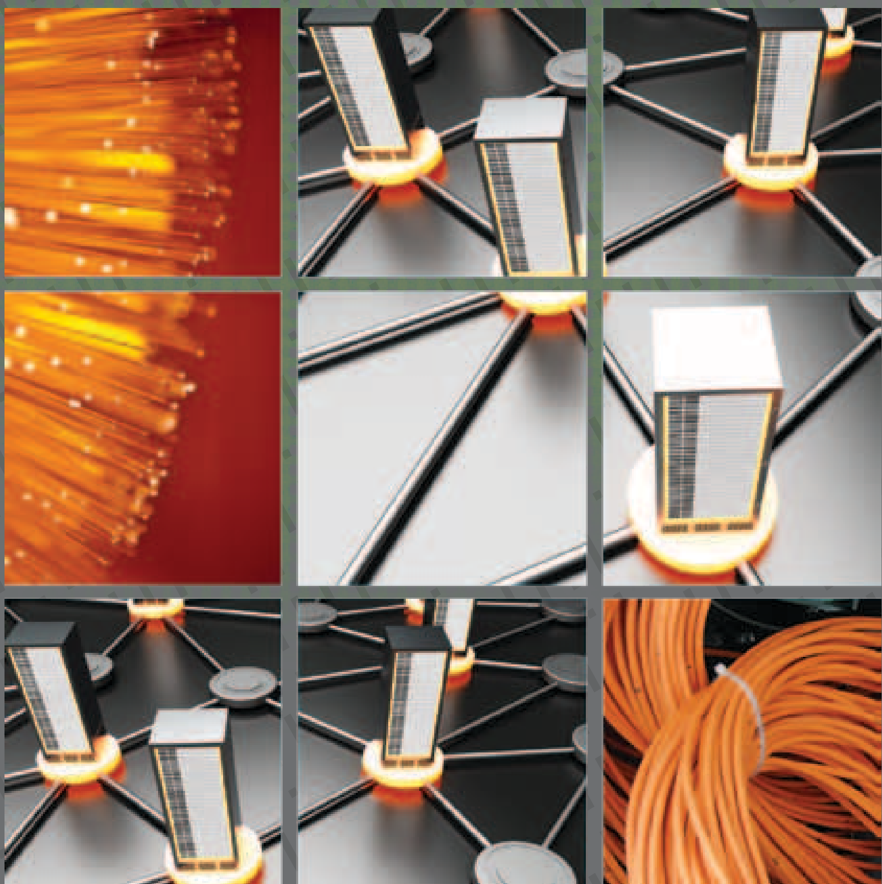
INFRASTRUCTURE

DIGITAL DIVIDEND: INSIGHTS FOR SPECTRUM DECISIONS



AUGUST 2012

Telecommunication Development Sector

Digital Dividend

Insights for spectrum decisions

August 2012

This report was co-written by ITU experts Mr Jan Doeven, Mr Peter Walop, and Mr Elmar Zilles, Mr Jean-Jacques Guitot, and Mr Stephen Ripley. It is designed to provide an insight into what the digital dividend means and to help decision makers and policy makers to understand the allocation of the digital dividend. For further information please contact: Mr Istvan Bozsoki, ITU project manager: Istvan.Bozsoki@itu.int.

Foreword

The rising importance of the radio spectrum in the world means that the way in which it is managed is vital for economical and societal development. As spectrum is freed up by the transition of analogue television services to digital, national and international spectrum decision makers are faced with the question of how to allocate the 'digital dividend' resulting from the spectrum efficiencies gained by this process in the frequency bands currently allocated to broadcasting.

Although reallocation of spectrum is an important aspect of the transition to digital terrestrial television, there are other reasons for introducing digital terrestrial television services. In addition to gaining spectrum efficiency, it will bring *consumer benefits* (more choice and quality in television services) and *industry benefits* (new revenue streams and business models).

By definition, the process by which the digital dividend will be allocated is closely related to the introduction of digital terrestrial television services. In order to support regulators and spectrum decision makers in the smooth transition from digital to analogue television broadcasting, ITU has published a set of guidelines[1]. As well as information and recommendations, the guidelines provide a framework for developing a roadmap for this transition process, comprising 43 functional building blocks, with one specifically dealing with the digital dividend. We therefore strongly urge you to consider the digital dividend allocation process within this wider context.

The ITU recognizes the need to provide a detailed insight into what the digital dividend process entails and to help national and internal spectrum decision makers to allocate and manage the digital dividend process. This report is intended to fulfil this need.

Brahima Sanou

Director, Telecommunications Development Bureau

François Rancy

Director, Radiocommunication Bureau

[1] See : http://www.itu.int/pub/D-HDB-GUIDELINES.01-2010/en

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1 Introduction

Terrestrial broadcasting uses significant parts of the frequency spectrum, mainly in the UHF band (470-862 MHz) and in the VHF band (173-230 MHz). For many decades, this spectrum has been used throughout the world to deliver analogue television signals to homes, these signals being broadcast by large networks of primary transmitters ("high power-high tower") and associated secondary transmitters towards roof-top, yagi antennas, and sometimes indoor antennas.

Given the current analogue television technology, in the spectrum available, this way of distributing television was limited to a few analogue programmes. Since the eighties, terrestrial television broadcasting has been increasingly challenged by cable and satellite television, and more recently by ADSL and internet television. All these alternative means deliver a much larger number of programmes and as a consequence the share of terrestrial television broadcasting has generally decreased, in some cases below 5 per cent of the population.

The transition of terrestrial television broadcasting from analogue to digital brings to the viewers a higher number of programmes, a better quality and new services such as high definition TV (HDTV). It therefore represents a very positive evolution for this type of broadcasting. In addition, digital television transmission is much more spectrum efficient than analogue.

As a basis for comparison, where a single analogue program can be broadcast on one transmission channel of 6 MHz to 8 MHz bandwidth, the same transmission channel could carry a multiplex of up to 20 digital programmes of equivalent quality. In addition, most Digital TV standards allow the implementation of single frequency networks (SFN), thereby permitting the reuse of the same spectrum over much larger areas and further increasing spectrum efficiency compared to the analogue networks.

Digital television broadcasting has been in service for over a decade and corresponding technologies have now fully matured. Their performance is such that maintaining analogue networks in place will soon become impossible to justify in economic terms for broadcasters. The interest of both providers and viewers is therefore to go digital. Remaining in the analogue world is no longer an option.

For these reasons, the transition to digital terrestrial television broadcasting has already started or even been finalized in many countries. In the European Union, a target date of 2012 has been set for the end of analogue transmissions and this date is expected to be met in most cases. In the 119 member countries of the GE06 Agreement, the cut-off date for the rights to use analogue transmissions has been set as 17 June 2015 in the UHF band. The same date applies in the VHF band, with an extension to 17 June 2020 for a number of developing countries.

Obviously, given the very important gains in spectrum efficiency which may result from this transition, there has been growing interest in the last few years on how these gains might be distributed. Consequently, the concept of *digital (television) dividend* has emerged, which may be defined as the amount of spectrum made available by the transition of terrestrial television broadcasting from analogue to digital.

The *digital dividend* 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).

This report addresses the transition to digital broadcasting in both the UHF and VHF bands. Since the use of the *digital dividend* in the VHF band is mostly foreseen for new broadcasting applications at this stage and no mobile service applications in the VHF band is currently envisaged, this paper discusses the use of the *digital dividend* for the mobile service mainly in the UHF band.

In the following chapters, this report will first address what the digital dividend is, when and how it will become available and its importance (Chapter 0). This will be followed by detailing the main spectrum management constraints and their impact on digital dividend allocation and its availability (Chapter 3). A description of the relevant market developments is provided in the next chapter (Chapter 4). Furthermore the various aspects of the national decision-making process for the digital dividend allocation are addressed in Chapter 5. Chapter 6 provides benchmarking elements on the digital dividend implementation, in particular in relation to spectrum licensing and valuation. The issue of the white spaces, although it is not part of the digital dividend, is discussed in Chapter 7.

Finally, in the last chapter of this report (Chapter 8) the main conclusions are given.

2 Scope and potential usage of the digital dividend

The term digital dividend is used to express the spectrum efficiency gain due to the switchover from analogue to digital terrestrial television services.

The transmission characteristics of digital systems involve a number of parameters which can be adjusted to trade-off service area, quality reception, transmission power, data capacity and spectrum. These include, in particular:

- frequency channel bandwidth (6, 7 or 8 MHz),
- type of digital modulation (e.g. QPSK, 16 QAM, 256QAM) and error correction coding (e.g. rate ½, ¾),
- compression algorithm (e.g. MPEG2, MPEG4),
- overall system standard (e.g. the families of ATSC, ISDB, DTMB, DVB-T or DVB-T2),
- reception mode (e.g. fixed, portable, portable indoor, mobile),
- network configuration (number, location and size of transmitters, SFN or MFN),
- constraints arising from cross-border frequency coordination.

The trade-offs reflected in the choice of these parameters will determine the overall spectrum required to permit the transition to digital terrestrial television, hence the size of the digital dividend.

As the above trade-offs are to a great extent related to state of technology at the time they are made, the size of the digital dividend will increase as more advanced technologies become available and can be factored into national decisions on the digital dividend.

2.1 Definition of the digital dividend

The digital dividend was initially perceived as the spectrum made available over and above what is required to accommodate the existing analogue television services. This was an attractive definition because it could lead to a digital dividend of 80 per cent of the UHF/VHF spectrum or more. This definition however, did not consider that, in order to obtain any digital dividend, analogue transmissions need to be switched-off, which requires that a successful transition to digital TV has occurred, and in turn that digital terrestrial broadcasting has been able to attract analogue viewers in sufficiently large numbers to make this possible. This can only happen if digital service offering is attractive enough to the viewers to justify the purchase of digital adaptors. This in turn requires a significant increase in the number of programmes and perceived quality (e.g. HDTV), hence a consequential increase in spectrum consumption by terrestrial broadcasting.

The considerations in this report are therefore based on the following definition: **the *digital dividend* is the amount of spectrum made available by the transition of terrestrial television broadcasting from analogue to digital.**

2.2 Potential usage of the digital dividend

The *digital dividend* may be used by broadcasting services (e.g. provision of more programmes, high definition, 3D or mobile television). This use may be accommodated in frequency planning arrangements already established at national level and with neighbouring countries as part of the preparations for digital switchover. It may also require modifications of these arrangements to make available additional spectrum resources.

The *digital dividend* may also be used by other services, within the same spectrum as broadcasting, for applications which can be operated:

– either under the envelope of frequency assignments or allotments already planned for broadcasting, i.e. under the assumption that no more interference is caused and more protection is claimed than the original broadcasting assignment or allotment,

– or using the so-called *white spaces* of the broadcasting frequency plan (i.e. the spectrum left unused by broadcasting) without disrupting broadcasting services, e.g. short range devices, such as wireless microphones used in theatres or during public events, WiFi or fixed wireless access[2].

The *digital dividend* may also be used in a distinct, harmonized frequency allocation to enable ubiquitous service provision, universally compatible equipment and international roaming (e.g. International Mobile Telecommunications, IMT). Such use requires national decisions to move broadcasting out of the corresponding frequency band, hence potentially significant modifications to the frequency planning arrangements already established for broadcasting. In addition, it generally needs to rely on regional harmonisation of spectrum usage in order to avoid interference in border areas between mobile and broadcasting services.

Spectrum management constraints on the allocation and availability of the digital dividend are addressed in Chapter 3.

2.3 Availability of the digital dividend

The digital dividend for broadcasting services (e.g. HDTV) may be made available as frequency channels in the UHF band become available through analogue switch-off. This is essentially an issue that can be integrated at the time of frequency planning of digital television, which may also involve negotiations with neighbouring countries.

In order to avoid interference with broadcasting services, the digital dividend for the mobile service (IMT) can only be made available after analogue switch-off. In addition, this also requires that the corresponding frequency band be freed from digital broadcasting and from other services to which it may be allocated and that the constraints arising from cross-border interference be waived. This generally requires regional harmonization decisions and the conclusion of regional and/or bilateral agreements.

There are also many countries with a limited number of analogue television services in operation which mainly broadcast in the VHF band. In these countries parts of the digital dividend in UHF could be made available more easily as soon as the national digital switchover policies have been adopted, subject to cross-border coordination constraints.

These issues are discussed in more details in Chapter 3.

2.4 Size of the digital dividend

As indicated above, the size of the digital dividend is determined by the trade-offs underlying the choice of the basic parameters of digital transmissions, in particular the type of digital TV reception (fixed

[2] See also Chapter 7.

rooftop, fixed indoor, portable or mobile), the percentage of population to be covered, the quality required, the technology used, the respective use of MFN and SFN.

Since the VHF and UHF broadcasting bands are also allocated in a number of countries to services other than broadcasting, e.g. to aeronautical radionavigation, radio astronomy, fixed services, or used by PMSE applications, two situations may occur:

- protection of these services may reduce the size of the digital dividend (e.g. aeronautical radionavigation and radio astronomy in some countries);
- services need to be adapted to the new situation or re-allocated (e.g. PMSE applications in many countries), which may entail additional costs.

The size of the digital dividend will therefore vary from country to country. It may also be impacted by the situation in adjacent countries, as a result of the need to avoid, or limit interference.

Attempts have been made to determine the size of the digital dividend. Due to the multiplicity of the possible choices in planning spectrum for broadcasting, and to the fact that many of these choices may have to be adjusted taking into account actual operational environment, this determination is in most cases impossible to make ex-ante with any significant degree of accuracy.

Rather than quantifying the digital dividend and trying to apportion it to the services involved, spectrum allocation decisions therefore have to rely on satisfying the requirements of these services in the most appropriate way. Fortunately, technology has evolved rapidly in recent years and superseded any such determinations.

For example, in the case of fixed rooftop reception, the use of the latest technologies in terms of modulation and compression permits, through the deployment of four multiplexes of 8 MHz bandwidth, the delivery of up to 80 standard definition television programmes or up to 20 high definition television programmes, which is likely to satisfy the broadcasting requirements of most countries.

Higher requirements may be satisfied through more intensive use of spectrum, by increased use of SFN and/or reduced frequency reuse distances between transmitters. This requires accepting both reduced interference margins and additional constraints on transmitted signals, such as shaping of antenna radiation patterns. Both of these may translate into losses in the service areas of the transmitting sites. The use of additional gap-fillers may not be sufficient to recover these losses.

More intensive use of the spectrum allocated to broadcasting will obviously reduce the amount of spectrum available for white space applications. Annex 2 of ECC Report 159[3] shows the results of studies on the amount of spectrum in the band 470 -790 MHz potentially available for white space devices in a number of European countries (see also Chapter 7).

2.5 Importance of the digital dividend

The essence of the digital dividend is to open the possibility of re-allocating a large part of the radio spectrum. Like any other spectrum allocation decision it is about allocating scarce resources. In this sense it is no different to what spectrum managers normally do. However the digital dividend has some specifics which set it aside and makes it one of the most important spectrum decisions expected to make for many years to come.

Before addressing the specific aspects of the digital dividend allocation, it is important to note that the digital dividend is not only about spectrum efficiency gains. By definition of the digital dividend (see section 2.1), the process is closely related to the introduction of digital terrestrial television. This introduction of new digital television services will deliver other important benefits.

[3] ECC Report 159 Technical and operational requirements for the possible operation of cognitive radio systems in the ‘white spaces’ of the frequency band 470 – 790 MHz, January 2011.

2.5.1 Digital television delivers customer and industry benefits

The introduction of digital television will bring the following customer and industry benefits:

1. *Customer benefits*: The customer benefits derive primarily from the possibility of digital processing and compression, making much more efficient use of the network's capacity. The key benefits include (as compared to analogue television broadcasts):
    a. wider choice in TV and radio channels;
    b. improved picture and sound quality (depending on the system settings);
    c. greater flexibility due to portable and mobile reception;
    d. enhanced information services including the Electronic Programming Guide or enhanced 'teletext' services (with enhanced graphics);
    e. increasing market competition and innovation thanks to the potential arrival of new entrants at different levels in the value-chain, for instance new service providers, broadcasters, multiplex operators or network operators. In addition, switchover implies specific benefits for some categories of market players: easier storage/processing of content and reduction of transmission costs.
2. *Industry benefits*: With the introduction of digital terrestrial television networks a new industry has arisen, producing:
    a. lower prices (per channel) for broadcasters;
    b. pay-tv services: digital terrestrial television networks can easily facilitate a full bouquet of services and incorporate a paying/billing system (i.e. conditional access system (CAS));
    c. new transmitter networks: including new transmitters, antennas and transport networks;
    d. new receiver devices: several devices are being produced in the current market, including set-top-boxes, PC-card integrated receivers, USB-based receivers and Integrated Digital Television sets (IDTVs);
    e. conditional access systems: the market comprises already 10 global players delivering integrated systems (head-end encryption and smart-card decryption).

2.5.2 Release of very valuable spectrum for mobile broadband

Governments see the availability and efficient management of radio spectrum as an important driver for economic growth. As an example, a communication from the European Commission to the parliament estimates that the total value of services that depend on the use of radio spectrum in the EU exceeds EUR 250 billion, which is about 2.2 per cent of the annual European GDP[4].

The 2008 US spectrum auctions of the 700 MHz band, provided also a good indication of the value of (a part of) the digital dividend. These auctions raised USD 19.1 billion for 56 MHz of spectrum, implying an average value of USD 340 million per megahertz[5]. The later German auction of May 2010 assigning 60 MHz in the 800 MHz band raised proceeds of EUR 3.57 billion[6], or EUR 60 million per megahertz. In

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[4] See Communication COM (2007) 700 from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the regions, dated 13 November 2007.

[5] From 24 January till 18 March 2008, the FCC auctioned 56 MHz (4 MHz for guard bands) in the 746-806 MHz band. This auction (no 73) raised USD 19.1 billion. Earlier auctions in the same 700 MHz raised significantly less money as at their time there was no firm switch off date for analogue television yet. It may evident that the proceeds from auctions are largely determined by the licence conditions and use that is stipulated.

[6] Please note that in total 358.8 MHz was auctioned of which only 60 MHz (i.e. 6 x (2x5 MHz)) was in the 800 MHz band.

France, the auction of 60 MHz in the 800 MHz band raised EUR 2.6 billion or EUR 40 million per megahertz[7].

Section 6 provides more elements on the valuation of the digital dividend spectrum and how it may be affected by national decisions and circumstances.

The importance of the digital dividend bands for the mobile community, compared with higher frequency bands, is essentially related to its ability to provide a larger service area per base station. Since this area increases as the square of the frequency, the number of base stations required to cover a given territory is approximately ten times greater at 2.6 GHz than at 800 MHz, hence the cost of the network. In addition, UHF frequencies penetrate buildings more easily.

An efficient allocation of the digital dividend is also expected to boost innovation in ICT and help provide new and more affordable services. The EU and the United States (US) see the availability of spectrum critical for their competitive edge in the global market place. Especially after the recent global economic downturn the importance of the digital dividend has been emphasized and policies have been accelerated[8].

On-going mobile market developments also show an exponential rise in data traffic on these networks, as a consequence of the growing success of smart phones. This evolution calls for rapid new allocations of spectrum to the mobile service, increasing the pressure of demand for the digital dividend allocation to that service.

2.5.3 Treatment of incumbent users

As discussed in the previous sections, the digital dividend becomes available when replacing analogue broadcasting networks with digital and more spectrum efficient networks. As a consequence existing users (including broadcast network operators and PMSE users) are present in the very same bands where new types of allocations/services are foreseen (i.e. non-broadcasting allocations/services). In such a situation incompatibility issues are bound to emerge and need to be resolved. This is discussed in Chapter 3.

