International Telecommunication Union

QUESTION 11-2/2

Final Report

ITU-D STUDY GROUP 2 4th STUDY PERIOD (2006-2010)

QUESTION 11-2/2:

Examination of terrestrial digital sound and television broadcasting technologies and systems, including cost/benefit analyses, interoperability of digital terrestrial systems with existing analogue networks, and methods of migration from analogue terrestrial techniques to digital techniques

THE STUDY GROUPS OF ITU-D

In accordance with Resolution 2 (Doha, 2006), WTDC-06 maintained two study groups and determined the Questions to be studied by them. The working procedures to be followed by the study groups are defined in Resolution 1 (Doha, 2006) adopted by WTDC-06. For the period 2006-2010, Study Group 1 was entrusted with the study of nine Questions in the field of telecommunication development strategies and policies. Study Group 2 was entrusted with the study of ten Questions in the field of development and management of telecommunication services and networks and ICT applications.

For further information

Please contact:

Mr Istvan BOZSOKI
Telecommunication Development Bureau (BDT)
ITU
Place des Nations
CH-1211 GENEVA 20
Switzerland
Telephone: +41 22 730 6347
Fax: +41 22 730 5484
E-mail: bozsoki@itu.int

Placing orders for ITU publications

Please note that orders cannot be taken over the telephone. They should be sent by fax or e-mail.

ITU
Sales Service
Place des Nations
CH-1211 GENEVA 20
Switzerland
Fax: +41 22 730 5194
E-mail: sales@itu.int

The Electronic Bookshop of ITU: www.itu.int/publications

International Telecommunication Union

QUESTION 11-2/2

Final Report

ITU-D STUDY GROUP 2 4th STUDY PERIOD (2006-2010)

QUESTION 11-2/2:

Examination of terrestrial digital sound and television broadcasting technologies and systems, including cost/benefit analyses, interoperability of digital terrestrial systems with existing analogue networks, and methods of migration from analogue terrestrial techniques to digital techniques

ACKNOWLEDGEMENTS AND PREFACE

The transition from analogue to digital terrestrial broadcasting is extremely complex and delicate process and it is having a profound impact on the entire broadcasting chain. While a complex process in its implementation for Administrations and Broadcasters, it provides the viewing public for greater entertainement and informational experiences then analogue television broadcasting ever envisaged. It is of concern to Governments and to relevant Authorities at international, national, regional and community level, Regulatory Authorities, Broadcasters, Broadcasting Industry, viewers and listeners- briefly to the entire population of the modern world.

The terms of reference before ITU-D Study Qustion 11-2/2 were so vast that the provision of extensive consultation and advice by world-wide broadcasting experts was a prerequisite for successful completion of this Report.

Indeed, ITU-R Study Group 6 has provided us with generous support from the onset and we should like to acknowledge the valuable inputs and advice provided by Messrs. Dr. Christoph Dosch, Chairman of ITU-R SG-6 IRT, Germany; Prof. Oleg Gofaizen, Vice Chairman ITU-R SG-6, Ukrainian Research Institute of Radio and Television; David Wood, Chairman of ITU-R WP 6C, EBU; Dr. Joseph Flaherty, Senior Vice President, CBS, USA; and Roger Bunch, Director of Engineering, Free TV Australia Ltd.

Indeed precious inputs from the Administrations of Brazil, Bulgaria, France, Germany, Russian Federation, Thales, France, DigiTAG, DVB, the European Broadcasting Union and the European Commission, together with comments from Rohde and Schwarz, have been incorporated thus contributing substantially to the value of this Report.

We should also like to acknowledge the continuous support by Mr. Lieven Vermaele, Technical Director, EBU; Dr. Roland Brugger, Head of Frequency Management Section, IRT, Germany; and Mr. Richard Salmon, Senior Research Engineer, BBC Research and Development, UK, who have shared knowledge and up to date research information enhancing further the value of this Report.

This Report is conceptualized to be considered as one component of a family of ready for use or ongoing publications of ITU-R SG-6.

Towards this end it is worth quoting the following ITU-R Publications which should be considered as complementary to it:

- Report ITU-R BT.2140 “Transition from analogue to digital terrestrial broadcasting”,
- Handbook on “Digital Terrestrial Television Broadcasting (DTTB) implementation”, and
- Handbook on “Digital television signals coding and interfacing within studios”.

At this juncture I am honoured to thank Messrs. Semen Lopato, Rapporteur of this Study Question, Russian Federation and Philippe Mege, Vice Rapporteur of this Study Question, Thales, France and the honourable delegates of ITU-D SG-2 for their constructive contributions and confidence bestowed on us.

Finally I should like to thank Mr. Izstvan Bozsoki, BDT Focal Point to this Study Question and the BDT Secretariat for extending their support and assistance in achieving the objectives of ITU-D Study Question 11-2/2.

Mr. Petko Kantchev
Acting Rapporteur on ITU-D Study Question 11-2/2
Advisor to the Deputy Minister,
Ministry of Transport Information Technology and Communications,
Sofia, Bulgaria
29 November 2009

TABLE OF CONTENTS

Page

Page

QUESTION 11-2/2

1 Background

Remarkably inventive people have conceptualized and developed a number of standards for sound (audio) and television digital broadcasting.

