrupt migration from DVB-T to DVB-T2 is not possible. More sophisticated migration strategies are required. In order to be successful, the migration should be based on additional offers to the consumer. These offers may consist of additional programmes or different service types.

In general, for the migration period, unused and/or additional spectrum is required. Different options could be proposed:

- Frequencies may be found in temporarily unused spectrum, available perhaps in countries where DVB-H is regarded as not being successful.
- Other countries may use available VHF spectrum for this purpose.
- A further possibility may be more compact aggregation of DVB-T programmes in existing multiplexes (with a possible slight loss of quality) in order to free spectrum for an additional DVB-T2 multiplex.
- In exceptional cases the switch-off of DVB-T programmes may also be considered in order to free up spectrum for a DVB-T2 multiplex.
- Some broadcasters may choose the enlarged possibilities of DVB-T2 to change or extend their coverage and/or service concept. For example, a change from a coverage which up to now mainly provides fixed reception to portable outdoor/mobile reception is possible. Also, the provision of better video quality is possible.

For countries that have already switched to DTT, the issue of consumer reinvestment becomes an issue. The introduction of DVB-T, perhaps within the last 10 years, was accompanied by the need for consumers to invest in new receiving equipment. Now, with the migration to DVB-T2, a further investment in receiving equipment is again required by consumers. This is a difficult situation, since consumers have been used to longer renewal cycles of TV receiving equipment. The introductory strategy for DVB-T2 has to be chosen carefully in order not to lose customers to other platforms, as happened in some countries with the transition from analogue TV to DVB-T. A special situation arises in countries that have started but not completed the process of DSO from analogue TV to DVB-T and that also start to introduce DVB-T2. This situation is not that uncommon. Countries where the terrestrial platform is used by a large percentage of the population as the primary means of reception will necessarily have a long transition period and they are now faced with the challenge of an additional migration. Special considerations have then to be applied.

Example 2b: Case study – United States (ATSC to next-generation TV "ATSC 3.0"

On 16 November 2017, FCC adopted new rules to let television broadcasters use the "next-generation" broadcast television transmission standard (*Next Gen TV*), also called *ATSC 3.0*, on a voluntary, market-driven basis.[14] *Next Gen TV/ATSC 3.0* [15] is expected to enable broadcasters to offer enhanced public safety capabilities, such as geo-targeting of emergency alerts to tailor information to particular communities and emergency alerting capable of waking up sleeping devices to warn consumers of imminent emergencies, and advanced accessibility options as well as more immersive pictures and sound, including ultra-high definition television, superior reception, mobile viewing capabilities, localized content and interactive educational children's content.[16] The new rules allow broadcasters the flexibility to deploy *Next Gen TV* service while

[14] FCC (United States). Authorizing Permissive Use of the "Next Generation" Broadcast Television Standard. *Report and Order,* 32 FCC Rcd 9930 (2017) (*Next Gen TV Report and Order*).

[15] National Association of Broadcasters (NAB) (United States). Next Generation Television (ATSC 3.0) Station Transition Guide. April, 2019.

[16] ATSC 3.0 is the new TV transmission standard developed by the Advanced Television Systems Committee as the world's first Internet Protocol (IP)-based broadcast transmission platform. It merges the capabilities of over-the-air (OTA) broadcasting with the broadband viewing and information delivery methods of the Internet, using the same 6 MHz channels presently allocated for DTV service.

minimizing the impact on consumers and industry stakeholders. For example, the Next Gen TV Report and Order:

- Requires broadcasters that use next-generation TV to partner with another local station in their market to simulcast their programming in the current DTV standard, called ATSC 1.0, so that viewers can continue to receive their existing broadcasting service without having to purchase new equipment.
- Subjects next-generation TV signals to the public-interest obligations that currently apply to television broadcasters.
- Requires broadcasters to provide advance on-air notifications to educate consumers about next-generation TV service deployment and simulcasting.

This is the first major upgrade to broadcast television adopted by FCC since the 2009 transition to DTV.

1.2.4 DTT regulation and policy[17]

The level of national regulation in relation to DTT standards is an essential factor, ensuring stability for broadcasters and consumers during adoption and migration to DTT standards. Regulation can take a variety of forms, including spectrum policies, licensing of DTT channels and mandatory migration to certain technologies. In general, regulation can assist market development in two ways (market-driven or regulator-assisted), although in reality there may be a mix of the two:

- Under a market-driven approach: The regulator works as a facilitator. The industry as a whole takes a joint decision to move forward with DTT and coordinates the migration to new standards.
- With a regulator-assisted approach: The regulatory authority represents the focal point that is entrusted with the responsibility of taking decisions. In this approach, the regulator asks for opinions from stakeholders to support its decisions, rather than encouraging them to take a shared position.

1.3 National experiences on spectrum-planning activities for the analogue switch-off

1.3.1 Italian digital terrestrial television towards 2020[18]

The trade association of radio and TV broadcasters in Italy shared its view on DTT development in Italy up to 2020. It reported that round 60per cent of TV services are provided using DTT, and more than 30 per cent of TV frequency channels are located at 700 MHz, with 60 per cent of the 700 MHz band being used by national TV, the rest by local TV.

DSO in Italy began the analogue switch off schedule with a heavy analogue terrestrial TV legacy. Single frequency networks (SFN) are used in the national DTT network and DVB-T2/HEVC has been in use since July 2016. Italy carried out phased implementation in different regions, which included frequency coordination with neighbouring countries. The switch-off schedule assumed

[17] Digital Television Action Group (DIGITAG) and Analysys Mason (op. cit.)

[18] Elena Cappuccio. *Confindustria Radio Televisioni* (CRTV) (Italy). Italian digital terrestrial television towards 2020. Presentation to the *ITU-MISE Regional Seminar for Europe and CIS on Spectrum Management and Broadcasting* (Rome, Italy, 29-31 March 2017).

a gradual implementation of DTT by region and analogue switch-off (ASO) was accomplished in 2012.

According to Law No. 220/2010, frequencies in the 790-862 MHz band (UHF channels 61-69) were intended for terrestrial mobile service as of 1 January 2013. Consequently, Italy auctioned released spectrum at 800 MHz in September 2011. With regard to repurposing of the 700 MHz band, the Telecommunication Administration of Italy is considering the following plan:

- 31 December 2017: Deadline for bilateral coordination agreement.
- 30 June 2018: Deadline for publication of national roadmaps to make the 700 MHz band available to the mobile service.
- 30 June 2020: Deadline to make the 700 MHz band available to the mobile service; possibility for administrations to ask, for justified reasons only, to postpone the deadline to 30 June 2022.
- The sub-700 MHz band will be available for broadcasting service and radio microphones (PMSE) at least until 2030.

Italy is considering a mix of different solutions that includes a general re-arrangement of both the VHF and UHF bands. A number of multiplexes (MUX) will be definitively switched off, while a number of MUX will be restacked in the sub-700 MHz band. Remaining MUX will transitionally adopt MPEG-4 encoding in order to double the number of programmes carried. Only after the release of the 700 MHz band (2020/2022) will the remaining MUX start the definitive upgrade towards DVB-T2/HEVC technology (assuming that, meanwhile, a significant number of customers' TV receivers will be renewed).

In order to migrate Italy's DTT at sub-700 MHz and allow the re-farming of the 700 MHz band for mobile-broadband use (5G), the cost for users (high legacy of DVB-T only sets, TV-set renewal cycle estimated to be more than seven years) and costs for TV operators (migration to DVBT-2/HEVC, transition and re-farming, network equipment, simulcast) should be taken into account.

1.3.2 Analogue switch-off spectrum planning in Brazil

For television broadcasting services, it was necessary to update the channel allotment plans, which contain all television channels that can be used in each municipality, and other technical conditions such as, *inter alia*, maximum power, geographic coordinates, frequency assignment and technology (digital and analogue).

Additionally, to allow for the usage of the 700 MHz band, studies were carried out to reorganize the allocation of television channels in the above-mentioned plans to free all the channels residing in the band. After a lot of debate, new channels were defined in the in lower UHF band for the broadcasters that operate in the 700 MHz band.

Furthermore, during the process, 4 300 additional digital channels were included in the channel allotment plans to ensure that the current analogue coverage would be preserved in the digital television transmissions, an important prerequisite for the planning effort.

The planning was an important part of the process and allowed an assessment of the number of channels that would need to be reallocated after the 700 MHz auction: a total of 1 050 channels in 1 096 municipalities (Brazil has 5 565 municipalities in total), accounting for around 43 per cent of the total population (Brazil has around 203 million people).

To guarantee execution of all necessary changes, a third-party entity, the *Entidade Administradora do Processo de Redistribuição e Digitalização de Canais de TV e RTV* (EAD), is managing the process related to the 700 MHz band, which entails planning, acquisition of the necessary equipment, and implementation of the entire infrastructure to enable the television broadcasters to operate in the new channels.

This entity is a facilitator of the whole process with the specific responsibility of fulfilling the task of making the spectrum available, which, in some cases and specific municipalities, can involve switching off analogue transmissions to allow the reallocation of channels. For example, in cities such as Brasília, São Paulo and Rio de Janeiro, which are surrounded by a multitude of other smaller cities forming dense metropolitan areas, the spectrum is today very crowded in the UHF band with several analogue and digital channels. Those metropolitan areas need to switch off analogue transmissions prior to the reallocation of channels to free up the 700 MHz band.

1.4 National experiences on interference-mitigation measures

1.4.1 Background

The radio spectrum is becoming increasingly crowded as technologies compete for sufficient bandwidth to operate effectively. The interference issues that may occur due to the coexistence of the different signals and services, and the resulting mutual interaction, must be carefully considered in order to reduce interference and ensure compatibility between services.

This is the case in the allocation of mobile services in close proximity to DTT, which is highly impacted by mobile transmission in the 700 MHz band due to its proximity to the receiver.

Generally, the risk of harmful interference can be eliminated through various interference-mitigation techniques, such as using a receiver with filter characteristics with sufficient interference-rejection capability. This part of the report will present some interference mitigation measures adopted in Europe (specifically to mitigate the coexistence risks from 700 MHz base stations and handsets to DTT reception), in addition to national experiences in Australia and Brazil.

1.4.2 Interference-mitigation measures adopted in Europe

1.4.2.1 New performance targets for TV receivers

In recent years, some European regulators have worked with industry partners and DTT receiver manufacturers to make new DTT receivers more resilient to interference from mobile services. New requirements in respect of DTT receivers have been imposed for placing products on the European market through Directive 2014/EU/53, the Radio Equipment Directive (RED),[19] which entered into force on 12 June 2016 with a transitional period that ended on 12 June 2017. The European Telecommunications Standards Institute (ETSI) has developed a harmonized standard which includes new performance requirements for broadcast receivers – ETSI EN 303 340,

[19] European Union. EUR-Lex. Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC. The RED replaces the Directive on Radio and Telecommunications Terminal Equipment (RTTE).

V1.1.2, 2016-09: [20] *Digital Terrestrial TV Broadcast Receivers; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU.*

The RED aims to ensure that radio equipment sold on the European market is constructed so that it effectively uses and supports the efficient use of radio spectrum in order to avoid harmful interference.

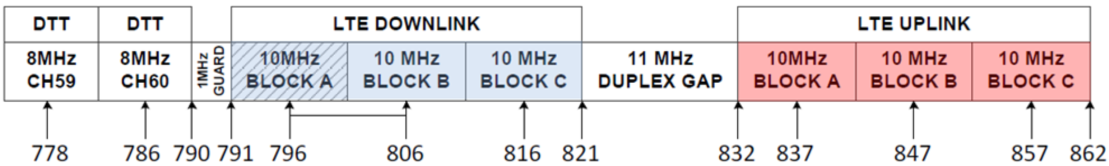
The new targets agreed in Europe specify carrier-to-interference (C/I) levels which are 5-6 dB stricter than the previous non-mandatory industry specifications. This improvement should benefit both 700 and 800 MHz cases as the worst-performing receivers are replaced.

1.4.2.2 Frequency separation

The case of the 800 MHz band plan

In the 800 MHz band plan, the base station transmit frequencies (downlink) are adjacent to the highest DTT channel 60, with a small 1 MHz guardband as shown in **Figure 3**.

Figure 3: LTE-800 band plan showing proximity of LTE and DTT services[21]



(Source: BBC)

The proximity of the base station downlink block to DTT in the current band plan means that the top DTT channels (channel 60 in particular) are somewhat more susceptible to interference than channels lower down the band, both in relation to adjacent channel leakage and receiver selectivity.

Reception of the top DTT channels closest to the 800 MHz downlink spectrum, particularly channel 60, is more challenging and better rejection performance is needed compared to lower channels. For example, while only 11 per cent of households in the United Kingdom receive DTT services on channel 60, these households make up 18*+ per cent of confirmed interference cases up to end January 2017.[22]

In this case and in order to sufficiently attenuate mobile signals in the lowest 800 MHz block, a very sharp filtering at the edge of channel 60 is required. This filtering could not be achieved with standard lumped element filters and requires more expensive filter technology.

[20] European Telecommunication Standards Institute (ETSI). Standard ETSI EN 303 340, V1.1.2, 2016-09. Digital Terrestrial TV Broadcast Receivers; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU. Sophia Antipolis, 2016.

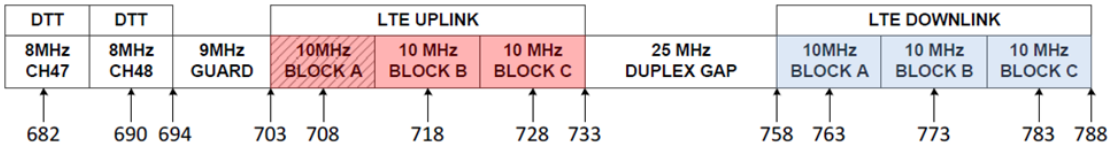
[21] Mark Waddell et al. British Broadcasting Corporation (BBC) (United Kingdom). The Radio Equipment Directive – A New Initiative to Ensure Compatibility between Broadcast and Mobile Services. *Research & Development White Paper WHP 311*. BBC, 2015.

[22] Ofcom (United Kingdom). Consultation. Coexistence of new services in the 700 MHz band with digital terrestrial television. 9 May 2017.

The case of the 700 MHz band plan

In the 700 MHz band plan, the downlink block is at the top of the band and is separated by 64 MHz from the highest DTT channel as shown in **Figure 4**. The greater frequency separation between the downlink and DTT means that this effect no longer occurs and the new top DTT channel 48 will be less susceptible to this type of interference relative to channel 60 in the current plan.

Figure 4: LTE-700 band plan showing proximity of LTE and DTT services



(Source: BBC)

However, in the 700 MHz band plan, mobile handsets will transmit in the frequencies adjacent to DTT services. The frequency separation between the lowest frequency of the mobile uplink and the highest edge of the TV band is only 9 MHz, which is much smaller than the 42 MHz separation for the current situation that exists between 800MHz mobile services and TV. This reduced frequency separation can result in increased susceptibility of TVs to the effects of IMT-Advanced (4G) handset emissions, either from adjacent channel leakage of the mobile handset, or due to the reduced selectivity of the receiver vis-à-vis the mobile transmissions.

Whilst the maximum transmission power radiated by a mobile handset is usually substantially lower than from a base station, high levels of interference can still be coupled when the mobile device is physically close to the television viewer's aerial.

In order to investigate this risk, a measurement campaign was undertaken by Ofcom in the United Kingdom in 2016/2017. The results were published in a technical Report entitled *700 MHz Coexistence: Study of mobile uplink interference effects upon DTT reception*,[23] which shows that the "majority of households would not experience any interference from a change of use of the 700 MHz band". In the minority of households that might suffer some harmful interference caused by 700 MHz handset transmissions, this can be mitigated effectively by the use of a filter. A tentative conclusion based on the measurements is that a filter with a moderate 5 dB of discrimination between the TV band and the 700 MHz band might be expected to cut the number of interference events by an order of magnitude.

[23] Ofcom (United Kingdom). Technical report. 700 MHz Coexistence: Study of mobile uplink interference effects upon DTT reception. 9 May 2017.

1.4.3 Country experience

1.4.3.1 Experience in the United Kingdom

A consultation on the coexistence of new services in the 700 MHz band with digital terrestrial television was published in May 2017 by Ofcom in the United Kingdom presenting initial views on the most technically effective solutions to mitigate these risks.[24]

Ofcom suggests that **receiver filters** will continue to be the most technically effective way to mitigate interference for the 700 MHz band. Two varieties of filters were presented: channel 60 and channel 59 filters.

- Channel 60 filters are used for areas where reception of DTT channel 60 is required.
- Channel 59 filters are used everywhere else. Channel 59 filters have a larger frequency separation of 9 MHz and this means that cheaper filter technology could be used for these filters.

In addition, Ofcom considered that the use of **group K aerials**[25] would help to mitigate 700 MHz coexistence issues. It considered that the rooftop aerial used to receive DTT can play a significant role in helping to mitigate interference because, chosen judiciously, it can increase the DTT signal and attenuate the mobile downlink, thus leading to a lower probability of interference.

1.4.3.2 Experience of Australia[26]

In Australia, there is a mature deployment of 700 MHz in the same spectrum as the CEPT frequency plan. However, the upper DTT channels are mostly not used in dense population areas. This is largely due to concerns about interference from handsets: the out-of-block emission limits in this region are more relaxed than the limits agreed in Europe. Other than the band edge licence condition, there is no specific mitigation scheme in Australia to deal with 4G-related interference and therefore no formal records on the numbers of 4G-related interference cases are available. Many mobile base stations have been operating across Australia for years without causing disruption to TV viewers.

In general, digital TV reception has not been significantly affected by the roll-out of 4G mobile broadband services. However, the Australian Communications and Media Authority (ACMA), the regulator in Australia, has reported issues in relation to mobile broadband and TV reception and has proposed measures to be applied to resolve these issues. Some people living near mobile base stations may experience reception difficulties following the roll-out due to receiver overload. This is also more likely if one or more of the following conditions apply:

- The area is covered by UHF, rather than VHF, television services
- The received television signal levels are low
- The TV antenna is directed towards the mobile base station
- The TV receive system uses sub-optimal antennas (such as inappropriate/legacy antenna configurations or antenna systems in poor condition)

24 Ofcom (United Kingdom). Consultation. Coexistence of new services in the 700 MHz band with digital terrestrial television, 9 May 2017.
25 A Group K aerial is the antenna designed for the reception of over-the-air broadcast television signals covering channels from 21 to 48.
26 The case of Australia was mentioned in the United Kingdom Ofcom consultation (op. cit.).

- The antenna system uses a masthead or distribution amplifier (also known as a signal booster).

In these cases, an improvement of the receiving system to enable continued TV reception is needed. Only a limited number of viewers should need to upgrade their equipment.

In addition, ACMA described how to prevent reception problems:

- Install the most appropriate reception equipment to obtain the best TV service and to decrease the chances of being adversely impacted by receiver overload.
- The risk of receiver overload is higher if you use a masthead or distribution amplifier. In principle, only use a signal booster in a marginal coverage area, and it should be deployed with the minimum gain that provides adequate reception. In some instances, upgrading to a high-gain antenna may eliminate the need for an amplifier and significantly increase the reliability of reception.
- Most areas where the new mobile base stations will be rolled out have adequate TV coverage. With adequate signal levels, do not use a signal amplifier. Use of an amplifier will increase the susceptibility of the television receiving system to signal overload.

In the case of TV reception being affected by a mobile broadband base station, some easy fixes include:

- Installing a simple filter at the appropriate point in the receiving installation
- Replacing the antenna with one that has a built-in filter
- Removing a signal booster if not needed
- Relocating the antenna to a location less prone to picking up the mobile-broadband signals.[27]

1.4.3.3 Experience of Brazil

In Brazil, an independent third party (EAD) was established to carry out several activities related to DSO. Among these duties is the mitigation of interference caused by radiocommunication stations operating on analogue and/or digital technology in the reception and/or transmission of mobile stations operating in the 700 MHz band.

To cope with the interference, some guidelines were approved within the DSO steering committee (*Grupo de Implantação do Processo de Redistribuição e Digitalização de Canais de TV e RTV*) (GIRED) (Main and Relay Stations Redistribution and Digitalization Process Implementation Group) to establish a clear procedure for the identification and mitigation of possible interference and to guide the work of the independent third party responsible for implementing it. The procedure may occur simultaneously with or after the procedure for the activation of mobile stations, and preventive mitigation and is detailed in **Annex 1** to this report.

1.5 Costs of the transition to digital broadcasting and implications for the various players: broadcasters, operators, technology providers, manufacturers and distributors of receivers, and consumers

Migration to digital broadcasting delivers many benefits. However, there are also significant costs to be considered, including new and upgraded broadcasting and transmission equipment,

[27] Australian Communications and Media Authority (ACMA). Consumer advice. TV and radio. TV reception and interference. TV reception overview.

end-user STB, and consumer-awareness programmes, among other things. Detailed information can be found in the Question 2/1 annual deliverable for 2020,[28] available in the six official languages.

1.6 Conclusions and lessons learned from national experiences

The transition to digital is above all a matter of national sovereignty	There is benefit in governments being involved in the transition, defining the scope of the switch to digital. Based on experience in Japan, it is important to formulate a common vision and roadmap in cooperation between public and private stakeholders who have an interest in carefully providing information for viewers on the attractiveness and means of receiving new services, and in making efforts to improve the receiving environment.
Specific entity for the transition	Since the transition to all digital involves various players, it is beneficial for all stakeholders that government sets up a national cooperation body for both planning and steering as well as for implementation and viewer information. This entity will be established specifically for the transition to digital. Its activities will be clearly set out, clearly limited in time and with a specific budget.
Thorough planning of the ASO process is fundamental	Planning can accelerate the transition. The planning should include the ASO strategy, spectrum planning, allocation of the digital dividend and interference mitigation, among other activities. In addition, the final switch-off date for analogue TV should be specified in the national switchover plan.
Initial diagnosis of the situation	Before embarking on the switch from analogue to digital terrestrial television, it is very important to undertake an initial diagnosis of the situation for each country. This should include an audit of the existing set up, an assessment of the possibility of re-using existing facilities, evaluation of the current coverage of the territory and population, and penetration rate of other means of reception.
Objective criteria for the ASO	Based on experience in Brazil, one of the best practices that can be highlighted is to use specific objective criteria to decide whether to switch off analogue transmission in a specific region of the country. These criteria need to assess whether the region is ready for the ASO or not, based on the availability of infrastructure to both transmit and receive digital television signals.
Technical standards	It is beneficial for stakeholders that government quickly define its TV standards, in order to publish the regulations governing the approval process and set up regulations governing the technical characteristics of TV receivers.
National frequency plan	It is beneficial if authorities define the national frequency plan, which is a strategic document for the transition considering choices regarding the digital dividend and the number of multiplexes to be broadcast.
Frequency coordination	It is beneficial to all stakeholders that frequency coordination with neighbouring countries and obtaining bilateral agreements be done early in the process in order to address technical issues and identify mutual sharing conditions.

