Technical Report 015

Defining Spectrum Requirements of Broadcasting in the UHF Band

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1. Introduction

WRC-12 has opened the door for an allocation of the 700 MHz band (694 - 790 MHz) to the mobile service, as from the end of 2015 in ITU Region 1 (WRC-15 agenda item 1.2). It has also agreed to identify frequency bands to satisfy additional spectrum requirements for the mobile service (WRC-15 agenda item 1.1).

If the 700 MHz band (or more) were to be released from broadcasting then this would question the long term viability of the terrestrial television broadcasting platform. This is a very serious threat for the broadcasting community, so any preparation towards WRC-15 cannot be envisaged without the joint forces of all stakeholders to support and develop a vibrant and sustainable terrestrial television broadcasting platform.

The time schedule for preparing WRC-15 is very tight; the Conference Preparatory Meeting CPM15-1 on 20 & 21 February 2012 agreed to establish the JTG 4-5-6-7 Joint Task Group (involving all concerned working parties, including ITU-R WP6A, responsible for broadcasting services) as the responsible group for WRC-15 Agenda items 1.1 and 1.2 concerning the 700 MHz band spectrum. Protection requirements for the broadcasting and mobile services need to be submitted before 31 December 2012. For additional frequency bands to be allocated to the mobile service, information needs to be submitted by 31 July 2013. The work of the JTG 4-5-6-7 should be completed by the third quarter of 2014, leaving enough time for the CPM report to be published before the CPM-2, scheduled in the first quarter of 2015.

As a most urgent task, the EBU Strategic Programme on Spectrum Management decided to create a Task Group to prepare an input on spectrum requirements for the broadcasting service. This Task Group started work by correspondence and actively contributed to the ITU-R WP6A meeting in April 2012, when a questionnaire was prepared to collect the spectrum requirements for DTT. The questionnaire has been distributed to all ITU Administrations and Sector Members in Region 1 (plus Iran) in the Circular Letter “6/LCCE/78” dated 11 May 2012 (see Attachment) and answers are expected before 31 July 2012. At the abovementioned WP6A meeting, several Administrations indicated that they would not be in a position to define their spectrum requirements by the deadline on their own and that they expect broadcasters to contribute. **It is therefore essential that broadcasters actively contribute their spectrum requirements at a national level**.

In many countries in Europe, the EBU members are not Sector Members of the ITU and therefore will not be able to respond directly to the ITU questionnaire. Commercial broadcasters are also in the same situation. In these countries the requirements of broadcasters need to be reflected in the Administration’s response to the ITU questionnaire. EBU members and commercial broadcasters should therefore jointly collaborate with their Administration to estimate and express the overall spectrum requirements for broadcasting in their country. The EBU will also reply to the ITU questionnaire on behalf of its Members taking into account the requirements of the member organisations and other related stakeholders.

This document provides guidelines for assessing spectrum requirements for broadcasting. It is sent to EBU members, commercial TV broadcasters in Europe (through the Association of Commercial Televisions, ACT) and broadcast network operators (through Broadcast Networks Europe, BNE). It is also sent to public and commercial broadcasters in other parts of Region 1 through sister broadcasting unions (AUB for Africa and ASBU for Arab countries).

2. Terrestrial Broadcasting

The terrestrial broadcasting platform comprises a unique combination of characteristics such as technical excellence and efficiency, favourable coverage and support of services, flexibility, market success and wide acceptance by industry as well as by the public in most European countries. As a result, the terrestrial broadcasting platform generates significant social and economic benefits.

Digitization of the terrestrial networks is driving analogue switch-off at a reasonable cost for consumers and broadcasters. In many countries, terrestrial broadcasting is the primary delivery means for broadcasting services to the public. It equally serves public service broadcasters and commercial broadcasters as well as a range of other players in the value chain.

The terrestrial platform is important for the broadcasting industry even in those markets that are dominated by other delivery platforms. It stimulates competition amongst the delivery platforms but can also be complementary to other platforms. It is therefore in the interests of both the broadcasting industry and society as a whole that the terrestrial broadcasting platform remains a viable, attractive and competitive alternative to other delivery platforms for viewers and listeners.

The terrestrial broadcasting platform is widely supported by manufacturers, network operators, broadcasters, regulators and the public. For this support to continue, regulatory clarity and certainty are required as they enable the public, the broadcasters and the associated industry to make the right investments into future technology and services.