In addition, incumbent broadcasters also claim significant parts of the digital dividend as they need additional spectrum to launch new channels and services (i.e. currently HDTV and perhaps later 3D television) and thus make these services sufficiently attractive to switch off their analogue networks.

Due to the potentially large impact of cross-border interference and the importance of achieving economies of scale for all users of the digital dividend, these conflicts need to be resolved preferably at sub-regional or regional level, through harmonization and coordination.

Apart from broadcasting and Programme making and Special Events applications, other incumbent uses in the UHF band include CDMA 850 mobile networks and military systems, including mobile and aeronautical radionavigation systems. Due to the extensive investments which have been made over the years in these systems, their spectrum requirements need to be addressed and refarming solutions, including financial compensations where applicable, identified and implemented before an allocation to the digital dividend can be envisaged.

7 www.arcep.fr/index.php?id=8571&tx_gsactualite_pi1[uid]=1478&tx_gsactualite_pi1[backID]=1&cHash=ffab4d3723

8 See for example the communication IP/09/1595 of the European Commission titled “European Commission wants airwaves freed-up by move to digital TV to work for swift economic recovery”, dated 28 October 2009.

3. Spectrum management constraints on digital dividend allocation and availability

3.1 Spectrum planning for broadcasting and mobile services

Television broadcasting is one of the most politically and socially sensitive applications in radiocommunications. It uses a public State resource (frequency spectrum) for a purpose which relates to freedom of information and cultural diversity.

Historically, governments, and later on broadcasting regulators have therefore been very closely involved in planning the spectrum allocated to television broadcasting. In making frequency assignments, they authorise, individually, the frequencies and associated characteristics to be used by each broadcasting station, i.e. where and how each television program will be received by the public in every part of the country. This approach is taken to ensure that the appropriate balance is struck between political, commercial, cultural, national and local interests.

There are also technical reasons for adopting such a centralized approach for managing spectrum allocated to broadcasting:

- The large potential for interference of high power-high tower analogue transmitters that are used to provide primary nation-wide coverage means that the same frequency cannot be used by two such transmitters unless they are separated by typically 150 – 200 km.
- Analogue transmission on one frequency also places constraints on the use of other frequencies. Consequently, frequency planning for broadcasting is a multi-dimensional puzzle which requires a large amount of centralized effort if spectrum is to be used efficiently.
- These difficulties are compounded in border areas, where spectrum has to be shared between two or more countries and becomes even scarcer. In these areas, there is a need to ensure equitable, interference-free access to spectrum between the countries involved and to satisfy the wish of local populations to receive the television programmes of the neighbouring countries. By the domino effect of interference, the choice of frequencies in border areas also has an impact on other areas far from borders.[9]
- High power transmitters and antennas are tailor made for the particular set of frequencies which they use. Any change of frequency for any of the programmes in one transmitting site is therefore costly and potentially disruptive on all programmes transmitted from this particular site. It has also implications on associated receiving installations in buildings, which need to be modified, which is also costly and disruptive.

For these reasons, a case-by-case cross-border coordination between neighbouring countries as new frequency requirements emerge cannot be used as a general solution to frequency planning of terrestrial broadcasting services. A well-established practice, in particular in Europe, Africa, Middle East and CIS countries, which form Region 1 of the International Telecommunications Union, has therefore been to conclude regional agreements ensuring equitable access to spectrum between the countries of the region by registering transmission rights on specific frequencies in specific locations or areas.

In signing these agreements, the administrations involved commit themselves to protect the use of these frequencies in other countries by not using frequencies other than those for which they have registered transmission rights, unless otherwise agreed through a procedure managed by ITU. The most recent of these regional agreements, the GE06 Agreement[10], was adopted in 2006 in Geneva. It establishes the

[9] A conceptual method for the representation of loss of broadcast coverage due to interference is given in Report ITU-R BT.2248 - www.itu.int/pub/R-REP-BT.2248

[10] www.itu.int/ITU-R/terrestrial/broadcast/plans/ge06/index.html

rights of countries for the use of the VHF and UHF bands for television and sound broadcasting (see section 4 below).

In contrast, the management of spectrum allocated to the mobile service does not require such a detailed involvement by regulators or governments: a mobile cellular network typically involves tens of thousands of base stations and its frequency plan is readjusted routinely as new stations are introduced, without impact on users. In border areas, the relatively small power radiated by the base stations makes cross-border interference a local issue, which is generally dealt with by regular frequency coordination meetings between neighbouring countries, without the need for multi-lateral a priori planning. Consequently, mobile operators are generally authorised to operate nation-wide within a given frequency band that is not shared with any other operator and to use that part of the spectrum under some general conditions without involvement of the regulator/government.

Another important differentiator between broadcasting and mobile services relates to the selection of standards. For the mobile service, recent regulatory trends have shown the growing importance of the so-called "technological neutrality", leaving mobile operators with the flexibility of implementing new technologies as they emerge, in a market where, as a result of the rapid evolution, most user equipment is replaced every two or three years. In the broadcasting world, the rate of renewal of user equipment has historically been much lower (once in ten or twenty years) and the need to achieve economies of scale therefore generally requires a national regulatory decision on the TV transmission standard.

3.2 Regional spectrum planning for broadcasting

The ITU Regional Radiocommunications Conference held in Geneva in 2006 (RRC-06) adopted the GE06 Agreement, which contains a plan (GE06 Plan) and associated procedures for the implementation and the modification of this plan.

The GE06 Plan achieved a situation of equitable access between 119 countries (118 countries from ITU Region 1[11], and the Islamic Republic of Iran) in the VHF and UHF frequency bands. Each country party to the Agreement has received a set of entries in the GE06 Plan, which define a right to use certain frequencies with certain characteristics within certain specified areas. For reasons of continuity with previous agreements concluded in 1961 and 1989, the UHF frequency band has been divided into 49 channels of 8 MHz bandwidth, numbered from 21 to 69, and the VHF band has been divided into eight channels of 7 MHz bandwidth, numbered from 5 to 12. Typically, each country received rights of use on seven channels for television in each area in the UHF band and 1 channel in the VHF band. To prevent interference, these channels differ from one area to another. The use of SFN enables larger areas to use the same frequency for the same multiplex content. Using the latest digital technologies, this plan allows to broadcast, free of interference, about 160 standard definition television programmes, or 40 HDTV programmes over the entire territory of each country contracting to the GE06 Agreement.

It is worth noting that, at the time of RRC-06, many countries had already established military mobile networks in channels 12 and 61 to 69. Several eastern European and central Asian countries also had established aeronautical radio-navigation systems in channels 42 to 69. The constraints arising from the existence of these networks were taken into account to balance the amount of resources given to each country so as to establish equitable access.

The GE06 Agreement contains a procedure which allows each country to implement any of its entries in the Plan in the form of transmit stations located in the corresponding allotment area, in the corresponding channel, provided that a certain envelope of interference is not exceeded. This leaves a large flexibility to each country to select transmit sites and their characteristics. This flexibility is obtained

[11] Parts of ITU Region 1 situated to the west of meridian 170° E and to the north of parallel 40° S, except the territory of Mongolia.

at the cost of a lesser spectrum efficiency compared with a situation where all the transmit sites would have been decided upfront.

The GE06 Agreement also contains a procedure which allows each country to modify the GE06 Plan to obtain more rights, for example by extending allotment areas or interference envelopes, or by using channels in addition to those agreed at RRC-06. This procedure requires the agreement of all neighbours within a relatively conservative distance, which is designed to permit administrations to negotiate such additional resources in a mutually satisfactory way, i.e. maintaining overall equitable access.

Finally, the GE06 Agreement specifies that analogue television transmissions in VHF and UHF bands will no longer be recognized after 17 June 2015, (with exceptions for a number of countries until 2020 in the VHF band only).

3.3 Spectrum aspects of the transition to digital television

In many countries, the penetration of analogue terrestrial broadcasting has decreased over the years as a result of the development of alternative means, such as cable, satellite or ADSL, to the point that it has become marginal (less than 5 per cent of population) in some countries. In these countries, transition of terrestrial broadcasting from analogue to digital may be relatively easy and the period of simulcast, during which both analogue and digital transmissions co-exist, may be limited, or even non-existent.

In other countries, analogue terrestrial broadcasting remained the main way to bring television to households. In these cases, analogue switch-off cannot be envisaged as long as the penetration of analogue broadcasting has not decreased sufficiently, i.e. as long as the population concerned has not migrated to digital terrestrial television. This generally requires several years of simulcast in the same part of the spectrum, and the deployment of a digital television broadcasting network which is sufficiently wide to reach the above objective[12].

In these countries, if the UHF band is extensively used by analogue television[13], the need to coexist in the same part of the spectrum with analogue television during this transition period limits the possibilities for the introduction of digital television services. Therefore temporarily restrictions to the digital transmissions are generally needed. Such restrictions are compounded in border areas by the requirement to also coexist with analogue and/or digital transmissions of neighbouring countries.

The digital dividend for broadcasting services therefore becomes available only when these restrictions have been waived, which can only occur at the time of analogue switch-off. For logistical reasons, analogue switch-off is generally phased geographically: a given geographic area is switched-off on the same day and the adjacent areas are switched-off a few weeks before or later, once logistical preparations have been made for the transmission sites and for the receiving installations. Once an area is switched-off, the digital dividend may materialize in that area, either immediately or more probably after all adjacent areas have also been switched-off, thus waiving the restrictions imposed by coexistence with analogue transmissions.

These restrictions may be either power limitations to limit interference into analogue transmissions, or interference accepted from analogue transmissions, or both. In all cases, these restrictions limit the service areas of digital transmissions. The digital dividend for broadcasting services will therefore firstly materialize in terms of an increase in service area. However, the full benefit of analogue switch-off may only occur once the frequency plan of digital transmissions has been modified: because digital

[12] In France or United Kingdom for example, broadcasting networks handling five to six multiplexes, for a total of about 30 standard and/or high definition television programs, were deployed and covered over 85 per cent of the population before analogue switch-off was started, which took over five years of simulcast.

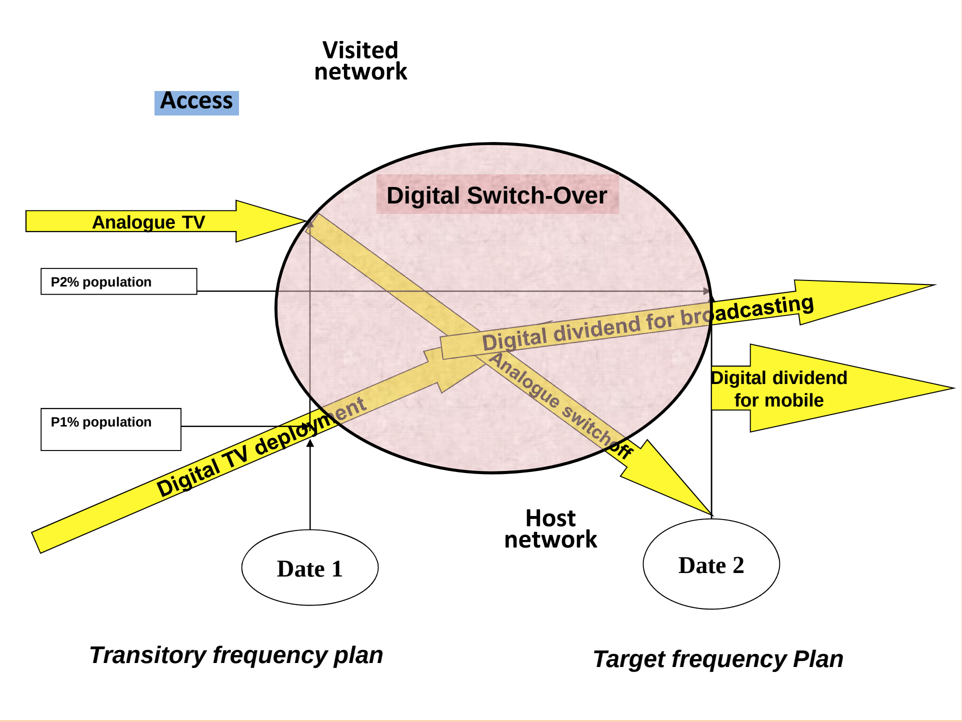
[13] In many countries, analogue television is broadcast mainly in VHF band. The difficulties highlighted in the remaining part of this section will therefore be avoided. However, TV users will need to buy a UHF antenna to receive digital television.

transmissions had to be planned "around" analogue transmissions, their frequency plan (i.e. the set of frequencies used by every single transmitter) could only be a ***transitory plan*** and not optimum once analogue transmissions have been switched-off.[14] Reaching maximum digital coverage and making available additional digital transmissions will therefore require the transition of digital transmissions to a new, optimized frequency plan, often called ***target frequency plan***. This transition is normally effected at the same time as analogue switch-off, hence the name of ***digital switchover (DSO)*** to designate the simultaneous operation of switch-off and frequency changeover.

From a spectrum management point of view, DSO therefore appears as a process through which the frequency plan for broadcasting services is gradually modified from a transitory frequency plan (accommodating digital transmissions together with analogue ones) to a target frequency plan (optimized for digital transmissions).

This process is illustrated by Figure 3-1. DSO starts with the first switch-off of an analogue transmission, which can only occur at a date D1 when digital TV coverage deployment has reached a sufficient percentage P1 of the population, which should be close enough to that achieved in analogue form. At a date D2 corresponding to the end of the DSO, a higher percentage P2 of the population is covered by digital TV, all analogue transmissions have been switched-off and all digital transmissions moved to the target frequency plan. Between these two dates, the digital dividend for broadcasting has gradually materialized into additional coverage for previously existing digital services and additional digital services (such as additional multiplexes). During the process, the transitory frequency plan and the target frequency plan coexist in adjacent areas, which may require intermediate frequency changes in order to control interference between such areas.

Figure 3-1: The digital switchover process from a spectrum viewpoint



Source: Authors

[14] Planning criteria for various methods of providing digital terrestrial television services in the VHF/UHF band are given in Recommendation ITU-R BT.1368-9. www.itu.int/rec/R-REC-BT.1368/en

Given the magnitude of these two operations, the political, cultural and social importance of the terrestrial television service and their potentially disruptive effect on this service, DSO is a national issue, which needs to involve:

APIs and service enablers are used to provide the user with a more varied, friendlier communication environment accessible with various types of fixed and mobile terminals anywhere where the network is available. Service enablers are generic components that make it easier to create services and applications:

- government and/or legislative backing,
- advance planning and coordination of all activities,
- communication to the public,
- technical assistance to the population,
- financial assistance to the population, which may cover the purchase of digital receivers or, in case of loss of terrestrial service, the purchase of alternative equipment, such as satellite receive equipment.

As part of the preparation of DSO, a clearly established *target plan* is a pre-requisite to avoid disruptive domino effects in case of changes.

If the *target plan* of a country is not agreed with its neighbours, this plan should therefore be negotiated with them before DSO can be envisaged. For countries which are contracting members of the GE06 Agreement, the GE06 plan, as adopted by RRC-06, was designed to provide this *target plan*. The decisions of WRC-07 and WRC-12 on the allocation of the digital dividend, which are discussed in the following section, have however, somewhat complicated the situation.

3.4 International framework for the digital dividend allocation

At international level, spectrum is managed by the Radiocommunication Sector of ITU (ITU-R). Its mission is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including those using satellite orbits, and to carry out studies and approve Recommendations on radiocommunication matters.

In implementing this mission, ITU-R aims at creating the conditions for harmonized development and efficient operation of existing and new radiocommunication systems, taking due account of all parties concerned. This is ensured by the following activities:

- timely adoption and/or update of the international regulations on the use of spectrum: the Radio Regulations and the Regional Agreements,
- standardization of radiocommunication equipment by the adoption of ´Recommendations´ intended to assure the necessary performance and quality in operating radiocommunication systems,
- information and assistance to ITU membership on the most efficient use of spectrum.

Frequency allocations are decided at the international level by ITU World Radiocommunication Conferences (WRC). These conferences are held every three to four years and update the ITU Radio Regulations (RR), an international treaty which has binding effect on ITU Member States.

In each frequency band, the RR specifies which radiocommunication services may be used: in regulatory terms, this frequency band is allocated to these services. Such services may relate to terrestrial radiocommunications (e.g. fixed, mobile, broadcasting, radiolocation, radionavigation, earth-exploration) or to satellite communications (e.g. fixed-satellite, mobile-satellite or broadcasting-satellite). These allocations support applications as varied as radio relays, radars, satellite television, FM radio, CB, news gathering, mobile telephony, WiFi, emergency communications, meteorology or satellite imaging or positioning and earth resource monitoring, which have taken an increasing importance in our day-to-day life in the past twenty years.

In making new allocations, WRCs base their decisions on studies carried out within ITU-R, which comprises most private and public stakeholders in the industry. These studies are intended to ensure that WRC decisions satisfy emerging spectrum requirements while protecting the investments which have been made in the past under the current allocations. The primary objective is to ensure that interference between radiocommunication systems is always kept under control.

WRCs generally take their decisions by consensus, which ensures that all ITU Member States are satisfied with these decisions and will continue to apply the Radio Regulations.

By allocating several services in each frequency bands, the Radio Regulations provide a large degree of flexibility to ITU Member States in establishing radiocommunication services which suit their needs. Each country may decide independently which service(s) it wishes to deploy in this part of the spectrum, provided that it carries out successfully frequency coordination with its neighbours. In practice, this flexibility is limited by the need to achieve cross-border coordination and to benefit from economies of scale, hence regional and world-wide spectrum harmonization are playing a more and more important role to ensure that the individual choices made by each country are going in a direction which benefits everybody.

In the last 25 years, WRCs have frequently discussed new allocations to the mobile service, in order to cope with the increasing development and success of mobile telephony worldwide. Since 1992, they have also focused on identifying particular frequency bands allocated to the mobile service and which may be used for IMT, thereby paving the way for worldwide development of upcoming generations of mobile telephony and broadband internet access.

The identification of common frequency bands at international level for IMT and the subsequent standardization activity within ITU have several key objectives:

- bringing worldwide economies of scale for the manufacturing of equipment (the same frequency band can be used in the same way in all countries),
- simplifying the design of equipment,
- allowing worldwide roaming,
- providing long term assurance to manufacturers and network operators, who invest in making the equipment and the service available, based on the intentions of regulators and governments worldwide.

All these objectives are essential in enabling the successful development of new services. As several previous world radiocommunication conferences had done, WRC-07 and WRC-12 had to make decisions on new frequency allocations to the mobile service and identification of frequency bands for IMT. Several factors influenced these decisions:

- the growing importance of data traffic in mobile networks, which increase pressure on spectrum;
- the cost of achieving coverage of low density population areas in the 2 GHz and 2.6 GHz bands[15], already identified for IMT, hence the risk of worsening the digital divide without making available additional spectrum at lower frequencies;
- the digitization of terrestrial television broadcasting, which had just been the subject of the GE06 Agreement, pointing to the possibility of a digital dividend in a relatively short term (2015);

[15] The service area of a base station reduces in proportion to the square of the frequency. The number of base stations to cover a given area in regions of low population density at 2 GHz is therefore four times greater than at 1 GHz, hence increasing the cost of the network accordingly.

- the availability of further improvements in digital modulation and TV signal compression, making available further efficiency gains in spectrum use by broadcasting.

WRC-07 decided to allocate the upper part of the UHF band, 790-862 MHz, to the mobile service and to identify it for IMT worldwide. In ITU Region 2 (Americas) and in several countries of Region 3 (Asia-Pacific), the band 698-790 MHz, which was already allocated to the mobile service in these regions, was also identified for IMT.