[28] ITU-D study groups. Annual deliverable 2019-2020 for ITU Question 2/1. Considerations about the cost structure of the digital transition, including new services and applications.

(continued)

Receiving antennas	It is important to pay close attention to receiving antennas. Based on experience in the United States, it is effective to develop new antenna guides based on the post-transition experience and post them on a single website ('www.dtv.gov') to provide consumers with the updated information.
Monitoring KPIs and performing surveys are important	ASO should not occur until the network infrastructure has been developed properly and is up and running and the vast majority of homes are adequately equipped for digital reception. Based on experience in Brazil, several parameters need to be monitored throughout the transition process to trigger decision-making, among them: coverage with digital transmissions in any certain area; number of households ready to receive digital transmissions. These key performance indicators (KPI) guide the entities responsible for the migration of television channels and the transition to digital television. The KPIs need to be periodically surveyed, until the ASO date, triggering decision-making, including postponing or not the ASO.
Close cooperation between the different stakeholders	In the United States, FCC collaboration with industry and federal, state and local government was very important to the success of the DTV transition. In Japan, for both digital broadcasting as well as analogue broadcasting, broadcasters, receiving equipment manufacturers, antenna manufacturers and industry associations have been cooperating and working together to promote user-friendly measures such as providing precise information to viewers.
Availability of receivers adapted to the new technical standard	It is beneficial that the country imposes obligations on manufacturers, distributors and vendors. Based on experience in the United States, requiring manufacturers to include a digital receiver tuner in new TV sets by a specific date works very well. It means that consumers do not continue to buy TVs that would be obsolete in the near future.
Establish communication strategies for consumer outreach	Communication to the public, in all possible ways (mass media, public relations, events, etc.) about the transition from traditional analogue TV (ATV) to digital TV (DTV) broadcasting is considered as a critical activity to ensure a successful transition process.
Promoting access to DTV receivers can accelerate the transition	Establishing a subsidy programme, funding consumers in the purchase of receivers, or directly giving receivers to people in the low-income population that might not be able to purchase them can strongly accelerate the transition process by better informing all the interested parties of the necessary actions.
Trial markets	Early transition of a few trial markets was important. "Soft" tests, which are coordinated across all the stations in a market combined with a local call-in centre, are beneficial.
Disposal of equipment that resulted from the DSO process	The experience of Brazil, where criteria were approved in the Steering Committee (GIRED) to establish a procedure and responsibilities for dealing with the disposal of the obsolete, discarded equipment that is no longer in use, may serve as an effective example.

Chapter 2 – Trends in new broadcasting technologies, services and applications

2.1 Introduction

Broadcasting services are evolving and undergoing transformations that are introducing **different ways of watching audiovisual content**. In this context, new broadcasting technologies, services and applications are being provided to users that are enriching their experience.

Currently, emerging media based on the Internet are developing at an extraordinary speed. At the same time, by means of broadband networks, which include 4K and UHD, multimedia broadcast TV, mobile TV, interactive network TV, IPTV (television content over Internet Protocol networks), for example, and other audiovisual new media services, such as augmented reality (AR)/virtual reality (VR), have gained strong development momentum, which in turn is **changing consumer habits and content consumption**.

Some of these trends point to the convergence of broadcast and broadband, with seamless switch between DTTB (digital terrestrial television broadcasting), 4G/5G and Wi-Finetworks, that can allow reductions in mobile-service payment, provisioning of high-quality and personalized services, and anytime/anywhere seamless multimedia services; and to the role of 5G Broadcast in helping offload traffic on mobile-broadband networks, using the strengths of the broadcasting model (high power, wide coverage, direct, free-to-air media delivery) and reducing CDN (content delivery network) bandwidth consumption and optimizing network resources, among other things.

As distribution of video has scaled and become central to the strategies of broadcast operators, telecommunication carriers and other companies, the broadcast industry is entering a new stage as technology and infrastructure are being deployed to support the enormous growth in demand. This is a **critical inflection point** in the evolution of video and audio distribution: as demand for all types of new technologies, services and applications grows exponentially, there are huge opportunities and challenges for all stakeholders.

This is a period of significant change, in which there are opportunities for each segment of this ecosystem. The critical transition that stakeholders must evaluate and execute in the near term is to pivot from treating their networks as conduits for data and move towards **new video-technology-centric networks**.

This new global strategy for video delivery from service providers needs to be considered to cater for future investments, and in that sense regulators/policy-makers need to look at removing barriers to innovation, allowing for co-investment, infrastructure sharing and consolidation in the market.

Figure 5: Distribution models (past/current)

Source: European Broadcasting Union (EBU)

Evidence of this scenario comes from the outcome report of the Workshop on the Future of Cable TV organized by ITU-T Study Group 9 and ITU-D;[29] after observing consumer needs (based on research across multiple countries by Liberty Global), a key trend towards adapting from fixed to flexible scheduling and viewing experience was noted. This trend results from the fact that customers are always online, including when they are on the go and on holiday, and that binge watching is a new viewing habit, as well as checking what is going on (with the family), switching on devices remotely at home, gaming, tuning (music/smart speakers) and chatting.

In that context, service reliability, security and a comprehensive ecosystem are key. These services would be delivered with a multi-screen user interface (very simple), service orchestration (based on customer profile/data, including parental locking of services), and smart home (although the business model/services are still debated on what is best/needed). Next-generation services are also to include voice service activation, predictive (on the basis AI) and tailored services (to the different user groups/individuals).

The same workshop also presented some trends in new user viewing experiences, which should include:

- A seamless viewing experience, recommending linear and non-linear content to viewers/ customers, and where the delivery method and switching would be transparent to the viewer.
- Appropriate "companion devices" based on technologies such as augmented reality, virtual reality and device synchronization.
- Enhancement of UHDTV with 360-degree video and free viewing point capabilities.
- Enhanced viewer/user interface by combining different kinds of inputs.
- Terminal devices could be connected to sensors and actuators, for example in e-health applications (i.e. IoT).

It can also be argued that system integration is key for the deployment of truly converged services, delivered over multiple platforms (including the mobile platform). Consequently, system-integration work should be outsourced, and content-distribution companies should focus on their content-aggregation role.

In that sense, technology development and standardization efforts in that field are under way, especially in ITU-T within ITU-T Study Groups 9 and 16, in areas such as multimedia application frameworks and their possible usage in the broadcasting arena, receivers/end systems (DTT and

[29] ITU-D SG1 Document SG1RGQ/66+Annex from the BDT Focal Points for Questions 1/1, 2/1, 3/1, 5/1 and 6/1; and ITU-D and ITU-T Study Group 9. Outcome Report of the ITU-D Workshop on the Future of Cable TV (Geneva, 25-26 January 2018)

hybrid set-top-boxes/receivers/end systems) and integrated broadcast-broadband (IBB) systems.

Bearing that in mind, the following sections present some trends in new broadcasting services and applications that use this new paradigm to enrich and personalize user experience and provide new possibilities to spectators: first by discussing the impacts of these new trends (section 2.2) and then by presenting some of the new services and applications in broadcasting (section 2.3). This chapter also presents some considerations on the cost structure for deploying such innovative services (section 2.4) and country case studies (section 2.5), and finishes by reporting lessons learned (section 2.6).

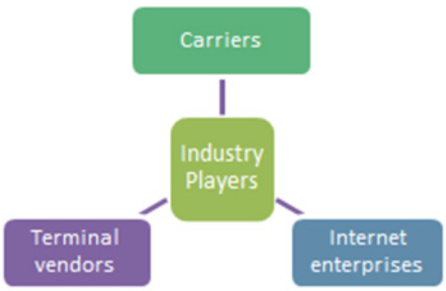
2.2 Economic and regulatory impacts

This section addresses some potential impacts in the television industry, either in terms of its structure (players, network technologies, etc.) or its regulation, so that developing countries can grasp some of the implications of these new trends and take advantage of other country experiences.

2.2.1 Industry players

The status of the broadcasting and TV industry, alongside the Internet industry, points to three major forces in future industry competition: carriers, Internet enterprises and terminal vendors.

Figure 6: Major forces in future industry competition



Carriers

Carrier development strategies mainly rely on the advantages of the traditional broadcasting and TV industry to:

- integrate the upstream and downstream of the industry value chain;
- provide the best convergent network service experience for users through their networks;
- adopt independent R&D, acquisition, merger and investment support;
- provide users with related products and services, such as the Mobile Plus strategy proposed by Vodafone;
- establish strategic alliances with Internet enterprises such as Microsoft, Yahoo, ebay, Google, and Myspace to build and improve their ecosystems.

For example, DirecTV, a cable TV operator in the United States, launched the "ubiquitous TV" service with Apple, giving mobile users access to more than 60 live TV programmes on the TV network.

Carriers can better control the value chain and forcibly form a unified standard. In this way, they can reduce the difficulty of developing applications and sharing information. In addition, carriers can use their own advantages to promote the development of convergent network services quickly. This is good at the early stage of service development. However, this closed model is unfavourable for the long-term development of the industry. It limits the development of some technologies and services, and is not conducive to fair and free competition in the industry.

Internet enterprises

The development strategy of Internet enterprises is to push Internet products and services to the broadcasting and mobile markets by leveraging Internet operation experience and user resources, and fully utilize carrier network resources to implement cross-platform interconnection.

Internet products are being transferred to the broadcast TV and telecommunication markets. The stickiness of user groups is extended or even amplified in the corresponding market. However, the business model is the same as that of the Internet.

It should be noted that Internet enterprises have begun to launch attacks on traditional broadcasting and television carriers, telecommunication carrier services, and industry links. For example, Facebook has entered the video release field; Google operates access services, not to mention the emergence of WeChat, iMessage, and Skypephone.

Terminal vendors

The development strategy of terminal vendors aims at building comprehensive service capabilities around terminals such as intelligent terminals to meet user requirements for audiovisual, network and data, including as IoT games, building self-owned application stores, enriching network applications of terminals and Internet services.

The development strategies and paths of these three forces are different; however, the final competition focuses on network access entrance and first contact of users. With the development of the market, new competitive forces may emerge in the future.

2.2.2 Regulators: Telecommunication operator video transformation already under way

With more and more players entering the broadcast and media industry, the regulation of broadcast is facing new challenges.

Most traditional pay-TV services are now supplemented by various IP-based enhancements. While adoption of traditional subscription services continues at a steady but relatively moderate pace globally, over-the-top (OTT) and mobile video services are emerging as big growth areas for content providers and distributors alike, especially in the period of the COVID-19 pandemic where OTT services have seen an increase in demand.

In television, telecommunication service operators have made slow but steady progress, accounting for around a fifth of global subscriptions. Telecommunication operator expansion beyond their IPTV networks into satellite, cable and OTT distribution is having a substantial impact on the video industry. Specifically, mergers and acquisition activity is enabling telecommunication operators to accelerate their standing in the TV market, in many cases transforming their competitive position from that of challengers to leaders. Among the recent spate of major telecommunication operator mergers and acquisition initiatives in the pay-TV and video entertainment market, we may cite the AT&T acquisition of DirecTV, the Verizon purchase of AOL (as well as its imminent takeover of the Yahoo web business), and the Vodafone expansion into the cable and triple-play markets through its ownership of German Kabel Deutschland and the Spanish operator ONO.

Some insights were also presented in the reportof the Workshop on the Future of Cable TV organized by ITU-T Study Group 9 and ITU-D,[30] where regulations to tackle the challenges of the new technological and user experience scenario were discussed.

Keeping this in mind, NRAs should give room for consolidation and co-investment in the industry. Accordingly, it seems that there would be a need to reverse previous policies whereby competition was encouraged by promoting new market entrants. Furthermore, the promotion of infrastructure sharing would be required. All these measures are needed as the required infrastructure investments are often too large to be carried by a single (smaller) company.

The following standardization gaps were also identified:

a) open platform for TV programme delivery;
b) a common set-top-box for the three different platforms (i.e. cable, terrestrial and satellite);
c) guidelines for (service and network) implementation;
d) IBB compatibility;
e) access services.

Finally, the area of standards for IP multicast was identified as an opportunity where more standardization work is needed.

It was also argued that better service integration depended more on the complex matter of intellectual property rights (IPR) than for example the technical standards of set-top-boxes, as the practical application of IPR is not keeping up with the rapid technological developments and the many different services on offer.

It is furthermore widely acknowledged that linear TV services should be part of a converged offering with truly integrated systems (i.e. seamless switching between services for the end user) and where the mobile platform is key (and, as argued by some, mobile is even the first platform). However, generally, the role of linear TV would change over time, albeit slowly. Linear TV would be more for event-based content and services. This event-based content is not automatically a domain for traditional content distribution companies to control, as (the larger) OTT providers are starting to buy the rights to sporting events and producing event-based content.

[30] ITU-D SG1 Document SG1RGQ/66+Annex from the BDT Focal Points for Questions 1/1, 2/1, 3/1, 5/1 and 6/1; and ITU-D and ITU-T Study Group 9. Outcome Report of the ITU-D Workshop on the Future of Cable TV (Geneva, 25-26 January 2018)

2.2.3 Network technology

The new broadcast technology network is based on broadcasting and TV technologies. It fully utilizes the advantages of radio and television networks, broadband networks and satellite coverage, comprehensively utilizes mature technology standards and industry chain resources, and constructs a multi-network converged, manageable, controllable and reliable broadcast TV and broadband media network.

The construction of the broadcast network and broadband media network complies with the development principles and objectives in **Table 1**.

Table 1: Building broadcast and broadband media networks: principles and goals

<table>
<tr><th>Development principles</th><th>Development goals</th></tr>
<tr><td>Convergence: Build the broadcast TV and broadband media network with mature technologies and achievements of broadcast, telecommunications and Internet.</td><td rowspan="2">1) Under the overall framework of multi-network integration, based on broadcasting and TV technology achievements, comprehensively utilize the broadcasting and television frequency resources, use the broadcasting TV network, broadband network and operation platform to make full use of the advantages of industry chain resource integration, build a converged broadcast TV and broadband media network.</td></tr>
<tr><td>Openness: Leverage the advantages of broadcasting and TV networks to ensure the openness of integrated network interfaces, promote the coordinated coverage of wired, wireless and satellite networks, and unify specifications and interconnection.</td></tr>
<tr><td>Security: The network can be managed, controlled and trusted, including network security, information security and data security, providing technical support for the rapid development of broadcast and television.</td><td rowspan="2">2) Optimize traditional broadcast and TV services, gradually provide high-quality new video services, and coordinate wired and wireless satellite traditional broadcast and TV distribution channels to form a seamless network with seamless coverage, providing a richer and smoother service experience.</td></tr>
<tr><td>Technology integration innovation: Fully consider the ecological development of the technology industry, promote the application deployment of new technologies, new specifications and new products, and build a new high-performance converged network infrastructure.</td></tr>
</table>

2.3 The introduction of new broadcasting technologies and emerging services

This section presents some of the trends regarding broadcasting technologies and emerging services. These can be divided into two categories: new broadcasting distribution and interaction technologies; and new broadcasting production technologies.

Table 2: Trends in broadcasting technologies (distribution and production)[31]

Broadcasting distribution technologies	Broadcasting production technologies
Integrated broadcast-broadband TV (HbbTV, Hybridcast and others)	UHD/HDR/HFR • Higher Resolution (SD, HD, UHD4K, UHD8K) • Higher frame rate (movement closer to real life) • Higher dynamic range HDR-TV (increased contrast, increased luminance range and richer colours)
DVB-I	Advanced immersive audiovisual (AIAV) systems (include augmented reality and virtual reality (AR/VR))
5G Broadcast	

2.3.1 Integrated broadcast-broadband (IBB) systems

One of the new paradigms in the implementation of new services and capabilities in broadcasting is the consumption of content from multiple sources/networks, more specifically from broadcasting and broadband networks. One of the technologies that are being used to perform the integration of content from both sources in the application layer is integrated broadcast-broadband (IBB) systems.

An IBB system is based on the combination of both broadband technologies and various broadcasting technologies, including over-the-air and cable. Various multiple devices are used for effective presentation of content and user interactivity. IBB is being standardized by the ITU Telecommunication Standardization (ITU-T) and Radiocommunication (ITU-R) Sectors within ITU-T Study Group 9 (Broadband cable and TV) and ITU-T Study Group 16 (Multimedia), and ITU-R Study Group 6 (Broadcasting service).[32] A wide range of services is enabled by the IBB systems.

Some use cases for the provision of new services with IBB include services such as catch-up TV, enriched service information, microsites campaigning, second synchronized screen, scalable videos, push video-on-demand (VoD) and targeted advertising.

Some use cases for the provision of new services with IBB are presented in **Annex 2** to this report. The use cases include the following services:

- Catch-up TV
- Enriched service information
- Microsites campaigning
- Second synchronized screen
- Scalable videos
- Push VoD
- Targeted advertising

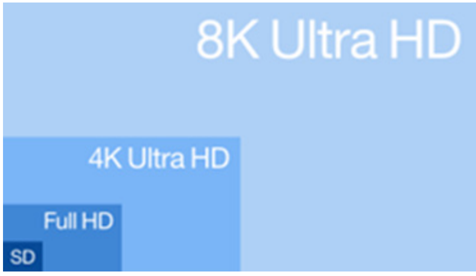
[31] Walid Sami. European Broadcasting Union (EBU). Trends in Broadcasting Technologies. Presentation to the *ITU-D Workshop on Trends in Broadcasting Technologies* (Geneva, 18 March 2019). ITU-D SG1 Document 1/TD/19+Annexes from BDT.

[32] For more information on integrated broadcast-broadband systems, refer to: ITU Intersector Rapporteur Group on Integrated Broadcast-Broadband (IRG-IBB).

Some of these new services may have regulatory implications which would need to be addressed in each country. More details are available in **Annex 2**.

2.3.2 Ultra-high-definition television[33]

Figure 7: UHD pixel comparison



Ultra-high definition television (also known as Ultra HD television, Ultra HD, UHDTV, UHD and Super Hi-Vision) today includes 4K UHD and 8K UHD, which are two digital video formats that were first proposed by NHK Science & Technology Research Laboratories and later defined and approved by ITU.[34]

TV service providers should evaluate their positioning regarding the deployment of 4K UHDTV. Currently, 4K UHD deployments are confined largely to IPTV and OTT services. However, there have been a significant number of launches, which can be noted in the Ultra HD Forum Service Tracker[35] following European TV providers in 2H 2016 with the English Premier League season as a driver for UHD service launches.

In the deployment of UHD, operators face two challenges:

1) the increased burden on their networks of third-party UHD distribution; and
2) how they wish to incorporate UHD distribution into their own service offerings.

However, it can be argued that UHD video and TV availability will have a major impact on the market. The emphasis on a differentiated level of video quality may enable higher prices. For operators to manage the increased network burden, it is critical that they monetize this additional data burden, not just for day-to-day operations but also to ensure that funding is available to maintain network investments to keep pace with growing audience demand for UHD services.

Despite some constraints – such as high prices for 4K UHDTV sets, limited availability of 4K-native content, and bandwidth limitations – TV operators are demonstrating their commitment to launching 4K UHD services and are promoting them along with set-top-box upgrades.

[33] The UHD formats include increased pixel resolutions (4K, 8K), high frame rates (HFR), high dynamic range (HDR), wide colour gamuts (WCG) and/or combinations thereof – UHD enhancements such as HDR and HFR can also be added to HD broadcasts. The Consumer Electronics Association (CEA) announced on 17 October 2012, that "Ultra High Definition", or "Ultra HD", would be used for displays that have an aspect ratio of 16:9 or wider and at least one digital input capable of carrying and presenting native video at a minimum resolution of 3 840×2 160 pixels. In 2015, the Ultra HD Forum was created to bring together the end-to-end video production ecosystem to ensure interoperability and produce industry guidelines so that adoption of Ultra-HD television could accelerate. From just 30 in Q3 2015, the forum recently published a list of more than 145 commercial services available around the world offering 4K resolution.

[34] ITU. Recommendation ITU-R BT.2020, on parameter values for ultra-high definition television systems for production and international programme exchange.

[35] UltraHD Forum. UHD Service Tracker.

Penetration of 4K UHD increased from just 2.5 per cent in 2015 to nearly 30 per cent in 2020. Over the past five years, 4K UHDTV has become increasingly popular. According to data provided by a report[36] from IHS, the shipment of 4K televisions reached around 120 million in 2020. At the same time, 4K UHDTV sales exceeded 10 per cent of total TV sales globally. Price decreases and the introduction of new 4K UHD pay-TV services will boost 4K UHD penetration to nearly half of all households with television by 2020. After China and the United States, Germany and the United Kingdom will become the world's third and fourth biggest 4K UHD markets.

The 4K UHD implementations are outlined in **Annex 3** to this report. These developments highlight the tendency to remain at the forefront of technical innovation.

The infrastructure impact of UHD

Attention should also be drawn to the potential of video delivered over broadband networks. There is growing adoption of UHDTV and video across the entire visual entertainment value chain. Studies also show that consumers enjoy video on mobile devices but not streaming video over cellular networks. Some argue that this is due to a lack of clarity over the amount of data used.

While *bill-shock* has historically constrained mobile video volumes, 4G increasingly addresses this with significantly larger data allowances. However, until there is enough penetration of such data service offers in a given market, video consumption over cellular will remain constrained and the willingness of companies to undertake the necessary experimentation to identify viable business models will not occur. There is a significant opportunity, but operators are exercising caution in rightsizing mobile video investments until there is a clear indication of a viable and sustainable commercial model, particularly when new network technology investments such as 4G and 5G are considered. Some operators are investigating the potential of a separate tariff or commercial model for video data entirely.

UHD potential for network operators lies in the significant rise in data volumes required to deliver higher-resolution video. The quality of video user experience, however, depends on several other factors such as video quality (blocking) and responsiveness of interactive functionality (requires very low RTT), which justifies relatively high price points.

2.3.3 The emergence of virtual and augmented reality

2.3.3.1 Virtual reality

Virtual reality (VR), created in the early 20th century, is a computer simulation system that can create an interface to experience a virtual world. It uses computers to generate a simulated environment and uses the interactive 3D dynamic view and entity behaviour simulation system to immerse users in the environment.