Audio, video and data are digitized and rigidly encoded, then broadcasted and finally decoded at the users' terminals. This innovation enables improvement in quality of reception, it permits increase of the number of broadcasted channels, or alternatively enables the National Regulatory Authority to reallocate spectrum and license other operators once the analogue broadcasting terminated. Furthermore it provides for a real innovation of services. This is possible because of the very rigid and reliable encoding of the digital broadcasting signal and the far reaching strategy of flexible use of the high capacity of the digital broadcasting channel, enabling reallocation of digital streams between audio, video and data. In brief, the digital broadcasting platform creates new opportunities yet to be explored.

The digital delivery of broadcasting services is done via CATV, terrestrial broadcasting and satellite broadcasting networks and is becoming operational or under test in many countries of the world. Recently same broadcast services are also delivered by Internet (IPTV) and by telecom service providers to the end users. Portable and mobile hand-held terminals make possible the reception of sound and TV broadcasting programs as well.

The sound and television broadcasting chain includes the following components:

a) contribution networks delivering various inputs for assembling of programs;

b) production centers to assemble and process the sound and TV programs;

c) distribution networks to transport these programs to transmitting networks;

d) transmitting networks broadcasting those programs to the audience and /or viewers, and, finally;

e) viewers/listeners' receiving and recording/playing back terminal park.

The broadcasting chain components a), b), c) and d) above may be entirely operated by broadcasting organization or as an alternative any of the said components may be subcontracted to specialized service provider/s. It is worth noting that the components a), b), c) and d) of the broadcasting chain, together with content production resources are usually incorporated in the overall budget of any broadcasting organization.

Follow-up of recent progress of digital broadcasting technology the migration to digital technology is facing sophisticated challenges also in components a), b) and c) of the broadcasting chain, affecting the audience/viewers.

It could be quite surprising to discover that the total infrastructure investment made by broadcasters might be substantially inferior to the total infrastructure investment made by the audience and viewers for their receiving, recording and playing back terminal park - component e) above, enabling reception, recording and play back of broadcasting programs in serviced areas.

There are compelling reasons and evidence suggests that it might be both unfair and risky to take any strategic decision on the migration to digital broadcasting, which will not take into account the interests and expectations of the key investor in the broadcasting chain – multiples of millions of people. Unavoidable questions to be posed are why should audience/viewers be forced to buy Set Top Boxes (STB) or face hurdles associated with renewal of their receiving/recording/playback terminal park just for the sake of changing from analogue to digital. What really matters to the said key investor is the excitement generated by attractive programmes and innovative services offered in increasing number with superiour quality. It may be assumed that the progress achieved by now in the analogue broadcasting technology domain may well suit the usual need for information, entertainment and education of the majority of viewers/listeners contributing to their social inclusion. The lack of offer of attractive content and value-added innovative services when shifting from analogue to digital might impose delays on the migration to digital broadcasting.

It has become evident, that the Administrations and Regulatory Authorities are the key driving forces towards this migration.

The Broadcasters must carefully select the most future-proof, feasible and well planned in advance migration strategy to digital broadcasting. The general public, investing in receiving/recording/playing back terminal park, will follow the strategy for migration to digital broadcasting, providing that its expectations for more and better programs and services are met and smooth transition to digital broadcasting ensured by timely availability of affordable Set Top Boxes (STB) and/or digital broadcasting receiving/recording/playing back terminals. The key investor is to be assisted and properly guided during the entire transition process.

Hundred and twenty ITU Members have participated at RRC-06, Geneva, (119 of them are from Region 1) where frequency planning and transition aspects from analogue to digital were agreed upon on treaty level.

Extensive planning exercise at national level is carried out not only in Region 1 countries, but in other countries from ITU Regions 2 and 3.

For the said reasons this report will pay particular attention to the aspects of migration from analogue to digital in components d) and e) above.

Currently in most of developing countries the introduction of digital terrestrial broadcasting is not yet initiated. Administrations of industrially developed countries, which have already approved the strategies and programmes of migration and declared the dates of analogue terrestrial broadcasting switch off, have at least three main reasons for switchover:

- optimization and more efficient use of spectrum;
- potential raising of revenue through spectrum auction to new ICT service bidders;
- revitalizing the broadcast service market through users' access to a wider variety of attractive programmes (including local broadcast programmes) with quality superior to analogue programmes complemented by innovative services and applications (in particular possible interactive services).

In most developing countries it should be mentioned that:

- developing countries' social/demographic data show limited tendancy to introduce more commercial broadcasters even on the basis of modern improved technology platforms like DTTV;
- there are no compelling market forces in most of developing countries to suggest that spectrum freed up could be readily used for innovative ICT services.

In turn the commercialization might not be the key driver to introduce digital broadcasting in most of developing countries and there are serious reasons for continuation of broadcasting via a predominately analogue terrestrial transmitting network. So for most of developing countries the switch-over from analogue to digital terrestrial broadcasting sounds feasible but not dictated by urgent necessity.