In so doing, WRC-07 did not suppress the existing allocation to terrestrial broadcasting in all three ITU Regions in the corresponding parts of the UHF band. It did not suppress either the previously existing allocations to the mobile service and to the aeronautical radionavigation service, which are still in use in some countries.

While the WRC-07 decision therefore left the choice of allocating the digital dividend to each country, it provided, however, a very strong indication on how this allocation might be done by national regulators.

The international regulatory framework for the digital dividend was further refined by WRC-12, in the following manner:

- it has clarified that no additional regulatory measures need to be taken to protect the broadcasting service in one country from the mobile service in another country,
- its preparation to address compatibility issues between the mobile service (IMT) and the aeronautical radionavigation service allocated in a number of Eastern European countries has led to the conclusion of bilateral agreements which resolve these issues and ensure availability of the 800 MHz band in all European countries,
- the misalignment in the mobile allocations of the digital dividend spectrum between the three ITU Regions has been corrected, by allocating the band 694-790 MHz to the mobile, except aeronautical mobile, service in Region 1 and identifying it for IMT. Subject to confirmation by WRC-15, this provides a worldwide mobile allocation and identification for IMT in all three Regions in the band 698-862 MHz.

Since WRC-07, the standardization efforts carried out in ITU and other bodies have paved the way for the possibility of an early implementation of the mobile service, with equipment and spectrum being available in many countries from 2012-13.

Many countries have already allocated or taken steps to allocate the *digital dividend* accordingly. Before discussing the specifics of national decisions in this respect, it is worth highlighting the role of regional bodies in building consensus on the use of the digital dividend and the key importance of cross-border coordination issues.

A consequence of WRC-07 and WRC-12 decisions to allocate and identify the upper parts of the UHF band to the mobile service is that any country wishing to use this allocation needs to vacate the corresponding band from existing uses, whether broadcasting, military or wireless microphones. For broadcasting, reconstituting the spectrum lost by existing transmissions requires international negotiations. More precisely, if the *target plan* for *digital switchover* already included channels falling in the bands in question, it has to be modified, hence re-negotiated with neighbouring countries.

Similarly, because of interference, the use of the mobile service in one country is only possible if neighbouring countries accept to protect it.[16] Cross-border frequency coordination, preferably at regional level, is therefore a pre-requisite for this purpose.

A regional coordinated approach, by which all countries in a region jointly agree to use these bands in a consistent way, is therefore obviously preferable. It also contributes to increasing economies of scale for

[16] Report ITU-R BT.2247 provides a study on field measurement and analysis of incompatibility between DTTB and IMT. www.itu.int/pub/R-REP-BT.2247

the provision of mobile equipment. The next sections discuss the role of regional harmonization and the scope of cross-border frequency coordination negotiations in this regard.

3.5 International harmonization

Regional harmonization has a key role to play for the allocation of the digital dividend in order to obtain the benefits resulting from economies of scale on the provision of services and avoiding insurmountable interference problems in border areas.

3.5.1 Europe

In Europe, spectrum issues are discussed through the following process:

- The Radio spectrum Policy Group (RSPG), provides the opinion of the 27 EU Member States to the European Commission (EC).
- On this basis, the EC issues mandates to the CEPT (the European conference of Posts and Telecommunications administrations, formed by 46 Member States) to provide technical conditions on the use of spectrum.
- Once received by the EC, these conditions are integrated into recommendations (not binding on EU Member States) or decisions (binding), after consultation of the Member States.
- The process also involves the European Council of Ministers and the European Parliament.

Within Europe, discussions on the digital dividend started in 2006 with the adoption of a first RSPG opinion and a first Mandate[17] from EC to CEPT in early 2007. In response, CEPT identified the upper part of the UHF band as the preferred band for the purpose of a mobile allocation as part of the digital dividend.

After WRC-07 decision, in April 2008, the EC issued a second Mandate[18] to CEPT on the technical considerations regarding “harmonisation options for the digital dividend in the European Union”. On the basis of the CEPT response, the EC adopted the following:

– European Commission Recommendation 2009/848/EC[19] on "Facilitating the release of the digital dividend in the European Union”, in October 2009",
– Commission Decision 2010/267/EU[20] on “harmonised 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.

Although this decision is not binding on EU Member States, it may soon become such as a result of the recent resolution of the initial difficulties with aeronautical radionavigation in Eastern Europe and once complete transition to digital television broadcasting has been achieved, i.e. by the GE06 Agreement deadline of 17 June 2015.

The technical considerations regarding harmonization options for the digital dividend in the European Union are described in CEPT reports. Four CEPT reports have been adopted, see Table 3-1.

[17] http://ec.europa.eu/information_society/policy/ecomm/radio_spectrum/_document_storage/mandates/mandate_dig_div.pdf

[18] http://ec.europa.eu/information_society/policy/ecomm/radio_spectrum/_document_storage/rsc/rsc23_public_docs/rscom08-06.pdf

[19] www.ero.dk/01B962D6-4069-40E1-BB32-0B23E872A7CC?frames=no&

[20] www.erodocdb.dk/Docs/doc98/official/pdf/2010267EU.PDF

Table 3-1: CEPT reports related to digital dividend

CEPT Report	Title
CEPT Report 29, 26 June 2009	Guideline on cross border coordination issues between mobile services in one country and broadcasting services in another country
CEPT Report 30, 30 October 2009	The identification of common and minimal (least restrictive) technical conditions for 790-862 MHz for the digital dividend in the European Union
CEPT Report 31 30 October 2009	Frequency (channelling) arrangements for the 790-862 MHz band
CEPT Report 32 30 October 2009	Recommendation on the best approach to ensure the continuation of existing Program Making and Special Events (PMSE) services operating in the UHF (470-862 MHz), including the assessment of the advantage of an EU-level approach

CEPT Report 29 gives guidance on cross-border coordination issues which are of particular relevance during the coexistence phase, i.e. when some countries may have implemented the technical conditions optimized for fixed and/or mobile communications networks, while others still have high- power broadcasting transmitters in operation in the band 790 to 862 MHz. The GE06 Agreement provides the applicable regulatory procedures for cross-border coordination.

CEPT Report 30 identifies restrictive technical conditions through the concept of Block-Edge Masks (BEMs), which specify the permitted emission levels over frequencies inside and outside the licenced block of spectrum, respectively. The report specifies three levels of protection of broadcasting channels:

A. digital television channels where broadcasting is protected;

B. digital television channels where broadcasting is subject to an intermediate level of protection;

C. digital television channels where broadcasting is not protected.

For the protection of terrestrial broadcasting channels in use at the time of deployment of Mobile/Fixed Communications Networks, baseline requirement mentioned in situation “A” is to be applied. For digital terrestrial television channels which are not in use when implementing an electronic communications network base station, an administration may choose between the baseline requirements mentioned in situations “A”, “B” or “C”. The intermediate level of protection in situation “B” can be justified in some circumstances (e.g. agreement between broadcasting authority and mobile operators).

However, it is recognized that even the BEM for category A does not provide sufficient protection in all cases and further measures are necessary, such as improved digital television receivers and/or additional measures to be taken by mobile operators to protect previously established broadcasting transmissions.

The additional measures include:

- Reducing the radiated power of the mobile base stations and adjusting their antenna characteristics to reduce interference problems, taking into account local conditions, especially for the base stations using the first frequency block above 790 MHz.
- Using a base station antenna polarization that is opposite to that of the digital terrestrial television transmitter, especially for base stations using the first frequency block above 790 MHz.
- Use of additional RF filtering at mobile base stations, especially for base stations using the first frequency block above 790 MHz.
- Use of on-channel low-power digital television repeaters at the mobile base stations to restore the degradation of signal to noise ratio at affected digital television receivers. Such remedies should be coordinated with the impacted broadcast multiplex operator, since it may not be easily applicable, such as in the case of digital television transmitters operating in a Single Frequency Network (SFN).

CEPT Report 31 concludes that the preferred frequency arrangement for the frequency range 790 to 862 MHz should be based on the FDD mode in order to facilitate cross-border coordination with broadcasting services, noting that such an arrangement would not discriminate in favour of or against any currently envisaged technology. The frequency arrangement is shown below. It has been included in the European Commission Decision mentioned above and is therefore of mandatory application in EU countries wishing to use the mobile service in this band:

Figure 3-2: Preferred harmonized channelling arrangement for the band 790-862 MH in EU

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)					

Source CEPT

CEPT Report 32 recognizes the interest in the continued operation of applications for PMSE and identifies a number of potential frequency bands and innovative technical developments as a solution to the current use of the band 790 to 862 MHz by these applications. More studies are considered necessary.

In other regions of the world, similar efforts have been undertaken to ensure regional harmonization of the parts of the UHF spectrum identified by WRC-07 for IMT. In the Asia-Pacific region, the APT (Asia-Pacific Telecommunity) has also adopted technical conditions for the use of the band 698-806 MHz band.

3.5.2 Asia Pacific

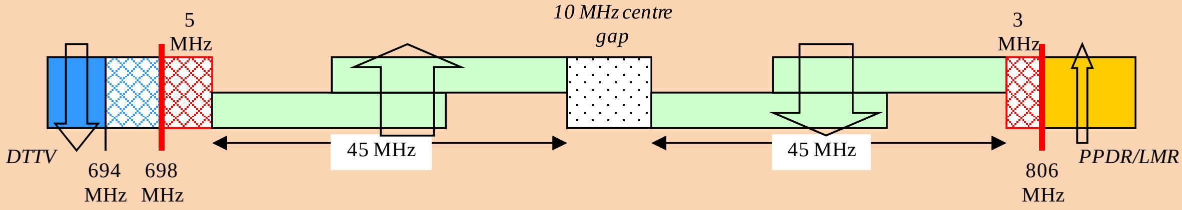
In the Asia-Pacific Telecommunity (APT) consensus was reached in regard to the basic structure of a harmonized frequency arrangement for the band 698-806 MHz[21]. Recognizing the need to provide sufficient protection for the services in adjacent bands, it was concluded that a combination of mitigation measures would be necessary, including sufficient guard-band allocations within the 698-806 MHz band. It was agreed that spectrum should be allocated as follows:

1. a guard-band of 5 MHz at the lower end, between 698-703 MHz,
2. a guard-band of 3 MHz at the higher end, between 803-806 MHz, and
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.

The overall structure of the harmonized FDD arrangement for the band 698-806 MHz is illustrated in Figure 3-3:

[21] APT Report on harmonized frequency arrangements for the band 698-806 MHz, No. APT/AWF/REP-14, September 2010.

Figure 3-3: Harmonized FDD arrangement of 698 to 806 MHz band in Region 3



Source: APT

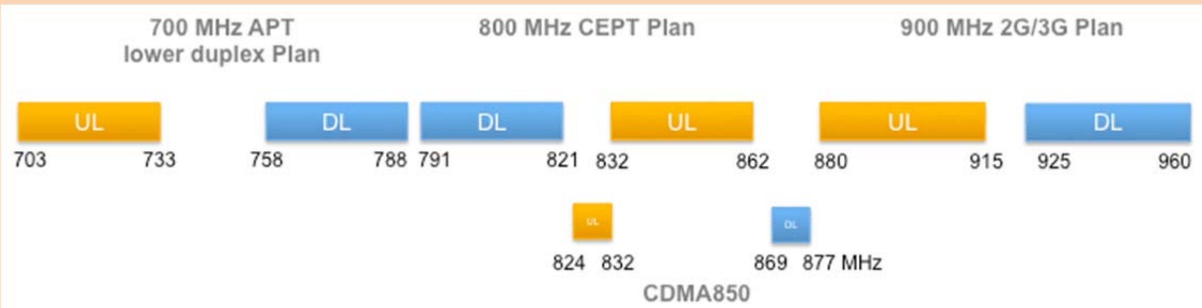
3.5.3 *Worldwide harmonization*

The decision of WRC-12 to allocate the band 694-790 MHz to the mobile, except aeronautical mobile, service in Region 1 opens the way for the worldwide harmonization of both the 700, 800 MHz and 900 MHz bands for IMT.

This harmonization would resolve the long standing differences in UHF mobile spectrum allocations between Regions, which result from the incompatible deployment of CDMA and GSM networks in the 850/900 MHz bands from the years 1990.

Significant activity is currently taking place for the adoption of such a plan. An example of solution proposed to reconcile the CEPT and APT plans while continuing to accommodate residual CDMA 850 networks is shown in Figure 3-4. This would provide a total of 2 x 60 MHz in the 700 and 800 MHz bands, while relying on the existing band plans of CEPT and APT.

Figure 3-4: Example of possible harmonized band plan for 700, 800 and 900 MHz bands



Source Qualcomm

Although it should be recognized that the current use of the 700 MHz by broadcasting may prevent its availability to the mobile service in many countries in the years to come, this band will however become available soon for the latter service in many countries, which have lesser requirements for broadcasting and will therefore benefit from worldwide harmonization of the frequency band plans for IMT.

3.6 Coordinating the digital dividend with neighbouring countries

WRC-07 and WRC-12 established an international framework which allows each country to decide, whether to continue its use of the upper UHF band by television broadcasting or military applications, or to use for mobile services. The only international condition to implement this national decision is that neighbouring countries agree, which requires bilateral or multilateral negotiations.

International and domestic pressures to make spectrum available to the mobile service as permitted by WRC-07 and WRC-12 can be expected to grow in coming years, if anything as a result of the remarkable growth of mobile data services and its positive impact on economic and social development, in particular in developing countries. This evolution can be expected to facilitate the above negotiations, especially where it is also formalized at regional level, as exampled in the previous section.

In cases where bilateral negotiations meet difficulties, the ITU assistance may be requested to facilitate a successful outcome.

The GE06 Agreement established the international framework applicable to 119 countries for the use of the UHF band by television broadcasting. Although this agreement in not applicable to all countries, many elements of the discussions currently in progress between countries contracting to this agreement may be of use for other countries.

The GE06 Agreement contains a procedure to modify the GE06 Plan. For a modification to be recorded in the Plan, this procedure, which is routinely applied, requires the agreement of all affected countries. This agreement may be obtained by bilateral and multilateral discussions. Renegotiating the GE06 Plan therefore does not require renegotiating the GE06 Agreement.

European coordination

In Europe, the corresponding negotiations started in 2008, with multilateral discussions held within two groups: eight countries around Belgium (WEDDIP group, for Western European Digital Dividend Implementation Platform), created in May 2009, and nine countries around Germany (NEDDIF group, for North-Eastern Digital Dividend Implementation Forum), created in October 2010. At the end of this process, the GE06 Plan will be modified using the above procedure, hence the ***target frequency plan***[22] will be the GE06 Plan, as updated by this process.

The objective of these negotiations was to restore equitable access among broadcasting transmissions (typically seven channels per geographical area) in a band limited to 470-790 MHz, and to distribute equitably any additional capacities among countries.

Obviously, this process will require a more intensive use of the spectrum used by broadcasting. Such a change requires acceptance of more technical constraints to either accept more interference in certain areas and/or to limit the interference produced in those areas. Technical solutions involve reducing transmit power, shaping and tilting transmit antennas to reduce power in certain directions, increasing the use of SFNs to consume less spectrum[23] and creating new transmitting sites to offset interference. In most cases, implementation of these solutions will result in additional cost compared to the original situation in the GE06 Plan.

From a formal point of view, the above objective may be achieved by the following:

- The current entries in GE06 Plan below channel 61 (i.e. below 790 MHz) have to be kept stable.
- Potential extensions may be considered by addition of assignments/allotments, on the basis of the main broadcasting sites. These extensions may be recorded in the GE06 Plan as modifications of the Plan, following the formal procedure of the GE06 Agreement.
- In order to ensure compatibility between potential extensions and existing entries in the GE06 Plan, some restrictions may have to be applied to some of the latter, e.g. reduction in the equivalent radiated power, antenna pattern restrictions in some sectors, selection of one type of polarization (V or H). These restrictions may be accepted without modifying the current entries (no loss of right).
- Restrictions on existing networks should be avoided.

The key factor in identifying additional opportunities in the GE06 Plan (as well as in the case of a Plan to be established between any group of countries) is to determine the areas that may be able to share the

[22] See description in section 3.3.

[23] The use of SFN to increase the size of allotment areas may be difficult for smaller countries.

same channels and agree on the measures that could be acceptable on each side to ensure that this sharing is possible. This may require carrying out on-site measurements in the areas where interference is predicted by the calculations, in addition to using terrain model interference predictions.

Once these areas of mutual compatibility have been identified, it is possible to develop a compatibility matrix between all the allotment/assignments that currently exist in the GE06 Plan, and those that may be considered as the replacement frequencies.

Once this compatibility matrix has been agreed, it may be used on a channel per channel basis to determine which channel may possibly be used in a given area/site: if this channel is incompatible with one or more existing allotments/assignments in the plan, it cannot be used in the given area/site. Otherwise, it may be used at potential areas/sites, provided that another area/site which is incompatible with it, does not request the same channel, in which case two or more scenarios may have to be considered, depending on which of the competing sites/areas is selected for this channel.

Various scenarios may then be combined and the most promising combinations of them be assessed, in an iterative process, against the requirements of each country involved until general satisfaction is obtained.

African coordination

Within the African Telecommunication Union (ATU), following a ministerial summit on the issue, two frequency coordination meetings have studied possible rearrangements of frequency assignments in order to make space for a harmonized frequency band for mobile services (694-862 MHz) while ensuring a minimum capacity of four nationwide broadcasting coverages for each African country and concluded on their feasibility[24].

4. Market developments

Allocating the digital dividend is a national strategic decision, taken in the context of an evolving international and regional framework. It requires, among other things, an assessment of future (market) developments in order to balance future demands for spectrum.

The digital dividend is considered an important driver for economic growth and demand for spectrum is expected to outstrip supply. Market developments like the introduction and uptake of new wireless services, most notably wireless broadband and additional TV services, including HDTV, are resulting in this spectrum demand growth.

Before addressing the specific digital terrestrial television and wireless broadband demand drivers it should be noted that:

- Although very thorough analyses have been conducted on these developments, the forecasts vary significantly and seem already outdated by the time they are published. Hence a phased approach of spectrum release is preferable.
- Demand is likely to vary between different countries for digital terrestrial television and wireless broadband depending on (interrelated) factors like geography (for example large rural areas), population density, development of infrastructure (especially the deployment of cable and fixed broadband networks) and the legal framework (e.g. restrictions on entering markets for new providers);
- Any model is bound to be very sensitive to economic growth or downturn. An important finding in analysing the various scenarios is that economic downturn will affect consumption (and

[24] http://atu-uat.org/images/eventlist/events/files/Broadcasting_ATU_Kampala_April12_Conclusions%20(EN).pdf

demand for spectrum), and the decline in consumption may be more severe than expected. The temptation to consider the market studies as accurate predictions of the future is to be resisted.

4.1 Digital terrestrial television demand drivers

In developed countries, the key spectrum demand driver for digital terrestrial television is clearly the consumer adoption of HDTV as the standard for picture quality. This is reflected in the sales volumes of HDTV television sets, HD STBs, HD subscribers and number of HD channels[25]. The introduction of HDTV services on digital terrestrial television platforms led to a sharp increase in demand for spectrum. This development gave impetus to the development of MPEG4 and recently the introduction of the DVB-T2 standard. Such technology developments reduce drastically the spectrum demand and started discussions on the possibility of a second digital dividend. In developing countries, the demand driver is an abundance of programmes with higher video and audio quality (including HDTV) and a larger coverage.

Another demand driver is the wish for unconstrained reception, avoiding the need for rooftop fixed antennas. This ranges from portable to fully mobile reception, with the corresponding need for higher field strength signals, hence more and/or higher power transmitters.