Oculu, a VR start-up that mainly made VR helmets, was bought by Facebook for USD 20 billion. Facebook wanted to be able to apply VR technology to a more vertical new area, including media, education, medicine, and so on. VR technology has a three-dimensional, vivid, all-directional immersion feeling and has penetrated many application fields, including tourism, driving, indoor design and real-estate.

[36] 4K TV and UHD : the whole picture

Traditional broadcasting has started to strategically position itself in new media markets. If live video broadcast and new media video displays are the second screen of the broadcast feed, then VR may become the third screen of broadcast content. Some TV stations have used VR technology to combine with live TV, for example providing more "immersive" news reporting using 360-degree panoramic cameras, where images and sounds have no dead angle, so users feel like a person on site. VR glasses allow uses to experience the full immersion of the virtual effect.

VR was also cited as a driver of data revenues, though the timing was deemed uncertain. Early deployments have relied on data rates in the region of 10 Mbit/s; however, this can rise exponentially as higher resolutions are used, depending on broad market adoption of the technology. VR is expected to shine as video game makers embrace the medium, high-end headsets become available, content creators get on board and smartphones provide the technology. VR also has a potential role in several industry verticals, where it will provide enhancements to existing video communication solutions. The health sector can benefit from VR applications, such as for surgery simulation, remote surgery and tele-medicine.

On 28 April, 2019, the first live 5G VR broadcast was realized for the Chinese Basketball Association Finals. During the finals, 3+1VR live broadcast spots were opened in Dongguan and Guangzhou, including VR live homes, bars, event theme pavilions and virtual social viewings in different places. Over 200 fans watched the event with a praise rating of 84 per cent, with the majority of viewers (94 per cent) willing to upgrade 5G and Gigabit services for VR live broadcast.[37]

2.3.3.2 Augmented reality

Augmented reality (AR) is an interactive experience of a real-world environment whereby the objects that reside in the real-world are "augmented" by computer-generated perceptual information, sometimes across multiple sensory modes, including visual, auditory, haptic, somatosensory and olfactory. The overlaid sensory information can be constructive (i.e. additive to the natural environment) or destructive (i.e. masking of the natural environment) and is seamlessly interwoven with the physical world such that it is perceived as an immersive aspect of the real environment. In this way, AR alters perception of a real-world environment, whereas VR completely replaces the user's real-world environment with a simulated one.

The primary value of AR is that it brings components of the digital world into a person's perception of the real world and does so not as a simple display of data, but through the integration of immersive sensations that are perceived as natural parts of an environment. The first commercial AR experiences were used largely in the entertainment and gaming businesses, but now other industries are also getting interested in AR possibilities, for example in knowledge sharing, education, managing information flow and organizing distant meetings. AR is also transforming the world of education, where content may be accessed by scanning or viewing an image with a mobile device. Another example is an AR helmet for construction workers that displays information related to the construction site.

The most significant mobile AR app is Pokémon GO and its global success may kick-start this segment. Pokémon GO relies on data over cellular networks because the basic premise of the game is that the player must play while walking.

37 ITU-D SG1 Document SG1RGQ/249 from Huawei Technologies Co. Ltd. (China)

Telecommunication operators are likely to start incorporating VR and AR components into the video communication solutions they already offer to enterprise and industry customers. The success of VR and AR in the enterprise will be highly dependent on the strength of the ecosystem developed in support of the hardware, and 360-degree cameras are one example of this ecosystem starting to build out. Enterprises are far more likely to embrace the less bandwidth-intensive AR applications than the consumer segment, which will gravitate significantly towards VR gaming scenarios. Coming with the option of a VR headset accessory is translating to lots of industry excitement, media coverage and early-adopter demand.

2.4 Considerations of the cost structure of new services and applications

The status of the broadcasting and TV industry, alongside the Internet industry, points to three major forces in future industry competition, namely: carriers, Internet enterprises, and terminal vendors.

The development strategies and paths of these three forces are different; however, the final competition focuses on network access entrance and first contact of users. With the development of the market, new competitive forces may emerge in the future.

Consolidation and co-investment in the industry are key movements that can be noted to cope with the new investments needed and to reach a new cost structure to allow growth. Specifically, mergers and acquisition activity are enabling service providers to accelerate their standing in the TV market, in many cases transforming their competitive position from that of challengers to leaders.

Accordingly, it seems that there would be a need to reverse previous policies whereby competition was encouraged by promoting new market entrants. Furthermore, the promotion of infrastructure sharing would be required. All these measures are needed as the required infrastructure investments are often too large to be carried by a single (smaller) company alone.

These movements (consolidation and co-investments) can be verified by the insights gathered in the report of the Workshop on Future of Cable TV organized by ITU-T Study Group 9 and ITU-D,[38] where regulations to tackle the challenges of the new technological and user experience scenario were discussed.

For example, some key findings that were highlighted are presented below:

- Promotion of infrastructure investments is needed and supported by the Polish regulator by following the EU directives/regulations closely, including co-investment and infrastructure sharing. The regulatory topics include bitstream access, local loop unbundled but also access to passive infrastructure – ducts/masts, connections and in-house wiring; the list of key challenges includes the use of infra – infra sharing, competition and cost-based access[39].
- Key enablers for broadband growth in Portugal are the regulatory and policy approach (free market entry, investment promotion, access to infra), infrastructure development,

[38] ITU-D SG1 Document SG1RGQ/66+Annex from the BDT Focal Points for Questions 1/1, 2/1, 3/1, 5/1 and 6/1; and ITU-D and ITU-T Study Group 9. Outcome Report of the ITU-D Workshop on the Future of Cable TV (Geneva, 25-26 January 2018)

[39] Marcin Cichy. Office of Electronic Communications (UKE), Poland. Towards Gigabit society – how to ensure the increase of telecommunication networks efficiency. Presentation to the *ITU-D Workshop on the Future of Cable TV* (Geneva, 25-26 January 2018).

competition (promote co-investments), and operators' strategies (including to deploy ADSL and FTTH as to complete their cable infrastructure).[40]

- It was stated that NRAs should give room for consolidation and co-investment in the industry. Accordingly, there is a need to reverse previous policies whereby competition was encouraged by promoting new market entrants. Also, the promotion of infrastructure sharing is needed. All these measures are needed as the required infrastructure investments are often too large to be carried by a single (smaller) company[41].
- In addition, it was remarked that the cable industry needs more regulatory room for co-investment, consolidation and network sharing so as to facilitate the required network investments for broadband capacity[42].

As it is stated in section 2.2.3, the new broadcast technology network is based on several broadcasting and TV technologies. Therefore, to implement new broadcasting technologies, services and applications in this new environment, which seems to be heading towards a global media strategy for service providers, not restricting the service offers to the traditional broadcasting market, it seems that consolidation, co-investment and infrastructure sharing are key trends to reduce costs and allow for massive investments in network deployment and content delivery.

The strategies and socio-economic aspects of the introduction of new broadcasting technologies, emerging services and capabilities can be found in the ITU-D Question 2/1 Annual Deliverable for 2020,[43] available in the six UN official languages.

2.5 National experiences on strategies and socio-economic aspects of the introduction of new broadcasting technologies, emerging services and capabilities

There is no doubt that different countries will adopt different strategies in the process of introducing new broadcasting technologies, emerging services and capabilities. They will bring better audiovisual experience to customers, promoting social and economic development. In this section national experiences will show how new broadcasting technologies, services and capabilities are being planned and deployed.

Implementation of UHD

With the maturity of HD, UHD is a natural upgrade path for broadcasters. UHD Forum data (April 2017) on UHD deployments around the world found that almost half (45 per cent) of the services launched are European initiatives, Asia-Pacific accounts for 31 per cent and North America 20 per cent. Some interesting cases from China with the *CUVA UHD Industry Development Action Plan 2018-2022* and Japan with the Tokyo Olympic Games are detailed in Box 2.1.

40 Cristina Lourenço. *Autoridade Nacional de Comunicações* (ANACOM), Portugal. Cable TV in Portugal: Market trends and key enablers. Presentation to the *ITU-D Workshop on the Future of Cable TV* (Geneva, 25-26 January 2018).

41 ITU-D and ITU-T Study Group 9. Outcome Report of the ITU-D Workshop on the Future of Cable TV (Geneva, 25-26 January 2018). §9.1, Session 1: Enabling Environment for Sustainable Growth and Deployment of Cable TV.

42 ITU-D and ITU-T Study Group 9. Outcome Report of the ITU-D Workshop on the Future of Cable TV (Geneva, 25-26 January 2018). §9.4, Session 4: Setting International Standards for Sustainable Growth of Cable TV.

43 ITU-D study groups. Annual deliverable 2019-2020 for ITU Question 2/1. Considerations about the cost structure of the digital transition, including new services and applications.

In 2017, the United States adopted ATSC 3.0. Several new services and applications are enabled by this new digital television standard, for example, enhanced public safety capabilities (see Box 2.2), advanced accessibility options as well as more immersive pictures and sound, including ultra-high definition television, superior reception, mobile viewing capabilities, localized content and interactive educational children's content.

Box 2.1. Ultra-high definition in China and Japan

China

In March 2018, CUVA (the China 4K Ultra High Definition Video Industry Alliance) was created in Beijing, China. CUVA includes members from broadcast and television equipment manufacturers, network and terminal manufacturers, academic universities and research institutions, television stations and programme manufacturing companies, and the *China Ultra HD Industry Development Action Plan 2018-2022* has been released. In 2018, ultra-high-definition TV sales in China accounted for 67 per cent of sales, the number of 4K set-top box users of the three major telecommunication operators reached 150 million, the Central Radio and Television General Station, Guangdong Radio and Television Station, officially opened 4K TV channels, and the Ultra High Definition Video Production Technology Collaboration Centre was established.

In 2019, the world's first 5G+8K TV, the world's first 8K surveillance camera and the first ultra-high definition 4K news camera were launched by CUVA members. More details can be found in a contribution from China.[1]

Japan

In Japan, the migration towards digital terrestrial broadcasting was completed at the end of March 2012, and broadcasting has been fully digitalized and Hi-Vision broadcasting infrastructure has been deployed since then.

As one of the next administrative priority issues in the broadcasting field, the Ministry of Internal Affairs and Communications (MIC) is promoting efforts to spread 4K/8K broadcasting. MIC has held meetings related to a 4K/8K broadcasting roadmap since February 2014, and released an interim roadmap in September 2014 that was revised in July 2015. The roadmap aimed to promote 4K/8K broadcasting so that viewers can enjoy 4K/8K programmes on commercially available TV sets when the Tokyo Olympic Games and Paralympic Games are held.

Comprehensive 4K/8K terrestrial broadcasting research and development and the technical feasibility of 4K/8K broadcasting with high capacity within limited terrestrial broadcasting frequency bands is ongoing.

[1] ITU-D SG1 Document SG1RGQ/251 from Huawei (China)

Even after the start of 4K/8K satellite broadcasting, conventional Hi-Vision (2K) broadcasting on Hi-Vision terrestrial, satellite and cable TV broadcasting will continue.

The dissemination of the New 4K/8K satellite broadcasting requires:

- public promotion of compatible receivers;
- enhancement of broadcast content;
- publicity for receiving methods;
- receiving environment improvements for left-hand circular polarization channels.

New services and applications in broadcasting are focusing on emergency alerting and disaster mitigation and prevention (see Box 2.2). The broadcasting infrastructure should be adapted to be a transparent system to ensure no signal blockage in the signal distribution chain and thus ensure the transmission of signalling in the appropriate area.[44]

Box 2.2. Emergence alerting in ISDB-Tb and enhanced public safety capabilities of ATSC 3.0

Japan, Brazil and other countries have adopted the ISDB-TB digital television standard, which implements the Emergency Warning Broadcasting System (EWBS), and has been launched in Japan as a major disaster-prevention mechanism.

EWBS is transmitted through a signal sent over free-to-air channels, triggering compatible reception equipment, such as televisions and radios, and warning the population of risks of a natural disaster and informing them of actions such as evacuation measures.

Enhanced public safety capabilities of ATSC 3.0 include new functionalities, such as:

- Geo-targeting of emergency alerts to tailor information to communities
- Emergency alerting capable of waking up sleeping devices to warn consumers of imminent emergencies.

More details can be found in a contribution from the United States[1]

1 ITU-D SG1 Document 1/206 from the United States

2.6 Conclusions: Lessons learned from national experiences

User demand for radio and television has shifted to a higher-quality audio and video experience and new changes are taking place in the broadcast industry. Alongside that, COVID-19 has reinforced the importance of broadcasting and hybrid systems (broadcast-broadband). Therefore, the media industry is often qualified as the major driver for increases in access network speeds and reliability.

44 For more information, including on EWBS, see: *Fórum do Sistema Brasileiro de TV digital terrestre* (SBTVD). Technical Standards – Brazilian Digital Terrestrial Television System; and ITU-D SG1 Document SG1RGQ/220 from Brazil.

Additionally, intelligent cooperative hybrid broadcast/broadband networks can help achieve highly resilient, high-throughput networks with optimum coverage.

Given also that broadcast has no congestion issues, it is therefore best for linear TV, notwithstanding that, technically, broadband networks have been highly reliable. However, with increased broadband traffic comes increased CDN costs.

Consumer habits and content consumption are changing. Emerging media based on the Internet are developing fast. At the same time, by means of broadband networks, which include 4K and ultra-high definition (UHD), multimedia broadcast TV, mobile TV, interactive network TV (through IPTV for example) and other audiovisual new media services, such as AR and VR, have gained strong development momentum.

There are huge opportunities and challenges for all the stakeholders. This is a period of significant change, in which there are opportunities for each segment of this ecosystem. The critical transition that stakeholders must evaluate and execute in the near term is to move their networks from conduits for data towards new video-technology-centric networks.

NRAs should consider consolidation and co-investment in the industry. Regulators can provide an enabling environment allowing for new business models and service offers, unleashing innovative services to the benefit of users, and providing certainty to stimulate investment in equipment, networks and services. There is benefit in regulators' incentivizing co-investment, infrastructure sharing and M&A movements that foster/boost investments in network infrastructure. They can support a long-term vision for the media sector as one of the important verticals of 5G. Market certainty is important for 5G media delivery implementation, as it allows the clear identification of business models and commercial arrangements required among stakeholders and associated economic and regulatory implications. It is important that regulators allow for diversity and plurality of voices in broadcasting services and their content, no matter on which technological platform.

4K+UHD will become the basic requirement of customers. 4K high-definition TV will become part of the information-society ecosystem, serving society and individuals.

5G and mobile communication technologies will greatly change the broadcasting industry. There is a potential for 5G networks in audiovisual content distribution, as another complementary platform to extend content's outreach and to combine linear TV and VoD with other applications such as VR/AR and interactive content. The complementary nature of 5G and broadcasting is also reflected in the way each technology reaches the consumer, with 5G being a good solution to address smartphones, tablets and mobile devices for content distribution.

Consolidation and co-investment in the industry are key movements that can be noted to cope with the new investments needed and to reach a new cost structure to allow growth. Specifically, mergers and acquisition activity are enabling service providers to accelerate their standing in the TV market, in many cases transforming their competitive position from that of challengers to leaders.

The emergence of virtual and augmented reality. With the development and increasing use and practical applications of VR and AR, this technology may fundamentally change the personal video experience, for example diverting TV viewers, changing education and expanding its scope to daily use in work and life.

Chapter 3 – Use of the digital dividend frequency bands resulting from the transition to terrestrial digital broadcasting, including technical, regulatory and economic aspects

3.1 A brief summary

The *digital dividend is* the spectrum that has been and will continue to be freed up in the switchover from analogue to digital television. It may be used by broadcasting services (e.g. provision of more programmes, high-definition, 3D or mobile television). It may also be used by other services, such as the mobile service, in a frequency band which could be shared with broadcasting (e.g. for short-range mobile devices, such as wireless microphones used in theatres or during public events). It may also be used in a distinct, harmonized frequency band to enable ubiquitous service provision, universally compatible equipment and international roaming (e.g. for International Mobile Telecommunications, IMT).

In 2015, ITU published a report on the transition to digital terrestrial television in the UHF bands including a definition of the digital dividend; technical, regulatory, economic and societal aspects in the area of spectrum management; and, in annexes, national and regional experiences on the implementation of the digital dividend.[45]

The 2018 version of the *Digital dividend: Insights for spectrum decisions* report provided a detailed insight into the digital dividend process and benchmarking of digital dividend spectrum decisions, in addition to country experiences in relation to allocation and implementation of the digital dividend.[46]

3.2 Availability of the digital dividend

The digital dividend for the mobile service (IMT) can only be made available after analogue switch-off in order to avoid interference with broadcasting services. For the 700 MHz band, the frequency band should be freed from digital broadcasting and from other services to which it may be allocated. A number of incumbent users will need to be migrated to other frequencies. These devices include wireless audio equipment such as wireless microphones that have traditionally operated using a class licence. It is critical that these modifications be clearly communicated to businesses and users who may be affected, and efforts should be made to restrict the sale of non-conforming devices and ensure that vendors of the relevant products are fully informed.

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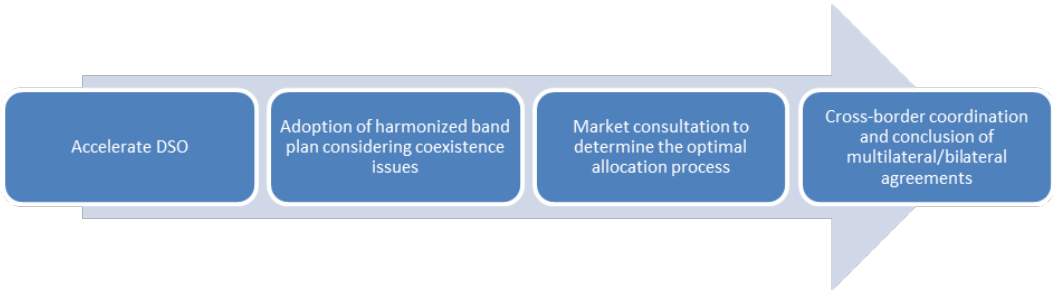
45 ITU-R. Report ITU-R SM.2353 (06/2015), on the challenges and opportunities for spectrum management resulting from the transition to digital terrestrial television in the UHF bands.

46 ITU. Thematic reports. Infrastructure. Digital dividend: Insights for spectrum decisions. Geneva, 2018.

Different actions and decisions should be considered by ministries and national regulatory authorities to secure the digital dividend across an entire region and to bring the DD1 (digital dividend 1) and DD2 (digital dividend 2) services to consumers (see **Figure 8**). More details are provided in **Annex 4** to this report regarding the availability of the 700 MHz band in Europe (Region 1).

Figure 8: Actions/decisions to be considered related to the availability of the digital dividend



3.3 Status of use of the digital dividend frequency bands

The digital dividend frequency bands can be made available in several ways, and regulators can choose the best option to reach their policy objectives.

Countries should assess their spectrum policies and regulations to attain these objectives, including for making the digital dividend available by auctions, as shown below for the United Kingdom and Brazil. However, it is worth noting that there are other ways of disposing of this spectrum, an example being to offer it at the minimum amount that the operator accepts as the winning bid reserve-price, defined for example by benchmarking.[47]

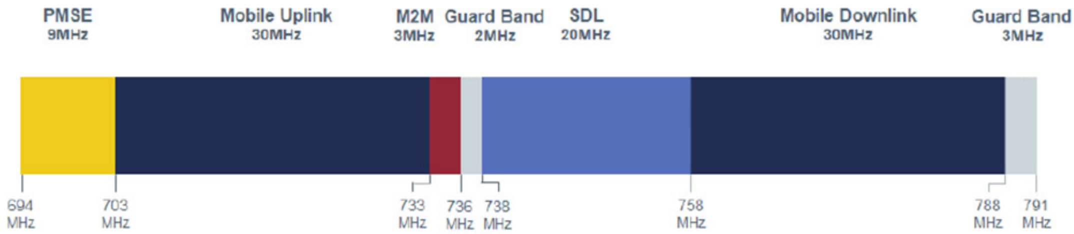
3.3.1 United Kingdom

Currently, the 700 MHz band is largely dedicated to the provision of DTT services, similar to the 470-694 MHz range. However, Ofcom has decided[48] to make this band available for mobile use by May 2020, in keeping with other EU countries. This requires the relocation of DTT and PMSE (programme making and special events) services. The planned configuration of the 700 MHz band is presented in **Figure 9**.

47 ITU-D SG1 Document 1/298 from ATDI (France)

48 Ofcom (United Kingdom). Decision to make the 700 MHz band available for mobile data (Statement of 19 November 2014; Maximising the benefits of 700MHz clearance (Statement of 17 October 2016); and Coexistence of new services in the 700 MHz band with digital terrestrial television (Statement of 14 December 2017).

Figure 9: Planned 700 MHz configuration in the United Kingdom

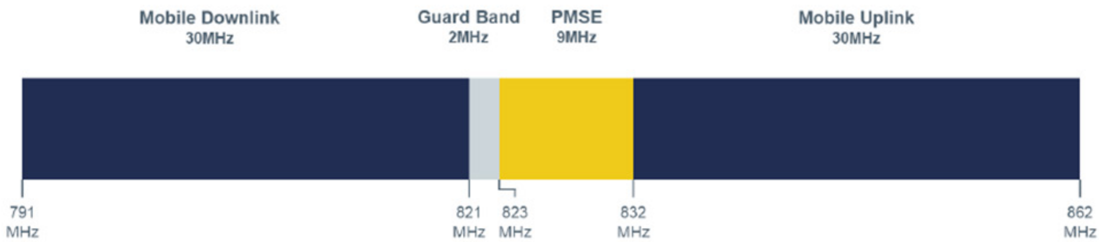


80 MHz of spectrum will be awarded in the 700 MHz band within the 694-790 MHz frequency range. As shown in **Figure 9**, this spectrum consists of two 30 MHz blocks of paired spectrum (703-733 MHz and 758-788 MHz), and a 'centre gap' of 20 MHz at 738-758 MHz. The paired spectrum in the 700 MHz band is configured under a mobile band plan based on a frequency-division duplex (FDD) arrangement, with the uplink delivered on frequencies at 703-733 MHz and the downlink on frequencies at 758-788 MHz. The centre gap is suitable for delivering supplemental downlink (SDL) signals for mobile services.