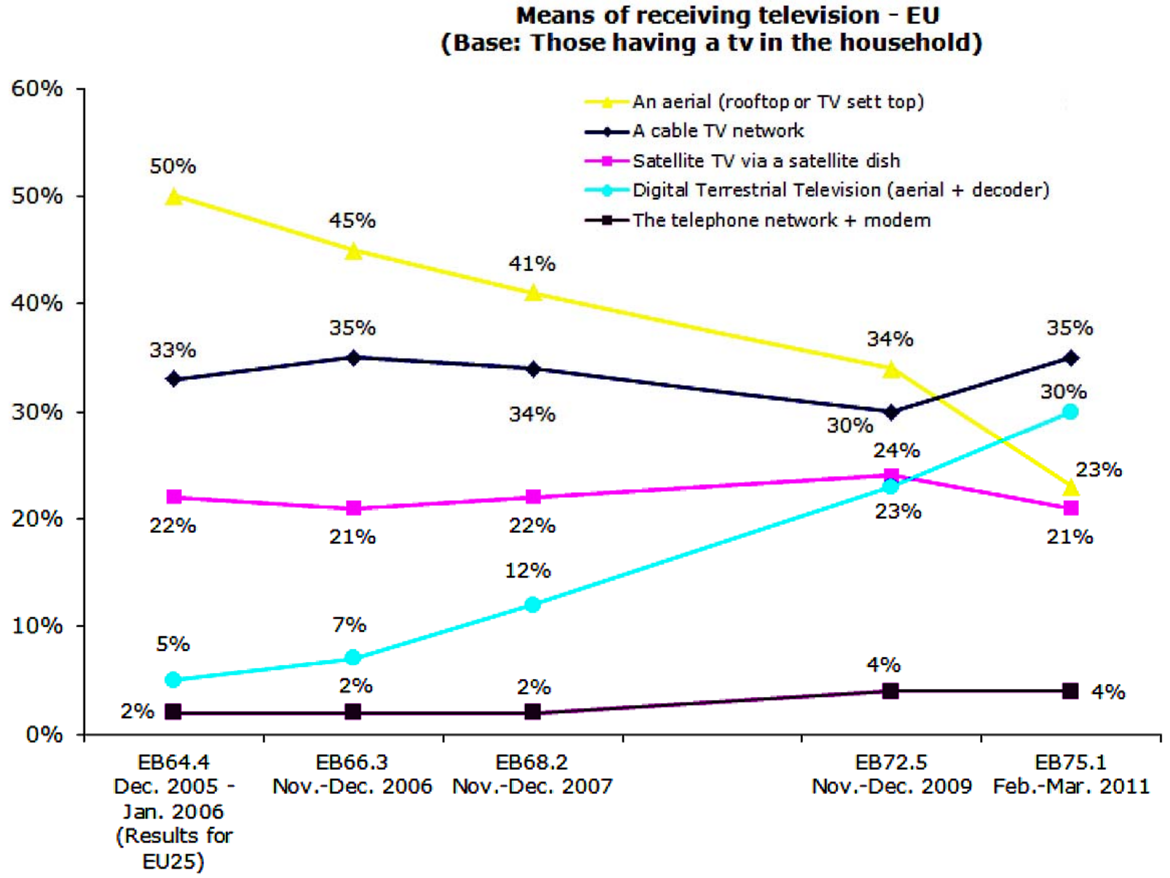
Radio frequency spectrum is an essential resource for terrestrial broadcasting. Sufficient spectrum must be available now and in the future to accommodate the evolving needs of terrestrial broadcasting and to protect the investments made by broadcasters, network operators and the public. The needs of both public service and commercial broadcasting must be taken into account.

Furthermore, spectrum policy needs to take account of the specific circumstances in each country. Any further reduction of the available spectrum for terrestrial broadcasting would have negative consequences for the public and broadcasters alike, for instance through increased interference levels, decreased coverage, fewer services and a reduced possibility for future development.

Degradation of the terrestrial platform is likely to entail a large-scale migration to other platforms. This will inevitably incur very high costs, much of which would have to be borne by the public. Terrestrial broadcast networks are optimised for the delivery of linear media services to large audiences and they will continue to be important in delivering these services in the future.

3. Market development of terrestrial TV in Europe

Terrestrial television has undergone tremendous development through the introduction of digital technology in the networks. The uptake of DTT is steadily growing and the terrestrial platform remains very important for television distribution in the vast majority of European countries. According to the latest data available, 53% of EU households rely on terrestrial networks for their TV reception (see Figure 1 from [1], Special Eurobarometer 362, July 2011; the addition of the figures for analogue and digital terrestrial television gives 53%). It should be noted that DTT use varies significantly with the different types of area. In particular, high usage is noted in urban areas (see [2]). DTT is a very successful platform, equally supported by broadcasters, network operators, the manufacturing industry and the public.