In Europe, the development of mobile television on terrestrial broadcast networks (on the basis of the DVB-H standard) seems to be stagnating, where leading countries like France, Germany and Switzerland have stopped development-related operations. A different development of such broadcast based mobile television services may apply to some African countries, where DVB-H services have been launched in Nigeria, Kenya, Namibia, and Ghana. Also the number of users of the T-DMB service in Japan and South Korea continues to be high, however with financial difficulty because the applied advertising-based business model seem not to generate sufficient returns.

An important indicator for mobile television uptake is the number of handsets (i.e. the number of models and manufacturers) enabled with T-DMB, or DVB-H receivers that are available to the public. This number should be considered at a global scale rather than at a national scale. The number of such handsets remains (too) low.

There is a clear trend that mobile operators migrate their mobile television offer to their switched networks like HSPA/UMTS. The recent development and launch of LTE based networks seem to accelerate this trend.

Another factor with critical influence on the demand for television spectrum is the availability of alternative platforms to distribute television services. Especially, the deployment of fixed broadband networks and the ever increasing transmission speeds they offer make television broadcasting feasible and attractive on such networks. The latest development in raising Internet access speed is the deployment of fibre-to- the-curb, where not only the backbone network but also the local networks are fibre based. The rise in the number of the so-called over-the-top (OTT) service providers is a good indicator for this market development. OTT providers deliver a television service bouquet directly over the Internet to end-consumers (i.e. without the intermediate network operator/service provider like telecom and cable companies).

Finally, television viewing habits should be included in the market analysis too. An important factor is whether viewers keep enjoying linear and scheduled television broadcast (traditional television) as opposed to ‘viewing on demand’ (including services like catch-up television and soap/video/film ordering).

Reports and discussions on this viewing pattern shift are numerous and very often conflicting, however, declining numbers of ‘traditional’ viewers would imply less need for traditional broadcast networks as

[25] See Ofcom report, “International communications market report”, dated 2 December 2010.

simultaneous en mass viewing does not take place. Following the advertising 'dollars' can help to identify the direction and the speed of this trend.

On the basis of often quoted studies[26] and ITU reports[27], a number of demand drivers can be identified. These can then be combined in various scenarios, which may be combined with appropriate benchmarking to estimate future spectrum requirements. In summary the four demand drivers and their associated indicators appear to be:

- <u>HDTV uptake</u>: indicators include the sales of HDTV television sets, HD enabled STBs, the number of HD subscribers and the number of channels/programming hours produced in HDTV quality[28]. It should be noted that the next step in 'picture quality' seems to be introduction of 3D television. It is yet unclear to what extent and when this development will significantly impact the demand for spectrum.
- <u>Deployment of more advanced technologies, such as MPEG4 and/or DVB-T2</u>: indicators include the price difference between e.g. DVB-T2/MPEG4 and DVB-T/MPEG2 receivers, the number of manufacturers and the number of countries deploying these technologies (and for how many multiplexes)[29].
- <u>Television viewing patterns</u>: indicators include the uptake of VoD and pay-per-view services, viewing figures for linear programming, the advertising spend allocation, the number of PVRs sold or other interactive recording devices[30].
- <u>Deployment and development of alternative platforms</u>: indicators include the number of fixed broadband subscribers[31], the number of cable/IPTV/satellite subscribers, the average available bandwidth (per platform), churn rates of the digital terrestrial television platforms, the number of alternative television providers (like the OTT providers).

Figure 4-1 illustrates a resulting scenario for digital terrestrial television demand in terms of television channels.

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26 Analysys Mason report for the European Commission, "Exploiting the digital dividend – a European approach", dated 14 august 2009. IPTS report for the European Commission, "The demand for future mobile communications markets and services in Europe", dated April 2005.

27 ITU Guidelines for the transition from analogue to digital broadcasting, January 2010. www.itu.int/pub/D-HDB-GUIDELINES.01-2010/en. ITU-R report SM2015 includes a list of factors to consider for scenario analysis, dated November 2006.

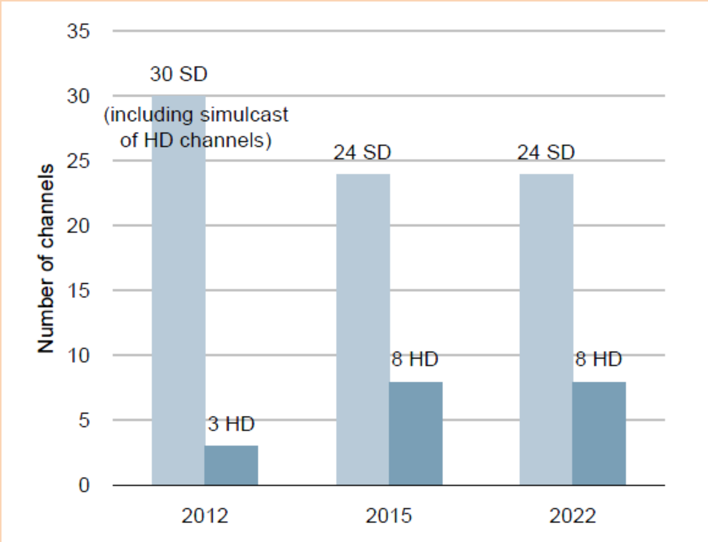
28 See footnote 15.

29 See DVB deployment data on http://dvb.org/about_dvb/dvb_worldwide/.

30 See footnote 15.

31 From Analysys Mason report, see footnote 26.

Figure 4-1: A demand scenario in terms of television channels[32]



Source: Ofcom

Translating any demand scenario into spectrum demand requires making assumptions about the technical or operational deployment. Given the current state of technology important deployment factors are:

1. the use of Single Frequency Networks (SFN) or Multi Frequency Networks (MFN)[33];
2. geographical or population coverage (e.g. not all multiplexes have to reach near nationwide coverage)[34];
3. the deployment of compression and modulation techniques.

The termination of existing licences could also make additional spectrum available.

4.2 Wireless broadband demand drivers

Internet access through mobile phones has been a common feature of handsets for some time. Initially through 2G networks (offering relatively low data speeds) and later over higher-speed 3G networks. But the recent emergence of 'smartphones' significantly changes the use pattern of mobile web; the mobile web is becoming wireless broadband.

Hence wireless broadband is a relatively new service category and includes many consumer and business applications/services, including personal applications such as m-banking, especially in developing countries. Smartphones enable users to download/upload content or stream audio and video/television content over a wireless Internet connection. They generally have an 'open' or advanced operating system allowing third parties to develop new applications and they have sufficient memory capacity to store content (including video). Hence the number of applications/services is virtually unlimited. Currently the following applications/services are common place, next to text messaging and voice calling:

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32 See footnote 25.

33 For more details on spectrum efficiency of SFN network see ITU Guidelines for the transition from analogue to digital broadcasting, chapter 4.3 available at www.itu.int/pub/D-HDB-GUIDELINES.01-2010/en.

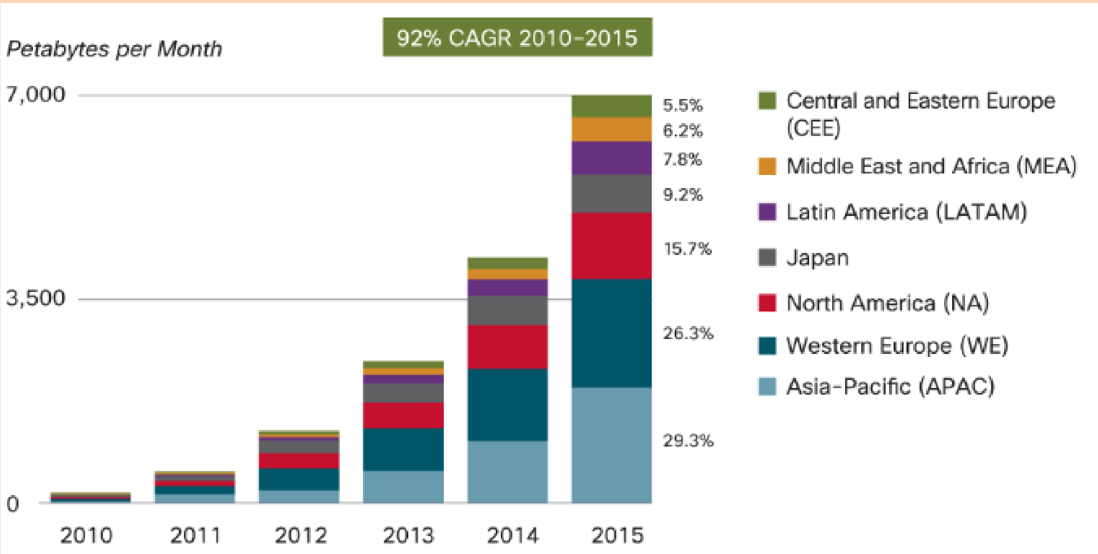
34 The number of frequencies needed to reach a certain geographical or population coverage is dependent on the application of SFN or MFNs and the acceptable reception quality.

- accessing, searching and downloading Internet content (business and consumers);
- playing games (including online);
- listening to audio/music (including Podcasts, MP3s and online radio);
- social networking (like Facebook and LinkedIn);
- messaging (including emails, MMS/photo messages, instant messaging);
- location based services (often on the basis of Google maps);
- uploading content (business and consumers uploading reports, video, pictures, clips, etc.);
- watching videos and television (including live and linear scheduled programming);
- video calling (business and consumers).

All these applications and services require wireless bandwidth and generate traffic. Given the high level of mobile penetration (i.e. the number of mobile phone users) in most countries and the high growth rate of penetration everywhere else, the key driver for more spectrum is now the increase in traffic per user, especially on the downlink. Most studies consider the number of mobile users as given[35]. The real driver for more spectrum is the change in use per mobile user. In technical terms this is the number of Petabytes to be transported per month or the number of billion minutes of 1 Mbit/s per day.

Figure 4-2 shows a forecast with wireless broadband traffic growing at an annual rate of 92 per cent. An important assumption in these traffic forecasts is what the minimum required bandwidth or speed per user has to be. Applications/service can work under various speeds but perhaps with a lesser (video/audio) quality. In a future scenario, where wireless broadband replaces fixed broadband speeds per user, these speeds tend to be significantly higher.

Figure 4-2: A forecast of wireless broadband traffic[36].



Source: Cisco

[35] See footnote 25.

[36] Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2010–2015, dated 1 February 2011.

Although there seems to be only one key demand driver for mobile spectrum (i.e. the traffic per mobile user), indicators for spectrum demand evaluation are numerous and include[37]:

- number of smartphones sold;
- number of smartphone subscribers;
- mobile broadband connections per 100 population;
- different number of operating systems for mobile phones and their deployment;
- average monthly revenue per mobile user;
- data as proportion of total mobile service revenue;
- mobile Internet advertising expenditure.

Several demand scenarios can be constructed. For example mobile broadband replaces fixed broadband, especially for rural areas, or wireless broadband is just supplementary to fixed broadband. Several factors may also affect demand for spectrum:

Firstly, it is important to note that new mobile applications not only increase the demand for more mobile bandwidth (e.g. Tb/Mb of traffic per month), but also increase the number of simultaneous connections. Mobile switched networks (e.g. GSM, UMTS, LTE) are deployed in a cellular structure and an important design factor is to optimize the blocking rate per cell. In other words the maximum traffic capacity is determined by the number of available channels in each cell and the acceptable percentage of calls that cannot be set-up or completed (i.e. the blocking rate). 'Always' online applications will increase the demand for more channels per cell and consequently more spectrum.

Secondly, in most countries several mobile operators deploy their own network. For example, in Europe the average number of networks is approximately three, and in African countries the number ranges from one to five network operators (e.g. in Kenya 4 and in Uganda 5). However, network sharing between mobile service providers is also common practice, such as the emergence of Mobile Virtual Network Operators (MVNOs), which are basically resellers of network capacity. Network sharing results in spectrum efficiency as networks are utilized at higher levels and more traffic is handled. Consequently there is less need for deploying parallel mobile networks, each with their own set of frequencies. Calculating spectrum demand entails making assumptions about the level of network sharing, which can vary per country and may be dependent on legislation.

Also one mobile network operator can balance traffic between already deployed networks (e.g. GSM/UMTS) and new networks (LTE). For example, voice and messaging can be handled and inserted easily in both networks. Hence assumptions have to be made about dynamic traffic balancing between networks.

Especially in rural areas, network sharing has been assumed. For covering large areas, network deployment in the 800/900 MHz bands would be very efficient. Providing broadband access in rural areas may be formulated as a universal service obligation or policy[38] and regulators rightly stipulate coverage/network rollout obligations to licence holders of such bands (see section 6).

Finally, there is no single wireless broadband standard and their spectrum efficiency may vary.

It should be evident from the above discussion that calculating spectrum demand for wireless broadband is based on many assumptions and practice has to prove whether they become reality.

Figure 4-3 shows an example spectrum demand forecast for wireless broadband.

[37] See for example Ofcom report, "International communications market report", dated 2 December 2010.

[38] For more details on Universal Service and Universal Access see www.ictregulationtoolkit.org, module 4, *Info*Dev/ITU.

Figure 4-3: A spectrum demand forecast for wireless broadband[39]

Parameter	*Demand Forecast 1*	*Demand Forecast 2*	*Demand Forecast 3*	*Demand Forecast 4*
Type of demand	Primarily mobile, urban, low bandwidth	Primarily mobile, ubiquitous, low bandwidth	Mobile and fixed, ubiquitous, high bandwidth	Mobile and fixed, ubiquitous, very high bandwidth
Spectrum per network	2×10MHz	2×10MHz	2×20MHz	120MHz[170]
Number of rural networks	2	4	4	2
Rural networks using 900MHz	2	2	1	0
Rural networks using digital dividend spectrum	0	2	3	2
Resulting demand for digital dividend spectrum	0MHz	40MHz + duplex band spacing	120MHz + duplex band spacing	240MHz

Source: European Commission

5. National decision-making

Given the international and regional context described in the above sections, national decision makers will need to take into account at least the elements in this section, ranging from the allocation of the digital dividend to the implementation of policy.

5.1 Allocation of the digital dividend

The bands identified for IMT by WRC-07 and WRC-12 open the possibility for each country to allocate them nationally as the *digital dividend* for the mobile service. As mentioned above, because of interference, cross-border frequency coordination, preferably at regional level, is a pre-requisite for this purpose. A regional coordinated approach, by which all countries in a region jointly agree to use these bands in a consistent way is therefore obviously preferable.

Allocating the 700 MHz and/or 800 MHz bands to the mobile service would still enable a large portion of the *digital dividend* to be allocated to television broadcasting in the remaining parts of the UHF band. This allocation however could result in the loss of channels which may already have been negotiated with neighbouring countries. Reconstituting these lost channels as a result of the above allocation to the mobile service and increasing their number to provide additional digital dividend for the broadcasting service is possible. It requires bilateral and possibly multilateral frequency coordination discussions with neighbouring countries, as seen in Chapter 3 above.

Parts of the bands that may be allocated nationally to the mobile service are currently used in many countries by wireless microphones or military applications. Migration of these services therefore needs to be considered, which may have financial consequences that need to be addressed upfront.

A clear regulatory situation also needs to be established upfront in relation to the handling of possible interference into broadcasting receivers in cases where a base station of the mobile service is established and transmits on frequencies adjacent to those to be used by broadcasting. An improvement of the immunity of broadcasting receivers may also be helpful and is being sought through international standardization to facilitate such situations.

[39] Analysys Mason report for the European Commission, "Exploiting the digital dividend – a European approach", dated 14 August 2009.

5.2 Coupling with the transition to digital terrestrial television

Successful transition to digital TV requires the successful achievement of two simultaneous events: analogue switch-off and successful digital switchover.

Digital switchover (DSO) involves the change of frequencies of a very large number of transmitters in a short period of time, from a *transitory frequency plan* to a *target frequency plan*[40]. This change is costly and, if not planed properly and well in advance, it may have widely disruptive effects on the availability of television service nationwide, with associated social consequences. For this reason, it is advisable to avoid any intermediate plan and therefore to plan DSO on the basis of a *target frequency plan* which is already agreed with neighbours.

The allocation of the digital dividend in a given country will most probably affect the *target frequency plan* of DSO in that country and in neighbouring ones. The *target frequency plan* therefore has to be negotiated with neighbouring countries prior to starting implementation of DSO and a regional (multi-lateral) approach should be sought in this negotiation.

The social implications of the transition to digital TV should be assessed with a view to facilitate this transition. This may involve:

- extensive communication to inform the population of the scope and consequences of DSO,
- technical assistance, in particular for elderly and/or isolated people,
- financial compensations for lower income households,
- financial aid for communities or individuals in cases where analogue service is discontinued without being replaced by digital service.

5.3 Decision making process for the transition to digital TV and digital dividend

Given the range of parameters which can be adjusted in digital transmissions, the trade-offs on the actual system characteristics, the number of programmes, the percentage of population served, the quality of service and the spectrum requirements will involve a mix of political, social, financial and commercial decisions, which will vary from country to country and may lead to apportioning the digital dividend for mobile and broadcasting services in various ways.

For these reasons, decisions on the transition to digital TV and the *digital dividend* are likely to be taken at the highest level and should be prepared in a way that maximises consensus. In this sense, the best approach appears to rely on a collaborative/coordinated approach involving all stakeholders, which may include:

- government,
- regulator,
- parliament,
- broadcasting operators,
- TV programme providers,
- equipment and site providers,
- users, public associations,
- multiplex operators,
- mobile operators, and

[40] See description in section 3.3.

- other users of the band (e.g. programme-making services).

As mentioned above, this approach should also heavily rely on regional harmonization and cross-border coordination negotiations.

5.4 Packaging of spectrum

Following the allocation of the digital dividend to the broadcasting and mobile services, the corresponding spectrum must be packaged appropriately. This involves several possible steps:

a) Determining the channel raster:

- For digital terrestrial television services: the national or international frequency plan provides the channel bandwidth. The bandwidth can either be 6, 7 or 8 MHz.
- For wireless broadband services: the duplex system has to be determined. Recent assignments in the US and Europe have shown that the duplex system is very often based on 2 x 5 MHz or 2 x 10 MHz (paired FDD system)[41].

b) Determining guard bands: In order to avoid harmful interference, guard bands may need to be set up between band allocations, but also within the band allocation and then especially for wireless broadband services choices have to made (for example in the duplex system variants the 'duplex gap' between the up and down link frequency blocks (or lots).

c) Packing lots: This entails assembling packages of frequencies which may be acquired through the licensing process. For both digital terrestrial television and mobile networks, lots may correspond to national or regional coverage. Lots may also be differentiated in their associated licence conditions. They may differ in the roll-out obligations or in the interference avoidance obligations (for example mobile broadband lots adjacent to digital terrestrial television lots).

d) Aggregation of lots: In order to help in reducing uncertainty or establishing an even playing field for bidders, the regulator may decide to aggregate several frequency bands into the same licensing procedure. An example is the latest auction in Germany where not only 800 MHz licences were auctioned but also the 1.8 and 2.4 MHz licences for wireless broadband services. The licensing of certain lots may also be postponed to a later process because frequencies have to be migrated before practical use is possible for those specific lots.

   The regulator may also decide to put a 'cap' on what a single bidder may acquire in the assignment procedure. Such aggregation limits are set to increase competition and to avoid that 'deep pockets' would dominate the market. The ultimate form of limitation would be to exclude certain potential bidders (for reasons of avoiding dominant market positions).

5.5 Usage rights and obligations

An overview of the licence conditions and obligations which are typically included in a spectrum licence for digital terrestrial broadcasting can be found in the ITU Guidelines for the transition from analogue to digital broadcasting (www.itu.int/pub/D-HDB-GUIDELINES.01-2010/en).