On the other hand, the lifespan of analogue terrestrial broadcasting in developing countries could be extended up to ten further years, which in turn, because of the technology obsolescence, would unavoidably force broadcasters and audiences/viewers to migrate to digital broadcasting. Broadcasters in developing countries would be faced with higher cost per viewer budgets to meet their universal service obligations in order to expand the population coverage of existing analogue transmitting networks. In particular they will be forced to continue reinvestments in outdated and expensive transmission technology (e.g. analogue TV requires around four times as much spectrum and up to several times more power to broadcast a single TV channel). The possible contribution of DTTV into bridging the digital divide and creation of information society in developing countries also should not be ignored especially taking into account that DTTV could be a basis for educational, health-care and other socially valuable ICT services and applications, including interactive ones.

Thus digital broadcasting would eventually be de facto imposed upon developing countries, because broadcasters and service providers would be adversely affected by diminishing availability of analogue technology and relevant technical support.

Indeed there are compelling reasons for administrations, regulators, broadcasters, stake-holders and other interested parties to examine various possible approaches to introduction of digital technology for terrestrial sound and television broadcasting in developing countries.

Digital terrestrial broadcasting standards are produced by ITU and various worldwide, regional and national standards-setting organizations/entities.

In this respect it is worth noting that the "political interoperability" is a much broader concept than technical interoperability. It embraces issues like market fragmentation caused by using multiple standards or technologies. The potential difficulty is that there are many options: 50Hz/ 60Hz; 720/1080 lines; interlace or progressive; multiple compression systems. There is therefore a risk of market fragmentation, which could have political repercussions. It is indicative that a market research study announced at IBC 2004 already called for a single standard within European Union. However at the time of writing of this report many national, international and industrial specifications came up scattered over many sources resulting in confusion.

Earlier legacy decisions to introduce services on 1080i or 720p should not prevent implementation of 1080p by those who may wish to do it. The challenge for example in a Europe of 27 Member States is to ensure sustainable co-existence of choices that will be made at different times by broadcasters in different Member States.

Concise overview of digital terrestrial sound and television broadcasting technologies, standards, and system migration, supplemented with number of case studies could be found at recent ITU-R Report BT.2140 "Transition from analogue to digital terrestrial broadcasting" www.itu.int/publ/R-REP-BT.2140/en . The said Report is outlining the available options for transition to digital as well as the route to be followed and is divided into two parts.

- *Part 1* deals with the main issues related to the transition to digital and presents principle problems and possible solutions.
- *Part 2* provides more detailed information on important aspects which have been covered in *Part 1.*

Both the ITU-R Report BT.2140 and this Report on ITU-D Study Question 11-2/2 are intended to provide information of complementary nature and arrangements have been made to avoid any duplication in both Reports.

The information pertaining to the migration to digital terrestrial sound broadcasting provided in Report ITU-R BT. 2140 is considered adequate. However, Chapter 9 of this Report provides concise information in condensed form about the advantages, technical platforms, implementation approaches, special features and possible phases of migration.

Furthermore, ITU-R SG-6 has established a Rapporteur Group for development of a "Handbook on digital television (DTV) implementation". The said Rapporteur Group will endeavour as well to avoid duplication with this Report to the extent possible.

2 Various possible concepts of introducing digital terrestrial broadcasting

Concept 1: Introduction of digital broadcasting by giving a key role to market forces

In case of such variant administration has to purely facilitate the introduction of new services and relevant applications and the granting of licenses. This could prove attractive to Pay TV services and smaller niche and regional operators that do not wish to be on satellite. This approach would therefore not be directed by strong drivers to influence the shape of digital broadcasting in developing countries. Mostly upper income group of citizens of developing countries would benefit from such digital broadcasting services.

Concept 2: Introduction of digital broadcasting on the basis of the managed market take up strategy

Since there is no clear market demand for services at present a managed/forced migration could be an effective way of introduction of digital broadcasting within given timeframe. Regulatory Authority/Administration should impose a moratorium on the roll-out of analogue DTTV broadcasting and announce the cut-off of analogue terrestrial television broadcasting well in advance and at fixed dates. This concept will accelerate the migration to digital broadcasting and would be a faster way of providing access to enhanced universal service of which education, health and other social applications are key components. Subsidized receiving terminals for consumers could be used as an incentive and catalyst. Here-in, last but not least, the governments would have to subsidize the migration cost increment for the public broadcasters as the existing funding model would not be adequate to cover the huge investment needed to migrate to digital broadcasting transmitting network/s.

Concept 3: Phased introduction of digital broadcasting using a combination of delivery platforms

Introduce new services in metropolitans first (so called "island approach") with a plan to later expand services to the rest of the country. The profile of consumer and the disposable income in these areas could lead to successful commercial and advertising revenue driven broadcast models which could, in turn, ease the financial investment for expansion. Such a migration plan should obviously bear the interests of the existing analogue broadcasters in mind. Therefore protection of existing analogue services in terms of interference levels would be of the utmost importance. Satellite technology, if appropriate, could be used for expansion into the underserved rural areas. Signal could then be relayed to community viewing centers or multi-purpose community centers. As costs come down and through financially successful roll-out in the metropolitan areas, DTTV transmitters with proper signal feed could be installed to provide local coverage.