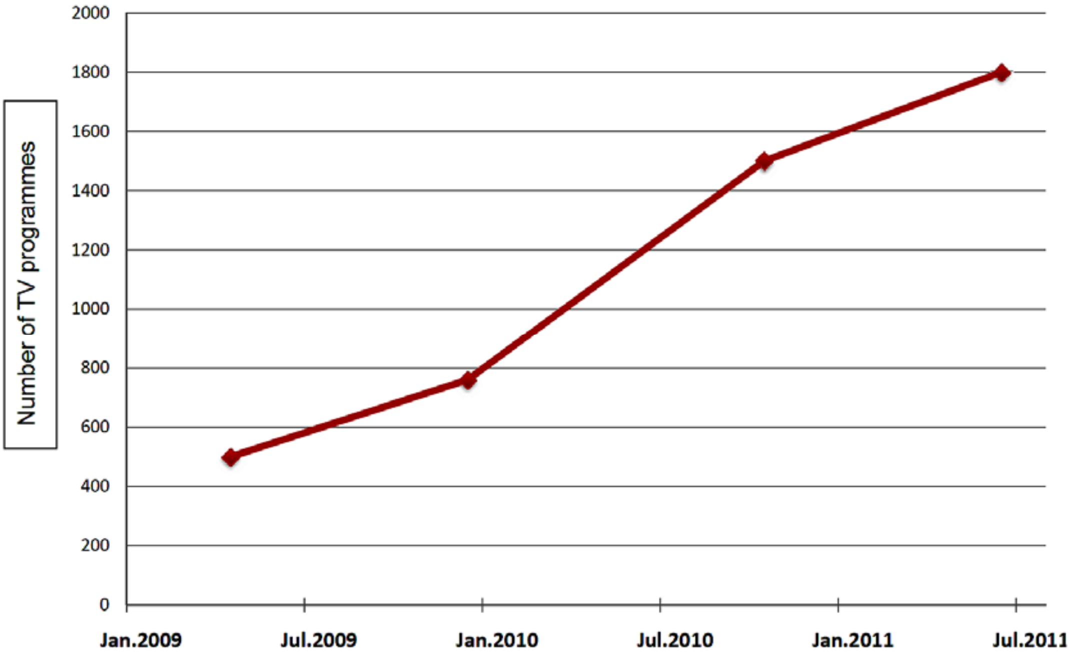


Note: the yellow line corresponds to analogue terrestrial broadcasts]

Figure 1: Means of receiving TV in Europe [Source: Special Eurobarometer 362, July 2011]

DTT has been established with different time scales across Europe and analogue switch-off has not yet been finalized everywhere. The first operational DTT networks were introduced in 1999 in some countries, while there remain European countries where DTT is still in an early stage of development. To be sustainable in a competitive market DTT needs to provide a wide and attractive programme offer and meet viewers' expectations of audio and picture quality.

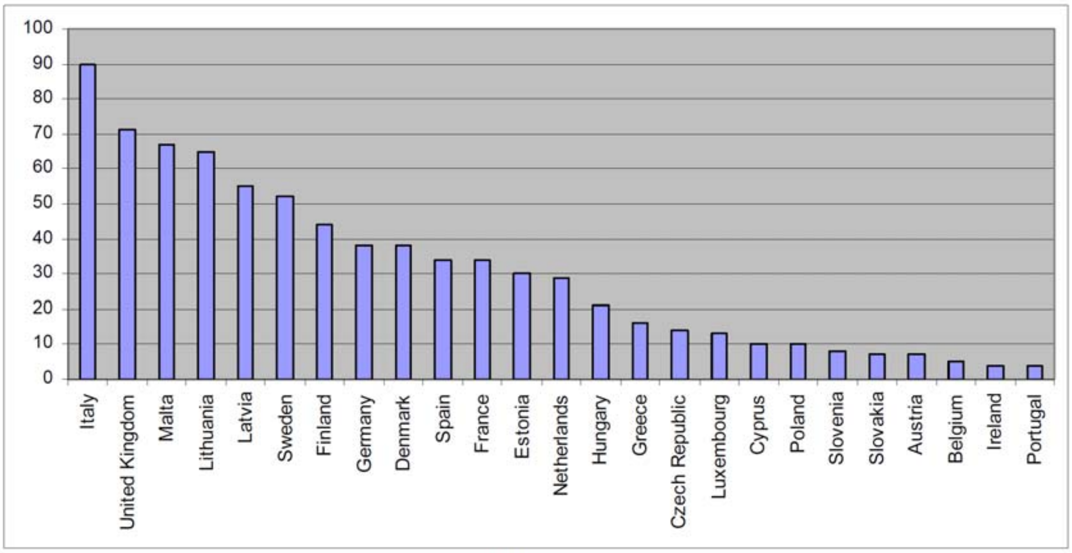
The total number of programme services on DTT across Europe is steadily growing as a result of the digital switchover and rollout of more spectrally efficient networks (See Figure 2, derived from [3]).



Source data: Mavise TV database (www.obs.coe.int/about/oea/pr/mavise_juin2011.html)

Figure 2: Growth in Numbers of TV Programmes on DTT networks in Europe

In countries with the most advanced markets, DTT today offers more than 50 national TV channels and, additionally, a large number of local and regional services, see Figure 3 (from [2] and [4]). Furthermore, for national services there is often a requirement for part-time regional breakdown. This could be due to various regional programming, such as local news, or for local advertising.



Source: MAVISE June 2011

Figure 3: National TV programmes on DTT networks in the EU

Linear TV is still a highly requested service. In 2011 the average worldwide daily viewing time stood at 3 hours and 16 minutes per person per day, an increase of 6 minutes in comparison with 2010. This progression was notably supported by Asia and especially China, which registered a strong growth of +12 minutes in one year. Similar increases were also reported in several European countries, with +15 minutes in France, +7 minutes in Italy and +5 minutes in Spain (See [5]).

Consumers are increasingly investing in TV sets with larger screens, resulting in higher requirements on picture quality. In the future many, if not all, TV services are expected to be produced and distributed in HD quality. HDTV services are already available on DTT in several countries, generally in parallel with corresponding SD services. It is expected that HDTV will become the standard for television delivery, at least to large screens.

Furthermore, it is expected that typical TV screen sizes for living room viewing will continue to increase. This will result in demand for even higher picture resolution. All relevant TV distribution platforms, including DTT, will then need to be able to support emerging technologies such as UHDTV and 3DTV.