Ofcom further announced a consultation on the possibility of allocating 3 MHz of the remaining centre gap to M2M services. The guardband at the bottom of the 700 MHz band (694-703MHz) has been designated by Ofcom for PMSE users. In contrast to other European countries (e.g. France), there is no allocation of spectrum for public protection and disaster relief (PPDR). This is due to plans to use commercial mobile networks for the emergency services network (ESN).

The 800 MHz band was made available for mobile-broadband services in 2013, following the decision to grant a co-primary allocation to mobile services after the digital switchover of broadcasting services to DTT. A total of 2 × 30 MHz is available for mobile network operators (MNOs) and the spectrum is being used to deliver IMT-Advanced (4G) coverage across the United Kingdom. Spectrum in the 823-832 MHz duplex gap is used by PMSE following a decision by the European Commission in 2014 to harmonize this spectrum for PMSE across Europe, with the intention of enabling economies of scale. PMSE applications are limited to audio devices (e.g. wireless microphones). The resulting configuration of the 800MHz band is presented in **Figure 10** below.

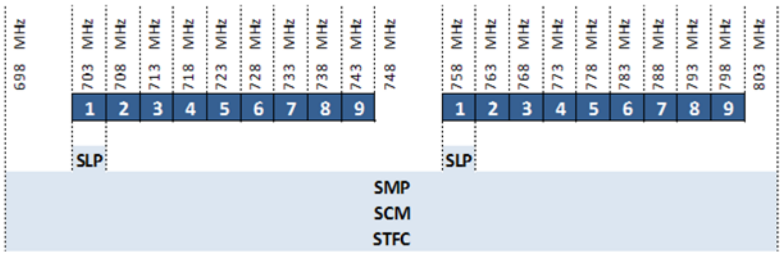
Figure 10: Current configuration of the 800 MHz band in the United Kingdom



3.3.2 Brazil

In 2013, Brazil approved the allocation of the 700 MHz band to fixed and mobile services to provide voice and data communications.[49] The band allocation was established to comply with frequency-division duplexing (FDD) and the band was divided into nine 5 + 5 MHz sub-bands. Use of time-division duplexing (TDD) in these sub-bands could be authorized if technically feasible. Finally, it was decided that the first 5 + 5 MHz sub-band would not be used for IMT-Advanced (4G) services, consequently it was allocated for public safety applications. The allocation of the band is shown in **Figure 11**.

Figure 11: Frequency allocation of the 700 MHz band in Brazil

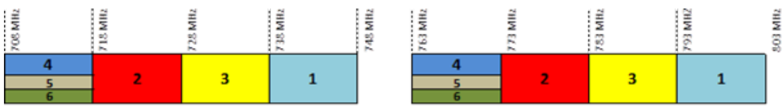


A spectrum cap of 10 + 10 MHz was also established for the first round of the auction. The cap could be increased to 20 + 20 MHz for the second round of the auction for any remaining spectrum. For small cities, the spectrum cap could be also increased to optimize investments, for example with the usage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

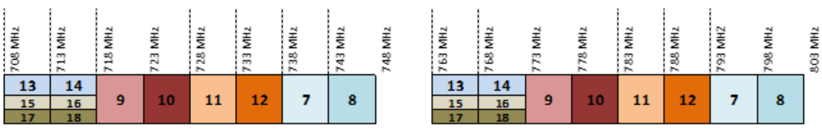
The auction established three national bands of 10 + 10 MHz and one band of the same size for certain regions. For the second round, the remaining spectrum needed to be sold in smaller chunks of 5 + 5 MHz.

Figure 12: Brazilian 700 MHz band auction rounds

First round

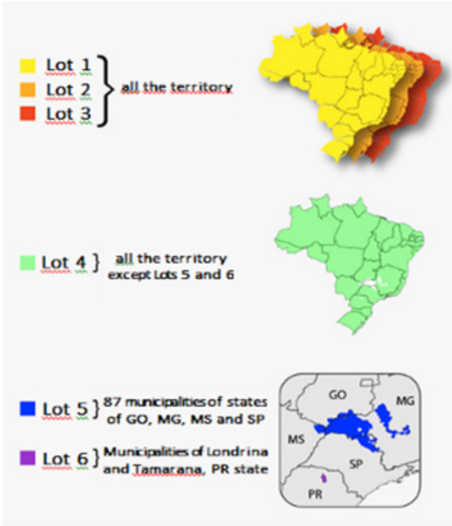


Second round



[49] *Agência Nacional de Telecomunicações* (Anatel) (Brazil). Resolution No. 625 of 11 November 2013. [in Portuguese]

Figure 13: Brazilian 700 MHz band auction areas



Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of ITU and of its secretariat concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Currently, the 700 MHz band is free and ready to be used by mobile services. The approval of the latest study on the release of 700 MHz frequencies for IMT-Advanced (4G) does not mean that all cities can take advantage of this technology. It means that everyone can use the band for 4G, but the practical implementation may depend on other factors. However, several municipalities throughout the country now benefit from 4G services in the band. Recent statistics show that there are more than 152 million 4G subscribers in Brazil (out of a total of around 228 million subscribers).[50]

3.4 Sharing of the digital dividend frequency bands

The introduction of wireless broadband in the 700/800 MHz bands calls for the development of technical conditions and sharing studies to ensure the deployment of wireless broadband services and appropriate protection for incumbent services such as broadcasting services, PMSE and M2M in addition to other coexistence and compatibility issues.

ITU-R, in collaboration with international standardization bodies, is working actively to define the technical and regulatory conditions for the 700 MHz band for wireless broadband alongside broadcasting services.

Recent recommendations and reports related to sharing conditions for the digital dividend frequency bands include:

- Recommendation ITU-R M.1036-6 (10/2019):[51] "Frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications in the bands identified for IMT in the Radio Regulations".

50 Anatel (Brazil). Painéis de Dados. Acessos. Telefonia Móvel.
51 ITU-R. Recommendation ITU-R M.1036-6 (10/2019): "Frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications in the bands identified for IMT in the Radio Regulations"

- CEPT Report 60:[52] "To develop harmonized technical conditions for the 694-790 MHz ('700 MHz') frequency band in the EU for the provision of wireless broadband and other uses in support of EU spectrum policy objectives".
- CEPT Report 30[53] "The identification of common and minimal (least restrictive) technical conditions for 790 - 862 MHz for the digital dividend in the European Union".
- CEPT Report 53[54]"To develop harmonized technical conditions for the 694-790 MHz ('700 MHz') frequency band in the EU for the provision of wireless broadband and other uses in support of EU spectrum policy objectives".
- ECC Report 239[55] "Compatibility and sharing studies for BB PPDR systems operating in the 700 MHz range".

3.5 Harmonization and cooperation at regional level

The digital dividend is a clear enabler for economic and social growth. However, regional/ international harmonization has a key role to play in its allocation. Spectrum harmonization can:

- enable global roaming;
- reduce the risk of cross-border interference;
- reduce interference with adjacent services;
- reduce the cost of mobile and the complexity of radio design.

Table 3 summarizes the actions undertaken in different regions in terms of spectrum harmonization:

52 European Conference of Postal and Telecommunications Administrations (CEPT). CEPT Report 60: Report B from CEPT to the European Commission in response to the Mandate "To develop harmonized technical conditions for the 694 -790 MHz ('700 MHz') frequency band in the EU for the provision of wireless broadband and other uses in support of EU spectrum policy objectives". 1 March 2016

53 CEPT. CEPT Report 30: Report from CEPT to the European Commission in response to the Mandate on "The identification of common and minimal (least restrictive) technical conditions for 790 - 862 MHz for the digital dividend in the European Union". 30 October 2009.

54 CEPT. CEPT Report 53: Report A from CEPT to the European Commission in response to the Mandate "To develop harmonized technical conditions for the 694 -790 MHz ('700 MHz') frequency band in the EU for the provision of wireless broadband and other uses in support of EU spectrum policy objectives". 28 November 2014.

55 CEPT. CEPT Report 239: "Compatibility and sharing studies for BB PPDR systems operating in the 700 MHz range". 30 September 2015.

Table 3: Actions in the Europe and Asia-Pacific regions in terms of spectrum harmonization

Europe region

For the 800 MHz band

Discussions on the digital dividend started in 2006 with the adoption of a Radio Spectrum Policy Group opinion and a European Commission mandate to CEPT in early 2007.

Following WRC-07 decisions, the European Commission issued a second mandate to CEPT on the technical considerations regarding "harmonization options for the digital dividend in the European Union". The European Commission adopted the following:

- European Commission Recommendation 2009/848/EC on "facilitating the release of the digital dividend in the European Union", in October 2009.
- Commission Decision 2010/267/EU on "harmonized technical conditions of use in the 790-862 MHz frequency bands for terrestrial systems capable of providing electronic communications services in the European Union", in May 2010.
- The preferred harmonized channeling arrangement for the band 790-862 MH in the EU is described in CEPT Report 31.

790-791	791-796	796-801	801-806	806-811	811-816	816-821	821 – 832	832-837	837-842	842-847	847-852	852-857	857-862
Guard band	Downlink						Duplex gap	Uplink					
1MHz	30 MHz (6 blocks of 5 MHz)						11 MHz	30 MHz (6 blocks of 5 MHz)					

For the 700 MHz band

Based on European Parliament and Council Decision 2017/899 of May 2017, a deadline of 30 June 2020 (or up to two years later with adequate justification) has been set for reassignment of the 700 MHz frequency band (694-790 MHz) to wireless broadband services in Europe.

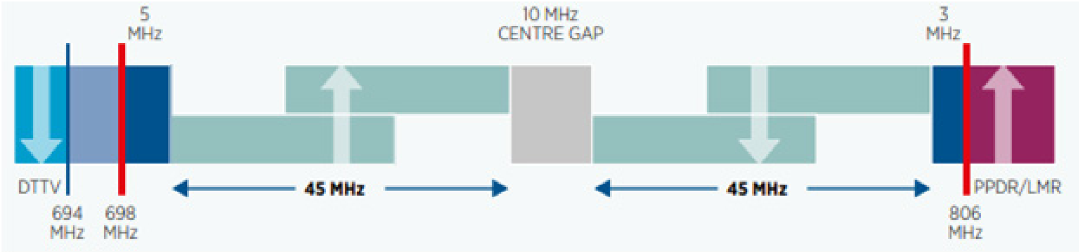
The harmonized technical conditions for the 700 MHz band (694-790 MHZ) are described in ECC Decision 15(01) and CEPT Report 61.

694-703	703-708	708-713	713-718	718-723	723-728	728-733	733-738	738-743	743-748	748-753	753-758	758-763	763-768	768-773	773-778	778-783	783-788	788-791
Guard band	Uplink						Gap	SDL (A)				Downlink						Guard band
9 MHz	30 MHz (6 blocks of 5 MHz)						5 MHz	20 MHz (zero up to 4 blocks of 5 MHz)				30 MHz (6 blocks of 5 MHz)						3 MHz

Asia-Pacific region

For the 700 MHz band

A consensus was reached concerning the basic structure of a harmonized frequency arrangement for the 698-806 MHz band as specified inapt Report APT/AWF/REP-14. In order to provide sufficient protection for the services in adjacent bands, it was concluded that sufficient guard-band allocations within the 698-806 MHz band are necessary in addition to other mitigation measures. It was agreed that spectrum should be allocated as follows:



Source: APT

1. A guardband of 5 MHz at the lower end, between 698 and 703 MHz.
2. A guardband of 3 MHz at the higher end, between 803 and 806 MHz.
3. Two duplex frequency arrangements of 2 x 30 MHz (703-733 MHz/758-788 MHz and 718-748 MHz/773-803 MHz) providing a total of 2 x 45 MHz of usable paired spectrum.

In addition, coordination at regional level, by which all countries in a region jointly agree to use these bands in a consistent way, is highly recommended. It also contributes to increasing economies of scale for the provision of mobile equipment. **Table 4** shows some examples of regional initiatives established to ease the frequency coordination issues carried out by their member countries and to facilitate the implementation of the digital dividend.

Table 4: Regional initiatives for frequency coordination

Europe	Different regional groups were established within Europe to carry out the cross-border negotiations and agree on a multilateral plan which was subsequently taken on board in bilateral agreements: • WEDDIP (West European Digital Dividend Implementation Platform): Created in May 2009 by the administrations of the following countries: Belgium, France, Germany, Ireland, Luxembourg, the Netherlands, Switzerland and the United Kingdom. • NEDDIF (North-East Digital Dividend Implementation Forum): Created in October 2010 by the administrations of the following countries: Czech Republic, Estonia, Finland, Germany, Hungary, Latvia, Lithuania, Poland and Slovakia. • (South-East Digital Dividend Implementation Forum): Created in October 2015 by 10 countries around Hungary for the second digital dividend. • BSDDIF (Black Sea Digital Dividend Implementation Forum): Created in October 2017 by four countries around the Black Sea for the second digital dividend.
Central America and Caribbean (CAC)	The San Salvador Declaration adopted by COMTELCA members on 26 July 2016 during the Central American Summit on Digital Terrestrial Television and the Digital Dividend, El Salvador, 25-26 July 2016, initiated the regional frequency coordination meetings on the use of the VHF band (174-216 MHz) and the UHF band (470-698 MHz). Four coordination meetings were organized (in March 2017, August 2017, May 2018 and September 2018) with ITU assistance in collaboration with CITEL, COMTELCA and CTU.[56] The purpose was to initiate multilateral coordination to ensure the compatibility of national frequency plans in support of terrestrial television broadcasting and mobile broadband in the VHF band (174-216 MHz) and UHF band (470-806 MHz) in Central America and the Caribbean.
Sub-Saharan Africa	Between 2012 and 2013, and following a ministerial summit on the issue, three frequency coordination meetings were organized jointly by ITU and the African Telecommunications Union (ATU) in Bamako (March 2011), Kampala (April 2011) and Nairobi (July 2013),[57] in addition to other bilateral and multilateral meetings held in 2011 and 2012. These frequency coordination negotiations have succeeded in setting up the mechanism to deploy digital television in 47 Sub-Saharan Africa countries and this has enabled countries to allocate the digital dividend to mobile services in the 694-862 MHz band.
Arab States	Between 2014 and 2015, and following the 35th meeting of the Permanent Arab Committee for Communications and Information (March, 2014) and contributions from the Technical Secretariat of the Council of Arab Ministers for Communications and Information, three coordination meetings were organized by the Arab Spectrum Management Group (ASMG) with ITU assistance in Dubai (May 2014), Hammamet (September 2014) and Marrakesh (April 2015)[58] This activity was intended to enable the 17 Arab States region countries involved in the process to ensure sufficient spectrum for broadcasting in the 470-694 MHz band (minimum four nationwide broadcasting coverages) and to be able to release the 700/800 MHz bands.

56 ITU-R. ITU regional frequency coordination for Central America and the Caribbean.
57 ITU-R. Sub-Saharan Africa GE06 frequency coordination meetings.
58 ITU-R. Arab Spectrum Management Group (ASMG) – GE06 frequency coordination meetings. For more details:

3.6 Role of the digital dividend in cost savings on the transition to digital, and best practice

Due to its propagation characteristics, spectrum in the 700 MHz band provides significant cost savings for operators that also benefit consumers:

- It provides superior performance inside buildings with less attenuation by terrain.
- It operates over a greater range, i.e. the coverage at 700 MHz can be up to 300 per cent greater than at 2.6 GHz.
- Fewer base stations are required, which means lower capital cost per area covered, more rapid roll-out for operators, and lower connectivity prices for consumers.

The economic benefits of the 700 MHz deployment are not restricted to mobile consumers. Improved availability and quality of mobile services can have a positive impact on economic growth, which spreads benefits across society: better productivity, new business activity, job creation, impact on GDP and tax revenues.

In addition, the 700 MHz spectrum can play an important role in bridging the digital divide by providing coverage in rural and remote areas where population density is low and where communication infrastructure investment may not be commercially viable (more details are given in section 3.7). **Annex 5** summarizes some of the research/studies carried out by analysts describing the socio-economic and commercial benefits to countries that allocate the digital dividend to mobile.

3.7 The use of the digital dividend to help bridge the digital divide, especially for the development of communication services for rural and remote areas

There is no doubt that the Internet has become one of the most fundamental and vital infrastructures around the world. According to the new Roadmap for Digital Cooperation launched by the United Nations Secretary-General on 11 June 2020,[59] 93 per cent of the world's population live within physical reach of mobile-broadband or Internet services. However, it is estimated that only 53.6 per cent use the Internet, leaving an estimated 3.6 billion people around the world without Internet access. Least developed countries (LDCs) remain the least connected with only 19 per cent of the population connected. During the launch of this new roadmap, ITU Secretary-General Mr Houlin Zhao said that now is the time to review our strategy and business models, based on the lessons learnt from COVID-19, to speed up the development of digital society and accelerate progress toward bridging the digital divide: "We have entered the Decade of Action. With 10 years left to achieve the Sustainable Development Goals and 3.6 billion people around the world still unconnected, ITU is redoubling its efforts to leave no one offline".

The digital divide, which refers to the gap in usage of and access to modern ICT between individuals, households, businesses, or geographical areas, remains significantly wide for emerging economies. Persons suffering from the connectivity gap can be divided into two categories: those who are covered but not connected, and those who are not covered at all. The vast majority of the uncovered population lives in rural and remote areas in developing

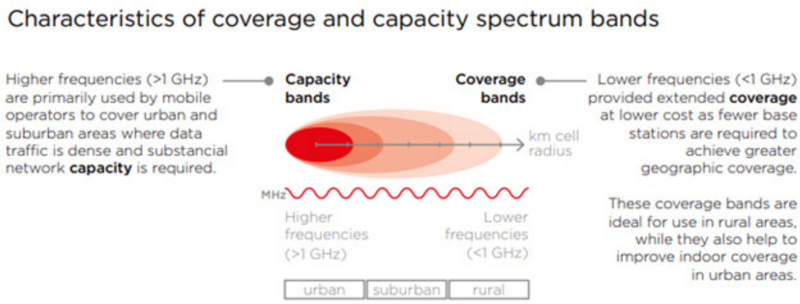
[59] United Nations. Report of the Secretary-General. Roadmap for Digital Cooperation. June 2020.

countries. The mobile coverage gap is most acute in Africa and in certain parts of Asia and, to a lesser extent, Central and Latin America.

It is important to mention that the lack of coverage in rural and remote areas is not a technical issue. It is the consequence of a basic economic challenge. According to a GSMA report,[60] the revenue opportunity for new base stations in remote areas can be ten times lower than at an equivalent site in an urban area. The operating costs can be as much as three times higher and the capital investment costs up to two times higher. For many of these reasons, rural and remote areas are often not considered viable business cases by telecommunication operators.

The digital dividend (700-800 MHz bands) could offer a good solution for covering rural and remote areas with mobile broadband. The characteristics of this part of spectrum (below 1 GHz) offer a perfect balance between transmission capacity and geographic coverage. In addition, using low-frequency spectrum means networks can be rolled out more quickly and cost-effectively. Fewer masts are required to provide a high level of service, resulting in cheaper mobile broadband for consumers. It is approximately 70 per cent cheaper to provide mobile-broadband coverage at frequencies around 700-800MHz than to use the 3G frequencies at 2 100 MHz, according to Coleago.[61]

Figure 14: Characteristics of coverage and capacity spectrum bands



Source: GSMA

The 2018 GSMA report on 'Indonesia's digital economy: Assigning the 700 MHz band to mobile broadband'[62] noted that the rural and remote population in Indonesia still suffers from a lack of Internet access. However, the report argues that by gaining access to the 700 MHz band, operators will be well placed to tackle the prevailing coverage gap, resulting in higher mobile penetration and improved access to services, such as education and healthcare, in rural areas. The digital dividend creates an opportunity for people in Indonesia to enjoy high-speed connectivity in the most remote areas, as well as accelerating prosperity and economic growth.

3.8 Conclusions and lessons learned from national experiences

Governments, policy-makers and mobile operators should coordinate their efforts and adopt innovative solutions to create favourable conditions for technology to be effective. Market competition, public-private partnerships and effective spectrum policy encourage private investment that can make access universal and affordable.

60 GSMA. Report. Enabling Rural Coverage: Regulatory and policy recommendations to foster mobile broadband coverage in developing countries. 5 February 2018.
61 Coleago Consulting: http://www.coleago.com/
62 GSMA. Report. Accelerating Indonesia's digital economy: Assigning the 700 MHz band to mobile broadband. 1 September 2018.

The digital dividend: *Regulatory aspects*

A forward-looking regulatory environment is essential.

- Reform and modernization of regulation in key areas.
- There is benefit in creating a predictable roadmap for future assignments of spectrum in the 700MHz band, in consultation with industry players to ensure fair and reasonable policies and regulations.
- Fairness, transparency and efficiency are beneficial to administrations.
- Keep the process as simple as possible: avoid unnecessary activities that will delay assignment.
- Licensing 700 MHz spectrum is key for governments to give their citizens access to affordable, high-quality mobile-broadband services at lower cost.

The digital dividend: *Technical aspects*

Digital dividend should be allocated in alignment with regionally harmonized band plans as soon as possible.

- Allocating digital dividend spectrum without delay for digital services will yield a wide range of benefits.
- Assigning the spectrum in a technology-neutral manner is a must in order to benefit from the best possible mobile-broadband experience.
- Spectrum harmonization is vital to accelerate the development of the ecosystem, drive down the cost of handsets for consumers and mitigate interference along national borders: channel arrangements should follow the Radio Regulations and relevant ITU-R Recommendations.
- Holding sufficient spectrum in the sub-1 GHz band allows operators to improve network availability in rural and remote areas relatively inexpensively and improve service quality in indoor environments.
- Consider re-farming the existing operators in the 700/800 MHz bands.

The digital dividend: *Economic aspects*

High-speed affordable connectivity is the basic building block of a digital economy.

- Excessive fees from licensing 700 MHz spectrum can lead to spectrum remaining unsold and risks impacting on network investment and deployment. Ultimately, it will limit the socio-economic benefits that affordable MBB access can deliver.
- Support effective spectrum pricing: There is benefit in governments' assigning spectrum to support their digital connectivity goals rather than as a means of raising revenue.
- Bridging the digital divide can play a critical role in the development of emerging economies, as it can improve social and economic equality, foster social mobility of people and boost innovation and economic growth.
- A spectrum policy that aims to improve coverage in rural areas can create incentives for MNOs to invest in network infrastructure.
- Revenues from reserve-price or auctions may finance the transition to digital broadcasting and re-farming.