To the extent possible, plans should avoid simultaneous broadcasting in given area by analogue and digital transmitting networks being very costly to the broadcaster. Evidence suggests that commercial TV broadcasters are extremely sensitive on this matter.

3 Choosing the strategy of migration

Currently most of developing countries are facing conflicting challenges of analogue to digital migration combined with higher budget priorities for education, health, etc.. However it is crucial that the long-term benefits of the creation of Information Society should not be overlooked because of prevailing short-term budget restrictions or other national priorities.

In most of developing countries digital terrestrial broadcasting can be a viable means to attain the following strategic objectives:

- to meet national radiocommunication objectives, e.g. by using distance education technology solutions;
- to provide the means to distribute public broadcast content to all citizens (universal service) through DTTV enhanced transmission capacity;
- to present commercial broadcasters with an opportunity to maximize additional revenue streams through DTTV enhanced transmission capacity.

However, most developing countries are not ready to easily meet the accessibility, affordability and take-up test criteria for digital broadcasting. The main disadvantage of Concept 1 is poor or no project planning at all entailing that this Concept will not be considered any further.

Therefore, the only feasible option for most of the developing countries towards constructive economic and social development would be to use a managed market take-up strategy as per Concept 2 and/or Concept 3 above. In fact, the Concept 3's faster and forced migration would yield significant savings in double operational transmitting costs as analogue services may be switched- off sooner and/or reconfigured in accordance with commercial and/or universal service objectives. A managed/forced approach would foster economies of scale benefits, the most obvious of which is the driving down of costs through greater market penetration.

It is crucial that all stake-holders understand and support this approach as most suitable strategy to be in harmony with national objectives for economy growth, universal service and ultimate creation of Information Society.

It is further recommended that the Regulatory Authority at highest possible level within given Administration takes strategic decision on the roll-out for digital broadcasting with a declared commencement date. This would allow sufficient time for realistic and comprehensive planning that would take into account impact and implications related to financing, staffing, skills, technology, etc. Such decision should stipulate the standards chosen for video and audio modulation, channel coding and transmission. Thus it will become an effective tool for introduction of digital broadcasting within desired timeframes Furthermore, the said Regulatory Authority should impose a moratorium on further license grants for analogue DTTV broadcasting and announce an early enough and fixed cut-off date for analogue DTTV broadcasting.

The analogue services should gradually be reduced once DTTV services are widely available with attractive content offer, nudging consumers towards digital. The first roll-out at least should be announced at fixed date. Analogue broadcasting may then be terminated on the completion of the transition simulcast period preferable to be coinciding with capital replacement plans for existing analogue transmitters as well as giving to consumers ample time to accomodate the new technology in their households.

Consideration may be given to limited state treasury subsidies for basic digital TV receivers or Set Top Boxes that can enable access to DTTV.

4 Migration to DTTV

Digital Broadcasting brings substantial changes, both in the broadcasting chain and to the stake-holders and their relationship, to make it operational.

National legislation should be adapted early enough to accommodate the requirements for migration to digital, inclusive content, production, multiplex, distribution and delivery to public and consumers.

Ownership, financing, licensing of content and spectrum nature, management and business aspects are to be enacted as well.

Overall national strategy for the transition to DTTV broadcasting is to be elaborated and approved at highest possible level. The broadcasting chain is complex and long – efficient cooperation of all players is essential.

Appoint National Task Force by relevant competent Authority to consider and recommend the right choices in rather sophisticated new digital broadcasting environment.

Plan early enough and in detail.

Appoint Service and Coverage Quality Manager/s to pay special attention to quality issues.

Last but not least-attractive enhanced content offer together with reception robustness are amongst the key factors for success of the transition to digital.

The strategy for migration from Analogue to Digital Terrestrial TV is made up of three phases and has been based on:

- the deployment of new DTTV networks utilizing available frequencies; and
- the availability of organizations ready and
- capable to deploy DTTV infrastructure at short notice.

Such an approach ensures that current broadcasts and consumer reception in analogue format will not be adversely affected in short-term and that there is a period of simulcasting during which programs are transmitted both in analogue and digital format.

The national legislation in force should be amended so that relevant licensing of a digital terrestrial networks be carried out. To this end the following suggestions may be applied:

Phase One: Introduction of Digital Terrestrial Television Transmissions

- The existing regulations should be reviewed to ensure that they reflect the implications of digital terrestrial broadcast transmissions.
- No further analogue licenses should be granted.
- Current broadcasters should be allowed to continue with analogue transmissions up to analogue broadcasting cut-off date.
- Special frequency channels should be allocated to the current broadcasters to provide for the simulcasting in digital format with the disadvantage of double transmitting cost to the broadcasters.
- Special channels should be dedicated to new services such as mobile DTTV broadcasting.