Reception of broadcasting content on portable, mobile and handheld devices will also become more important in the future as society moves towards more mobile consumption of content. For example, large numbers of people commute daily between home and work, spending hours on the move and choosing to pass their time watching and listening to broadcast content.

DTT was originally introduced using DVB-T technology and MPEG-2 coding. More efficient transmission and coding standards have since been developed and provide scope for increasing efficiency and capacity in the DTT networks. DVB-T2 has, for example, already been introduced in some countries. The increased capacity of DVB-T2 will be needed to migrate from existing SDTV services to HDTV.

New technology implies upgrades and investments in the networks and, even more significantly, requires consumers to purchase new receiver equipment. As has been experienced with analogue switch-off, this is not a straightforward process and it will generally take a considerable time. It is a sensitive issue both from a political and a market perspective to ask all viewers to again upgrade their digital receiver equipment, shortly after the analogue to digital switch-over.

New technology generally needs to be introduced in parallel with existing technology to give consumers the chance of investing in new equipment according to their wishes, while the existing services are maintained during a transition period with simulcast transmissions. DTT technology and services can also be expected to develop in the future, thus creating recurrent needs for upgrades and simulcasting of existing services. This requires corresponding spectrum resources.

In conclusion, the success of DTT should not be jeopardized by restricting the scope for development, which would inevitably happen if the amount of available spectrum is further reduced.

4. Frequency Planning for Terrestrial Television Broadcasting

Frequency planning for terrestrial broadcasting in ITU Region 1 is governed by the GE06 Agreement [6]. This contains a frequency plan for broadcasting networks in the Bands III, IV and V for Region 1 which includes Europe. Intentions to make use of this spectrum and bringing transmitters into operation are subject to the application of the procedures contained in GE06.

The generation of the GE06 frequency plan was based on planning principles such as an appropriate radio wave propagation model, sharing and compatibility criteria between digital terrestrial broadcasting and other services, as well as planning parameters to achieve given coverage objectives. In order to cope with the requirements of different countries both allotment and assignment planning approaches were applied.

All the elements above have been used to establish a frequency plan for DVB-T in Europe employing the entire frequency range between 470 and 862 MHz. The actual frequency allocation to an allotment or an assignment was determined by several fundamental factors such as:

- the underlying high-power-high-tower network planning philosophy of terrestrial broadcasting;

- the envisaged network topography, i.e. single or multi frequency networks;
- the actual radio wave propagation conditions in a given geographic area;
- the size and shape of the allotment areas or the coverage area associated to an assignment;
- the decision of participating Administrations to define their requirements in terms of coverage areas (allotments or assignment coverage areas) which can be grouped in nation-wide layers without gaps; and
- the number of such coverage layers required by Administrations.

It is important to understand that the approach of defining nationwide coverage layers is a direct consequence of the principle of equitable access to the spectrum. This way of addressing the definition of spectrum requirements was, and still is, considered the only viable possibility on an international level. Thus, application of the principle of equitable access to the spectrum is meant to ensure that every country has the same access rights to spectrum independent of the individual national implementation of these rights.

The planning effort resulted in a frequency plan providing 7 nationwide coverage layers for each country across Europe in the UHF band. To this end, the entire spectrum between 470 and 862 MHz was consumed. This corresponds to 49 channels with a bandwidth of 8 MHz each. Therefore, 7 channels per layer have been used on average.

This result has to be interpreted carefully. Application of the agreed planning principles did not allow the accommodation of 7 layers in the UHF Bands IV and V. Rather, many thousands of so-called administrative declarations had to be signed which were meant to overrule the formal incompatibilities that were detected by the planning algorithm between pairs of requirements. For many of these declarations, detailed transmitter-to-transmitter analyses were carried out by the affected Administrations to determine the conditions under which two formally incompatible frequency allocations could nevertheless share the same channel. In other cases, the declarations simply contained the statement that before any of the concerned frequency allocations can be put into operation, successful coordination with neighbouring Administrations is mandatory.

5. Estimation of Spectrum Requirements for Terrestrial Broadcasting

As explained in §4 above the spectrum demand within a given country cannot be determined solely by looking at the country in isolation. The requirements of neighbouring countries play a crucial role. This refers mainly to the size and shape of coverage areas, their total number and the actual radio wave propagation conditions.

In order to estimate the current and future spectrum demands for digital terrestrial broadcasting the following steps should be carried out:

- The number of programmes to be distributed by digital terrestrial television has to be specified. This number may vary from region to region resulting in different target coverage areas.
- Depending on
  - The reception mode (fixed, portable, mobile)
  - The network topology (MFN, SFN)
  - The system (DVB-T or DVB-T2)
  - The system variant (code rate, guard interval, etc.)
  - The compression technique (MPEG-2, H.264/AVC)

the capacity of a single multiplex is determined[1] and then the number of multiplexes required to accommodate the programmes is calculated, taking into account statistical multiplex when used. A method for this is given in **Annex A**.