Chapter 4 – Digital sound broadcasting transition

4.1 Background

The FM band is either rapidly saturating or has already become saturated. As a result, reception quality is suffering more and more from mutual interference between transmissions. In many countries, there are very few or no prospects of additional radio services being provided by means of the existing analogue technologies. In parallel, digitization has arrived in all areas of communication. In other words, another technological leap is imminent for radio.

Digital radio services are available on different platforms, such as Internet (fixed and mobile broadband) on 3G and 4G/5G IMT-Advanced, satellites and cable, but terrestrial delivery is by far the most popular way of receiving radio services. Most of the audience uses terrestrial as their primary means of reception.

Today, different systems/standards for terrestrial digital radio are recognized by ITU, such as DRM+ (*Digital Radio Mondiale*)[63] mainly used in India, HD Radio (IBOC) used in Mexico and the United States, ISDB-T in Japan, and DAB/DAB+ mainly adopted in Europe. Based on the latest figures,[64] DAB+ continues to expand in Europe especially with the adoption of the new EECC[65] that requires all new car radios sold in the EU from 21 December 2020 to be capable of receiving digital terrestrial radio in addition to any FM and AM functionality. However, its growth is not limited to Europe. Some countries in the Asia-Pacific, Africa and Arab States regions already have regular services. In addition, trials have been undertaken or are ongoing in other countries. Since 2013, China has also developed its own digital radio standard – Convergent Digital Radio (CDR). A general overview of these systems is given in **Annex 6** to this report.

While digital sound broadcasting is a topic in many countries, the stage of development varies widely from country to country. National media policies and timetables also reveal large differences. Important factors should be considered such as coverage, content, planning and collaboration between all stakeholders. In addition, the migration process will falter if digital usage does not increase markedly. The automobile industry plays an important role in this.

The main focus of this chapter is to present national experiences on the strategies and policies adopted for the digitization of radio. Cases from different regions with different standards adopted are presented in section 4.2 (China, India, Kuwait, Norway, and Japan). Other interesting cases where the process is still in the planning phase are also presented (Brazil and Tanzania). This chapter provides lessons learned on the transition to digital sound broadcasting focusing on the experiences of those countries that have completed this process. Some key success factors are illustrated with specific national examples. **Annexes 7** and **8** provide more

63 Digital Radio Mondiale (DRM). What is DRM?
64 WorldDAB. WorldDAB is the global industry forum for DAB digital radio. PowerPoint presentation: Figures related to the deployment of DAB/DAB+ in Europe and Asia-Pacific.
65 European Union (EU). EUR-Lex. European Electronic Communications Code. Article 113, Annex XI.

examples of countries having regular digital sound broadcasting services (France, Switzerland, Tunisia and Ukraine).

4.2 National experience on the transition to digital sound broadcasting and strategies implemented

4.2.1 Norway[66]

On 4 February 2011, the Ministry of Culture in Norway published the report 'Norwegian proposal on the digitization of radio' to the national assembly (the Storting).[67] The ministry proposals build on the following principles:

- Digitization of radio should be industry driven. This includes the choice of broadcast technology.
- The authorities should actively stimulate the digitization process by developing a plan for the migration to digital radio.

Figure 15: Milestone for the digitization of radio in Norway (2010-2019)

The role of the authorities in the migration process has been facilitative. The main tasks of the Norwegian Media Authority (NMA) have been to:

- Issue necessary licences.
- Provide the Ministry of Culture with annual reports regarding fulfilment of the switch-off conditions.
- Survey on digital radio listening and knowledge of the digitization process in cooperation with the broadcasters.
- Manage an information campaign directed at the general public.

Broadcasters in Norway have been responsible for developing the national DAB networks. They have chosen to use DAB technology (Eureka 147) to replace the current FM technology. Most radio channels in the DAB networks were transmitted using DAB+ as it is a more efficient radio standard compared to the original DAB-standard. In a press release published on 16 April 2015, the government set 2017 as the date for the switch-off of Norway's FM radio stations, having concluded that the criteria for the technology shift had been met.[68]

In December 2017, Norway became the first country to completely switch off national FM services, completing a year-long process of switching off region by region. Today, national radio broadcasts in Norway have been fully digitized. Smaller local radio stations may continue to broadcast on FM until 31 December 2021. The coverage for DAB+ is 99.7 per cent of the

[66] Useful links:
- Medietilsynet (Norwegian Media Authority) https://medietilsynet.no/en/about-medietilsynet/digital-radio/
- Radio.no https://radio.no/dekning/
- WorldDAB. Norway. Services on air. Last updated 3 March 2021.

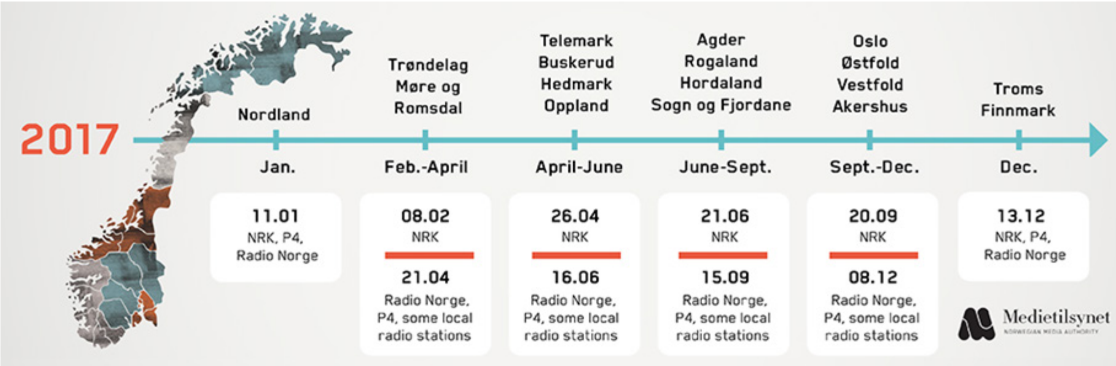
[67] Norwegian Ministry of Culture. Summary of Report No. 8 (2010-2011) to the Storting. Norwegian proposal on the digitization of radio. 4 February 2011.

[68] Norwegian Government (Government.no). Press release. Radio digitisation in 2017. 16 April 2015.

population for NRK radio services[69] and 92.8 per cent for commercial national services (P4 and Radio Norge).

The cost of transmitting national radio channels through the FM network is eight times higher than with the DAB-network, and P4, Radio Norge and NRK are currently spending large sums on parallel distribution. With the termination of the analogue services, national radio channels will achieve savings of more than NOK 200 million a year, releasing funds for investment in radio content.

Figure 16: Regional plan for FM switch-off in Norway



In March 2019, a report released by WorldDAB, at the Radio Days Europe conference in Lausanne, revealed how the switchover has impacted radio listening in Norway.[70]

4.2.2 China

In China, the Convergent Digital Radio (CDR) system was designed for digital terrestrial sound broadcasting to vehicular, portable and fixed receivers in VHF Band II. CDR supports digital-analogue simulcast mode that meets the needs of various broadcast scenarios in the transition process from digital-analogue simulcast to pure digital broadcast, and the receiver uses uniform tuning rules during the process. At present, nearly 700 CDR transmitters are implemented throughout China.

China's experience in promoting the digital sound broadcasting transition includes:

- *A nationwide digital sound broadcast transition project*: In 2015, the Chinese Broadcasting Administration replaced 563 FM transmitters (at the prefecture level) with new CDR transmitters. All new transmitters operate in simulcast mode, which can provide three new digital programmes and former FM programmes within one channel. The new CDR multiplexing stream is generated in Beijing and distributed to the 563 transmitters by satellite transmission link. More than 20 provinces, cites, autonomous regions and municipalities have successively introduced CDR services locally.
- *Continuous improvement of the CDR ecosystem*: Established in 2016, the CDR Working Group (China Digital Sound Broadcasting Technology and Industry Promotion Working Group) is composed of a number of core enterprises in the CDR industry chain, and is committed to promoting in-depth research on CDR-related technical standards and business models, thereby further promoting the development of the CDR industry.
- *Promotion of affordable CDR radio receivers*: The first CDR microchip was released in 2016 and the digital radio receiver with decoding microchip was released in 2017. In

[69] NRK is the nationwide digital radio channel operated by the Norwegian Broadcasting Corporation.
[70] WorldDAB. Report. Norway – One year after.

2018, the design of a CDR vehicle receiver based on the NXP microchip was completed, and cars equipped with a CDR receiver will be available in 2021. CDR functional interfaces have been reserved in new car models of some carmakers and others have CDR set-up plans in place. The mass production of CDR radio is gradually making the digital sound broadcasting technology more affordable.

4.2.3 India[71]

India is currently rolling out the largest digital radio deployment worldwide, as the public service broadcaster All India Radio (AIR) is upgrading the terrestrial broadcast infrastructure. The broadcast standard adopted for this project is Digital Radio Mondiale (DRM)[72] in the medium-wave (MW) and short-wave (SW) bands.[73]

Figure 17: Indicative locations of MW DRM transmitters in India

Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of ITU and of its secretariat concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

A total of 35 MW transmitters with a power range from 20 kW to 1 000 kW continue to operate in DRM:

- 2 in pure DRM and 33 in simulcast;
- 25 in pure DRM daily for one hour.

Two SW transmitters are also carrying DRM services. Two more SW transmitters, 100 kW each, are under trial in New Delhi and are expected to be operational for service to neighbouring countries.

While Phase I of the national DRM roll-out project, which was successfully concluded in 2017, was focused on establishing the nationwide transmitter network, Phase II is now concentrating on optimizing the DRM coverage and service quality and finalizing the content offerings with

[71] Useful links:
- DRM. DRM digital radio broadcasting in India;
- Asia Radio Today. News. DRM at Association of Radio Operators for India's AGM. 18 July 2019
- Frauenhofer Audio Blog. DRM's progress in India. 20 December 2018;
- Radio World. Columns and views. Digital Radio Mondiale – An update from India: AIR moves toward full service DRM, while receiver development continues. 19 June 2018.

[72] DRM (op. cit.)

[73] MW: Broadcasting allocations within 526.5-1606.5 kHz; SW: The range includes all of the HF band and generally extends from 3 to 30 MHz.

additional audio services and innovative advanced DRM features such as Journaline[74] advanced text.

These enhanced DRM services are already being used on-air in Delhi and Bangalore, and remaining DRM transmissions will be gradually upgraded to the full DRM experience as part of Phase II throughout India. A dedicated webpage has been added by AIR Bangalore entitled "DRM Digital Radio Bengaluru" for easy access to audio and Journaline text functions.

Most of the leading car manufacturers in India have either already incorporated DRM receivers in new models or are in the process of incorporating them, as an option without extra cost.

4.2.4 Kuwait[75]

Regular DAB+ radio was launched in the State of Kuwait in October 2014. Digital audio broadcasting DAB+ services are on-air in Kuwait via a single frequency network (SFN) platform between South Subahiya and Subiah (with 4.5 kW power transmission each) and Liberation Tower (with 2 kW power transmission). This SFN platform with 15 programmes covers 100 per cent of the population in Kuwait. Two DAB+ stations joined the existing SFN network in October 2017.

In February 2018, the Minister of Information inaugurated the new generation of digital DAB+ audio broadcasting stations in Al-Metlaa, to the north of Kuwait City. The launch of the digital broadcasting service was part of a plan started two years ago and is motivated by the New Kuwait 2035 development strategy plan. There is a single regular national multiplex on-air.[76]

Table 5: DAB+ programmes in Kuwait

	Simulcast on AM / FM	Exclusive on digital	Total services
DAB+ programmes	16	0	16

4.2.5 Japan[77]

In 1996, Japan began to consider the adoption of digital sound broadcasting in parallel with the adoption of digital television broadcasting. Two advisory groups were established and started discussions to give advice on the implementation of those services to the Minister for Internal Affairs and Communications (MIC). The first group was the Roundtable Conference on Terrestrial Digital Broadcasting, which addressed policies, whilst the second group was the Telecommunication Technology Council, which addressed technical standards.

One of the Roundtable Conference's recommended policies, which was considered the most important, proposed that digital sound broadcasting should start as a new broadcasting service while existing analogue sound broadcasting was maintained, rather than shifting from analogue sound broadcasting to digital sound broadcasting. The reason for this policy was that many natural disasters have occurred in Japan, such as the Great Hanshin-Awaji Earthquake, in 1995,

[74] Frauenhofer Institute for Integrated Circuits (IIS).News Service Journaline –The digital radio text service.
[75] Useful links:
- WorldDAB. Countries. Kuwait. Current situation. Last updated 10 May 2018;
- Radio World. Kuwait welcomes more DAB+ services. 20 February 2018.

[76] WorldDAB. Countries. Kuwait. Multiplexes.
[77] ITU-D SG1 Document SG1RGQ/367 from Japan.

just before the Roundtable was formed. Furthermore, analogue sound broadcasting has a role as an important information and communication medium in emergency disasters because receivers are small and simple. This was reconfirmed in a survey to determine which media were useful for collecting information in the days immediately following the Great East Japan Earthquake (which took place on 11 March 2011). AM radio broadcasting was the highest ranked medium, at 60.1 per cent, followed by FM radio broadcasting at 39 per cent, and television at 26.8 per cent.[78] After the Great East Japan Earthquake, MIC distributed 10 000 portable radio receivers to each local government in the disaster area.

In November 1999, the Telecommunication Technology Council submitted a report on a technical standard known as Integrated Services Digital Broadcasting for Terrestrial Sound Broadcasting (ISDB-Tsb), the Japanese standard for digital sound broadcasting.

Following the recommendations on policies and technical standards, seven broadcasting operators established a terrestrial digital sound broadcasting preparatory committee on 27 May 2000. They held briefing sessions for those who were interested in terrestrial digital sound broadcasting in Tokyo and Osaka in January 2001, with a view to increasing their membership. This preparatory committee was transformed into the Digital Radio Promotion Association, with 37 regular members and 47 supporting members. The member companies include not only broadcasting companies but also other companies such as manufacturers, and trading and communication companies. The association set up a steering committee and a technical committee in Tokyo and Osaka, which were scheduled to carry out test broadcasting. The steering committee examined assembly of the business model, organization for starting broadcasting, and actual operation method. The technical committee made proposals for equipment maintenance, equipment construction, and the formulation of operating rules for operating companies.

The Digital Radio Promotion Association created posters and a website for general users, among others, to carry out public relations activities towards the start of broadcasting. Noting that it was found that publicity through existing media was the most effective method for creating awareness of digital sound broadcasting in the UK, the association actively promoted PR amongst its members and through the media.

On 10 October 2003, test broadcasting began in Tokyo and Osaka. It was composed of six channels in Tokyo and eight channels in Osaka. The phase of test broadcasting finished in 2011 and moved to the phase of commercial broadcasting.

Following test broadcasting, commercial digital sound broadcasting services were launched in the form of multimedia broadcasting. As mentioned above, this service uses the frequency on which analogue television broadcasting previously operated and switched off in 2011.

There are two types of multimedia broadcasting, depending on the frequency bands that are used.

1) A service called NOTTV, which was started by Japanese mobile telephone operator NTT DOCOMO, Inc. in April 2012 in the upper VHF frequency band of 207.5-222 MHz. This service is a combination of telecommunication and broadcasting, and provides a new broadcasting style with three types of broadcasts:

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[78] Ministry of Internal Affairs and Communications (MIC) (Japan). 2012 White Paper: Information and communications in Japan. July 2012.

- content provision in various formats such as video/music, newspapers/magazines/e-books/games;
- storage-based broadcasts not available in conventional broadcasting; and
- high-resolution/high sound quality real-time broadcasts.

This service adopted ISDB for Terrestrial Multimedia Broadcasting (ISDB-Tmm), which is an enhanced version of ISDB-T, to support these services. Nationwide broadcasts were launched using compatible smartphones sold by the company.

2) A service called i-dio, which was started by six multimedia broadcasting companies (software operators) and VIP Co., Ltd. (hardware operator) in July 2016 in the lower VHF frequency band of 90-108 MHz. This service adopted ISDB-Tsb and provided broadcast service tailored to the characteristics of each region, such as high-resolution high-quality digital radio broadcasting, disaster information distribution (V-ARART) and local FM radio broadcasting. A special receiver and application for smartphone is needed in order to listen.

4.2.6 Tanzania

In Tanzania, the DSB transition is still in the consultation phase. Different factors and parameters need to be considered: the technical aspects, the licensing options, and the implementation strategies.

In regard to the technical aspects, the standards/systems to be used should be defined, in addition to the allowed bandwidth, the maximum allowed power and the number of programmes in a single radio-frequency (RF) channel.

Different licensing options could be considered for DSB:

- Tender-based award for one single provider of DSB services with the public sound broadcaster (PSB) given an exclusive authorization under a PSB charter with reserved spectrum (multiplexes) for public and disaster communications, and future uses.
- Existing digital terrestrial broadcasting multiplex operators through service-level agreement (SLA) can be mandated to construct DSB infrastructure as provided under the Electronic and Postal Communications (digital and other broadcasting networks) Regulations, 2011.
- Incumbent national radio licensees can be given a mandate and authorization to construct DSB infrastructure and enter into SLAs with interested parties in accordance with regulations to be put in place.
- Authorize DRM30[79] under a PSB charter exclusive to public service only.
- Maintain the existing set-up whereby each service provider may build its own infrastructure.

For the DSB implementation strategy, different factors must be considered:

- Implementation to be market driven and therefore no deadline with FM systems to be replaced gradually. This approach will be complemented by government initiatives to embrace new technologies.
- Establishment of a national steering committee on DSB responsible for policy issues.
- Formation of a national technical committee on DSB to monitor and oversee technical matters.

[79] DRM. DRM for AM (DRM30). DRM30 modes can deliver FM-comparable sound quality and are specifically designed to utilize the AM broadcasting bands below 30 MHz (LW, MW and SW) which allow for very-long-distance signal propagation.

Different factors could serve as drivers for DSB uptake:

- FM scarcity in urban areas, especially major cities.
- DSB service features with value-added services such as datacasting on radio, electronic programme guide (EPG), still pictures, HTML webcasting, subscription radio services (bouquet based), artist's name, song title and lyrics, traffic information, weather, Global Positioning System (GPS) information, multiple reception mode feature, hybrid world-class system of free-to-air (FTA) radio/TV, pay services radio/TV, etc.
- Interactive services and innovation brought by technology convergence is an added advantage for uptake.

The consultation document will present to stakeholders: the DSB technologies and standards established, frequency bands allocated by the World Radiocommunication Conference (WRC), receiver standards and reception modes, coverage issues, regulatory implications as well as proposed DSB technologies/standards, applicable licensing framework, and licence award methodology.

FM sound broadcasting is a broadcasting technology that will dominate the broadcasting industry in the future. Therefore, improvement in its administration, spectrum optimization/technical parameter enforcement and availability of expertise need to be reviewed. However, scarcity of and demand for FM spectrum in urban areas requires complementary services through DSB.

Africa being part of ITU Region 1 under the Radio Regulations, the issue of DSB needs to look at regional harmonization in standards/systems to be implemented based on ITU spectrum allocation, in order to achieve common benefits such as coordination, common receivers (economies of scale), and shared expertise and knowledge.

The main objectives of the public consultation process are:

- To provide an overview of DSB standards and systems deployed in the world and the spectrum allocated
- To introduce feasible DSB technology alternatives to already exhausted urban FM sound broadcasting
- To propose a regulatory framework for the introduction of DSB
- To make operators understand the need for introducing DSB in the country
- To develop skills in DSB
- To enable broadcasting stakeholders to make an informed decision on suitable DSB standard(s) to be adopted in the country.

4.2.7 Brazil

The process of discussion and deployment of digital broadcasting technologies for radio services in Brazil is summarized below:

- System testing[80] and trials on an experimental basis to compare different services for assessing performance and business models.

[80] For the Test script details, see: Anatel (Brazil). Critérios para Avaliação do Sistema de Rádio Digital FM IBOC. June 2007. [in Portuguese].

- Introduction of MC Ordinance No. 290/2010 on the Brazilian System for Digital Radio to establish the usage of the digital radio system for MW and FM and the objectives of the deployment.[81]
- Creation of a governance framework to advise the minister through the Digital Radio Advisory Council (CBRD) and its subgroups and with full stakeholder representation.
- Trials performed and technologies assessed based on the consensus that the systems needed to be deployed in both FM and AM and have minimal financial impact on broadcasters.

The deployment of digital radio in Brazil is still under discussion due to the prioritization of other activities such as the migration of radio stations from AM to FM and the digital television switchover, in addition to the release of the 700 MHz digital dividend band.

In Brazil, the general consensus was that the tests had to be directed to "in-band on-channel" systems, which use the same band as analogue systems, 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).

The only systems that met these requirements during the tests and were standardized for both FM and AM were DRM and IBOC (HD radio), and tests were focused on these systems. Additionally, it was the view of the ministry and the *Associação Brasileira das Emissoras de Rádio e Televisão* (ABERT) (Brazil Association of Radio and Television Broadcasters) that these systems should be deployed in both FM and AM and have minimal financial impact on broadcasters. However, other systems can be also tested in the future.

More information can be found in the detailed contribution submitted by Brazil.[82]

4.3 Lessons learned on the transition to digital sound broadcasting

Table 6 sets out the key success factors and action taken to launch digital terrestrial radio based on the experiences of different countries. It focuses on good practices for introducing digital radio and important factors[83] that contribute to the success of the digitization. Each key success factor is illustrated with national examples.

[81] Ministry of State for Communications (Brazil). Ordinance No. 290/2010 of 30 March 2010. Institui o Sistema Brasileiro de Rádio Digital – SBRD e dá outras providências. [in Portuguese]
[82] ITU-D SG1 Document SG1RGQ/219(Rev.1) from Brazil
[83] For more details, see: European Broadcasting Union (EBU). **Digital Radio Toolkit: Key factors in the deployment of digital radio.** December 2014.

Table 6: Key success factors for the transition to digital sound broadcasting based on national experiences

<table>
<tr><th>Key success factor</th><th>Actions</th><th>National experiences</th></tr>
<tr><td rowspan="3">Policy and regulation</td><td>Provide regulatory incentives</td><td>In the United Kingdom, different regulatory incentives were implemented:
1. the automatic renewal of analogue licences for broadcasters launching DAB services;
2. reducing local content requirements;
3. a funding hub set up for the roll-out of local DAB transmitters, including partial public subsidies.</td></tr>
<tr><td>Rethink the licensing system</td><td>In Norway, the licensing regime comprises three different licences: (for more details, click here):
1. a broadcasting licence (except NRK, which has a legal right to broadcast);
2. a facility licence (for establishment or operation of wireless, ground-based transmitting facility used for broadcasting);
3. a spectrum licence (right to use the spectrum).