- A call for expressions of interest/letters of intent for the operation of commercial DTTV networks should be issued. The call will be based on predefined number/s of frequency channels and relevant multiplexes that will be assigned under corresponding license.
- Licenses for use of frequency channels by commercial DTTV networks should be granted against a fee. Potential commercial broadcasters should be formally informed of the envisaged annual license fee per frequency channel.
- Free-to-air broadcasters, who will share frequency/ies with other broadcasters in the digital environment, should not be liable to license fee.
- Applications received following call for expressions of interest should be selected on the basis of "beauty contest".
- Multiplex and Transmitting network operators should be subject to the same regulations as applicable to electronic communications networks.
- The start-up phase of digital broadcasting should be closely monitored in terms of coverage, reception quality and interference.
- A "stake-holders" group should be set up to co-ordinate the transition process.
- Infrastructure-sharing arrangements, involving broadcasting chain operators, should be explored.
- The award of a frequency license to commercial DTTV networks should be subject to a roll-out requirement covering the entire national territory within a specified timeframe.

Phase Two: Simulcast Period

- The date for the commencement of Simulcasting to the viewers should be established. The simulcasting period is twice more expensive to the broadcasters, therefore reasonable measures are to be taken to reduce its duration.
- The public broadcaster should be encouraged to establish a migration plan. Discussions should be undertaken with broadcasters, in order to encourage the establishment of fixed date, when all current free-to-air analogue broadcasts are to be also made available as digital transmissions.
- Established national broadcasts should be transmitted with "must carry" obligation on digital terrestrial TV broadcasting platform/s available, but free-to-air for public service broadcasters.

Phase Three: Analogue Cut-Off (ACO).

The date for the analogue broadcasting cut-off (not later than) should be established.

This phase should fix the switching-off of all analogue terrestrial broadcasts. Prior to analogue cut-off date all current broadcasters should have migrated to a digital platform and households should have available either digital terrestrial TV receivers or digital terrestrial TV Set Top Boxes, enabling reception on conventional analogue TV receivers. The ACO date should defined on the basis of the migration option selected by the broadcasters/regulators and on the overall market reaction to the introduction of DTTV.

Possible government actions facilitating provision of population with DTTV receivers/STBs

Concerning the provision of population with DTTV receivers the following measures could be undertaken by the government:

1. Extending long-term purpose-oriented interest free or low interest credits out of state or local community budgets (for the term of one year or more) to the population to purchase DTTV receivers.
2. Granting government guarantees to private banks for purpose-oriented credits to the population to purchase DTTV receivers.
3. Fixed amount voucher or subsidy may be granted to any household of lowest income category towards purchase either of STB or digital TV receiver.

5 DTTV platforms and networks

5.1 Executive introductory remarks

Terrestrial Digital Audio Broadcasting (TDAB) (radio) services and radiomobile communication (UMTS) services are not included in the term DTTV and therefore not considered herewith in Chapter 4.

In planning digital terrestrial television a balanced compromise has to be made between multiplex capacity, coverage quality and radiation characteristics. Multiplex capacity itself is of great interest for the service quality (picture impairements, artefacts, etc).

The relationship between net data rate of the multiplex and the number of services within multiplex is determined by the data rate per TV programme.

Coverage quality is important for the number of people (alternative term used is "population coverage") able to receive the service. It is defined as the probability to receive the wanted signal at given location in the presence of noise and interference.

We either receive the TV programme signal on our screen or not at all – there is no any more possibility for "graceful degradation" of received picture quality inherent to analogue TV broadcasting.

All locations with the required reception probability form together the coverage area. Transmitter's radiation characteristics are related to transmission costs. Transmitter power and antenna specifications, either from a single transmitting station or from a Single Frequency Network (SFN), determine the field strength generated for reception at given location.

The trade-off between service quality, number of potential viewers and transmission costs itself is a very complicated because of many conflicting ingredients to be taken into account. The choice to be made is limited for operational, regulatory and technical reasons.

For each type of service the compromise made may be different resulting in different radiation characteristics, different choices regarding sampling, compression, modulation and transmission system, different number of transmitting sites and different number of multiplexes.

Regulatory environment

A market based approach may increasingly be applied to frequency management. This approach might lead to less spectrum made available for broadcasting and potentially resulting in increase of interference levels.

Relevant frequency plans should allow implementation of broadcasting transmission with defined characteristics so that no interference is caused whereby modifications are possible subject to agreement of neighbouring countries concerned.

Digital switch-over (DSO) is the national process of transition from analogue to digital television. Within the European Union (EU), it is recommended that member-states switch-off analogue television before 2012. The released spectrum will in the first place be used for digital television services that were formerly transmitted in analogue format. Furthermore new services, both of broadcasting or non-broadcasting nature, will be licensed in the remaining spectrum, called "digital dividend".

Digital Dividend

The digital dividend is generally understood as the spectrum made available above the spectrum required to accommodate the analogue television services in a digital format.

The digital dividend could be used for broadcasting services, such as digital terrestrial television with rooftop, indoor or outdoor reception, mobile TV, HDTV and interactive television services. But mobile radiocommunication services may also be implemented in the upper part of UHF Band V(790-862 MHz) and certain low-power applications could be allowed to make use of so-called "white spaces" in the radio frequency spectrum on a non-interference and non-protection basis, depending of frequency plan of each country.