- The set of coverage areas resulting from the first two steps needs to be organized in terms of contiguous national coverage layers, in the GE06 sense described above. The total number of layers is the basic input for the determination of spectrum requirements.
- Referring to the GE06 Plan broadcasters may derive the number of channels which is required for a national layer of coverage areas under conditions applying to their countries. These conditions refer to the number, size and shape of their coverage areas and also those of their neighbouring countries. Furthermore, the envisaged network topology, i.e. MFN or SFN, as well as the system variant and the reception mode have an impact on the spectrum demand for a layer.
- Multiplying the number of layers by the required number of channels per layer provides an estimate for the spectrum demand.

Certain representative combinations of factors can be used to determine the number of channels required to implement a single full coverage layer throughout a large and heterogeneous area such as Europe. Table 1 gives figures for some of the more common planning options in the UHF Bands IV/V (8 MHz channels).

Table 1: Number of channels required per layer for Typical Network Configurations

Reception Mode	Network topology	Number of channels Required per layer
Fixed	MFN	7
Fixed	SFN	6
Portable	SFN	8

If neighbouring regions or countries have differing planning requirements, a higher number of channels may be required to accommodate the differing requirements. The appropriate size of an MFN or SFN area within a country also depends on the need for regional breakdown within a country.

The planning process leading to the GE06 Agreement was based on a situation where heterogeneous (mixed) requirements, generally aiming for nationwide coverage in each country, had to be taken into consideration. The result achieved were 7 layers for each country while using the entire UHF band between 470 and 862 MHz, i.e. 49 channels. Therefore, on average 7 channels per layer are needed for complete coverage. Clearly, as this is an average there are areas in Europe where more than 7 channels are needed (such as the region around Luxemburg or the Baltic Sea region) while in others less would suffice (such as northern Scandinavia, central France and Spain). This fact reflects the different conditions which are encountered across Europe in terms of size and shape of envisaged coverage areas as well as the wave propagation conditions.

The calculated spectrum requirements need to be expressed as numbers of 8 MHz channels. **Annex B** shows the form in which these spectrum requirements can be expressed as a response to the ITU questionnaire.

[1] The capacity in a multiplex varies across the different combinations, including the network topology and the reception mode:

- Large area SFNs require a large guard interval which reduces the capacity in a multiplex
- Portable reception requires more robust mode which also reduces the capacity in a multiplex.

As explained in §3 above, any estimation of spectrum requirements also needs to take into account the migration aspects when a new technology is introduced in parallel with existing technology. Examples are the introduction of HDTV services while corresponding SDTV services need to be broadcast in parallel for a certain time period, or where DVB-T based services must be maintained for a period in parallel with the same service in DVB-T2.

6. References

[1] Special Eurobarometer 362, July 2011 (http://www.eubusiness.com/topics/telecoms/eurobarometer-362)

[2] Digitisation 2010 - Broadcasting gearing up for the internet - the changing face of structures and actors - published by Commission on Licensing and Supervision (ZAK) of the German media authorities (http://www.die-medienanstalten.de/fileadmin/Download/Publikationen/Digitalisierungsbericht/2010/Digitalisierungsbericht_2010_english.pdf)

[3] Mavise TV database (http://mavise.obs.coe.int/)

[4] Press release of EC/DG Communication and European Audiovisual Observatory (http://www.obs.coe.int/about/oea/pr/mavise_juin2011.html)

[5] Press release Mediametrie – Eurodata TV Worldwide 22nd March 2012 (http://www.mediametrie.fr/presse/communiques/la-tv-internationale-transforme-l-essai-en-2011.php?id=628)

[6] FINAL ACTS of 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 (RRC-06) (http://www.itu.int/pub/R-ACT-RRC.14-2006/en) (pay publication)

[7] EBU Technical Report 014 - What follows HDTV? A status report on 1080p/50 and '4k' (http://tech.ebu.ch/docs/techreports/tr014.pdf)

[8] "Spectrum usage and requirements of future terrestrial broadcast applications" Roland Brugger and Abiodun Gbenga-Ilori - Institut für Rundfunktechnik, München – EBU Technical Review 2009 Q3 (http://tech.ebu.ch/docs/techreview/trev_2009-Q4_Spectrum_Brugger.pdf)

[9] EBU Tech 3348 - Frequency & Network Planning Aspects of DVB T2 – 3 May 2012 (http://tech.ebu.ch/docs/tech/tech3348.pdf)

Annex A: Method to calculate the required number of multiplexes (layers)

A1. Introduction

Spectrum is used to deliver broadcast content according to editorial, commercial and political requirements. The means of broadcast delivery, and the number of services to be delivered, determines the spectrum required so to do.

Spectrum requirements should therefore be a consequence of the number and nature of services to be delivered, and the means of delivery used and not the other way around.

This annex examines the information that determines the spectrum requirements for broadcasting.

A2. Services, multiplexes and spectrum usage

The calculation of the amount of spectrum needed for TV broadcastings depends, *inter alia*, on the number of TV programmes to be transmitted over the terrestrial network and the requirements for regional and/or local services. Furthermore, the coverage requirements such as the reception mode (portable/mobile/fixed) and the required coverage (universal, 90% or other) need to be considered.

The following diagram shows, at a high level, the factors to be considered when calculating spectrum requirements. Each block is considered in more detail in §A3 below.