Facility and spectrum licences were awarded together in an auction (jointly held by the Media Authority and the Postal Authority). Broadcasters interested in DAB must contact the holder of the facility and spectrum licences to reach a commercial agreement on renting capacity. Once this has been obtained, these companies can apply to the Media Authority for a broadcasting licence. When the agreement is terminated, the broadcasting licence is also revoked.
The broadcasting licence has no content requirements but needs to be obtained. Content requirements can be included in the facility licence for the multiplex operator, so diversity is ensured when the latter negotiates with broadcasters.</td></tr>
<tr><td>Introduce new regulatory modalities</td><td>In the Czech Republic[84], Gama Radio was originally the local analogue station in the city of Northern Bohemia. Since they had limited options to increase coverage, the station management started to collaborate with TELEKO and RTI cz, the network operators. Thanks to this collaboration, the coverage area was expanded. Gama Radio now covers 5 million inhabitants without dramatically increasing costs. In addition, there were no licences needed for the frequencies and the content licences for digital radio were issued without any obstacles.</td></tr>
</table>

[84] For more information, see: dab+ (Czech Republic) at http://www.digitalradiodab.cz/index.html and http://www.dab-plus.cz/files/DAB_CR_EN.pdf

Table 6: Key success factors for the transition to digital sound broadcasting based on national experiences (continued)

Key success factor	Actions	National experiences
Switchover process	Equal opportunities for new entrants	In Japan, securing equal opportunities for new entrants was a key factor in attracting new investment in digital sound broadcasting. Digital sound broadcasting was introduced as a new service with a limited service area due to frequency restrictions. In addition, it should be ensured that new operators can share and use management resources and know-how which existing operators have in order to promote digital sound broadcasting.
	Plan the process	In the United Kingdom, industry and government worked together to produce the Digital Radio Action Plan. The purpose of this was not to implement a transition to digital radio, but to provide the information to allow for a well-informed decision by government on whether to proceed with a digital radio switchover. The final version of this plan was published on 9 January 2014. The plan was built around consumer choice, quality, affordability, accessibility and awareness, producing publicly available documents in different key areas.
	Fix a clear calendar	In an official white paper, Norway proposed a calendar combining a clear commitment to switchover but with flexibility. Analogue switch-off was set for 2019 but there was provision for the possibility of an earlier switch-off if additional criteria were met. The calendar included additional milestones such as a date for defining some of the criteria, the date of evaluation of the criteria and a calendar to assess the situation of local radio. (Details on the regional switch off calendar).
Content and offer	Add value to your offer	In Norway, a government website explained the switch from FM to DAB: - higher quality and better accessibility; - more choice; - improved technology; - money for more and better radio content; - better road coverage than FM; - improved emergency preparedness.

Table 6: Key success factors for the transition to digital sound broadcasting based on national experiences (continued)

Key success factor	Actions	National experiences
Technology	Ensure good coverage	In India, the DRM standard was adopted. A webpage has been created by the DRM Consortium dedicated to India giving useful information about the implementation of the DRM standard, one of the biggest digital roll-out projects in the world. Some 600 million people are covered at present by DRM digital signals thanks to All India Radio (AIR) transmissions using 35 MW transmitters. More than 1 million new cars are equipped with DRM radios at no extra cost to the owners. In Switzerland, network coverage is almost complete. Outdoor coverage was prioritized and reaches 99 per cent of the population. Indoor coverage is also very high (98 per cent). Additionally, commercial stations have expanded FM coverage and for the first time will be able to cover nearly all their linguistic areas. This represents a clear improvement for listeners.
	Frequency planning	In Japan's experience, careful consideration is needed for frequency planning, taking into account the transition phase towards the switchover of existing analogue television broadcasting. Selected frequencies must not cause interference to existing analogue television broadcasting. It may be necessary to consider a restructuring of digital sound broadcasting in the VHF band for the period after the completion of the transition from analogue television broadcasting to digital broadcasting.
	Reduce transmission costs	In 2007, the Norwegian Parliament decided that radio in *Norway* would be digitized. The following three conditions had to be fulfilled regardless of when the switch-off would take place: - Digital coverage for NRK radio services must correspond to that of NRK P1 on FM. - The multiplex that carries commercial national services (Riksblokka) must cover at least 90 per cent of the population. - The digital radio offer must represent added value to listeners. To fulfil these requirements in a large, sparsely populated country of 5 million people, 762 transmitters are needed. Digitization has enabled NRK to reduce its transmission costs and increase its offering. Currently, about 2 000 masts are required to distribute three FM channels.

Table 6: Key success factors for the transition to digital sound broadcasting based on national experiences (continued)

Key success factor	Actions	National experiences
Public communications	Raise awareness among the public about the availability of digital radio	Netherlands: Since the start of the campaign in 2014 "Let's get digital", awareness of digital radio increased to 72 per cent. The number of DAB+ radios sold in 2016 increased by 33 per cent compared to 2015. This campaign was supported by public and commercial broadcasters and the Ministry of Economic Affairs. The website http://www.digitalradio.nl/ was set up to raise awareness of DAB+ in the Netherlands. In 2015, a spring campaign for digital radio (DAB+) was launched on the national radio stations to remind listeners of the benefits of digital radio. Different activities were also organized to increase awareness of DAB+. At the AutoRAI event, a presentation was given to inform the automotive industry about digital radio. In Germany, different DAB+ promotion campaigns were implemented. In May 2017, ARD and Deutschlandradio started a cross-media nationwide marketing campaign for DAB+ radio from May 2017. The campaign included radio, television and Internet, as well as images for print and online use. Also, a new logo for DAB+ was adopted.
	Persuade the public to switch to digital radio	In 2018, a new multimedia campaign was launched to promote DAB+ with the slogan "DAB+, Mehr Radio" (DAB+, More Radio) branded across TV, radio, print and online. In 2019, the digital radio industry organized a DAB+ promotion week from 13 to 24 May. These activities included on-air radio spots, consumer and B2B print advertisements and advertorials, social media and posts on www.dabplus.de.
	Communicate a clear and accurate message	In the United Kingdom, Digital Radio UK is the organization charged with overseeing the promotion of digital radio. The national information and promotional campaign is coordinated under one single message: 'Get digital radio'. Originally it focused on 'DAB', but this was later seen as a mistake and the label used was changed to 'digital radio', including on other platforms. Consumers and listeners can find out about digital radio at www.getdigitalradio.com. Digital is a concept familiar to many citizens and normally has positive connotations for them.

Table 6: Key success factors for the transition to digital sound broadcasting based on national experiences (continued)

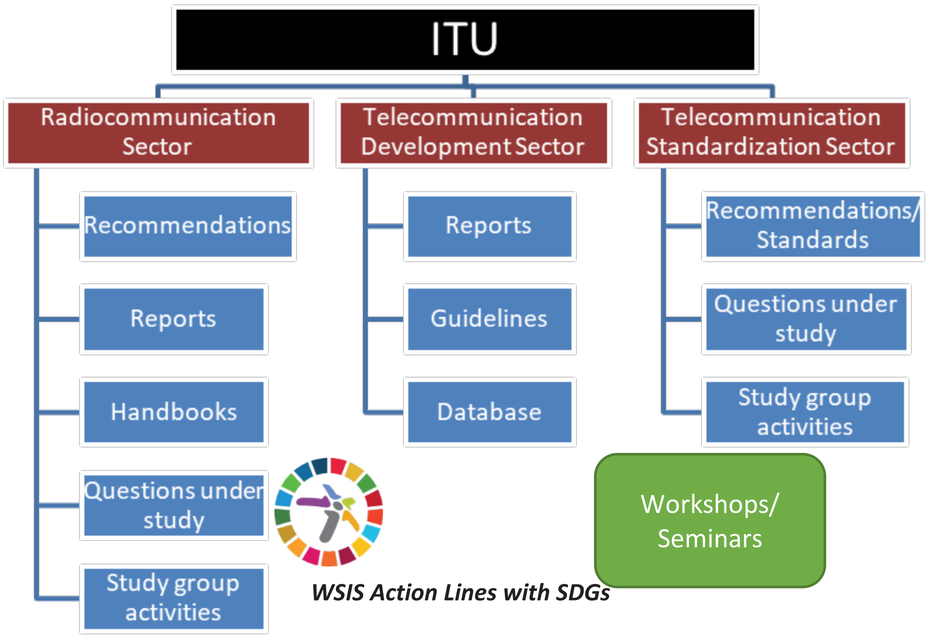
Key success factor	Actions	National experiences
Consumer electronics	Make affordable devices available on the market	In Italy, a product catalogue was created and published on digitalradio.it to help people choose the digital radio that is right for them. A wide range of devices (for cars, at home, and outdoors) are described with all the details needed and the price to cater to all listener target groups. In the Netherlands, the successful launch of DAB+ was due to the high sales figures for digital receivers. There are many types and models of DAB + devices available on the market. Through the equipment page you can search for the type and brand of DAB + device and you can click for more information to the website of the brand or manufacturer (for home use, for use on the road).
Car industry	Target the car industry early	In India, one of the welcome features of the current roll-out of DRM has been the early and overwhelming commitment of the car industry, which is already equipping new car models with DRM radio sets at no extra cost to the customers – even before the official launch of the DRM services by AIR. Keeping pace with the digital radio developments, the automobile receiver industry in India has invested heavily in the domestic development of DRM digital-radio-capable receivers and chipsets. The roll-out of DRM-equipped cars is growing rapidly with each month. For more information, click here. In Germany, in September 2019, the Bundestag reiterated its commitment to DAB+ by passing a revision to its Telecommunication Law, which was approved and made official in November 2019. According to the revised law, all new car radios should be capable of receiving digital terrestrial radio as from 21 December 2020 – as required by the EECC. The revised law also requires all new consumer radios capable of displaying a radio station name to be able to receive digital signals (for example, DAB+ or IP).

Chapter 5 – ITU activities related to digital broadcasting and digital dividend

Figure 18 shows ITU activities and studies, including standards/Recommendations adopted or currently being studied by ITU Sectors, related to digital broadcasting and the digital-dividend frequency bands resulting from the transition to terrestrial digital broadcasting, including technical, regulatory and economic aspects. The three ITU Sectors, each within its own sphere of competence, are responsible for activities and studies relating to digital broadcasting and digital dividend.

Annex 9 to this report lists details of all publications and activities highlighted in **Figure 18** in relation to ITU-D Question 2/1.

Figure 18: ITU activities and publications in relation to ITU-D Question 2/1



Annex 1: Interference mitigation measures adopted in Brazil

In Brazil, an independent third party (EAD) was established to carry out several activities related to DSO. Among these duties is the mitigation of interference caused by radiocommunication stations operating in analogue and/or digital technology to the reception and/or transmission of mobile stations operating in the 700 MHz band.

To address this interference, some guidelines were approved in the DSO steering committee – the *Grupo de Implantação do Processo de Redistribuição e Digitalização de Canais de TV e RTV* (GIRED) (Main and Relay Stations Redistribution and Digitalization Process Implementation Group) – to establish a clear procedure for the identification and mitigation of possible interference and to guide the work of the independent third party responsible for implementing interference mitigation. This procedure may be implemented simultaneously with or after the procedure for the activation of mobile stations and preventive mitigation:

i. Winning bidders must file a complaint with EAD of any harmful interference to the operation of their mobile stations in the 700 MHz band. The formal submission must be accompanied by evidence of the interference, using any supporting technical means, such as site-surveys, drive-tests, FFT or KPIs of the station itself, activation tests, etc., which can be obtained even before installing or activating the mobile station.
ii. The EAD may refuse the request of the winning bidder if there is no adequate proof of the interference, indicating the reason for refusal so as to allow for the possibility of subsequent correction by the interested parties.
iii. Once the interference claim reported by the winning bidder is accepted by the EAD, the latter should investigate it and identify possible interfering sources.
iv. If the interference is solely due to saturation of the mobile station receiver, the EAD shall inform the winning bidder (complainant) that it shall adjust its network planning and/or fund the necessary actions.
v. If the source of interference originates outside Brazilian territory, or if there is evidence of irregular use or unauthorized use of radio frequencies, or it is not caused by main or relay station transmitters, the EAD shall collect all necessary evidence and forward it to the Telecom Regulator for action.
vi. If the interference is caused by main or relay station transmitters, excluding the scenarios under item v, the EAD, within the scope of its remit, should identify the best mitigation technique. Subject to authorization by the person in charge, the EAD shall immediately resolve interference that requires only the use of the medium power filter specified herein.
vii. If the action specified in item vi is not sufficient to solve the problem, and other procedures such as the use of a high-power filter, modification or digitization of the main or relay station channels are required, the EAD shall certify that the station operates within the undesirable emission limits provided for in the regulations and propose a solution that is the most financially advantageous and subject to GIRED approval.

Once the interference complaint has been received, the EAD will have up to 30 days to identify the source of interference and to mitigate cases under its responsibility that do not require GIRED approval. The minimum filter requirements for medium power filters are presented in the table below:

Minimum filter requirements for medium-power filters

The filter defined below serves to reduce unwanted emissions from TV or RTV stations and can be used in intermediate stages of medium power, making it the simplest and cheapest way to mitigate any cases of harmful interference under EAD's responsibility.

Parameter values:

Working power: 100 W to 300 W; Impedance: 50 Ohm; Bandwidth: 6 MHz

Channelling: TV channels; Insertion loss: <2 dB; Minimum rejection at 45.75 MHz + Video carrier frequency: >60 dB

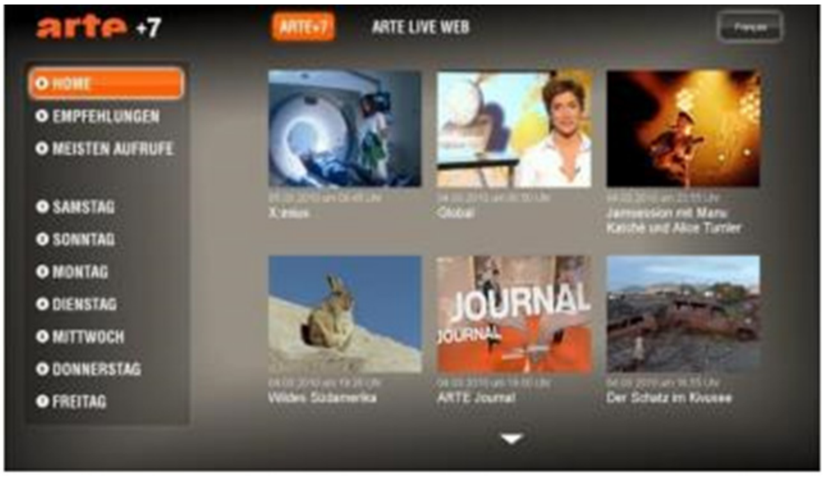
Annex 2: Integrated broadcast-broadband systems use cases and prerequisites

Use case: Catch-up TV

Catch-up TV is a system for watching TV programmes after they have been broadcast, using a computer, smartphone or even the television set, that is connected to a broadband Internet connection. The offering allows people who miss a programme to be able to view it on demand. In addition to the availability of the content after it has been aired, broadcasters can integrate this offer with their Electronic Programme Guide (EPG), thus providing a seamless experience to users. This service can be funded, for example, by advertising, with pre-roll advertisement preceding the programme, therefore keeping the main broadcasting business model.

Besides this, video-on-demand (VoD) applications can be offered and new content, such as films, TV series, and educational content can be provided as well. As an example, a screenshot of such an offering is shown in **Figure A.1.1** below.

Figure A.1.1: Possible look-and-feel of a catch-up TV and VoD interactive application



To offer such a service, the broadcasting service provider needs to adapt its digital broadcasting platform to provide metadata describing the programmes and also implement interactive multimedia application frameworks[85] to present the user interface and look-and-feel of the catch-up TV application. Together with this, synchronization and consumption of content from both the broadcast and broadband networks is also needed, in which case the broadcaster will need also to conceal the main broadcast video programme being aired and allow for the presentation of the catch-up TV content.

In the provision of these new services, some regulatory and economic implications need also to be addressed. Firstly, the national legal and regulatory framework needs to allow for retransmission of free-to-air television content over the Internet and no infringement of copyright laws may take place. Another important matter to be addressed is the business plan for such an offering. The new service is recommended to be complementary to the broadcaster's overall advertising/

[85] ITU-T. Recomendations in the ITU-T H.760 Series. Multimedia application frameworks (MAFR)

commercial strategy, and then allow for new revenue streams from users that otherwise would not tune into the current programme being aired.

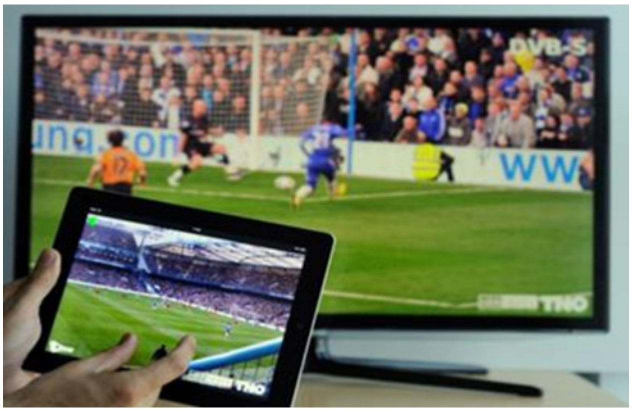
Catch-up TV can be also thought of as a value-added service (VAS) for which a subscription could be charged. In this case, however, the broadcasters need to carefully plan what services to offer by subscription and the value of these to the consumer due to the fierce competition broadcasters are facing with online streaming services. Furthermore, there may also be regulatory implications: for example, some countries do not allow payment for access to free-to-air television programmes.[86]

Use case: Second synchronized screen

The use case of a second synchronized screen is based on the offering of an individualized interactive experience of the user with the programme being aired. It is basically the provision of an interactive multimedia application which relates directly to the current television programme. However, the interaction is performed by a secondary device, for example a tablet or smartphone, and the main audiovisual programme is kept on the television screen.

One example of such an application would be additional content regarding a soccer match. The broadcaster could send information relating to all the players/coaches; images of the players' kits and studded shoes; additional videos, such as multi-camera views; replays of certain scenes (offsides, goals, etc.); further information regarding one or several of the opponents; etc. It is also possible to provide a TV-commerce application to buy, for example, the same shoes a player is wearing. The **Figure A.1.2** below presents a simulation of such a service.

Figure A.1.2: Second synchronized screen



One of the purposes of this new service is to retain users' attention on the broadcaster's content by providing additional content (text, images, secondary videos, TV-commerce applications, etc.). With the fragmented user experience that Internet television offers, users are becoming increasingly distracted and less attached to a single content stream. A new audiovisual experience therefore needs to be available to consumers in the broadcasting service, so to involve the user in such a way as to retain his or her main focus on the television content.

86 Brazil is an example of a country where payment for free-to-air television programmes is not allowed; however, broadcasters are currently offering their own catch-up TV applications to users on the Internet as a value-added service.

Use case: Scalable videos

This use case relates to enhancing user experience with the broadcasting video content by improving the video resolution of the compressed video transmitted via the broadcasting network with an enrichment layer provided via broadband networks. In other words, the broadcaster can provide a better video experience without increasing its radio-frequency (RF) spectrum resources. This new service can make it possible for broadcasters to provide, for example, 4K resolution videos to broadcasting service offers. One possible business model could be to provide such a resolution for prime-time programmes, in order to increase their ratings/shares, or for special events, such as the Super Bowl, the Oscars, or the World Cup and the Olympic Games. It is important to point out, however, that partnerships between broadcasting and broadband service providers would be important to make such programmes/events feasible.

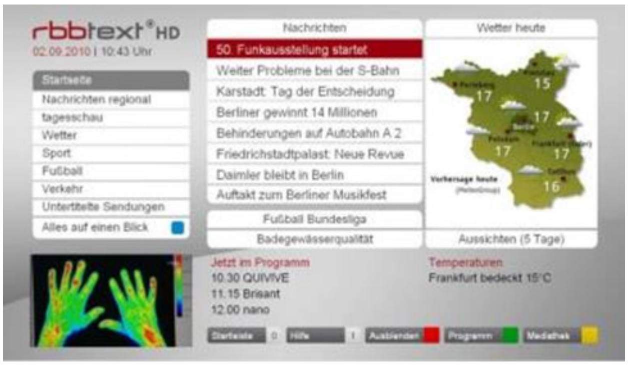
To provide such an improvement, firstly, the broadcaster needs to use scalable video coding (SVC)[87] in the broadcasting content and synchronize multiple sources of content from broadcast and broadband networks.

Use case: Enriched service information (SI)

This use case is based on enhancement of the features provided by the digital broadcasting metadata (SI – service information) with content from the broadband network to collect enriched service information to be shown by interactive applications to users. Examples of applications could be weather forecast, traffic information, poll/surveys, voting and polling follow-up, etc.

Figure A.1.3 below shows an example of a simple interactive application that could use enriched service information.

Figure A.1.3: Enriched service information (SI) interactive application



In summary, the broadcaster needs to implement a multimedia application framework and provide an application that performs the tasks and features described above.

Use case: Microsite campaigning

Advertising is the core of broadcasters' business models. Therefore, enhancing the user experience with rich content in ads is a goal for broadcasters in general. Bearing that in mind, this use case proposes that specific interactive applications be provided to users by broadcasters implementing interactive campaigning via an advertising microsite for specific advertisers. For

[87] ITU-T. Recommendation ITU-T H.264 (06/2019) (MPEG-4 AVC). Annex G: Scalable video coding (SVC).

example, a car manufacturer could provide additional content related to a new vehicle offer, alongside the availability of technical information and commercial material for users to choose from and watch at their convenience. **Figure A.1.4** below shows a possible example of such a microsite campaigning application.

Figure A.1.4: Microsite campaigning application

The microsite app can provide additional videos from several sources, for example broadcast and broadband networks. Additionally, localized content could be also available. In other words, a more tailored user experience could be provided to consumers.

Another possibility is to trigger the launch of the microsite by means of events or user interaction with the main audiovisual content. More details are available in the targeted advertising use case.

Use case: Push VoD

Push video-on-demand (Push VoD) is a technique used by a number of broadcasters on systems that lack the interactivity to provide true VoD, to simulate a true VoD system. A Push VoD system uses a personal video recording (PVR) device to automatically record a selection of programming, often transmitted in spare capacity overnight. Users can then watch the downloaded programming at times of their choosing. As content occupies space on the PVR hard drive, downloaded content is usually deleted after a week to make way for new programmes. The limited space on a typical PVR hard drive means that the flexibility and selection of programmes available on such systems is more restricted than with true VoD systems.