On July 10, 2009 the European Commission published for public consultation until September 4, 2009 a document on *"transforming the digital opportunity into social benefits and economic growth in Europe"*, attached as Annex 6 to this Report. The consultation is aimed at collecting views from all interested stakeholders on the use of the digital dividend radio spectrum released from the transition from analogue to digital terrestrial television (DTTV). The Commission intends to adopt a communication on the digital dividend, including an official proposal for an EU policy roadmap, to be submitted to the European Parliament and Council in autumn 2009. The Commission also identifies two urgent measures to facilitate the process of making the UHF 790-862 MHz band ('800 MHz band') available on a technology and service neutral basis as quickly as possible within a harmonised technical framework. One of the priority objectives is to improve consumers' experience by ensuring high quality standards for DTTV receivers across Europe by ensuring availability of compression standards of defined minimum efficiency (at least that of the MPEG-4) on all DTTV receivers sold after 1 st of January 2012 and by setting standards for the ability of DTTV receivers to resist interference

For digital terrestrial television services, once implemented, it may be necessary to change the station characteristics when the service requirements change. Depending on required station changes and the characteristics, a modification of the Plan may be needed, subject to agreement with the neighbouring countries concerned.

Changes to transmitting stations could relate to:

- Radiation characteristics to achieve better coverage;
- Different configuration of the DTTV system to achieve either better coverage or more capacity;
- Improved encoders, an enhanced compression system (MPEG-4), installation of additional multiplexes or a different system, and more advanced system in the future , in order to achieve more capacity or a better coverage; and
- Additional sites to improve or extend coverage.

Partitioning of Bands IV and V for different kind of services (digital television for large area coverage, mobile TV and mobile radiocommunications) is under discussion. Establishment of sub-bands reduces the spectrum capacity for digital television broadcasting and will require a revision of the Plan for digital television. The loss of spectrum capacity restricts future developments and may require modifications to the networks of existing services.

These modifications could involve:

- Frequency change as a result of replanning;
- DTTV system with higher capacity, improved compression system (MPEG-4) or, in the
- future, a more advanced system, such as DVB-T2, in order to compensate for loss of data rate capacity; and
- Change of radiation characteristics and installation of additional sites to compensate for loss of coverage.

Implementation of mobile communication services in part of Bands IV and V may cause interference to digital broadcasting services.

Low-power applications that may be allowed on a non-interference and non-protection basis in the so called "white spaces" of the spectrum have no direct impact on digital terrestrial television services, provided that in practice the non-interference conditions can be guaranteed under all circumstances.

Networks

Changes to digital terrestrial television networks may be necessary due to the introduction of new services, regulatory obligations or changes of technology. Some of those changes are costly while others may be marginal if partial equipment adjustment will be needed. Most of the changes may have an impact on coverage.

Radiation characteristics

Frequency and maximum radiated power per bearing must be specified. Antenna characteristics are frequency dependent. Coverage for different frequencies transmitted from the same site may therefore be different. Close to the transmitting site, coverage problems may occur due to “nulls” in the vertical radiation pattern.

Compression and transmission system

Depending on the trade-off choice made for given service, a variant may be chosen that enables a relatively large multiplex capacity, but high required field strength. Alternatively a choice can be made for a robust variant with relative lower field strength, but leading to more limited multiplex capacity.

The quality of the encoders of the compression system improves over time until the technology becomes mature. By updating encoder software or frequently replacing the main encoders at TV programme production centre (sort of expendable items with quick depreciation cycle), a more efficient use of multiplex capacity can be achieved. An enhanced compression system (MPEG-4) is readily available on the market and large-scale manufacturing will continue leading to further reduction of its retail cost. The MPEG-4 encoders have significant efficiency gains compared with MPEG-2. The ISDB-T system, operational in Brazil already, has benefited from the improvements of MPEG-4 compression system.

DVB-H, T-DMB and ISDB-T are transmission systems adapted to the needs of mobile television with hand-held receivers.

DVB-T2 is expected to become operational during 2010 and will enhance the multiplex capacity which is of particular importance for HDTV.

Change of compression or transmission system has no direct impact on coverage.

Sites

Additional sites in the same network are used to improve or extend coverage. Power distribution over several sites (Single Frequency Network- SFN) improves frequency spectrum efficiency for provision of coverage for portable, indoor and mobile reception over large areas. However, SFN planning is more costly and complex, specifically about the synchronization of timing of each transmitter, and in some cases coverage problems occurs due to internal network interference (self interference due to time delay of signals received from network transmitters exceeding the “guard interval” duration as well as the so-called “0 dB echo” interference due to signals of equal field-strength received in certain locations of dense SFN).

Multiplexes

Additional multiplexes provide extra transmission capacity. They could be installed on existing sites, but could also form a partly or completely new network. In case of non co-sited transmissions interference could occur around the transmitter sites.