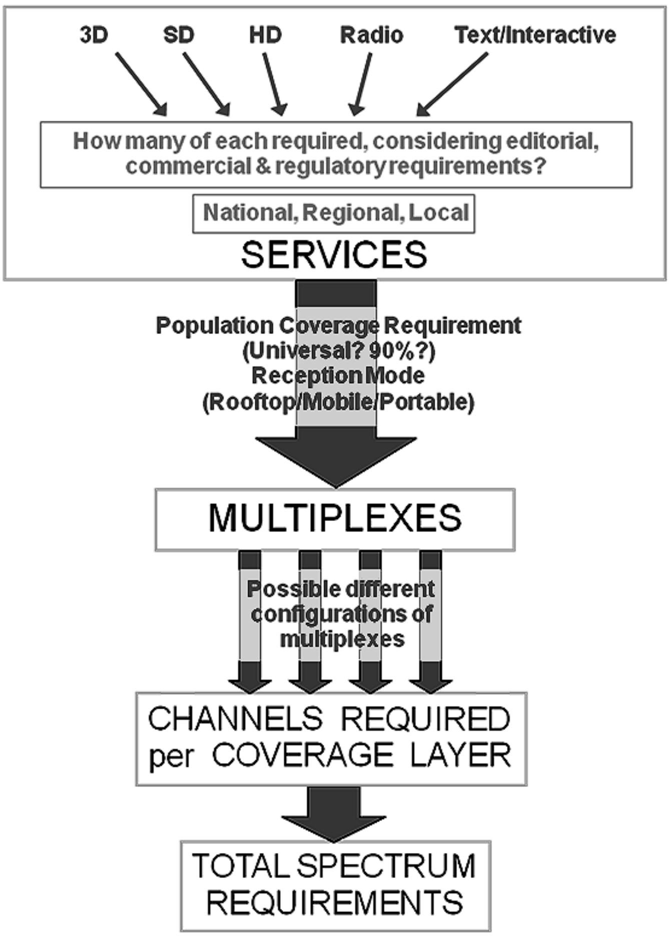


Figure A1: Flow chart of calculating broadcasting spectrum requirements

A3. Calculations

A3.1 Services

The broadcasters need to consider current and future requirements for services to be broadcast on the platform. When calculating total spectrum requirement, it is important to include services from all broadcasters, not just public service channels.

Factors to consider may include:

- HD is the new television standard. It is expected that there will be a demand for many, if not all services, to migrate to HD in the long-term. It is likely that there will be a transitional period where most HD services require to be also broadcast in a SD version to ensure they can be received by all viewers. Decisions also need to be taken on HD picture format, for example 720p/50, 1080i/25 or 1080p/50.
- If new technology such as DVB-T2 or other upgraded coding technique is introduced to deliver services already provided for instance in DVB-T, there is normally a need for a simulcast period to give consumers a chance to purchase necessary new receiver equipment. It should be noted that consumers are not likely to do this voluntarily if the content offered in the new technology is not considerably extended or improved. The simulcast period may then need to be quite long.
- 3DTV might gain further audience, especially for special occasions such as major sporting fixtures and other public events. For example, the BBC broadcast the 2011 and 2012 Wimbledon tennis finals in 3D on DTT and will be broadcasting the Opening and Closing Ceremonies and daily highlights of the 2012 Summer Olympics in 3D on all platforms, including DTT.
- Ultra High Definition services are developed and showcases are planned for the 2012 Summer Olympics. Particular the so-called 4k level (4 times HDTV) may find broadcast applications in the coming years, which requires substantial transmission bitrates.
- Some services may be pan-national, while others may have regional variations, or be entirely regionally-based. Spectrum requirements for these may be different, due to the different structures of SFNs required to carry them.
- There may also be demand for local, regional and community services.

A3.2 Source Coding

After defining how many SD and HD programmes should be carried by the platform, calculations considering the source and the channel coding need to be carried out to determine the total bit-rate required.

In several European countries, early implementation of the DTT services has lead to the choice of MPEG-2 for the coding of SD programmes, while HD programmes have been coded using MPEG-4 (H.264/AVC).

At the time of writing (July 2012), the latest and state of the art techniques are H.264/AVC for the video source coding and DVB-T2 for the channel coding, but these are not necessarily compatible with existing receiving equipment (see §3 in the main body of this document). Table A1 shows examples of typical data rates depending on the picture format.

Table A1: Suggested data rate for one programme[1], for different formats and different source coding techniques (current)

Format	Source coding	Video data rate (Mbit/s)	Programme associated data (Mbit/s)	Total data rate for one programme (Mbit/s)
SD	MPEG-2	3.00	0.85	3.85
SD	H.264/AVC	2.10	0.85	2.95
HD – 720p/50	H.264/AVC	7.50	0.85	8.35
HD – 1080i/25	H.264/AVC	8.25	0.85	9.10
HD – 1080p/50	H.264/AVC	12	0.85	12.85

Table A2 shows examples of expected typical data rates in few years time taking into account the continuing development[2] of H.264/AVC encoding equipment.