An important part of the spectrum licence is of course the spectrum rights. As discussed before, when defining the spectrum rights (resulting from the digital dividend), account should be taken of:

1. the international regulatory provisions,
2. the compatibility constraints, and
3. the time schedule of band allocations.

[41] Unpaired (TDD) variants exist too and may lead to different lot sizes and numbers.

In addition, the licence conditions should include provisions for resolving incompatibility and interference issues. Financing of any migration costs, customer assistance, time schedules in the national switchover plans are all relevant for drafting these provisions.

Coverage obligations are also an important element of the process of licensing the use of the digital dividend, in order to ensure that the propagation characteristics of the UHF band are effectively used to reduce the digital divide.

5.6 Spectrum assignment instruments

Some specific issues may be observed for licensing the digital dividend:

a) There may be a need to consider the special position of public entities (like Public Service Broadcasters or emergency services). For example in the USA, the FCC reserved 2 x 5 MHz for a national public safety network. Such reservations need a policy justification (e.g. based on the external value, see section 6.3.2) and likely to be endorsed by parliament.

b) Consideration may also be given to PMSE and wireless microphone users in the digital dividend bands. Diverse and widespread communities of users use these frequencies and may not be able to take part effectively in an auction.

c) When auction is selected as the preferred assignment instrument, there may also be a need to calculate or assess the likely value of the spectrum. This is important in cases where the auction proceeds will be (partly) reserved for covering migration costs. A minimum bid price can assure that those costs are always covered. However, this minimum price should be selected so as not to disturb competition or lead to the 'winners curse'.

Three basic assignment instruments are available; first-come-first-served, public tender and auction. It is outside the scope of this report to discuss all of them in detail[42]. As many spectrum managers have or are intended to licence significant parts of the digital dividend through an auction, a table is included in the appendix with the various auction designs, their applicability, and pros and cons.

It should be noted that the most applied auction design is the standard simultaneous/open multi-round auction as this design is considered to provide a good balance between allocation efficiency and complexity. Bidders acquire information on the spectrum value from other bids and can increment their bids steadily (avoiding the 'winners curse') and interdependent value between the spectrum lots is incorporated. 'Combination' auctions, in which package bids (e.g. for two lots) can outbid single bids, are deemed to be too complex.

5.7 Policy implementation procedures

The digital dividend licensing process should specifically consider:

1. Arrangements for avoiding harmful interference: bidders may be required to commit to take preventive actions to avoid interference and/or to resolve any interference problems if they occur.

2. Spectrum reservations for public broadcasters and other public users (e.g. wireless broadband for emergency services). Consideration should be given to avoid creating 'artificial' scarcity and hence pushing up spectrum prices.

[42] Report ITU-R SM.2012, "Economic aspects of spectrum management", and more specifically section 2.5.1 of the ITU Guidelines for the transition from analogue to digital broadcasting, provide more details on this issue www.itu.int/pub/D-HDB-GUIDELINES.01-2010/en.

3. The digital dividend is often 'market consultation' intensive. Depending on the market consultation results, a more careful design of appeal procedures (grounds for appeal, evaluation, duration, etc.) may be necessary.
4. When phasing the licensing procedures (e.g. first the 800 MHz band and later the interleaved spectrum), information should be provided not only on the current procedure but also on future procedures (e.g. which elements are subject to change). In this way bidders may assess the value of the current licences better. This may also avoid appeals in later procedures.

6. Benchmarking of digital dividend spectrum decisions

6.1 Recent decisions in relation to the allocation of the digital dividend

Important decisions concerning the digital dividend need to be made on the analogue switch-off date, the technology for digital terrestrial television and the allocation of a sub-band for mobile services. Examples on these decisions in a number of countries are shown in this section.

6.1.1 Analogue switch-off dates and applied digital system

An overview of the announced/achieved analogue switch-off (ASO) dates and the applied compression system for digital television in a number of European countries is provided by DigiTAG and reproduced below[43].

Table 6-1: Overview of digital switchover dates in Europe

Country	Launch date	Compression format	Completion of ASO
UK	1998	MPEG-2	2012
Sweden	1999	MPEG-2	Completed
Spain	2000/ 2005	MPEG-2	Completed
Finland	2001	MPEG-2	Completed
Switzerland	2001	MPEG-2	Completed
Germany	2002	MPEG-2	Completed
Belgium (Flemish)	2002	MPEG-2	Completed
Netherlands	2003	MPEG-2	Completed
Italy	2004	MPEG-2	2012
France	2005	MPEG-2/MPEG-4 AVC	Completed
Czech Republic	2005	MPEG-2	Completed
Denmark	2006	MPEG-2/MPEG-4 AVC	Completed
Estonia	2006	MPEG-4 AVC	Completed
Austria	2006	MPEG-2	Completed
Slovenia	2006	MPEG-4 AVC	Completed
Norway	2007	MPEG-4 AVC	Completed
Lithuania	2008	MPEG-4 AVC	2012
Hungary	2008	MPEG-4 AVC	Completed
Ukraine	2008	MPEG-4 AVC	2014

[43] See www.digitag.org/

Latvia	2009	MPEG-4 AVC	Completed
Portugal	2009	MPEG-4 AVC	2012
Croatia	2009	MPEG-2	Completed
Poland	2009	MPEG-4 AVC	2013
Slovakia	2009	MPEG-2	2012
Ireland	2010	MPEG-4 AVC	2012
Russia	2009	MPEG-4 AVC	2015

Source: DigiTAG

Information on the adoption and deployment of digital terrestrial television technology (transmission standard and compression system) in a great number of countries in all regions is provided by DVB[44].

6.1.2 Allocations to mobile services

Table 6-2 provides an overview of a number of selected countries regarding the allocation of the digital dividend to mobile services and the corresponding decision timeframe.

Table 6-2: Overview of the allocation of sub-bands for mobile services in a number of countries

Country	National situation
Australia	• Analogue TV switch-off in 2013 • 694 – 820 MHz allocated to mobile broadband services • Auction of licences in 2012
Finland	• Analogue TV switch-off in 2007 • 790 – 862 MHz allocated to mobile broadband services • Agreement with Russia on protection of Aeronautical Radionavigation services from mobile services in the band 790 – 862 MHz in December 2010 • Re-allocation of PMSE services to 700 MHz band
France	• Analogue TV switch-off finalized on 30 November 2011 in Metropolitan France and overseas territories • 790 – 862 MHz allocated to mobile broadband services • Migration of broadcasting and military from 790 – 862 MHz • Auction of licences in December 2011
Germany	• Analogue TV switch-off in 2008 • 790 – 862 MHz allocated to mobile broadband services • Migration of broadcasting from 790 – 862 MHz • Auction of licences in December 2010
India	• Analogue TV switch-off in 2015 • 698 – 806 MHz allocated to mobile broadband services
Japan	• Analogue TV switch-off in 2011 • 710 – 780 MHz allocated to mobile broadband services
Korea	• Analogue TV switch-off in 2012 • 698 – 806 MHz allocated to mobile broadband services • Frequency plan for 698 – 806 MHz to be developed

[44] See www.dvb.org/about_dvb/dvb_worldwide/index.xml

Spain	• Analogue TV switch-off in 2010 • 790 – 862 MHz allocated to mobile broadband services • Migration of broadcasting from 790 – 862 MHz • Auction of licences in July 2011
Sweden	• Analogue TV switch-off in 2007 • 790 – 862 MHz allocated to mobile broadband services • Migration of broadcasting from 790 – 862 MHz • Auction of licences in February 2011
UK	• Analogue TV switch-off in 2012 • 790 – 862 MHz allocated to mobile broadband services • Migration of broadcasting from 790 – 862 MHz • Auction of licences planned in 2012
USA	• Analogue TV switch-off in 2009 • 698 – 806 MHz allocated to mobile broadband services, mobile TV and public safety services • Auction of licences in 2008 and before

Annexes 1 and 2 provide more detailed information on the experience reported by countries in response to a questionnaire sent by ITU in relation to the allocation and implementation of the digital dividend.

6.2 Trends in the licensing process

Licensing of the digital dividend spectrum entails one of the largest spectrum operations for the years to come. Recent decisions have given the opportunity for the introduction of new approaches, related to the specifics of the UHF band.

Particular effort has been made to ensure that the licensing process for the use of the digital dividend by the mobile service is "technology neutral". The first countries assigning mobile licences in these bands, such as Germany, Sweden and the United States, did not stipulate technology standards or services to be deployed.

Although resolving incompatibility issues is not new for spectrum managers, having different 'unknown' systems being deployed in adjacent channels may complicate matters. Especially when due to great economic and political pressure, spectrum is released before all incompatibility issues are fully understood or resolved. In this light, the practical solution of the Swedish regulator (PTS) may prove an effective way for resolving these issues. In the licence conditions it is stipulated that the new licence holders are responsible for resolving interference and have to establish a common entity in which they cooperate to resolve any problems that may occur[45]. A similar approach was followed in the Netherlands when DVB-T was introduced and interference on cable networks was expected. At the time of launching the service the magnitude of this problem could not be accurately estimated and also here an entity was established to resolve any interference problems. A similar discussion is now taking place in Europe on the interference of 800 MHz broadband wireless networks on cable networks[46].

Lifting system or standard requirements can lead to complications and will require careful analysis. Some licence holders might get competitive advantages which may lead to market distortions. This may require

[45] For more details see PTS website: www.pts.se/en-gb/Industry/Radio/Autctions/Licences-in-800-MHz-band/.

[46] For more details see the EU website on the digital dividend, EU workshops on cable interference: http://ec.europa.eu/information_society/policy/ecomm/radio_spectrum/topics/reorg/dividend/index_en.htm.

spectrum managers to revoke spectrum from licence holders[47]. This is a measure with considerable impact and may hamper the objective to interfere as little as possible.

Next to advocating more flexible approaches to spectrum management, also promoting more economic incentives for assigning the available spectrum has been discussed and applied over time. Given the focus on the economic value of the digital dividend, market based assignment tools are more and more applied in allocating and assigning the digital dividend. This in contrast whereby spectrum is assigned on the basis of technological considerations (like application type, spectrum efficiency, number of services, etc.).

In recent digital dividend allocations and assignments the following market (or economic value) based instruments have been applied, which are often interrelated:

- auctions;
- economic or administrative incentive pricing;
- licence trading.

Spectrum auctions have been applied for some years. The first spectrum auctions were in New Zealand in the late 1980s, followed by Australia and the USA in 1994. Many countries have since auctioned spectrum including Canada, China/Hong Kong, Nigeria and a large number of European countries (including Belgium, Denmark, Germany, Italy, Netherlands, Switzerland and the United Kingdom). Auctions have raised very large sums of money for governments. For example, the US PCS auctions in 1994-1995 attracted bids of over USD 17 billion, and winning bids in the 3G auction in the UK in 2000 totalled over 22 billion pounds. Although some hefty debates have occurred after these bids, whether these bids would not lead to the 'winners curse' and may force companies into bankruptcy, almost without exception the recent digital dividend licences in the 700/800 MHz bands are all auctioned.

The main advantage of auctions is that they are transparent, relatively simple and return economic value to society. A well designed auction can reduce the risks of the 'winners curse'. The so-called simultaneous open multi-round auction is often applied, also in the latest spectrum auctions in the 700/800 MHz bands.

However, auctions should be applied with careful consideration in particular when licensing bidders from different industries, for example the television and mobile industry. In such a case, market distortions may occur and the results of the auction may be flawed. As the Oliver & Ohlbaum report points out free-to-air television service providers operate a different business model to mobile service providers[48]. The business model of free-to-air television service providers does not reflect consumer but advertiser's value. In addition, their individual bids cannot reflect network effects, that is to say the value of having a complete bouquet of services. A way to resolve such distortions is not to auction service (or technology) neutral licences but licences with service stipulations.

In countries such as the UK, France, Australia and New Zealand, so called 'administrative incentive pricing' (AIP) regimes have been introduced. These pricing regimes are not based on costs but on economic value to make spectrum allocation more flexible and return this economic value to society. For determining the economic value of licences (i.e. the licence fee to be paid each period) complex models are used based on principles of 'next-best-alternative' or opportunity pricing.

Finally, trading of licences is also already applied in some countries and again in the UK, Ofcom intends to allow trading of the 800 MHz licences. Setting trading conditions can be complex[49] and can be closely related to other licence conditions. With trading licences the spectrum manager try to reduce its interference in the market and the question arises whether an oversight of this trading is necessary (i.e.

47 See the current debate between Ofcom and two incumbent licence holders Vodafone and O2 about revoking a part of their spectrum rights in the 900 MHz band.

48 Oliver & Ohlbaum report, The Effects of a Market-Based Approach to Spectrum Management of UHF and the Impact on Digital Terrestrial Broadcasting, dated 27 February 2008.

49 Many variants are possible, like total, partial and concurrent transfer of (parts of) the licence.

the spectrum manager should check the trade). For example is the new licence holder capable or qualified to comply with the spectrum licence conditions. Also hoarding could be a risk. When a licence holder does not use the spectrum the licensee should return the licence (or a part of the rights). To avoid competitors to enter the market, the incumbent licence holder could decide to sell to a 'related' party.

Clearly, the above discussion shows that spectrum managers should carefully incorporate new spectrum management approaches in the design of digital dividend allocation and assignment procedures and should not underestimate the effort required.

6.3 Benchmarking on spectrum valuation

When allocating the digital dividend, economic, social, educational and cultural values of spectrum usage need to be evaluated carefully, in particular when considering the following choices:

- Exclusive spectrum allocations for specific services or users. For example the decision to set aside a part of the digital dividend for television broadcasting (for example for HDTV). Insight in the value (both economic and social/cultural) will help to justify such a decision. Allocating spectrum for specific services will always imply denying spectrum access for others services and/or users.
- Use of auctions for spectrum licensing. When auctioning spectrum it is common that a minimum bid price is determined. In the light of possible migration costs (e.g. example to migrate the wireless microphone band) and cost for resolving harmful interference (e.g. wireless broadband on cable networks), the minimum price and like bidding prices are important to establish as the auction proceeds are (partly) to cover these costs.
- Impose a market based or administrative incentive pricing (AIP) fee on spectrum licence holders. Assessing the value of the licence is then important as a too low fee will not result in more spectrum efficient and reversely a fee to high might result in financial problems for the licence holder.

From the above list it can be concluded that it is not always necessary to put a value to spectrum bands. For example, a country may decide to follow the EU recommendation and allocate the 800 MHz band for wireless broadband services (for reasons of spectrum harmonization) and assign the spectrum on the basis of a public tender.

When spectrum valuations still need to be carried out, they should also use a benchmarking approach to come to a value or to validate their own valuation (on the basis of economic /cash flow models). For example the recent in the US and Germany, the 700/800 MHz auctions delivered the actual market value for these bands. However careful consideration should be given to the specifics of those auctions. One should compare geographical size /population of the country/coverage area, licence conditions, number of competitors, legal framework etc.

Basically two different types of value categories can be distinguished:

- <u>Economic value (also referred to as private value which comprises the consumer and producer surplus):</u> the value end-consumers place on the services minus the costs of producing this service. This also includes migration or spectrum re-farming costs and cost to avoid harmful interference.
- <u>Social, educational and cultural value (also referred to as external value):</u> the value of a service which groups of people attach to it and which cannot be directly expressed in financial terms.

6.3.1 Economic value

In section 2.5.2 of this report some economic valuations of the digital dividend spectrum have been provided. Spectrum managers building their own economic valuation models may base their model on incremental value or 'next-best-alternative' value. This value is the value generated by a service from using spectrum in the 470-862 MHz band over and above the value that would be realized if the service was provided by alternative means (i.e. the next best alternative). Please note that the incremental value may also include the value of having more competition and hence lower end-consumers prices and/or better quality. It is evident that quantifying such 'competition' value is difficult.

If the service can only be provided by the digital dividend spectrum the value would include all benefits (less costs) associated with the service. This seems highly unlikely as there are (almost) always alternatives available. For example in the case of the digital dividend HDTV services could be delivered through other platforms than the terrestrial platform (e.g. cable, IPTV networks or even the open Internet). This also applies for wireless broadband services. Mobile network operators can use other spectrum than the 470-862 MHz band.

Incremental valuation models are very often complex and can be debated. This is because of several reasons, including:

- difficulty in determining what a next-best-alternative is with comparable services and/or levels;
- high speed of technological innovation (see for example the impact of having the DVB-T2 standard available);
- existence of alternatives in the same spectrum band (470-862 MHz) that the spectrum manager is trying to value.

An alternative valuation approach is a straightforward discounted cash flow method. However, such models also suffer some of the same disadvantages as the incremental models. For example, technological innovation may result in unforeseen competition and hence market shares or churn figures in the model are too optimistic. These models also require a profound and detailed knowledge of the business (e.g. service packages, prices, Capex, Opex, etc.).

If resources and time are available, it is advisable to calculate the value in different ways and compare outcomes. Additionally results can be compared with recent auction results and other international studies.

In any valuation exercise one should consider the costs, not for rolling out the service(s), but also costs imposed on other users of the spectrum. For the digital dividend allocation process the following cost categories are relevant:

- Migration or re-farming costs for broadcast, PMSE and wireless microphone channels. Most evident is the clearing of the 800 MHz band for wireless broadband services. In countries like Spain and the Netherlands, incumbent digital terrestrial television operators have to migrate one of more channels in their network. Costs may then be incurred for:
  - retuning and re-allocating transmitters/sites;
  - loss of revenue due to smaller coverage areas (replacement channels have to be found in highly congested bands which may result in restrictions and hence coverage losses);
  - marketing and client support costs for informing clients to retune receivers and possibly antenna installations.
- Costs for avoiding or limiting harmful interference on cable and digital terrestrial television networks. For the latter generally four possible methods have been suggested[50]: filtering of (new) digital terrestrial television receiver, polarization discrimination between mobile and broadcasting transmitter antennas, on channel repeaters on the base stations of the mobile network and improved on-block/out-block masks. Apart from that the first solution does not deal with the large installed base of digital terrestrial television receivers, most of them are costly and have industry wide impact. Also it is not known yet to what extent these solutions

[50] See EBU workshop on the digital dividend, October 2010, Ofcom presentation on "Considerations related to the licensing of the 800 MHz band in the UK".

will suffice. In summary, these costs could be substantial and should be included in valuing the spectrum.

6.3.2 Social, educational and cultural value

The social and cultural value is a value that is not directly reflected in the value of the service to consumers or end-users. The social, educational and cultural value is also referred to as the external value. Several source of external value can be identified[51]:

- educated citizens;
- informed democracy;
- cultural understanding;
- belonging to a community;
- access and inclusion;
- quality of life.

It may be evident from the above list that these sources are interrelated and are difficult to quantify. Especially given that also here the availability of alternatives should be considered (i.e. incremental value). It may be clear that valuing these sources and taking (spectrum allocation) decisions upon this value will require political involvement and endorsement. Services with a highly perceived social and cultural value may be 'classified' as universal services or be included in the task portfolio of a public entity (for example a public broadcaster).

For the digital dividend allocation two services are generally perceived as being most strongly associated with social, educational and cultural value:

- Television and in particular public broadcasting and regional/local television. Clearly, the latter would not be able to bid high prices in a spectrum auction (e.g. because their advertising income is limited) and is in that sense dependent on its social value. This may be the very reason why people attach a high social and cultural value to it.
- Broadband access in rural areas. Like telephony or television, governments are considering more and more (broadband) access to the Internet as crucial in people's social inclusion and educational development. In this light it is understandable that spectrum managers include roll-out obligations in the wireless broadband licences.