Practical experience gained

Practical experience suggests that:

- Digital transmissions may be subject to restrictions as long as analogue TV has not been switched-off in the home country and/or in neighbouring countries. There are disadvantages and big risks if broadcasters move to another system asynchronously in a non-coordinated manner.
- Frequency changes to SFNs may be complex and require careful preparations and detailed planning.
- DVB-H may need dense transmitter networks. It is to be noted that in case of the ISDB-T, the signal for the mobile TV is multiplexed with the HDTV signal.
- HDTV requires MPEG-4 compression. The ISDB-T system operational in Brazil already has incorporated improvement with MPEG-4. The new DVB-T2 transmission system is expected to have MPEG-4 incorporated as well.
- National decisions are to be made in close collaboration with the receiver manufactures on timely availability of adequate receivers /set top boxes for the public at affordable cost.

Consumer concerns

Network changes as a result either of introduction of new services or of implementing regulatory measures may require actions by the viewer in order to receive the new services or continue to receive existing services as follows:

- Define and advertise widely the Analogue Cut-Off date (ACO). Provide information to consumers on suitable receivers/set-top boxes to be procured and on attractive content offer.
- If in harmony with national law, provide subsidy for procurement at least of set-top boxes by population with low income.
- A frequency change, installation of additional sites and additional multiplexes force consumer to retune his receiver.
- A change of frequency, transmitting antenna, DVB-T or ISDB-T variant and changes to an SFN, as well as non co-sited transmissions could result in coverage problems in some areas. The consumer may have to deploy improved antenna installation in order to receive one or more multiplexes.
- A change of compression system (from MPEG-2 to MPEG-4) and transmission system requires the purchase of a new receiver in order to receive the services transmitted this way. However, after a certain transition period and not later than 2012, all receivers (at least in European Union) will be able to receive the old (MPEG-2) and the new (MPEG-4) compression system.
- The quality of the encoders of the compression system improves over time until the technology becomes mature. By updating encoder software or frequently replacing the main encoders at TV programme production centre (sort of expendable items with quick depreciation cycle), a more efficient use of multiplex, or alternatively, a better picture quality to viewers can be achieved.
- In cases where new sites are installed the best signal may arrive from a different bearing and receiving antenna adjustments may be necessary.
- Communication to consumers about network changes, help and information regarding necessary consumer action is essential and of utmost importance. Telephone helpdesks and websites can provide detailed information and advice based on accurate coverage predictions, but they are not enough. Efficient personal counseling is essential.
- Effective and fast shadow area measurement is important.
- One change at a time rule is to be established.
- Advertisements, an information channel in the multiplex and Teletext, and information on dedicated websites can help viewers. Local dealers can provide information and refer the public to websites or telephone helpdesks.
- "Digital Godfathers", specially trained to help population upon request, are highly appreciated.

5.2 Service requirements

This Section deals with services and applications that will drive digital terrestrial television network evolution. Network evolution depends on:

- The choice of services to offered to viewers. Since the conditions are different from country to country, the serviceoffers are likely to be different in each country, e.g. market based economies may choose to leave the service offer in the hands of market forces etc;
- Regulations, which will define give the framework for the development of services. Regulations reflect political priorities which may also differ between countries;
- Technology, transmitting and receiving equipment will facilitate the introduction of services, but have their inherent limitations.

Therefore it is important to make the right choices taking into account the service requirements and the regulatory environment.

For a successful introduction of services market players and regulators should cooperate in the development of services. All market players (broadcasters and content providers, multiplex and network operators, consumer electronics manufacturers) have a great interest in digital terrestrial television and should support the choices made for the evolution of the network.

Digital terrestrial television services can be categorized by type of reception: Rooftop, Indoor or Outdoor Portable, Mobile and Handheld and by type of content delivery: Standard Definition TV (SDTV), High Definition TV (HDTV), Interactive TV and Data Services.

In planning digital terrestrial television, a compromise has to be found between:

- Multiplex capacity;
- Coverage quality;
- Radiation characteristics.

The compromise made will determine to a great extent the type of terrestrial television network and the evolution the network may undergo.

Multiplex capacity is of interest for the service quality. The net data rate of the multiplex and the number of services in the multiplex determine the data rate per programme. Multiplex capacity is limited by the technology of the compression and transmission system and the choice of the DVB-T or ISDB-T variant.

Warning: data rates below 4Mbits/s per programme might lead to smearing and artefacts on viewers' flat panels resulting in consumers' complaints. Growing loudly complaints by consumers would emerge when they have larger screen flat panels at home. Better avoid them!

Coverage quality is important for the number of potential viewers and is expressed as the probability to receive the wanted signal at a location in the presence of noise and interference. All locations with acceptable reception probability form together the coverage area. Coverage quality also depends on the choice of the DTTV system and on the characteristics of the receiving installation, in particular the receiving antenna and specified reception conditions. The exact relation between analogue and digital radiated power in terms of coverage area is difficult to calculate. This problem arises mainly due to the fact that broadcasted analogue TV programme can still be received far outside of the nominal coverage area but with a lot of noise in the picture and sound - specific feature of the analogue TV reception also known as "graceful degradation". However this is not the case of the digital transmissions, which depending on the coding applied and the quality of the TV receivers used, when reaching a certain Modulation Error Ratio (MER) value, will deliver picture on the TV screen that becomes frozen or black (so called "Fall of the cliff" effect).