Table A2: Suggested data rate for one programme[2], for different formats, using H.264/AVC source coding (estimated in a few years time)

Format	Source coding	Video data rate (Mbit/s)	Programme associated data (Mbit/s)	Total data rate for one programme (Mbit/s)
SD	H.264/AVC	1.80	0.85	2.65
HD – 720p/50	H.264/AVC	7.00	0.85	7.85
HD – 1080i/25	H.264/AVC	7.50	0.85	8.35
HD -1080p/50	H.264/AVC	10	0.85	10.85

Although the video signal takes the majority of the available bit rate, there is some other data that also needs to be transmitted:

- Audio: 0.2 to 0.5 Mbit/s (0.3 Mbit/s used in Tables A1 and A2) – dependent on number of audio channels (stereo/surround sound/multilingual);
- Service Information and EPG: (SI) 0.1 to 0.3 Mbit/s (0.15 Mbit/s used in Tables A1 and A2);
- Interactivity/Teletext: 0.1 to 1.0 Mbit/s (0.2 Mbit/s used in Tables A1 and A2);
- Access services (subtitles/audio description/spoken subtitles): 0.2 Mbit/s.

All of the above are regarded as programme associated data in Tables A1 and A2.

[1] The figures given in Tables A1 and A2 should be regarded as typical requirements. Different programme material has different bit-rate requirements. Since broadcasters can make some trade-off in the video quality levels applied to programmes, the table shows suggested lower limits for typical mixed-genre programming. It is possible to have better-quality programmes with higher data rates for video and this means that the number of programmes in a multiplex would be reduced.

[2] For video, the decoding process in the receiver is standardized. There are multiple tools defined which can be used in the encoding process and the receiver has to support all of these tools. In early implementations of the encoder, however, and due to technical limitation e.g. processing power, not all tools are used or are not fully exploited. Over time more use is made of those tools, which then allows a reduction in the bit rate whilst maintaining the same picture quality or alternatively retention of the same bit rate whilst increasing the picture quality.

A3.3 Multiplex use with future formats and future coding techniques

As the resolution and size of TV receiver panels continues to grow, higher quality formats have to be introduced (see [7]). These formats, such as 1080p/50 in the shorter term, require higher bitrates than current HD services. In the mid to longer term, the demand for even higher data rates for the broadcast delivery of Ultra High Definition services becomes likely.

A3.4 Statistical Multipexing

If more than one video programme is transmitted in a multiplex, statistical multiplexing can be applied.

In a constant bit rate system, each video service in the multiplex has a fixed data rate, regardless of the content. However, depending on the content the data rate could be varied in time without losing quality. Different programmes bundled in one multiplex exhibit different data rate patterns over time. Hence, they will not all require a high data rate at the same moment of time. This fact is exploited by statistical multiplexing. Therefore, it is expected that an intelligent multiplexer will use the output data rate of the encoders so that the one whose programme momentarily makes the highest demands on the MPEG coding process is also instantaneously allocated the highest output data rate.

Statistical Multiplexing therefore leads to a reduction in the average video data rate needed per programme, as shown in Figure A2 (see [8]).

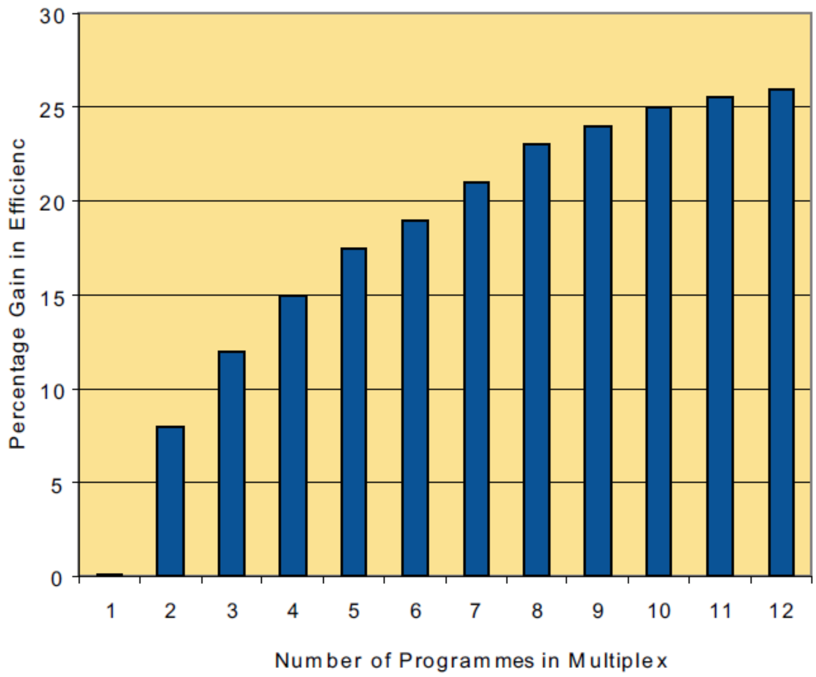


Figure A2: Efficiency gain of statistical multiplexing

A3.5 Capacity of a Single Multiplex

Each Radio Frequency channel carries one DVB-T multiplex of programmes. The capacity of a multiplex depends on the channel coding. EBU Tech 3348 [9] sets out some example scenarios for DVB-T2 coding schemes out of the large possibilities of parameter combinations.

Examples of MFN DVB-T mode for fixed reception, SFN DVB-T mode for fixed reception and SFN

DVB-T mode for portable reception are presented in Table A3 (see also [8]).