Figure 6-1 provides an example of an evaluation of the different sources of external value associated to the digital dividend.

[51] Analysys Mason report for the European Commission, "Exploiting the digital dividend – a European approach", dated 14 August 2009, p184.

Figure 6-1: Evaluation of sources of external value associated with the digital dividend[52]

	Citizen education	Cultural exchange	Social inclusion	Sustainable development	Regional development	Health public services	Competitive advantage	R&D
DTT	√√	√√	√	√	√√	√	√√√	√√
Mobile TV	√√	√	√	√	√	√	√	√
Wireless broadband	√√√	√√√	√√√	√√	√√√	√√√	√√√	√√√

Note: indicative assessment only.

Extent of social value is rated between zero and three ticks, where zero = negligible or no value; √√√= significant positive social value

Source: European Commission

Table 6-3 attempts to benchmark the results of recent licensing processes of the digital dividend bands to the mobile service. It shows that all licences involve coverage obligations to ensure that the digital dividend bands are used to reduce the digital divide within the corresponding countries. It also gives an indication of how the obligation to protect broadcasting in adjacent bands may impact the value of spectrum for mobile (in the case of the French and Spanish processes, a 25 per cent discount may be observed).

[52] Analysys Mason report for the European Commission, "Exploiting the digital dividend – a European approach", dated 14 August 2009.

Table 6-3: Benchmarking of recent licensing processes for the use of the digital dividend bands by the mobile service

Digital Dividend spectrum allocations	USA	Germany	Sweden	Spain	France	Italy	Switzerland
Frequency bands considered in the same process	**700 MHz (698–787 MHz)**	**800 MHz, 1.8 GHz, 1.9/2.1 GHz & 2.6 GHz**	**800 MHz**	**800 MHz, 900 MHz & 2.6 GHz**	**800 MHz**	**800 MHz, 1.8 GHz, 2.0 GHz & 2.6 GHz**	**800, 900 MHz 1.8 GHz, 2.1 & 2.6 GHz (FDD & TDD)**
Date of licensing decision	24/1/2003-3/2/2012	12/10/2009	4/3/2011	May 2012	17/01/2012	18/05/2011	May 2012
Licence duration	10 years	**15 years**	25 years	Until 31 December 2030	20 years	17 years	12-16 years. Until 31.12.2028
Type of licensing process	Auction	Auction	Auction	Auction	Auction + weighted commitments	Auction	Auction
Packaging of DD band	Three 2x6 MHz, one 2x11 MHz, and two unpaired 6 MHz blocks = 70 MHz	3x2x10 MHz = 60 MHz	6x(2x5) MHz = 60 MHz	6x(2x5 MHz)= 60 MHz	3 blocks of 2x10 MHz = 60 MHz	6 blocks of 2x5 MHz	Each of the 3 bidders (Orange, Sunrise, Swisscom) won a package of 2 x 10 MHz.
Amount raised for DD band	**19.1 GUSD** (Sum of net bids in auctions 44, 49, 60, 73, and 92)	**1.212 GEUR** **1.210 GEUR** **1.154 GEUR** **Total 3.576 GEUR**	2054 MSEK **(220 MEUR)**	3 operators got two blocks of 2x5 MHz each. For each block of 2x5 MHz: 170 MEUR 221.9 MEUR 230.0 MEUR 226.3 MEUR 228.5 MEUR 228.5 MEUR **Total 1.305 MEUR**	3 operators got one block each: 683 MEUR 891 MEUR 1065 MEUR **Total 2.639 GEUR**	3 operators got 2 blocks each: 978 MEUR 992 MEUR 992 MEUR **Total 2.96 GEUR**	N/A (During the auction, bidders could bid on different packages consisting of frequency blocks in different bands. Therefore the prices are per package)

Digital Dividend spectrum allocations	USA	Germany	Sweden	Spain	France	Italy	Switzerland
Amount raised /MHz/population	0.98 USD	0.73 EUR	0.39 EUR	0.48 EUR	0.70 EUR	0.82 EUR	N/A
Coverage obligations	Three types: 1. Economic area (EA) 2. Cellular market area (CMA) 3. Regional economic area groupings (REAGs) CMA & EA: 35% coverage within 4 years of end of DTV transition. 70% coverage at end of licence term. REAG: coverage based on EA; 40% of population in each EA within 4 years and 75% by end of licence term.	For 800 MHz Band: List of municipalities per federal state. Priority class system: P1: pop <5k P2: pop 5-20k P3: pop 20-50k P4: pop >50k Staged rollout. P1 areas must be covered first at 90%, before moving to next priority stage areas and so on. The last areas, P4, must be covered at 90% by 2016. Total population coverage must be 50% by January 2016.	Priority to a list of households without broadband connection. To be reviewed annually. SEK 300 million of auctions proceeds comprise bids for coverage and the licence holder that has won the frequency block FDD6 shall use this sum to cover those permanent homes and fixed places of business that lack broadband.	Operators who have been awarded 2x10 MHz in the 800 MHz band (Telefónica, Vodafone and France Telecom), will have to fulfil, altogether and before January the 1st of 2020, a coverage of at least 90% inhabitants of towns with less than 5 000 people with at least 30Mbit/s speed (considering offers with other technologies or in other frequency bands).	98% /99.6% population after 12/15 years + 40%/90% of priority population after 5/10 years + 90% of population of each *département* after 12 years + (optional but weighted in selection process) 95% of population of each *département* after 15 years	For each region, five lists of municipalities with less than 3000 inhabitants have been formed; each list was associated to one spectrum lot (2x5MHz) (the first lot, the lower, assigned as specific lot, has not coverage obligations associated); the list are formed by uniform rotation of municipalities ordered by population. The coverage obligations are: 30% of the municipalities included in the lists associated to the assigned spectrum lots within three years, 75% within five years. the commercial launch (retail or wholesale) of broadband service must start within three years. a new entrant is allowed two additional years to reach the same objectives. Coverage obligations can also be fulfilled using frequencies in other bands. In this case the switch to 800 MHz frequency of municipalities covered with	General obligation regarding utilisation: the licensee is obliged to use the allocated frequencies as set out in Article 1 TCA and to provide commercial telecommunications services over its own transmission and reception units. In addition, licensees who have the right to use frequencies in the 800 MHz band are obliged to ensure coverage of 50% of the population of Switzerland with mobile radio services via their own infrastructure by 31 December 2018 at the latest

Digital Dividend spectrum allocations	USA	Germany	Sweden	Spain	France	Italy	Switzerland
						different frequencies, should be at least 50% of the obligations in 7 years and completed in 10 years.	
Additional obligations	Open platform requirement on the 2x11 licence	For all bands: Obligation to apply for site specific technical radio parameters for every base station before bringing into operation.	Obligation placed to only one licence in 800 MHz to provide a minimum broadband service of 1Mbps to the priority list. Obligation to not cause interference to reception of terrestrial broadcasting (according to definition in licence conditions)	Obligation to protect broadcasting in lower adjacent band	Obligations on infrastructure sharing, opening to MVNO and roaming. Obligation to protect broadcasting in lower adjacent band by stringent out-of-band power limitations on base stations, provision of impact studies and by "taking all necessary measures to restore previously existing broadcasting services if interference occurs"	Obligation to accept any reasonable request of access by third parties on commercial terms after 5 years in areas where frequencies have not been used. Obligation to offer national roaming to new entrants Obligation to site sharing on commercial and reciprocal terms for at least 5 years Obligation to use all mitigation and coordination techniques, standards, methods and best practices for protecting broadcasters. Administration reserves to intervene in case of persistent problems in a justified and proportionate way	none
Other obligations				Additional annual fee for spectrum use: 7.76 MEUR per year for a block of 2 x 5 MHz,, applicable from effective use of spectrum (before 1st January 2015))	Additional annual fee for spectrum use: 1% of annual income every year.	Obligation to publish and maintain for at least 5 years a data offer where no traffic management technique is introduced	none

7. Use of television white spaces

The so-called *white spaces* are the portions of spectrum left unused by broadcasting, also referred to as interleaved spectrum. They may be used by other services on a secondary basis, i.e. on the condition of not disrupting broadcasting services and not claiming protection from them. This has been the case until now for short range applications ancillary to broadcasting, such as wireless microphones used in theatres or during public events, smart grid/telemetry, video surveillance, broadband and enhanced location services.

Because the white spaces are not directly a result of the transition to digital broadcasting and already exist (probably in larger quantities) within the spectrum used by analogue broadcasting, they cannot be considered as part of the digital dividend. They constitute however a potential reserve of spectrum that may be allocated and therefore merits consideration when addressing digital dividend decisions.

The non-protection/non-interference nature of the use of white spaces makes their availability greatly dependent on time and location:

- in time, because of possible changes in the frequency plan used by broadcasting, in particular as a result of the allocation of the digital dividend;
- in location, depending on local and regional usage of the band by broadcasting.

The number and extent of the white spaces is higher in analogue television broadcasting as compared to digital television broadcasting because digital TV stations are in general more densely planned. Moreover, in countries using analogue TV system G/PAL, there is a 1 MHz gap on top of each UHF channel.

White spaces in the VHF and UHF broadcasting bands are often used for services ancillary to broadcasting or programme making (SAB/SAP), also referred to as programme making and special events (PMSE) services.

A new approach to the use of white spaces is cognitive radio, which consists in obtaining information about the spectrum usable locally before transmitting. On the basis of this information, the system dynamically adjusts its operational parameters. This adjustment can be performed through sensing techniques or a geo-location database.

The protection of existing services from interference from applications using cognitive radio systems, especially from the dynamic spectrum access capability of these systems, is of great importance. In addition, these systems should not adversely affect other services in the same band with the same or higher status in the ITU Radio Regulations. This section gives the status of compatibility studies in ITU, Europe and the USA.

ITU

WRC-12 concluded that no changes in the ITU Radio Regulations are necessary to accommodate cognitive radio systems (CRS). Studies are continuing however, within the ITU-R sector, to further investigate the implementation and use of CRS in relevant radiocommunication services to ensure that this remains in accordance with the ITU Radio Regulations. The introduction of CRS is also a challenge in term of spectrum monitoring and this issue is also under study within ITU-R.

Europe

The regulators in Europe, including CEPT and European Commission, are working on the technical and regulatory conditions that would enable introduction of cognitive radios in the UHF TV white spaces.

ECC report 159 [53] provides technical and operational requirements for cognitive radio systems in the white spaces of the frequency band 470-790 MHz in order to ensure the protection of the digital broadcasting, PMSE services, Radio Astronomy in the 608-614 MHz, Aeronautical Radio navigation 645-790 MHz and Mobile and Fixed services in bands adjacent to the band 470-790 MHz.

With regard to the protection of broadcasting the conclusion is:

"The sensing technique investigated, if employed by a stand-alone white space device (autonomous operation), does not to be reliable enough to guarantee protection of nearby digital terrestrial television receivers using the same channel. Therefore, the use of a geo-location and to avoid possible interference to digital terrestrial television receivers appears to be the most feasible option. In addition it is concluded that in cases where the use of a geo-location database can provide sufficient protection to the broadcast service, sensing is not required. There may be some potential benefit in using a combination of sensing and geo-location database to provide adequate protection to digital terrestrial television receivers but these benefits would need to be further considered".

USA

In the USA, the FCC decided in October 2008 to authorize white space devices in the television band on a licence-exempt basis, with two types of devices: portable/mobile low power devices and fixed outdoor high power devices. The use of a geo-location database is made mandatory, at least in the first phase of introduction.

The FCC ruling to appoint ten 'white space' database administrators, is a clear step towards utilizing flexible spectrum management tools in allocating the interleaved spectrum (or 'white spaces') in the television bands[54]. The FCC allows 'white space' devices (i.e. 'WiFi-like' devices that seek an available channel without causing interference) to operate in the television bands.

To prevent interference to incumbent and authorized users of the television bands, 'white space' devices must include a geo-location capability and the capability to access a database that identifies incumbent users entitled to interference protection, including, for example, full power and low power television stations and broadcast auxiliary point-to-point facilities. This usage information should be collected, stored and managed in a database. This is a task that the FCC has now outsourced to these white space database administrators (Comsearch, Frequency Finder, Google, KB Enterprises LLC and LS Telcom, Key Bridge Global LLC, Neustar, Spectrum Bridge, Telcordia Technologies, and WSdb LLC).

8. Conclusions

The use of radio frequency spectrum for different services and applications for all citizens has a social and economic impact for a country. It is therefore a public choice and often implies highly political discussions.

WRC-07 and WRC-12 decisions provide a major opportunity to national spectrum decision makers to bridge the digital divide by allocating part of the *digital dividend* to the mobile service. International harmonization is already well advanced in this regard and should quickly ensure the availability of low cost equipment for broadband mobile access in the corresponding parts of the UHF bands.

In order to ensure rapid and optimum benefit from these decisions, the regulatory environment needs to be organised to address jointly the planning of the *digital dividend* and the planning of *analogue switch-off* and *digital switchover*.

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[53] ECC Report 159 Technical and operational requirements for the possible operation of cognitive radio systems in the 'white spaces' of the frequency band 470 – 790 MHz, January 2011.

[54] See FCC publication in the Matter of Unlicenced Operation in the TV Broadcast Bands and Additional Spectrum for Unlicenced Devices Below 900 MHz and in the 3 GHz Band, DA-11-131, dated 26 January 2011.

Moreover, for the purpose of achieving a successful transition to digital terrestrial television and to successfully implement the digital dividend, the following aspects need to be considered as essential pre-requisites:

- planning and coordination processes to cover legal and regulatory measures for the migration to digital networks;
- the harmonised allocation of the *digital dividend* spectrum; and
- the integration of all the relevant stakeholders into the process.

This process should also heavily rely on regional harmonization and cross-border coordination negotiations.

Efforts should be undertaken as soon as possible to avoid the need for costly re-organization and repair work and potential disruptions later on.

ANNEX 1 – Countries experiences in relation to the allocation and implementation of the digital dividend – Germany

1 Legislative framework

What is the general legislative framework (and resulting institutional organization/distribution of responsibilities) for spectrum management and what were the modifications made to this framework in order to take or facilitate the decisions on digital dividend?

The political background of the implementation of digital dividend in Germany is the Federal Government´s broadband strategy: the 800 MHz band shall be used promptly to provide sparsely populated areas with innovative mobile applications and broadband internet access. At that point, approximately 2.5 million households in Germany were not provided with an internet access with a minimum of 1 Mbit/s. The original idea can be sketched as follows:

- no later than the end of 2010, efficient broadcasting connections should be available throughout Germany;
- no later than 2014, 75 per cent of the households, until 2018 for all households connections with at least 50 Mbit/s should be available
- answers to current available dynamic demands due to improved offers;
- high-speed radiocommunication high power networks; in addition further construction/expansion of wired high power networks as well as in seemingly non lucrative areas;
- goal to be achieved with "mixed resources".[55]

The general legislative framework for spectrum management in Germany is dealt with at the following levels:

- **Constitution (German Basic Constitutional Law):**

  At constitutional level, the German Basic Constitutional Law gives competence to the German Federal States for legislation as well as for putting laws into execution in general. Exceptions from this as a competence of the Federal Republic have to be mentioned explicitly in the German Basic Constitutional Law. This is done for the whole field of telecommunications and hence for frequency regulation and frequency management as well, by an explicit provision stating that the Federal Republic has to establish a telecommunication administration. Thus, for the underlying telecommunication service no responsibility is given to the German Federal States.

  The situation is completely different for the regulatory competence for the content. No explicit provision is given in the German Basic Constitutional Law. Thus, the German Federal States are in charge of legislation as well as putting into execution (regulation) to the full extent on this field.

  No modification has been necessary, and no modifications have been made on this level to take or to facilitate the decisions on digital dividend.

- **Telecommunications Act**

  The Telecommunications Act gives competence to the Federal Ministry of Economics to set ordinances on the national Frequency Band Allocation and the way to set a Frequency Usage Plan and to the Federal Network Agency to assign frequencies (see section 2 regulatory

[55] Broadband atlas, www.zukunft-breitband.de

framework). Whenever matters concerning broadcasting could be touched, the German Federal States gain influence on decisions to be taken. For the national frequency allocation table the German Bundesrat has to be asked for their agreement, and for the Frequency Usage Plan this holds for relevant authorities of the German Federal States. The assignment of frequencies for broadcasting within the jurisdiction of the German Federal States requires consultation with the state authority with competence, based on the broadcasting regulations.

No modification has been necessary, and no modifications have been made on this level to take or to facilitate the decisions on digital dividend.

2 Regulatory framework

What is the general regulatory framework for spectrum management and what were the modifications made to it in order to take or facilitate decisions on digital dividend?

The general regulatory framework for spectrum management in Germany is dealt with at the following levels:

- **Ordinance on Frequency Band Allocation**

  For the frequency band 790 MHz to 862 MHz, a new national usage regulation was added. It was stated that this frequency band has to be used for mobile broadband internet access. The highest priority is seen in closing the gaps of an adequate service provision in rural countries. Consultation with the German Federal States is needed. The mobile service in the frequency band 790 MHz to 862 MHz must not interfere with the broadcasting service. Modifications had to be agreed by the German Bundesrat.

- **Frequency Usage Plan**

  For the frequency band 790 MHz to 862 MHz, a systematic entry for the new type of mobile service was made.

  Modifications had to be implemented for the use of wireless microphones as well. Formerly authorized in all the frequency band 470 – 862 MHz, their operation will mainly be restricted to the frequency band 470 MHz – 790 MHz, step by step. In accordance with CEPT recommendations, substituting capacity for their operation had been identified, e. g. in the 1.8 GHz band or in the FDD duplex gap 823 – 832 MHz.

- **Frequency assignments**

  Broadcasting transmitters being operated on channels 64, 65 or 66 had to be re-channelled. Frequency assignments for their operation had to be modified.

  The assignment of frequencies for the mobile service in the band 790 MHz to 862 MHz had to be based on several steps to be taken by the Federal Network Agency. Main steps had to be decided by the ‘President´s Chamber’ in a transparent process.

  Frequency assignments for regular operation of base stations of the mobile service in the frequency band 790 MHz to 862 MHz in accordance with the legislative framework mentioned above have been granted starting from November 2010.

3 Allocation of the digital dividend

Given the above legislative and regulatory framework, how was the allocation of digital dividend made in your country?

The key element of allocation of the digital dividend was the accelerated switchover from analogue to digital terrestrial TV. In advance of allocating spectrum, first it had to be freed from analogue usage. In practice this process started in 2002, based on a regional approach. At the beginning it was felt that some simulcast phase was needed. Nine months of simulcast were foreseen in the first regions where the switchover was done. Learning from the experience, this period was melted down region by region, because better communications and information in advance of the switchover were found more helpful. In the end of the transition, some regions were switched-over without any simulcast phase.

In parallel to freeing parts of the spectrum, an overall concept for a more flexible use of spectrum was developed, which can be sketched as follows:

- liberalisation of existing licences at 450 MHz (wideband trunked radio [PAMR]), 900/1800 MHz (GSM), 2 GHz (IMT/UMTS) and 3.5 GHz (BWA) as quickly as possible (decision published 21/10/2010);
- award of approximately 360 MHz of spectrum (decision published 21/10/2009);
- combining award at 1.8/2/2.6 GHz with award at 800 MHz;
- spectrum auction (conducted in April/May 2010);
- technology and service neutrality for Electronic Communications Services (ECS); can be used for mobile, fixed or nomadic systems or applications);
- spectrum cap in the band 800 MHz (2 x 20 MHz, paired).

The main formal steps for the allocation of digital dividend in Germany had to be done in connection with the actions and modifications mentioned in section 2 of this annex (regulatory framework), especially on the levels of the ordinance on Frequency Band Allocation and of the Frequency Usage Plan. Supporting action had to be taken on the level of frequency assignments as well, which therefore is described here, too.