This use case proposes the usage of either broadcast or broadband content to feed the broadcaster Push VoD offer. Additional videos can be delivered by the broadcasting network and it is also possible to provide augmented reality features via broadband content. An interactive application could be provided to establish an attractive look-and-feel and provide users with recommendations on available content.

As in catch-up TV, the idea here is retain the users' attention and avoid them changing to other means of content delivery. The same concerns apply here as well, i.e. the video offers need to be complementary to the overall advertising/commercial strategy of the broadcaster and allow for new revenue streams from users that otherwise would not tune into the current programme being aired.

In **Figure A.1.5** below, a screenshot of a possible Push VoD application is presented.

Figure A.1.5: Push VoD application

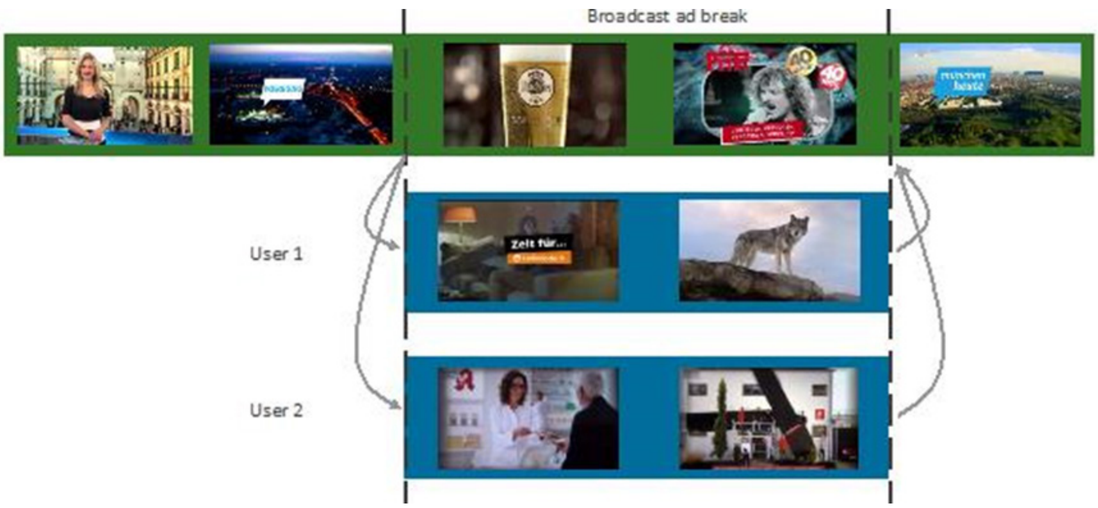
The main prerequisite for such a service is the provision of content from several networks and also several contents from the broadcasting side (multiple carrousels for delivery) so that the user's choice of content can be delivered notwithstanding the main audiovisual content of a specific TV channel.

__Use case: Targeted advertising__

This use case proposes that broadcasters personalize their ads based on consumers' preferences. In other words, the ads would be tailored to the spectator's preferences, which can be directly input to the digital broadcasting terminal device or be assessed by a resident application and sent to a personalization server that could then trigger the adaptation of the ads to the user. In the provision of this new functionality, the spectator's privacy and the protection of their personal data need to be addressed and no infringement to privacy and data-protection laws/ regulations can be permitted.

Figure A.1.6 below illustrates content adaptation based on the personalized ads defined by user preferences.

Figure A.1.6: Targeted advertising



The main prerequisites of such a solution are the implementation of media synchronization languages, such as NCL (nested context language),[88] to synchronize the media in both the main stream and secondary video streams (main and ad video, respectively). This is particularly important to make sure that the user experience with the programming is not disturbed by glitches or stalls in the main video stream caused by changes in the source of the content.

Another prerequisite is the consumption of recommended content from broadband networks and the implementation of personalization features (sensitivity to context). To implement recommendations of content, personalization features/algorithms can be used, for example, based on IPTV application event handling (ITU-T H.740 series). The idea is that exchange of user usage information is handled via the broadband network to a personalization server and the recommendation information is relayed to the user terminal device either via broadcasting or broadband.

Main prerequisites for use cases

Main prerequisites for catch-up TV offering:

In summary, the main prerequisites for the catch-up TV offering are the following.

- Consumption of service information (SI) metadata
- Consumption of metadata and broadband content
- Concealment of the broadcast video
- HTTP adaptive streaming.[89]

Main prerequisites for second synchronized screen:

The main prerequisite for this service is the provision of an interactive multimedia framework and specific application with the following functionalities:

- Multi-device presentation support
- Consumption of broadband content
- HTTP adaptive streaming
- Input events generated directly by the mobile app
- Synchronization between events in the main screen and the secondary screen.[90]

Main prerequisites for scalable video:

In summary, the main prerequisites for providing scalable videos are:

- Scalable video coding (SVC) in the broadcast content
- Consumption of content from broadband
- HTTP adaptive streaming

[88] For more information, see: ITU-T. Recommendation ITU-T H.761 (11/2014) on nested context language (NCL) and Ginga-NCL.
[89] For example, adaptive streaming protocols over HTTP (HAS), such as MPEG-DASH, which have become the de-facto solutions to deliver video over the Internet. By avoiding buffer stalling, HAS increases end users' quality of experience (QoE).
[90] Synchronization between different media objects can be achieved by NCL (nested context language), standardized by ITU-T in Recommendation ITU-T H.761 (11/2014).

- Synchronism of multiple sources:
  - Recorded video: Pre-fetch from broadband
  - Live video: Buffering from broadcast.

Main prerequisites for enriched service information:

The main prerequisites for providing enriched service information are:

- Consumption of service information (SI) metadata
- Consumption of broadband content
- Regionalization (sensitivity to context)
- Reuse of web content, in some cases (for example with HTML-5).

Main prerequisites for microsite campaigning:

In summary, the main prerequisites for providing microsite campaigning are:

- Consumption of broadband content
- Regionalization (sensitivity to context)
- Adaptive streaming
- Reuse of web content, in some cases (for example with HTML5).

Main pre-requisites for Push VoD:

In summary, the main prerequisites for providing Push VoD are:

- Consumption of broadcast and broadband content
- Partial delivery of content
- Concealment of broadcast video
- Multiple carrousels for delivery.

Main prerequisites of targeted advertising:

In summary, the following prerequisites need to be addressed for targeted advertising:

- Consumption of broadband content
- Sensitivity to context
- Concealment of broadcast video
- Synchronism with frame resolution
- Synchronism of multiple sources: pre-fetch.

Annex 3: 4K UHDTV services: Chronology of launches

Q3/11	Japan succeeds in the complete digitalization of terrestrial television broadcasting by terminating analogue broadcasting. ISDB-T is the Japanese standard for digital terrestrial television broadcasting
Q4/13	Netflix** adds first 4K titles to its online streaming library
Q1/14	UHD pay-TV trial by Japanese NTT* (STB-based; vendor: Sumitomo)
Q2/14	KT Corporation* (South Korea) launches the world's first UHD pay-TV service, called "Olleh GiGA UHDTV"
Q3/14	DirecTV (US) launches its first non-STB RVU (Remote Viewing)-based 4K UHD pay-TV service
	China Telecom* Sichuan launches the first commercial 4K UHD STB service in China (developed with Huawei)
Q4/14	Comcast becomes the second US pay-TV operator to launch a UHD pay-TV service (non-STB, Samsung app)
	Amazon** and M-Go* launch 4K UHD offers
Q1/15	Dish Network (US) launches the first 4K STB service among US pay-TV operators
Q2/15	Free* (France) launches its first "Mini 4K" STB
Q3/15	BT* launches YouView box, the first UHD STB in the UK
	DirecTV unveils its first 4K STB, the Genie Mini
	Videotron (Canada) launches a 4K UHD commercial service
	Totalplay* (Mexico) launches the first UHD STB in Latin America
Q4/15	SFR* (France) launches a UHD gateway, La Box Fibre Zive
	UltraFlix** launches its 4K offer on Roku 4
Q1/16	Etisalat* (UAE) launches the Middle East and Africa region's first UHD 4K IPTV service
Q2/16	Swisscom* launches its TV UHD Box 2.0
	Vodafone* Portugal launches TV Box 4K

Source: Ovum

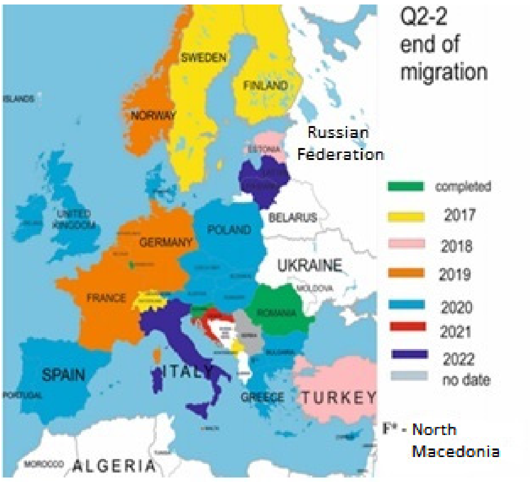
Note: ***Telco **OTT player**

Annex 4: Availability of the 700 MHz band in Europe

In Europe, a deadline of 30 June 2020 (up to two years later with adequate justification) has been set for reassignment of the 700 MHz band (694-790 MHz) to wireless broadband services. In addition, a deadline of 30 June 2018 was also set for NRAs in Member States to adopt and publish a national roadmap outlining how this reassignment will be achieved.

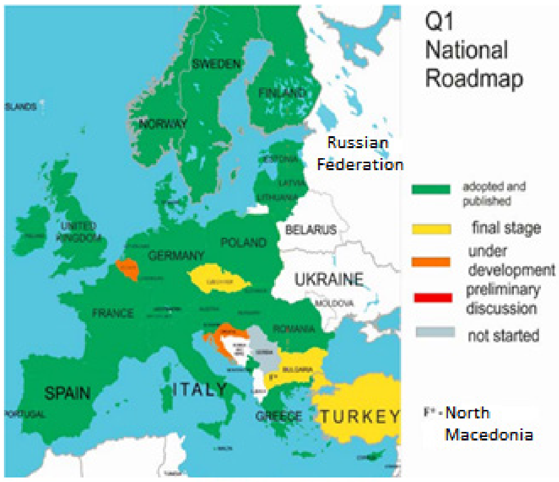
On 8 October 2018 the Radio Spectrum Policy Group (RSPG)[91] published the results of the responses to the 6th release of the Questionnaire on cross-border coordination regarding 700 MHz.[92]

Figure A.4.1: National roadmap for the 700 MHz band in the EU



Source: RSPG

Figure A.4.2: End of migration for the 700 MHz band in the EU



Source: RSPG

Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of ITU and of its secretariat concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Figure A.4.1 shows that the majority of countries have agreed a national roadmap for the 700 MHz band. Most of them appear to be on track to have cleared the band by the June 2020 deadline (**Figure A.4.2**). The planned end-of-migration date is beyond 2020 for some countries, such as Italy, Latvia and Lithuania (all 2022) as well as Croatia and Malta (both 2021).

In almost all cases, cross-border coordination within EU Member States has been finalized. However, some difficulties remain, largely due to unresolved cross-border interference from non-EU countries, including Albania, Belarus, the Russian Federation and countries in North Africa. A heavy reliance on DTT in some markets is also a factor, most notably in Italy, where significant complexity arises due to the large number of TV multiplexes in operation.

[91] The Radio Spectrum Policy Group (RSPG) is the high-level advisory group that assists the European Commission in the development of radio-spectrum policy.

[92] RSPG. Results of the 6th RSPG Questionnaire. Good offices – 700 MHz band. *Cross-border coordination issues*. RSPG18-041 FINAL. September 2018

Annex 5: The socio-economic and commercial benefits for countries that allocate the digital dividend to mobile

Report	Summary	Source
The Economic Benefits of Early Harmonization of the Digital Dividend Spectrum and the Cost of Fragmentation in Asia-Pacific *May, 2012*	In terms of economic impact, by 2020 the allocation of the 700 MHz band to mobile could have a positive impact across the region, generating a GDP increase of more than USD 1 trillion (NPV of USD 960 billion) and tax revenue growth of USD 215 billion, along with the creation of an additional 1.4 million new businesses (including new departments or business units within existing firms) and 2.7 million new jobs.	GSMA/ Boston Consulting Group
The Digital Dividend in Serbia *June, 2010*	Allocating 140 MHz of digital dividend to mobile broadband in Serbia would yield EUR 908 million in extra economic growth. This will also have a strong effect on boosting employment.	Europe Economics
Economic Benefits of the Digital Dividend for Latin America *September, 2011*	If the digital dividend is allocated to mobile broadband, it would contribute up to almost USD 11 billion in the five countries studied in detail (Argentina, Brazil, Colombia, Mexico and Peru) compared to just under USD 3 billion if the band is reserved for broadcasting. Mobile-broadband coverage could increase from 75 per cent to approximately 95 per cent of the population in Argentina, 75 per cent to 95 per cent in Brazil, 53 per cent to 90 per cent in Colombia, 39 per cent to 94 per cent in Mexico and 65 per cent to 89 per cent in Peru. The deployment of the 700 MHz spectrum for mobile broadband across Latin America also delivers significant social and economic benefits. This includes an additional USD 3.1 billion in GDP growth, 5 540 more jobs and USD 2.6 billion further tax revenue than would be created through broadcasting services. It would also help generate a consumer surplus of USD 5.2 billion. Furthermore, there will be significant social impact, through improved access to educational resources, improved health services and greater financial inclusion.	GSMA/ AHCIET
The benefits of releasing spectrum for mobile broadband in Sub-Saharan Africa *December, 2011*	The study focuses on six case-study countries - Ghana, Kenya, Nigeria, Senegal, South Africa and Tanzania. The study shows that releasing more spectrum would allow mobile-broadband penetration to rise to nearly 40 per cent by 2025.If harmonized spectrum is released, especially at 700/800 MHz and 2.6 GHz, then the economic and social benefits could be substantial.	Plum Consulting

(continued)

Report	Summary	Source
The socio-economic benefit of allocating harmonized mobile-broadband spectrum in the Kingdom of Saudi Arabia *April, 2012*	The Kingdom of Saudi Arabia would receive considerable socio-economic benefits from the release of harmonized spectrum in the 700/800 MHz and 2.6 GHz bands for use by mobile operators to deliver next-generation mobile-broadband services. In particular, the Kingdom of Saudi Arabia would see: • a total GDP gain of SAD 358 billion in net present value over the period 2013 to 2025 • jobs for 424 000 people by 2020 • mobile coverage to large rural areas, providing education and information benefits to poorer areas. Any delay in the release of this harmonized spectrum would have a significant impact on these benefits. A five-year delay in the release of harmonized spectrum would reduce the total GDP gain over the period 2013-2025 to just SAR 96 billion, and reduce the number of jobs created to 75 000.	Analysys Mason

Annex 6: The different systems/standards adopted for terrestrial digital radio

Digital System	Standard	Frequency band*	Reference documents	Global Industry Forum	Countries
DS A	DAB/ DAB+ (Eureka-147)	VHF Band III	ITU-R BS.1114-11 ITU-R BS.1660 Annex I ETSI EN 300 401 DSB Handbook Annex A Status of the deployment of DAB+	www.worldab.org	European countries Australia Republic of Korea North Africa Arab region
DS F	ISDB-Tsb	VHF, UHF	ITU-R BS.1114-11 ITU-R BS.774 ITU-R BS.1660 Annex II DSB Handbook Annex F	http://www.arib.or.jp/english/index.html	Japan Countries in Asia-Pacific, Latin America and Africa
DS G	DRM+	VHF Band I, II, III	ITU-R BS.1114-11 ITU-R BS.1660 Annex III Report ITU-R BS.2214-2 (2016) ETSI ES 201 980 V4.1.1 DRM Guide Use of the DRM+ in the FM band	www.drm.org	India Some European countries
DS C	IBOC DSB (NRSC-5)	VHF Band II	ITU-R BS.1114-11 DSB Handbook Annex C https://www.fcc.gov/media/radio/digital-radio	www.dts.com	United States
DS I	RAVIS	VHF Band I, II	ITU-R BS.1114-11 Report ITU-R BS.2214-2 (2016) Standard GOST R 54309-2011	http://ravis-radio.ru/en/	Russian Federation
DS H	CDR	VHF Band II	ITU-R BS.1114-11 Standard GY/T 268.1-2013 (2013.08)		China

* Band I: 47-68 MHz; Band II: 87.5-108 MHz; Band III: 174-230 MHz.

Annex 7: Other case studies on digital sound broadcasting services

National experience: Switzerland

In 2013, a working group (Digital Migration Working Group – DigiMig)[93] was created to develop a joint strategy for coordinated migration of radio stations from FM to DAB+. In December 2014, DigiMig's final report[94] was presented to the Head of the Federal Department of the Environment, Transport, Energy and Communications (DETEC), the Federal Council and the Media Minister. The report proposed two main phases for the switchover:

Table A.7.1: Phases adopted in Switzerland for DAB+ transition

Phase 1 (2014-2019) *All FM broadcasters commence DAB+ transmission*	Phase 2 (2020-2024) *Gradual switchover from FM to DAB+*
Effective financial support for DAB+ broadcasting	Coordinated switch-off of major FM transmitters by private broadcasters and the SRG
Massive marketing campaigns	Mountain assistance now only for DAB+ broadcasting
Provision of DAB+ in the major road tunnels	Gradual reduction of technology support
Easing of the FM broadcasting obligation, relinquished FM frequencies remain with OFCOM	Coordinated switch-off of the remaining FM transmitters by the end of 2024 at the latest
No tender procedures for FM licences, unchanged coverage areas	
Extension of the FM radio frequencies by a maximum of five years with simulcast operation	

In terms of regulation, two key facts were considered. First, the FM licences will expire at the end of 2019. Second, the Federal Council must examine the number and structure of the coverage areas by mid-2017 at the latest. Since these dates almost coincide, this a favourable opportunity to take fundamental decisions on the future of radio broadcasting. It was also recommended to have a simulcast phase that is as short as possible since the parallel offering of FM and DAB+ will increase the cost of coverage of the current licence areas by approximately 50 per cent.

In order to ease the financial burden on broadcasters during the simulcast phase, a generous interpretation of the existing provisions to support new technologies was recommended as a first step. In a second stage, a significant increase in support funding for the radio industry from the Confederation was proposed. Swiss OFCOM officially confirmed on 29 August 2019 that FM will be switched off in Switzerland by no later than the end of 2024. After the shutdown of the last FM transmitter, the Federal Council will decide on the future use of the FM band.

93 DigiMig consists of representatives of the Swiss Broadcasting Corporation (SRG/SSR), the Association of Swiss Private Radio Stations (ASPR), the *Union Romande des Radios Régionales* (RRR), the Union of Non-Commercial Radio Stations (UNIKOM) and the Federal Office of Communications (OFCOM).

94 DigMig (Switzerland). From FM to DAB+. Final Report of the Digital Migration Working Group. Biel/Bienne, 1 December 2014.

Based on latest figures,[95] 65 per cent of radio listening is now digital (using different platforms), 35 per cent of which is via DAB+, and only 17 per cent of radio listening is now exclusively via FM. Digital radio on DAB+ in Switzerland reaches over 99 per cent of the population (outdoor 99 per cent, indoor over 96 per cent). Also, 99 per cent of roads are covered, including highway tunnels. Also the proportion of new vehicles in which DAB+ reception is fitted as standard is now 91 per cent, compared with 85 per cent in the previous year.

To support the transition to DAB+ and the radio industry, OFCOM issued an invitation to tender for a four-year DAB+ information campaign beginning in 2019 in order for the population to be able to prepare for the migration of the broadcasting of radio programme services from FM to DAB+ in good time. Since February 2017, the new DAB+ website www.dabplus.ch and various social media channels (facebook, twitter and Instagram) have been active online. The main objectives of the promotional campaign are to raise awareness of DAB+, increase its use and promote the sale of DAB+ compatible devices.

Also, DAB+ was present as a partner of the Swiss Music Awards in Zurich. The musicians will also be DAB+ ambassadors, since they will show that their music also moves on DAB+. In addition, the first content of the campaign will be shared via social media and with hashtags #DABplus and #LaRadioDemenage.[96]

National experience: France[97]

In August 2013, DAB+ was added to the French standards. In 2014, DAB+ was officially launched for the first time in France, in the cities of Paris, Marseille and Nice. In December 2018, the *Conseil supérieur de l'audiovisuel* (CSA), the French regulator, announced that following the launches of DAB+ in Strasbourg and Lyon, 21.3 per cent of the population of France was now covered by DAB+. As of October 2019, population coverage in France stands at 25 per cent and it is expected that, by 2020, 70 per cent of French territory will be covered by DAB+.

In December 2017, CSA published on its website the roadmap for the deployment of DAB+ (Feuille de route 2018-2020 pour le déploiement du DAB+). DAB+ is expected to launch in over 15 cities in throughout 2019 and 2020. Currently, there are: 15 regional multiplexes (six in Paris, four in Nice, four in Marseille, one in Lille) and three trial multiplexes on air:

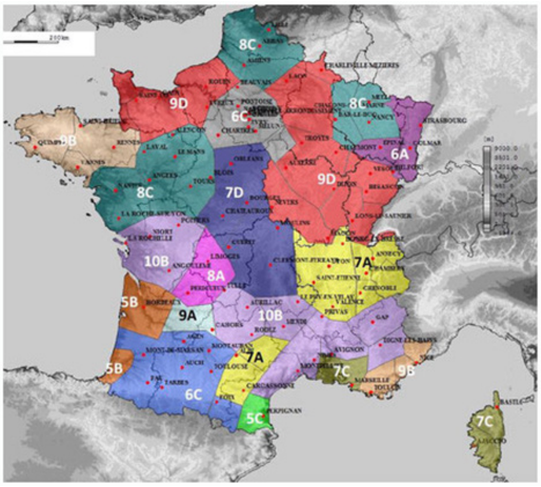
	Simulcast on AM/FM	Exclusive on digital	Total services
DAB+ programmes	76	90	166

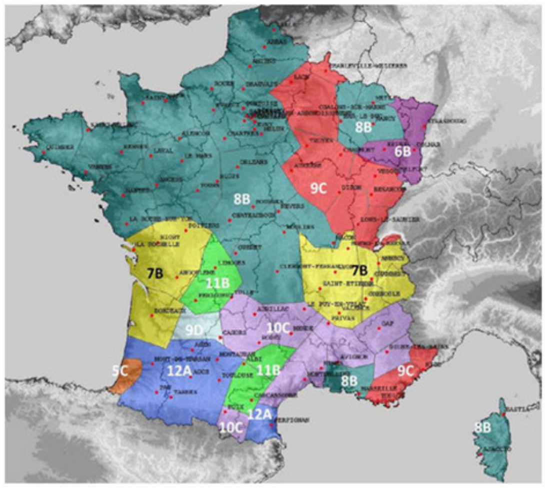
Analogue and digital licences are both issued free of charge. The current analogue rules which govern advertising and sponsorship as well as the quota for French music and new artists will also apply to digital radio.