Examples of MFN DVB-T2 mode for fixed reception, SFN DVB-T2 mode for fixed reception and SFN DVB-T2 mode for portable reception are presented in Table A4 (see also [8]).

Table A3: Capacity of a single multiplex
Example Fixed MFN, Fixed SFN and Portable SFN Scenarios (DVB-T)

	Fixed MFN DVB-T	Fixed SFN DVB-T	Portable SFN DVB-T
Channel Bandwidth	8 MHz	8 MHz	8 MHz
FFT mode	8k	8k	8k
Guard interval	1/32 (28 µs)	1/4 (224 µs)	1/4 (224 µs)
Modulation	64 QAM	64 QAM	16 QAM
Code rate	2/3	2/3	2/3
C/N	19.3	19.3 dB	14.2 dB
Capacity (Data rate) per multiplex	24.1 Mbit/s	19.9 Mbit/s	13.3 Mbit/s

Table A4: Capacity of a single multiplex
Example Fixed MFN, Fixed SFN and Portable SFN Scenarios (DVB-T2)

	Fixed MFN DVB-T2	Fixed SFN DVB-T2	Portable SFN DVB-T2
Channel Bandwidth	8 MHz	8 MHz	8 MHz
FFT mode	32k	32k	16k
Carrier mode	Extended	Extended	Extended
Scattered Pilot Pattern	PP7	PP4	PP3
Guard interval	1/128 (28 µs)	1/16 (224 µs)	1/8 (224 µs)
Modulation	256 QAM	256 QAM	64 QAM
Code rate	2/3	2/3	2/3
C/N	20.0 dB	20.8 dB	17.9 dB
Capacity (Data rate) per multiplex	40.2 Mbit/s	37.0 Mbit/s	26.2 Mbit/s

The choice of the transmission mode automatically gives the capacity per multiplex, which is one factor of the spectrum requirements calculation.

Based on the data rates in Tables A1 and A2 and the capacity of a single multiplex for the examples in Tables A3 and A4, the number of programmes per multiplex is derived in Tables A5 and A6 (statistical multiplexing assumed).

Table A5: Number of programmes per multiplex for a fixed MFN, Fixed SFN and portable SFN mode with DVB-T and statistical multiplexing (current codec performances)

Number of programmes per multiplex				
		Fixed MFN DVB-T	**Fixed SFN DVB-T**	**Portable SFN DVB-T**
SD	MPEG-2	7	6	3
SD	H.264/AVC	9	8	5
HD - 720p/50	H.264/AVC	3	2	1
HD - 1080i/25	H.264/AVC	2	2	1
HD - 1080p/50	H.264/AVC	2	1	1

Table A6: Number of programmes per multiplex for a fixed MFN, Fixed SFN and portable SFN mode with DVB-T2 and statistical multiplexing (codec performances in a few years time)

Number of programmes per multiplex				
		Fixed MFN DVB-T2	**Fixed SFN DVB-T2**	**Portable SFN DVB-T2**
SD	H.264/AVC	18	16	12
HD - 720p/50	H.264/AVC	6	5	3
HD - 1080i/25	H.264/AVC	5	5	3
HD - 1080p/50	H.264/AVC	4	3	2

A3.6 Required total number of layers

The number of layers required in a network equals the number of programmes that need to be carried divided by the number of programmes per multiplex (rounded to the first upper integer).

Annex B: Form of presentation of the broadcasting spectrum requirements in the ITU Questionnaire

(*See attachment*)

In Annex 1 of the ITU questionnaire (related to the current situation), the penultimate column entitled "Total spectrum bandwidth used or intended for implementation (MHz)" should be filled in with the number of TV channels and limits of bands used or intended to be used to implement the total number of layers. For example, if the total number of multiplexes is 6 (i.e. corresponding to a total of 6 layers) and they are implemented in specific parts of the UHF band, the answer in the "Total spectrum bandwidth used or intended for implementation (MHz)" column in ITU Annex 1 could be:

(*example*)

Number of channels: 39 TV channels, from channel number 21 to 60 except channel 38,

Spectrum bandwidth and boundaries: 39x8=312 MHz, from 470 to 606 MHz and from 614 to 790 MHz.

In Annex 3 of the ITU questionnaire (related to the foreseen future situation), the penultimate column entitled "Total spectrum bandwidth needed (MHz)" should be filled in with the required number of TV channels and the corresponding spectrum bandwidth. For example, assume that the required total number of multiplexes is 5 (i.e. corresponding to a required number of 5 layers) calculated using the method set out in Annex 1 of the present document. Assume also that the corresponding required number of TV channels is 35 calculated using guidelines in §5 of the present document. Then the answer in the "Total spectrum bandwidth needed (MHz)" column of ITU Annex 3 should be:

(*example*)

Number of channels: 35 TV channels

Spectrum bandwidth: 35x8=280 MHz

Attachment

ITU-R Circular letter 6/LCCE/78, dated 11 May 2012-07-10

ITU-R Questionnaire on spectrum requirements for terrestrial television broadcasting in connection with WRC-15 Agenda item 1.2

Annexes 1,2 & 3 to the Questionnaire

See next page.