- **Ordinance on Frequency Band Allocation**

  The Federal Minister of Economics had to amend the existing ordinance on Frequency Band Allocation. After consultation within the Federal Government, the draft new ordinance was forwarded to the German Bundesrat, because an agreement from this institution was needed. After intense considerations, the German Bundesrat gave their agreement on 12June 2009.

- **Frequency Usage Plan**

  For the frequency band 790-862 MHz, a systematic entry for the new type of mobile service was made.

  Modifications had to be implemented for the use of wireless microphones as well, as described in section 2 of this annex (regulatory framework). To this effect, the legal process for modifications to the Frequency Usage Plan had to be started, once the Ordinance on Frequency Band Allocation had been amended. This process contains steps of consultations as well as steps of agreements by relevant authorities on the level of the Federal Republic and on the level of the German Federal States. Subsequently to the successful modification of the Ordinance on Frequency Band Allocation, agreements were achieved in due time. On 21 October 2009, the relevant modifications to the Frequency Usage Plan were made public in the Federal Law Gazette and in the official gazette of the Federal Network Agency.

- **Frequency assignments**

  The assignment of frequencies for the mobile service in the band 790-862 MHz had to be based on several steps to be taken by the Federal Network Agency. Main steps had to be decided by the so-called President´s Chamber in a transparent process. Consultations had to be conducted or decisions had to be taken on:

  - combining the award of spectrum at 800 MHz with 1.8 / 2 / 2.6 GHz;
  - the auction rules;
  - the award conditions;
  - consultations on award at 1.8 / 2 / 2.6 GHz;

– the order for an award.

Further on, the abstract frequency blocks won were to be allotted to their highest bidders at the end of the auction with a view to assigning contiguous spectrum. The successful bidders had the opportunity to agree amongst themselves, within a period of three month of the close of the auction, the spectral position of their blocks in the particular frequency band. Since an agreement between the successful bidders was not reached within this period, BNetzA concentrated initially on the aspect of assigning contiguous spectrum and allotted the abstract blocks won in the bands at 800 MHz and 2.6 GHz. Based on this, frequency assignments were processed for the use of the frequency blocks.

The approvals of individual sets of technical characteristics for regular operation of base stations of the mobile service in the frequency band 790 MHz to 862 MHz in accordance with the legislative framework mentioned above have been granted starting from November 2010.

Eleven broadcasting transmitters, being operated on channels 64, 65 or 66, had to be re-channelled. Frequency assignments for their operation were modified in the course of the year 2010, in the context of auctioning the frequency band 790-862 MHz in April/May 2010. The operational switchover for those broadcasting transmitters, thus practically freeing the band 790 MHz to 862 MHz from broadcasting, was finalized by 31October 2010.

4 International coordination/harmonization

What were the measures taken at international level that have played a role in the decision on digital dividend at national level?

What measures have been taken at international level to ensure that the digital dividend allocation and use can be made in your country?

Germany has played an active role in all international activities addressing the use of the 800 MHz for mobile services on all international levels dealing with that issue. Since sustainable progress can only be made in a transparent and fair manner, facilitating international coordination and harmonization while applying an equitable access has been the basic idea and principle throughout this process. Examples to be mentioned are:

- The GE06 Agreement provides a large amount of flexibility to implement broadcasting networks, provided certain thresholds are kept.
- Following mandates from the European Commission, the CEPT investigated the technical framework of the implementation of the digital dividend, including aspects like the identification of an appropriate frequency band in compliance with the difficult demands for remaining broadcasting in different countries, interference issues, mitigation techniques.
- WRC-07 co-allocated spectrum to the broadcasting and mobile services. For Region 1 this was done to the extent identified during the above-mentioned activities of CEPT.
- Within EC the benefits of a harmonized approach have been discussed and identified. Limitations in harmonizing the timeframe have also been identified. To improve the situation, several activities have been started, so as to encourage administrations in taking efforts appropriate to the individual economical and technical situation, e. g. in terms of coordination.
- There are several examples of multilateral initiatives to ease the frequency coordination issues carried out by their member countries with a view to implementing the digital dividend, e.g. Western European Digital Dividend Implementation Platform (“WEDDIP” group), created in May 2009 by the administrations of the following countries: Belgium, France, Germany, Ireland, Luxembourg, the Netherlands, Switzerland, and the United Kingdom. There is also in initiative by a group of central European countries known as the North-Eastern Digital Dividend Implementation Forum (“NEDDIF” group; Czech Republic, Estonia, Finland, Germany, Hungary,

Latvia, Lithuania, Poland, and the Slovak Republic), created in October 2010, amongst others with the objective to ease the cross-border coordination with non-EU countries.

More specifically, these groups aim at achieving mutual compatibility of the spectrum resources to be used in the implementation of the digital dividend in each country, for broadcasting and mobile services and also for other services, where needed. Eventually, this should facilitate any consequential modifications to the GE06 Plan, while respecting the principle of equitable access to spectrum resources in border areas. These groups are also useful for sharing experiences and best practices concerning the implementation of the digital dividend among their members (use of Channel 60, DVB-T2 etc.).

5 Supporting measures

What measures (technical, regulatory, financial) have been taken to ensure that the impact of the digital dividend decision on the broadcasting service/other allocated services is accepted by the population/stakeholders?

On a regulatory and technical level, the main issues in the process of acceptation have turned out to be:

- **Compatibility issues between mobile and broadcasting services,**

With its roll-out, the mobile service has to protect broadcasting. This was already settled in the basic decisions of the President´s Chamber. But it had to be accompanied by additional measures. In the context of the compatibility issues between mobile and broadcasting services, Germany has applied a three-step-approach:

1. definition of Block Edge Mask in advance (see-above) in order to have a framework for the further-on construction of devices, in accordance with the European Commission's Decision on harmonized technical conditions of use in the 800 MHz band,
2. definition of sets of technical characteristics for mobile base stations to be done individually per station, after the auction, but in advance of each single use of a station, and
3. corrective steps in case of unforeseen problems, e. g. interference occurring from the operation of a station.

Step 2 and step 3 are on-going while the roll-out of the mobile networks is being processed.

- **Compatibility issues between mobile and PMSE**

In principle, there is no legal basis for claiming protection for PMSE. However, due to its great meaning for cultural background, the political interest is huge. Therefore, on the regulatory and technical level frequency allocation issues had to be solved by a new concept for PMSE.

At political level, in addition to the efforts mentioned above, a compensation for necessary replacements of equipment had to be defined. The agreement to the mentioned amendments of ordinances, given by the German Bundesrat, was based on the approval by the Federal Government to refund:

- for necessary measures taken by broadcasters, and
- for necessary measures taken by PMSE-users.

While the necessity of taking a measure in the broadcasting field can easily be derived from regulatory measures like re-channelling, for PMSE it has to be taken into account that interference must not occur during a play in the theatre or during a performance on an event. This means, the necessity of exchanging the PMSE-equipment has to be assessed from the moment of establishing a transmitter site already. Responsibilities in this have already been distributed, and negotiations on the detailed conditions like lump approaches for refunding are going on.

- **Compatibility issues between use in Germany and use in adjacent countries.**

Concerning this issue, on the long run, a harmonized approach is preferred. Short-term problems have to be solved on a bilateral basis. The approach in this context can be described as "common tackling of common issues".

6. Licensing process and conditions

What are the conditions and the process of licensing for the use of the digital dividend? In particular in respect of:

– coverage of the territory (reduction of the digital divide),

– protection of broadcasting in adjacent frequencies.

In licensing for the use of the digital dividend there have been the following major formal steps:

- the auction, from which the outcome was the spectrum award in terms of an amount of spectrum (abstract frequency blocks),
- the procedure of allotting the abstract frequency blocks won to their highest bidders at the end of the auction with a view to assigning contiguous spectrum, which had to be done by the Federal Network Agency, since the bidders had failed to agree amongst themselves, within a period of three month of the close of the auction,
- the formal assignment of frequencies, indicating the concrete frequency block per bidder and referring to the conditions published in advance of the auction,
- the approvals of individual sets of technical characteristics for regular operation of base stations of the mobile service in the frequency band 790 MHz to 862 MHz in accordance with the legislative framework, which have steadily been processed starting from November 2010.

The reason for the relevance of the 800 MHz band to be used promptly to provide sparsely populated areas with innovative mobile applications and broadband internet access was the unavailability of a single alternative infrastructure to provide sufficient service in a reasonable timeframe. Thus, the goal was to be achieved with "mixed resources", and the 800 MHz was to play an important role very fast. To comply with the broadband strategy, conditions for the usage of the 800 MHz were formally set with the decision(s) of the President´s Chamber. The idea can be seen from the following:

- Four priority classes are categorized:
  – Priority 1: Towns/villages with less than 5 000 inhabitants;
  – Priority 2: Towns with 5 000 to 20 000 inhabitants;
  – Priority 3: Towns with 20 000 to 50 000 inhabitants;
  – Priority 4: Towns/cities with more than 50 000 inhabitants.
- In terms of these priorities, each Federal State compiled its own list of all areas needing coverage.
- There is a general requirement for each assignee to meet the obligation with 800 MHz spectrum.
- Other technologies are credited (with the exception of satellite).
- The degree of coverage to be met is 90 per cent of the population by 2016.
- Towns of priority 2 may be provided with broadband access based on the usage of frequencies in the 800 MHz band not before a percentage of 90 per cent of towns/villages of priority 1 has been provided with a sufficient broadband access, regardless the technology used. Towns of priority 3 may be provided with broadband access based on the usage of frequencies in the 800 MHz band not before a percentage of 90 per cent of towns of priority 2 has been provided with a sufficient broadband access, regardless the technology used. Towns/cities of priority 4

may be provided with broadband access based on the usage of frequencies in the 800 MHz band not before a percentage of 90 per cent of towns/villages of priority 3 has been provided with a sufficient broadband access, regardless the technology used.

Following the Ordinance on Frequency Band Allocation, the mobile service in the frequency band 790-862 MHz must not interfere with the broadcasting service. This led to provisions in the frequency assignments, giving clear statements that the broadcasting service (and to the necessary extent also its development) has to be protected. According to the three level approach mentioned above, on the technical level the approvals of individual sets of technical characteristics for regular operation of base stations of the mobile service in the frequency band 790 – 862 MHz is the most critical step for the roll-out. To the effect of minimizing the interference potential the Federal Network Agency established a procedure, which applies for each base station individually:

1. Broadcasting reception has to be protected in all relevant reception situations in channels, but only where it occurs. Therefore, starting from channel 60 downwards, the checks mentioned below are done for all channels. Since in practice and from the experience with measurements done no case has come to the knowledge, in which problems below a frequency deviation of more than 72 MHz (i.e. 9 channels below 790 MHz) occurred, this procedure is done downwards including channel 52.
2. Due to the emission restrictions for base stations (especially in the band up to 790 MHz), from a certain distance from the base station on no more harm can be put to a potentially existing relevant reception situation. Relevant reception situations are identified as those following the formal broadcasting demands of the Federal States, which form the legal basis of the implementation of networks. In rural areas, this comprises the stationary reception with roof top antennas. Therefore, in these areas the distance from a base station to the first building to live in is taken into account. In practice, for any distance beyond 1 100 m it is assumed that a base station won´t put any harm to the broadcasting reception.
3. For relevant reception situations within that distance, from the detailed knowledge of the Federal Network Agency of provision of broadcasting service per channel and per region a comparison is done between the field strength of broadcasting and the upper field strength limit to be expected from the emission of the individual base station with its individual set of technical characteristics in the adjacent band. In each case, in which for all relevant reception situations within the mentioned distance from a base station the broadcasting field strength is above a certain threshold, which depends on the distance of the relevant reception situation from the base station, the individual set of technical characteristics for this base station is approved.
4. In any other case, the responsible mobile operator has to provide for appropriate amendments of the planned technical characteristics of the base station and/or additional measures in advance of a re-assessment.

To be able to minimize the necessary efforts to be granted the approvals, the mobile operators are provided with the relevant data of broadcasting transmitters and broadcasting service provision. With that they can predict the results of the assessment to be done by the Federal Network Agency.

7 Other services

White spaces, public safety services, microphones

Due to their high meaning for cultural purposes, provisions for microphones have been crucial for the whole political process in Germany, as already described in more detail above. Due to the frequency allocation and the frequency usage, safety services were not touched. The military service had freed their parts of the usage of the band 790 MHz to 862 MHz as early as 2009.

Concerning white spaces there were some intentions in advance of the harmonized digital dividend. For some regions in certain Federal States it seemed to be attractive to make use of frequencies planned for broadcasting, but not needed for its distribution due to a lack of interest of the private program providers. Tests were made, and equipment was installed for a little number of sites, thus proving for the feasibility. On the other hand it was also foreseeable that the number of user equipment for an unharmonized usage of the band 790-862 MHz would not lead to economies of scale. Therefore, this issue was no longer pursued. From the regulatory point of view, harmonized international efforts to investigate white space usage with new approaches and technologies seem to be promising and are supported.

ANNEX 2 – Countries experiences in relation to the allocation and implementation of the digital dividend – France

1 Legislative framework

What is the general legislative framework (and resulting institutional organization/distribution of responsibilities) for spectrum management and what were the modifications made to this framework in order to take or facilitate the decisions on digital dividend?

The broadcasting sector is regulated by the Broadcasting Act **(***Loi n°86-1067 du 30 septembre 1986 relative à la liberté de communication***/** *Freedom of Communication Act No. 86-1067 of 30 September 1986*[56]**).**

The transition to digital broadcasting and the allocation of the digital dividend has required modifications of the Broadcasting Act. These modifications have taken into consideration the advantages of digitalization, the need to bring these advantages to all the population and the need to reduce the digital divide.

The law of 5 March 2007 contains the main modifications to the Broadcasting Act in relation to the analogue switchover and allocation of the digital dividend. Its main elements are the following:

- Analogue switch-off is to be completed on 30 November 2011 at the latest and for 95 per cent of the population to be covered at this date.
- The frequencies released by terrestrial analogue TV broadcasting switch-off are subject of a transfer by the Prime Minister to the administrations, to the Broadcasting Authority (CSA) and/or to the Regulatory Authority for electronic communications and Post (ARCEP), within the framework of a national plan of re-use of the released frequencies. The law states that « *This plan aims at favouring the diversification of the offers of services, improving overall the territory the digital coverage and the equitable access to the electronic communications networks and developing the efficiency of the radiocommunication access of public utilities and the optimal management of the radio frequency spectrum asset*».
- A committee for the digital dividend**,** which is composed of four members of the Parliament and four members of the Senate appointed by their respective bodies, is established to provide recommendations for the establishment of this Plan after public consultation. These recommendations were published in July 2008.

2 Regulatory framework

What is the general regulatory framework for spectrum management and what were the modifications made to it in order to take or facilitate decisions on digital dividend?

Within the framework described above, the national plan for re-use of the released frequencies was adopted by the Prime Minister in December 2008 and modified in December 2010 to include the specific case of the French overseas departments and communities. This Plan was prepared under the auspices of the Strategic Committee on Digital Transition (*Comité stratégique pour le numérique CSN*), established by the President of the Republic in May 2006 to coordinate and direct national efforts on the development of digital terrestrial broadcasting, analogue switch-off and digital dividend. This committee is chaired by the Prime Minister and composed of all involved institutional actors (ministerial departments, regulatory authorities, ANFR, France Tele Numérique).

[56] English translation- www.legifrance.gouv.fr/html/codes_traduits/libertecom.htm

The main objectives of this plan are:

- *Pursue the development of the offer of Terrestrial digital television, notably by allowing the switchover high definition of existing TV services and the launch of new services, local or national, in the SD, HD modes or in the personal mobile television mode as well as the development of the digital radio.*
- *Improve the coverage of the electronic communications services, in particular by the launch of high data rate internet mobile services over the whole territory…*

As a consequence, the national plan recommends to use of 790-862 MHz band for the mobile service and the harmonization of this sub-band at the European level, and invites the Broadcasting Authority not to use the channels of the sub-band 790-862 MHz in any given region once analogue switch-off has been effected in that region[57].

It is to be noted that launch of digital television in French overseas territories was started later than in metropolitan France, and the standard MPEG4 (SD/HD) with DVB-T has been adopted.

3 Allocation of the digital dividend

Given the above legislative and regulatory framework, how was the allocation of digital dividend made in your country?

On the basis of the recommendations of the committee for the digital dividend, WRC-07 decisions and the national plan described above, the National Frequency Allocation Table was modified in December 2008 by an Order of the Prime Minister allocating (from 1 December 2011) the frequency band 790-862 MHz to the mobile service in metropolitan France. The National Table was revised in December 2010 to address the specific case of the French overseas departments and communities, with the same allocation made to the mobile service in Regions 1 and 3 and the allocation of the band 698-862 MHz to the mobile service in Region 2.

It is worth noting that these revisions to the National Frequency Allocations Table were made following the same formal process as for other frequency allocations decisions: the decision was taken by the Prime Minister, upon proposal by the Board of ANFR, and after consultation with both CSA and ARCEP. The changes introduced by the Law of 5 March 2007 introduced two additional elements in this process: formal consultation of the committee for the digital dividend and prior publication of the national plan for re-use of the released frequencies. This formal process was prepared and coordinated by the strategic committee on digital transition.

4 International coordination/harmonization

What were the measures taken at international level that have played a role in the decision on digital dividend at national level?

What measures have been taken at international level to ensure that the digital dividend allocation and use can be made in your country?

The Geneva 06 Agreement governs the frequency planning the 174-230 MHz band and the 470-862 MHz band.

WRC-07 co-allocated spectrum to the Broadcasting Service and Mobile Service in ITU Region 1, opening the possibility of implementation of mobile public networks.

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[57] *Arrêté du 22 décembre 2008 approuvant le schéma national de réutilisation des fréquences libérées par l'arrêt de la diffusion analogique* www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000019981950

In metropolitan France, frequency planning needs to be coordinated with more than ten European countries. This coordination is considered and managed through bilateral and multilateral meetings.

A special platform, WEDDIP (for Western European Platform for digital dividend implementation), started its activities in September 2009. Administrations represented are: Belgium, France, Germany, Ireland, Luxembourg, the Netherlands, Switzerland, and the UK. It is covering strategic topics related to the implementation of the digital dividend (DD) in the scope of frequency management related issues. Discussing these issues is beneficial for Administrations involved in bilateral negotiations processes. The objectives of the WEDDIP are:

- discuss issues from a strategic perspective;
- exchange views on possible solutions for network requirements;
- sharing plans and ideas on possible approaches for identifying (additional and/or alternative) resources;
- discuss alternative solutions/approaches for the DD implementation;
- discuss background for chosen solutions;
- identify overlapping activities and stumbling blocks;
- facilitate the negotiation processes (with the aim to advise negotiation teams on relevant topics).

For assignments of TV frequencies previously planned in the 790-862 MHz band, the French Administration has taken in consideration ECC Report 142[58] "Rearrangement activities for broadcasting services in order to free the sub-band 790-862 MHz" in particular:

- by modification of modifications of initial requirements of allotment and assignment formulated for the establishment of the Plan,
- by minimizing the interference potential on neighbouring co-channel GE06 Plan entries with lower power transmitters instead of planning one,
- by restricting transmit power in certain directions for broadcasting networks implemented in conformity with the GE06 Plan entries or/and changes in transmitter characteristics (e.r.p., antenna diagram, tilt, etc.) of planned and implemented broadcasting networks interfering towards new requirements,
- by accepting that modifications of GE06 entries involve additional investment costs.