[95] Plilippa de Roten and Luc Mariot (RTS-SSR). DAB in Switzerland – On time, too soon or too late? EBU New Radio Day, 25 October 2019.
[96] Useful links:
- SRG/SSR Broadcast.ch. Ratgeber / Broschüren [in German/French/Italian]; OFCOM (Switzerland).
- Radio industry sets a course to phase out FM. Last updated 1 December 2014;
- SwissMediaCast. [in German]

[97] For more details, visit: *Conseil supérieur de l'audiovisuel* (France). DAB+ : tout savoir sur la radio numérique terrestre. [in French]

Figure A.7.1: The 1st and 2nd metropolitan multiplex in DAB+





Source: CSA

Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of ITU and of its secretariat concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

In March 2019, the CSA released the list of radio stations that have been granted a national DAB+ licence alongside the six Radio France national radio stations.

The availability of DAB and DAB+ receivers in France continues to grow, with a range of devices now on the market, including kitchen radios, handheld and tuners. As more DAB+ services launch, with marketing campaigns to support them, sales are expected to grow significantly across the country over the next few years.

As of H1 2018, the percentage of new cars equipped with DAB+ technology in France stands at approximately 20 per cent. However, this figure is expected to grow significantly following the triggering of the French receiver law, which is expected to be implemented in three phases over a period of 18 months and will require all automotive receivers in cars sold within 18 months of the law being triggered to include DAB+ capabilities.

The website DABplus.fr was set up to inform the public about the benefits of DAB+, the availability of DAB+ receivers and to summarize the deployment of DAB+ in the different cities. It is paid by and for stakeholders of DAB+ in France.

In addition, large retailers including FNAC and DARTY are informing consumers about the benefits of digital radio through their websites.

National experience: Ukraine[98]

On 29 March 2018, the National Council announced the results of the competition for digital radio broadcasting in Kyiv. A total of 10 radio stations are to broadcast in DAB+ format, with three of those being dedicated to public broadcasting. The digital broadcasting licences have been granted to broadcasters for a period of seven years.[99] The first stations began transmissions in June 2018.

In July 2018, the National Council announced the results of another competition for digital radio broadcasting in Kyiv. Four additional radio stations are to broadcast in DAB+ format. As of today, 14 DAB+ services are on air.

There is one regular local multiplex on air. The population coverage of the local regular DAB+ multiplex on air in Ukraine is about 3 million people (the capital city - Kyiv). The 7D frequency block will be used before the switch-off of analogue television, after which it will be converted to 11D.

The competition for the DAB+ broadcasting licences was won by 14 companies: nine of the stations on the multiplex are simulcasts of FM stations and five are exclusive to DAB+. The transmissions are being implemented by the Broadcasting, Radiocommunications and Television Concern (BRT), which is also the telecommunications operator.

	Simulcast on AM/FM	Exclusive on digital	Total services
DAB+ programmes	9	5	14

National Experience: Tunisia[100]

Following successful trials starting in 2008, a national multiplex operated by the *Office National de la Télédiffusion* (ONT), the national public broadcaster, is now on air covering over half (51 per cent) of the country's 11 million inhabitants, while the second phase of the expansion – set to bring population coverage to 75 per cent by July 2020 – is already under way.

The multiplex, which hosts 18 DAB+ programmes, covers the capital, Tunis, as well as other regions in the north-eastern part of the country, including Ariana, Ben Arous, Nabeul, Sousse, Monastir, Manouba, Zaghouan, Bizerte and Mahdia, while the second phase will see DAB+ expand to cover four new sites, namely Ain Draham, Goraa (Beja), Trozza (Kairouan) and Ghraba (Sfax). Currently, there is one regular national multiplex on air.

98 Useful links:
- RadioWorld. News and business. Nine DAB+ stations launch in Kiev: Digital radio trials cover Ukraine's capital and surrounding areas. 26 June 2018;
- Ukrinform. "Army FM" won the competition for digital radio. "Chanson" lost. [In Ukrainian];
- National Council of Television and Radio Broadcasting of Ukraine. The Association of Digital Broadcasters is set up in Ukraine. 31 July 2018.

99 For more details, see: National Council of Television and Radio Broadcasting of Ukraine. 10 radio stations will broadcast in digital format in Kyiv. 29 May 2018.

100 Useful links:
- BroadcastPro Middle East. Tunis leads the way on DAB+. 10 November 2019.
- Wohnort. DAB Ensembles Worldwide. Tunisia

Annex 8: List of countries with regular digital sound broadcasting services

List of countries with regular services	
Country	**Reference links**
Australia	https://www.acma.gov.au/tv-and-radio-broadcasters http://www.digitalradioplus.com.au/ https://mediarealm.com.au/articles/digital-radio-australia-dabplustechnical-overview/
Austria	https://dabplus.at/
Azerbaijan	https://1news.az/news/testovoe-veschanie-cifrovogo-radio-v-baku-i-na-absheronskom-poluostrove-proshlo-uspeshno
Belgium	https://brf.be/ https://www.digitalradio.be/ https://www.dabplus.be/fr/ https://www.norkring.be/
Czech Republic	http://pureradio.cz/eshop-info-www/dab-digitalni-rozhlas-v-Cr/ https://www.ctu.cz/ http://www.dab-plus.cz/ https://digital.rozhlas.cz/ https://dobadabova.cz/ https://www.worlddab.org/public_document/file/1109/DAB_CR_EN.PDF?1550499291
Denmark	http://www.digitalradio.dk/ http://www.kanalplus.fm/site/index.php?side=dab.php http://www.anpdm.com/newsletterweb/434459417445435C4277484359/42415C4B7642415C407747415A43
France	https://www.csa.fr/ https://www.dabplus.fr/ https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000028134369&dateTexte=&categorieLien=id https://www.worlddab.org/countries/france/multiplexes
Germany	https://www.dabplus.de/ https://www.rundfunkforum.de/viewforum.php?f=11 https://www.worlddab.org/public_document/file/890/aktionsplan-tranformation-hoerfunkverbreitung-en.pdf?1496824667 https://www.worlddab.org/public_document/file/885/Draft_Bill_of_the_Federal_Ministry_for_Economic_Affairs_and_Energy_5.4.17.pdf?1494941728
Gibraltar	https://www.worlddab.org/countries/gibraltar/multiplexes

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List of countries with regular services	
Country	**Reference links**
Greece	https://www.eett.gr/opencms/opencms/admin/News_new/news_0766.html https://www.worlddab.org/public_document/file/964/Greek_DAB__frequency_and_sites_map.pdf?1516356222 https://www.worlddab.org/public_document/file/965/Greek_DAB__licencing_law_%28articles_220_-_238%29.pdf?1516356254 https://www.worlddab.org/countries/greece/multiplexes
Vatican City State	https://www.worlddab.org/countries/holy-see-(vatican-city-state)/multiplexes
Ireland	https://www.bai.ie/en/
Italy	http://www.dab.it/home/ http://digitalradio.it/ https://www.eurodabitalia.it/ https://www.worlddab.org/countries/italy/multiplexes https://www.gazzettaufficiale.it/eli/id/2017/12/29/17G00222/sg
Kuwait	http://www.media.gov.kw/ https://www.worlddab.org/countries/kuwait/multiplexes
Malta	http://www.ba-malta.org/home https://www.dab.com.mt/en https://www.worlddab.org/countries/malta/multiplexes
Monaco	http://www.mmd.mc/fr/radios.html https://www.worlddab.org/countries/monaco/multiplexes
Netherlands	https://digitalradio.nl/ https://www.dabtuners.nl/ https://www.radiowinkel.com/ https://www.dabforum.nl/
Norway	https://medietilsynet.no/en/about-medietilsynet/digital-radio/ https://radio.no/dekning/ https://www.nrk.no/ https://www.regjeringen.no/globalassets/upload/kud/medier/rapporter/v-0951e-summaryreportno8_2010-11.pdf https://www.regjeringen.no/en/aktuelt/radio-digitisation-in-2017/id2406145/ https://www.worlddab.org/public_document/file/1125/One_Year_After_-_report_and_appendices.pdf?1553793724 https://www.worlddab.org/system/news/documents/000/011/092/original/One_Year_After_-_report_and_appendices_-_1st_update.pdf?1568890164 https://www.worlddab.org/countries/norway#services_on_air
Poland	http://dab.polskieradio.pl/ http://www.krrit.gov.pl/radio-cyfrowe https://www.worlddab.org/countries/poland#services_on_air

(continued)

List of countries with regular services

Country	Reference links
Slovenia	https://digitalniradio.si/ https://www.akos-rs.si/javni-razpis-za-dodelitev-desetih-pravic-razsirjanja-radijskega-programa-v-digitalni-radiodifuzni-tehniki-na-celotnem-ozemlju-republike-slovenije https://www.akos-rs.si/monitor:-digitalno-radijsko-oddajanje https://www.rtvslo.si/dab/oddajniki https://www.worlddab.org/countries/slovenia#services_on_air
Republic of Korea	https://www.worlddab.org/countries/south-korea#services_on_air
Sweden	http://dabplus.se/ https://www.mprt.se/en/broadcasting-radio-and-tv/radio/digital-radio/
Switzerland	https://www.worlddab.org/countries/switzerland https://www.dabplus.ch/ https://www.bakom.admin.ch/bakom/en/homepage/electronic-media/technology/digital-transmission/radio-industry-sets-a-course-to-phase-out-fm.html https://www.broadcast.ch/de/startseite/
Tunisia	http://www.telediffusion.net.tn/?lang=fr https://www.worlddab.org/countries/tunisia
Ukraine	https://www.worlddab.org/countries/ukraine https://www.nrada.gov.ua/en/u-kyyevi-movytymut-10-radiostantsij-u-tsyfrovomu-formati/ https://www.nrada.gov.ua/en/u-kyyevi-movytymut-shhe-4-radiostantsiyi-u-tsyfrovomu-formati/
United Kingdom	https://www.ofcom.org.uk/tv-radio-and-on-demand/information-for-industry/radio-broadcasters/coverage/dab-coverage-plans?pageNum=1#in-this-section https://getdigitalradio.com/ https://www.ofcom.org.uk/research-and-data/tv-radio-and-on-demand/radio-research/digital-radio-reports https://www.worlddab.org/countries/united-kingdom https://ukfree.tv/radio/digitalstations/all

Annex 9: ITU activities and publications in relation to Question 2/1

ITU Radiocommunication Sector

List of ITU-R Recommendations

SM.1682	Methods for measurements on digital broadcasting signals
SM.1603	Spectrum redeployment as a method of national spectrum management
BT.2033	Planning criteria, including protection ratios, for second generation of digital terrestrial television broadcasting systems in the VHF/UHF bands
BT.1306	Error correction, data framing, modulation and emission methods for digital terrestrial television broadcasting"
BT.1368	Planning criteria, including protection ratios, for digital terrestrial television services in the VHF/UHF bands
BT.2077	Real-time serial digital interfaces for UHDTV signals
BT.2073	Use of the high efficiency video coding (HEVC) standard for UHDTV and HDTV broadcasting
BT.2052	Planning criteria for terrestrial multimedia broadcasting for mobile reception using handheld receivers in VHF/UHF bands
BT.2038	Transport of HDTV 3DTV programmes for international programme exchange in broadcasting
BT.2050	Use of UHDTV image systems for capturing, editing, finishing and archiving high-quality HDTV programmes
BT.2025	1 280 × 720 digital image systems for the production and international exchange of 3DTV programmes for broadcasting
BT.2020	Parameter values for ultra-high definition television systems for production and international programme exchange
BT.2016	Error-correction, data framing, modulation and emission methods for terrestrial multimedia broadcasting for mobile reception using handheld receivers in VHF/UHF bands
BT.1877	Error-correction, data framing, modulation and emission methods for second generation of digital terrestrial television broadcasting systems
BT.1895	Protection criteria for terrestrial broadcasting systems
BT.2123	Video parameter values for production and international programme exchange
BT.2420	Collection of usage scenarios and current statuses
BT.2124	Objective metric for the assessment of the potential visibility of colour differences in television
BT.2111	Specification of colour bar test pattern for high dynamic range television systems
BT.2075	Integrated broadcast-broadband system
BT.2037	General requirements of IBB systems

(continued)

BT.2053	Technical requirements for IBB systems and various aspects of IBB systems including App. Types and App. Control
BS.2051	Advanced sound systems for programme production, to include headphones associated with metadata, which are a vital part of the AIAV systems experience
BS.774	Service requirements for digital sound broadcasting to vehicular, portable and fixed receivers using terrestrial transmitters in the VHF/UHF bands (2014)
BS.1114	Systems for terrestrial digital sound broadcasting to vehicular, portable and fixed receivers in the frequency range 30-3 000 MHz
BS.1660	Technical basis for planning of terrestrial digital sound broadcasting in the VHF band
P.1546	Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 3 000 MHz
M.1036	Frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications (IMT) in the bands identified for IMT in the Radio Regulations

List of ITU-R Reports

SM.2353	The challenges and opportunities for spectrum management resulting from the transition to digital terrestrial television in the UHF bands
BT.2343	Collection of field trials of UHDTV over DTT networks
BT.2339	Co-channel sharing and compatibility studies between digital terrestrial television broadcasting and international mobile telecommunication in the frequency band 694-790 MHz in the GE06 planning area
BT.2301	National field reports on the introduction of IMT in the bands with co-primary allocation to the broadcasting and the mobile services
BT.2302	Spectrum requirements for terrestrial television broadcasting in the UHF frequency band in Region 1 and the Islamic Republic of Iran
BT.2337	Sharing and compatibility studies between digital terrestrial television broadcasting and terrestrial mobile broadband applications, including IMT, in the frequency band 470-694/698 MHz
BT.2338	Services ancillary to broadcasting/services ancillary to programme making spectrum use in Region 1 and the implication of a co-primary allocation for the MS in the frequency band 694-790 MHz
BT.2387	Spectrum/frequency requirements for bands allocated to broadcasting on a primary basis
BT.2254	Frequency and network planning aspects of DVB-T2
BT.2294	Construction technique of DTTB relay station network for ISDB-T
BT.2295	Digital terrestrial broadcasting systems
BT.2140	Transition from analogue to digital terrestrial broadcasting
BT.2143	Boundary coverage assessment of digital terrestrial television broadcasting signals

(continued)

BT.2267	Integrated broadcast-broadband systems
BT.2381	Requirements for high dynamic range television (HDR-TV) systems
BT.2390	High dynamic range television for production and international programme exchange
BT.2408	Operational practices in HDR television production
BT.2386	Digital terrestrial broadcasting: Design and implementation of single frequency networks (SFN)
BT.2207	Accessibility to broadcasting services for persons with disabilities
BT.2245	HDTV and UHDTV including HDR-TV test materials for assessment of picture quality
BT.2246	The present state of ultra-high definition television
BT.2420	Collection of usage scenarios and current statuses of advanced immersive audio-visual systems
BS.1203	Digital sound broadcasting to vehicular, portable and fixed receivers using terrestrial transmitters in the UHF/VHF bands
BS.2208	Possible use of VHF Band I for digital sound broadcasting services
BS.2214	Planning parameters for terrestrial digital sound broadcasting systems in VHF bands
BS.2384	Implementation considerations for the introduction and transition to digital terrestrial broadcasting
M.2373	Audio-visual capabilities and applications supported by terrestrial IMT systems (11/2018)
M.2480	National approaches of some countries on the implementation of terrestrial IMT systems in bands identified for IMT (09/2019)

Questions under study by ITU-R

Question ITU-R 140-1/6	Global platform for the broadcasting service
Question ITU-R 132-5/6	Digital terrestrial television broadcasting planning
Question ITU-R 143/6	Advanced Immersive Sensory Media Systems for Programme Production, Exchange and Presentation for Broadcasting

ITU-R study group activities

SG1	Spectrum management	WP1C working document towards a preliminary draft NEW REPORT ITU-R SM.[POPULATION_COVERAGE] WP1C working document towards a preliminary draft revision of RECOMMENDATION ITU-R SM.1875-2 "DVB T/T2 coverage measurements and comparison with coverage predictions"
SG3	Radiowave propagation	SG 3K Correspondence Group 3K-4 on issues relating to Rec ITU-R P.1546
SG5	Terrestrial services	WP 5D: IMT Systems WG Spectrum Aspects: revision of Recommendation ITU-R M.1036-5 WG General Aspects: draft new Report ITU-R M.[IMT.EXPERIENCES]
SG6	Broadcasting service	WP 6A current work items: https://www.itu.int/en/ITU-R/study-groups/rsg6/Pages/wp6a-current-work-items.aspx WP 6B current work items: https://www.itu.int/en/ITU-R/study-groups/rsg6/Pages/wp6b-current-work-items.aspx WP 6C current work items: https://www.itu.int/en/ITU-R/study-groups/rsg6/Pages/wp6c-current-work-items.aspx

ITU Telecommunication Standardization Sector

ITU-T study group activities

SG9	Broadband cable and TV	Question 4/9 "Guidelines for implementations and deployment of transmission of multichannel digital television signals over optical access networks". Question 11/9 "Accessibility to cable systems and services"
SG16	Multimedia coding, systems and applications	Question 13/16 "Multimedia application platforms and end systems for IPTV" (ITU-T H.760 series and ITU-T H.720 series) Question 21/16 "Multimedia framework, applications and services" Question 26/16 "Accessibility to multimedia systems and services"

ITU-T Recommendations

H.702	Accessibility profiles for IPTV systems
H.720-H.729 series	IPTV terminal devices
H.760-H.769 series	IPTV multimedia application frameworks

ITU Telecommunication Development Sector

ITU-D Reports

Report on Question 8/1 (2014-2017)	Examination of strategies and methods of migration from analogue to digital terrestrial broadcasting and implementation of new services
Guidelines related to Question 8/1 (2014-2017)	Guidelines on communications strategies for the transition from analogue to digital terrestrial broadcasting
Report on Question 7/1 (2014-2017)	Access to telecommunication/ICT services by persons with disabilities and with specific needs
Report on Question 11-3/2 (2010-2014)	Examination of terrestrial digital sound and television broadcasting technologies and systems, interoperability of digital terrestrial systems with existing analogue networks, and strategies and methods of migration from analogue terrestrial techniques to digital techniques
Model ICT Accessibility Policy Report, G3ict-ITU	The report offers concrete solutions to implement successful national ICT accessibility policies. It supports ITU members in the realization of the Connect 2020 Target on the creation of an enabling environment for accessible telecommunications/ICTs for persons with disabilities
Making TV Accessible, G3ict-ITU	This report looks at the strategic implications of making audiovisual content accessible to persons with disabilities.

ITU database and publications

The Master International Frequency Register (MIFR) (for all ITU-R Regions: 1, 2 and 3) and the GE06 Digital Plan (only for Region 1, except the territories of Mongolia, and the Islamic Republic of Iran)
Plan for use of the band 87.5-108 MHz for FM sound broadcasting in Region 1 and part of Region 3, Geneva, 1984 (GE84)
ITU-D DSO database (main ITU source of information regarding Digital terrestrial television (DTT) networks and services)
ITU-R Handbook on Digital terrestrial television broadcasting networks and systems implementation (2016)
The Future of Cable TV: Trends and Implications (edition of 2018)
Trends in broadcasting: An overview of developments (edition of 2013)
DTTB Handbook - Digital terrestrial television broadcasting in the VHF/UHF bands (2002)
ITU Report: Digital dividend insights for spectrum decisions (2018)
ITU GUIDELINES for the transition from analogue to digital broadcasting (2014)
ITU-R FAQ on the digital dividend and the digital switchover

Workshops and seminars in relation to Question 2/1

5G and broadcasting (WSIS Forum session 352)	31 August 2020 (Virtual)
ITU Public Webinar on Broadcasting services for COVID-19 response	3 July 2020
ITU Regional Symposium for Europe and CIS on Spectrum Management and Broadcasting	1-2 July 2020 (Virtual)
International Training Programme on "Emerging Trends in Broadcasting" ITU-TRAI	9 -11 October 2019, New Delhi, India
PRIDA[101] Project Workshop on the Use of SMS4DC	16-20 September 2019, Monrovia, Liberia
Workshop on The Future of Television for Europe	7 June 2019, Geneva, Switzerland
Panel session related to Q2/1 on "Trends in new broadcasting technologies, services and applications"	18 March 2019, Geneva, Switzerland
Workshop on The Future of TV for the Americas	26 November 2018, Bogotá, Colombia
Workshop on Interference to DAB reception	18 October 2018, Geneva, Switzerland
Workshop on Multimedia Applications and the Future of Digital Society	9 July 2018. Ljubljana, Slovenia
Regional Seminar for Europe and CIS on 5G Implementation in Europe and CIS: 5G Implementation in Europe and CIS: Strategies and Policies Enabling New Growth Opportunities	3-5 July 2018, Budapest, Hungary
Regional Workshop on the Future Utilization of UHF band in the Arab States region	12 April 2018, Marrakesh, Morocco
ITU Regional Workshop on Digital Broadcasting Technologies for Sub-Saharan African countries	6-7 March 2018, Nairobi, Kenya
Workshop on The Future of Cable TV	25-26 January 2018, Geneva, Switzerland
Regional Seminar for Europe and CIS on Spectrum Management and Broadcasting	29-31 May 2017, Rome, Italy

Relevant United Nations Sustainable Development Goals (SDGs) and WSIS action lines

Study group	Relevant SDG/WSIS action line
Q2/1	

[101] Policy and Regulation Initiative for Digital Africa (PRIDA) is a joint initiative of the African Union (AU), the European Union (EU) and ITU that enables the African continent to reap the benefits of digitalization. It is supported by the EU-funded Pan-African Programme.

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Note: These chapter coordinators will be featured in the acknowledgements, and so this annex will be deleted from here.

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