For the planning of the mobile service, European administrations, French Administration practices the recommendations given in the CEPT Report 29[59] "Guideline on cross border coordination issues between mobile services in one country and broadcasting services in another country". This report provides reference field strength trigger values for coordination. The values are derived from the GE06 Agreement.

In order to prepare the technical conditions to be included in the future public tender, measurements have been conducted for evaluating the possible interference between mobile and broadcasting services. A technical study[60], based have on ECC Report 148 "Measurements on the performance of DVB-T receivers in the presence of interference from the Mobile Service (especially from LTE) » has been published and trials been made in cooperation with CSA (Independent Broadcasting Authority) and ARCEP (Independent Telecommunication Authority). The conclusions are, if the potential risks of interferences

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58 www.erodocdb.dk/Docs/doc98/official/pdf/ECCREP142.PDF

59 www.erodocdb.dk/Docs/doc98/official/pdf/CEPTREP029.PDF

60 *Etude sur l'évaluation du risque de brouillage du canal 60 par les stations de base des réseaux mobiles opérant dans la bande 790-862 MHz* www.anfr.fr/fileadmin/mediatheque/documents/etudes/etude_canal_60.pdf

exist, the level of percentage of TV receivers interfered with by mobile base stations are low, urban and suburban areas are the most sensitive. Special measures case by case can solve the difficulties.

Works provided in ITU-R SG 6 and ITU-R JTG 5-6 about studies on the use of the band 790-862 MHz by mobile applications and by primary services are supported in order to improve the frequency planning.

5 Supporting measures

What measures (technical, regulatory, and financial) have been taken to ensure that the impact of the digital dividend decision on the broadcasting service/other allocated services is accepted by the population/stakeholders?

In order to facilitate the transition from analogue to digital and assist in the analogue switch off, financial help has been set up through different funds managed by *France Télé Numérique*[61], a Public-Private Partnership (PPP) between the State and the national analogue TV program providers. Its task is to manage communication campaigns in relation to analogue switch-off operations and manage the above funds[62]. Its duty ends with the deadline of the analogue switch-off.

The first fund provides full financial assistance to limited income households for the purchase of a digital adapter and modification of the antenna system if needed. The second fund is intended to provide technical assistance. The third fund is intended to cover the cost of implementation of alternative reception where digital terrestrial TV is not available as a replacement to analogue terrestrial TV. This fund is used irrespective of household income.

France Télé-Numérique has conducted a national advertising campaign to inform the viewers. This campaign has been successful. Transition to digital and analogue switch-off have been welcome by the population as shown by the Observatory for the Digital TV[63], managed by the Broadcasting Authority (CSA). From the end of the DSO, the population could receive 33 SD programmes and 5 HD national programmes, 19 national free on air TV, 9 national pay TV and local programmes broadcast through 6 multiplexes.

6 Licensing process and conditions

What are the conditions and the process of licensing for the use of the digital dividend? In particular in respect of:

- coverage of the territory (reduction of the digital divide);
- protection of broadcasting in adjacent frequencies.

For the broadcasting service, the use of digital dividend was organised by the legislative framework and detailed in a regulatory framework. After the analogue switch-off on 30 November 2011, a first digital dividend used by six multiplexes came on air and the digital dividend was made available for mobile services At this date, incumbents as analogue broadcasting stations stopped their analogue transmissions or as with defence stations have been relocated in another part of spectrum with the mechanism of the relocation funds[64].

[61] www.tousaunumerique.fr/

[62] www.tousaunumerique.fr/aides/les-aides-financieres/a-propos/

[63] www.csa.fr/infos/observatoire/observatoire.php

[64] www.anfr.fr/fr/planification-international/frs-et-fan/800-mhz-et-2600-mhz.html

After the end of DSO, the broadcasting regulator (*Conseil supérieur de l'audiovisuel*) launched a public tender for new HD TV and six new editors have been named[65]. The contents will be broadcasted over two multiplexes; the national coverage is planned to reach 97 per cent of the population at the end of 2014.

The use of the digital dividend for broadband mobile was open for public tender by an order of the Minister in charge of electronic communications [66] that has adopted the proposals made by ARCEP[67]. The ARCEP is in charge of the procedure for the designation of licensees.

In the 800 MHz band, reserve prices for each block of frequencies were the following:

– EUR 400 million for the block 791 MHz – 801 MHz and 832 MHz – 842 MHz;
– EUR 300 million for the block 801 MHz – 806 MHz and 842 MHz – 847 MHz;
– EUR 300 million for the block 806 MHz – 811 MHz and 847 MHz – 852 MHz;
– EUR 800 million for the block 811 MHz – 821 MHz and 852 MHz – 862 MHz.

The deadline for applications for 800 MHz band was 15 December 2011. The objectives for the use of the 800 MHz band by the high speed data rate mobile were:

– Digital coverage of the territory as a primary target, in application of the Law against the digital divide[68]. Priority areas represent 18 per cent of the metropolitan population and 63 per cent of the territory. In remote areas, mutualisation is encouraged and required for the overages of "white areas", dispositions organised the regulatory framework in order to facilitate negotiations between competitors and implement wideband channels.
– Commitment to open the network to MVNOs.
– Valorisation of the frequencies as public asset of State. Each candidate proposes the amount of money for the use of corresponding to its requirement of frequencies, taking into account the corresponding reserve prices.

This selection model corresponded to a combinatorial single-round sealed bid process with three selection criteria taken into account: frequency valuation, enhanced engagement for local and regional coverage.

The ARCEP Decision n° 2011-0599 of 31 May 2011 provides the technical conditions for the use of frequencies between 790-862 MHz by terrestrial mobile systems[69]. This decision gives information about:

– regulatory and legal framework,
– frequency planning of the band,
– protection of the broadcasting service in the 470-790 MHz band,
– case of frequencies uses at the borders.

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[65] www.csa.fr/Espace-Presse/Communiques-de-presse/Selection-de-six-nouvelles-chaines-en-haute-definition-pour-la-TNT

[66] www.arcep.fr/fileadmin/reprise/textes/arretes/2011/arr140611-modal-attrib-4g.pdf *Arrêté du 14 juin 2011 relatif aux modalités et aux conditions d'attribution d'autorisations d'utilisation de fréquences dans les bandes 800 MHz et 2,6 GHz en France" métropolitaine pour établir et exploiter un système mobile terrestre*

[67] www.arcep.fr/uploads/tx_gsavis/11-0600.pdf *Décision proposant au ministre chargé des communications électroniques les modalités et les conditions d'attribution d'autorisations d'utilisation de fréquences dans la bande 800 MHz en France métropolitaine pour établir et exploiter un réseau radioélectrique mobile ouvert au public.*

[68] *LOI n° 2009-1572 du 17 décembre 2009 relative à la lutte contre la fracture numérique* www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000021490974

[69] www.arcep.fr/uploads/tx_gsavis/11-0599.pdf

These technical conditions are repeated in the licences granted to the operators.

ARCEP licenced the 800 MHz frequencies in January 2012 to three operators[70]. The general budget of State has obtained EUR 2.6 million for the use of frequencies[71].

7 Other services

White spaces, public safety services, microphones

7.1 Existing mobile systems in the UHF band have been moved in another part of the spectrum. The spectrum relocation fund (FRS) has been used to help the migration.

7.2 White spaces, i.e. frequency positions available at a certain place at a certain point of time (or for a certain period), the availability of which is due to different planning assumptions than those for the prevailing service and due to the assumption that interference with different services with higher priority must not occur and no protection can be claimed. At this stage, no decision has been taken to introduce this type of systems; however, from the ANFR's point of view, harmonised international efforts to study white spaces applications and implementations are supported.

7.3 Radio microphones are allowed in the 470-830 MHz band with secondary status (no interference may occur and no protection can be claimed); the increase of use of more TV channels and the introduction of mobile networks are restraining the band to 790 MHz. Improvement in technology and some rechanneling are needed in order to improve the frequency plans.

[70] www.arcep.fr/index.php?id=8571&tx_gsactualite_pi1[uid]=1478&tx_gsactualite_pi1[backID]=1&cHash=ffab4d3723

[71] Ibid.

Appendix A: various auction designs

The table below gives an overview of the advantages and disadvantages of the different types of auction. The table is divided into three parts. In each part the different auction designs are compared with one another.

Table A1. Advantage and disadvantages of the various auction designs

Auction type	Advantages	Disadvantages	Risks	Use if
Dutch Auction	- does not drive up prices	- starting price is difficult to fix - no information about value of product so danger of winner's curse - little allocation efficiency - practically only possible sequentially so no use of synergy	- incorrect starting price can result in no bid or no realistic price - relatively more prone to collusion	- homogeneous products which are not interdependent - product value is known or can be derived from previous auctions - high speed is required - product value is low
Conventional Auction	- Different versions possible (Vickery, multi-round simultaneous, etc.) - easier to set starting price/minimum bid - information about value of product in open auction - more allocation efficiency	- has a greater potential to push up prices (however countermeasures possible such as not bidding on price and limiting the number or rounds	- pushing up prices	- Flexibility is required in the auction design - little information is known about the value of the asset - assets/products are interdependent
Closed/Single round	- more protection against collusion - fast - reduces upward price pressure - simple and hence cheap	- winner's curse - less allocation efficiency - less transparent	- large price differences possible (and with Vickery it can lead to very low prices, embarrassing the Regulator)	- product value is low (other types of auctions are too expensive in relationship to the product value) - there is a large number of products and speed is required - relatively little importance is attached to allocation efficiency - there is deemed to be a high risk on collusion - value of the product is more or less known in the market
Open/multi-round	- less risk of the Winner's curse - higher allocation efficiency - is generally considered as fair (chance to revise bid)	- less protection against collusion - greater risks of pushing up prices - auction can last a long time, depending on the stopping rules - more complex and hence more expensive to organize	- pushing up prices	- allocation efficiency is considered to be important - a fair auction is required, considering the 'public/market opinion' - there is uncertainty about the value of the product

Auction type	Advantages	Disadvantages	Risks	Use if
				- product value is deemed to be high
Sequential	- simple and hence cheap - results in slight upward pressure on prices	- problem with the sequence when there are several products: which products first and in which combinations? - little utilization of synergy (less allocation efficiency if interdependence)	- sequence not correctly set - not seen as `fair' (no opportunity to revise bid)	- no dependency between one product and another - Low product value
Standard simultaneous/ open/multi-round	- high degree of allocation efficiency when products are dependent on one another - less danger of winner's curse - no sequencing problems	- complex but manageable (even with greater number of bidders), but more expensive - complex for bidders - many rules and much preparation necessary - auction can last a very long time depending on activity and stopping rules	- can take a long time - greater chance of errors in how auction is set up because of the many rules needed - pushes up prices	- products are interdependent - product value high
Combination/ open/multi-round	- highest degree of allocation efficiency for interdependent products - analogous to standard simultaneous auction	- the most complex (probably no longer manageable when there are many bidders) and therefore most expensive type of auction - the `free rider' problem as a result of which there is a good chance that only package bidders win	- free rider problem - analogous to standard simultaneous auction	- analogous to standard simultaneous auction

Glossary of abbreviations

3D TV	Three dimensional television
AIP	Administrative Incentive Pricing
APT	Asia-Pacific Telecommunity
AVC	Advanced Video Coding
BEM	Block-Edge Mask
Capex	Capital Expenditure
CEPT	European Conference of Postal and Telecommunications Administrations
CPM	Conference Preparatory Meeting
DSO	Digital Switch Over
DVB-H	Digital Video Broadcasting – Handheld
DVB-T	Digital Video Broadcasting – Terrestrial
DVB-T2	Digital Video Broadcasting – Terrestrial 2^{nd} generation
EBU	European Broadcast Union
ECC	Electronic Communications Committee of CEPT
EDGE	Enhanced Data Rates for GSM Evolution
EPG	Electronic Program Guide
EU	European Union
FCC	Federal Communications Commission
FCFS	First Come First Served
FDD	Frequency Division Duplex
FLO	Forward Link Only
G/PAL	Analogue TV system G with colour system according to the 'Phase Alternating Line' standard
GDP	Gross Domestic Product
GE06	Geneva Agreement of 2006
GSM	Global System for Mobile Communications
HDTV	High Definition Television
Heff	Effective antenna height
HSPA	High Speed Packet Access
ICT	Information and communications technology
IDTV	Integrated Digital Television Set
IMT	International Mobile Telecommunications
IPTV	Internet Protocol Television
ITU	International Telecommunication Union
ITU-R	ITU – Radiocommunication Sector
LTE	Long Term Evolution, often marketed as 4G

LTE+	Long Term Evolution Advanced
Mbps	Megabits
MFN	Multi Frequency Network
MHz	Megahertz
MMS	Multimedia Messaging Service
MP3	MPEG-1 or MPEG-2 Audio Layer 3
MPEG	Moving Picture Expert Group
MVNO	Mobile Virtual Network Operators
Opex	Operational Expenditure
OTT	Over-the-Top; broadcast service provider via the Internet
PMSE	Program Making and Special Events services
PVR	Personnel Video Recorder
RF	Radio Frequency
RR	Radio Regulations
SAB/SAP	Services Ancillary to Broadcasting or Program making
SDTV	Standard Definition Television
SFN	Single Frequency Network
STB	Set-Top-Box
Tb	Terabit
T-DAB	Terrestrial – Digital Audio Broadcasting
TDD	Time Division Duplex
T-DMB	Terrestrial – Digital Multimedia Broadcasting
UHF	Ultra High Frequencies
UMTS	Universal Mobile Telecommunications System
US	United States of America
USB	Universal Serial Bus
VHF	Very High Frequencies
VoD	Video on Demand
WRC	World Radiocommunications Conference
WRC-07	WRC in 2007
WRC-12	WRC in 2012

Office of the Director
Telecommunication Development Bureau (BDT)
Place des Nations
CH-1211 Geneva 20
Email: mailto:bdtdirector@itu.int
Tel.: +41 22 730 5035/5435
Fax.: +41 22 730 5484

Deputy to the Director and Administration and Operations Coordination Department (DDR)
Email: bdtdeputydir@itu.int
Tel.: +41 22 730 5784
Fax: +41 22 730 5484

Infrastructure Enabling Environmnent and E-Applications Department (IEE)
Email: bdtiee@itu.int
Tel.: +41 22 730 5421
Fax: +41 22 730 5484

Innovation and Partnership Department (IP)
Email: bdtip@itu.int
Tel.: +41 22 730 5900
Fax: +41 22 730 5484

Project Support and Knowledge Management Department (PKM)
Email: bdtpkm@itu.int
Tel.: +41 22 730 5447
Fax: +41 22 730 5484

Africa

Ethiopia
International Telecommunication Union (ITU)
Regional Office
P.O. Box 60 005
Gambia Rd. Leghar ETC Bldg 3rd Floor
Addis Ababa – Ethiopia
E-mail: itu-addis@itu.int
Tel.: +251 11 551 49 77
Tel.: +251 11 551 48 55
Tel.: +251 11 551 83 28
Fax.: +251 11 551 72 99

Cameroon
Union internationale des télécommunications (UIT)
Bureau de zone
Immeuble CAMPOST, 3ème étage
Boulevard du 20 mai
Boîte postale 11017
Yaoundé – Cameroun
E-mail: itu-yaounde@itu.int
Tel.: + 237 22 22 92 92
Tel.: + 237 22 22 92 91
Fax.: + 237 22 22 92 97

Senegal
Union internationale des télécommunications (UIT)
Bureau de zone
Immeuble Fayçal, 4ème Etage
19, Rue Parchappe x Amadou Assane Ndoye
Boîte postale 50202 Dakar RP
Dakar – Sénégal
E-mail: itu-dakar@itu.int
Tel.: +221 33 849 77 20
Fax.: +221 33 822 80 13

Zimbabwe
International Telecommunication Union (ITU)
Area Office
TelOne Centre for Learning
Corner Samora Machel
and Hampton Road
P.O. Box BE 792
Belvedere Harare, Zimbabwe
E-mail: itu-harare@itu.int
Tel.: +263 4 77 59 41
Tel.: +263 4 77 59 39
Fax. +263 4 77 12 57

Americas

Brazil
International Telecommunication Union (ITU)
Regional Office
SAUS Quadra 06 Bloco "E"
11 andar – Ala Sul
Ed. Luis Eduardo Magalhães (AnaTel.) –
CEP 70070-940 – Brasilia – DF – Brasil
E-mail: itubrasilia@itu.int
Tel.: +55 61 2312 2730
Tel.: +55 61 2312 2733
Tel.: +55 61 2312 2735
Tel.: +55 61 2312 2736
Fax.: +55 61 2312 2738

Barbados
International Telecommunication Union (ITU)
Area Office
United Nations House
Marine Gardens
Hastings – Christ Church
P.O. Box 1047
Bridgetown – Barbados
E-mail: itubridgetown@itu.int
Tel.: +1 246 431 0343/4
Fax.: +1 246 437 7403

Chile
Unión Internacional de Telecomunicaciones (UIT)
Oficina de Representación de Área
Merced 753, Piso 4
Casilla 50484 – Plaza de Armas
Santiago de Chile – Chile
E-mail: itusantiago@itu.int
Tel.: +56 2 632 6134/6147
Fax.: +56 2 632 6154

Honduras
Unión Internacional de Telecomunicaciones (UIT)
Oficina de Representación de Área
Colonia Palmira, Avenida Brasil
Edificio COMTELCA/UIT 4 Piso
P.O. Box 976
Tegucigalpa – Honduras
E-mail: itutegucigalpa@itu.int
Tel.: +504 2 201 074
Fax. +504 2 201 075

Arab States

Egypt
International Telecommunication Union (ITU)
Regional Office
c/o National Telecommunications Institute Bldg (B 147)
Smart Village – Km 28
Cairo – Alexandria Desert Road
6th October Governorate – Egypt
E-mail: itucairo@itu.int
Tel.: +20 2 35 37 17 77
Fax.: +20 2 35 37 18 88

Asia and the Pacific

Thailand
International Telecommunication Union (ITU)
Regional Office
3rd Floor Building 6,
TOT Public Co., Ltd
89/2 Chaengwattana Road, Laksi
Bangkok 10210 – Thailand
Mailing address:
P.O. Box 178, Laksi Post Office
Bangkok 10210, Thailand
E-mail: itubangkok@itu.int
Tel.: +66 2 574 8565/9
Tel.: +66 2 574 9326/7
Fax.: +66 2 574 9328

Indonesia
International Telecommunication Union (ITU)
Area Office
Sapta Pesona Building, 13th floor
Jl. Merdeka Barat No. 17
Jakarta 10110 – Indonesia
Mailing address:
c/o UNDP – P.O. Box 2338
Jakarta – Indonesia
E-mail: itujakarta@itu.int
Tel.: +62 21 381 35 72
Tel.: +62 21 380 23 22
Tel.: +62 21 380 23 24
Fax.: +62 21 389 05 521

CIS countries

Russian Federation
International Telecommunication Union (ITU)
Area Office
4, building 1
Sergiy Radonezhsky Str.
Moscow 105120
Russian Federation
Mailing address:
P.O. Box 25 – Moscow 105120
Russian Federation
E-mail: itumoskow@itu.int
Tel.: +7 495 926 60 70
Fax. +7 495 926 60 73

Europe

Switzerland
International Telecommunication Union (ITU) Europe Unit EUR Telecommunication Development Bureau BDT
Place des Nations
CH-1211 Geneva 20 – Switzerland
E-mail: eurregion@itu.int
Tel.: +41 22 730 5111

International Telecommunication Union
Telecommunication Development Bureau
Place des Nations
CH-1211 Geneva 20
Switzerland
www.itu.int

Printed in Switzerland
Geneva, 2012

08/2012