Radiation characteristics are related to the transmission costs. Transmitter power and antenna specifications, either from a single transmitting station or from a Single Frequency Network (SFN), determine the field strength generated at a receiving location. Radiation characteristics are limited by transmitting equipment and transmitting station facilities. Evidence suggests for example, that 10 kW analogue TV transmitter could usually be replaced by DTTV (OFDM) transmitter with 2 kW to 2,5 kW thus requiring around 4 to 5 times less transmitter radiated power to cover given service area. It is to be noted however that the analogue and digital terrestrial TV transmitters have different references, namely peak power on sync pulse versus average power. Nevertheless in some cases, depending on particularities of relevant service area, the inherent to digital TV reception principle of "To be or Not to be" (in the absence of analogue TV graceful degradation possibility) might require DTTV transmitter power close to the power of the analogue transmitter for coverage of the same area.

It is worth noting that some DVB-T transmitters might consume more energy from the power supply grid than analog transmitters of identical radiated power output.

However, as a rule of the thumb, the modern DTTV transmitters have higher power efficiency than older ones in terms of electric power input / Radio Frequency (RF) power output. Moreover, a steady recent trend has been noted that DTTV transmitter manufacturers are dedicating research and development resources for achieving even higher DTTV transmitter efficiency.

In brief summary the digital terrestrial television transmitter networks offer higher energy efficiency than analogue ones thus representing a better and future-proof choice for terrestrial TV broadcasting.

It is also worth noting that, in sharp contrast to the established analogue DTTV broadcasting practice, any stand-by digital DTTV transmitter should be of equal radiated power to that of digital regular transmitter to be backed-up in case of failure.

The trade-off between service quality, number of potential viewers and transmission costs is a rather complicated choice, and could be dictated predominantly by market considerations.

Rooftop and portable indoor and outdoor reception

Rooftop reception, also called fixed reception, is characterized by a fixed directional receiving antenna mounted on the roof of a house. Rooftop reception can be seen as the basic requirement for digital terrestrial television. In most countries it is required that nearly full coverage is provided for rooftop reception, at least for public broadcasting services. In areas where cable television has been established, rooftop antennas have often disappeared. Local communities have sometimes even mandated the dismantling of rooftop antennas. Evidence suggests, e.g. recent experience in Germany, that with the migration to DTTV, this service reactivates the interest of the public and rooftop antennas are reappearing again. At this juncture it is worth noting, that DTTV has the potential of becoming respected competitor to cable, satellite TV and IPTV, thus balancing the marked (terrestrial analog TV broadcasting in Germany was preferred by around 5% of the households, but after the transition to DTTV around 22% of German households subscribed to it).

Indoor or outdoor reception with simple antennas is an important feature of digital terrestrial broadcasting. This way of reception is called portable reception. Different types of indoor or portable receiving antennas and portable receiving devices have appeared on the market, including active indoor antennas and digital terrestrial television receivers for use with PCs. The minimum field strength requirements for portable reception are much more demanding than for rooftop reception, because of the low receiving height, screening of the building and no or moderate directivity of the receiver’s antenna. In a number of countries, networks are designed in such a way that indoor reception in areas with high population density has been optimized.

SDTV Multiplex capacity

In order to motivate consumers to buy a digital receiver for digital terrestrial television (DTTV) service, an attractive broadcast package needs to contain 20 to 30 popular TV programmes. Such a number is also needed to provide better competition with the satellite and cable delivery media. A large number of elitists’ services of high individual interest to only a few people can best be delivered by means of on-demand services via broadband TV.

The EBU has recommended before RRC-06, that in order to provide an acceptable video quality in conventional displays, the average data capacity allocated to each SDTV programme should range from 3 to 4 Mbit/s with MPEG-2 source coding depending on the DVB-T variant and on the statistical multiplexing, if used. In Australia however for DVB-T in 7 MHz channel with 64 QAM multiplex and data rate capacity of 23 Mbit/s the SDTV video data rate chosen in year 2001 was 4.3 Mbit/s.

In practice the decision on the number of TV programmes in a multiplex taking into account the data bit rate allocated to TV programme is often favourable to the number of TV programmes to be incorporated into the multiplex data capacity.

However it should be noted that quality of service requirements need to be increased with the advent of flat panel displays. Research has shown that flat panel screens are more sensitive to artefacts and smearing and require about two times higher bit rate for a high-quality picture than the conventional Cathode Ray Tubes (CRT). Furthermore, current trends show that consumers are purchasing increasingly larger screens compared with their old television sets. Therefore, the subjective decrease in picture quality becomes even more apparent with large screen sizes as encoding and decoding artefacts are becoming subjectively more visible. Therefore, as a rule of the thumb, if source coding is MPEG-4/AVC, than net data rate of 4 Mbits/s for each SDTV programme within statistical multiplex could be considered appropriate with regard to service quality requirements, however, if the source coding is MPEG-4/AVC, than net data rate of 3 Mbits/s for each SDTV programme with statistical multiplex might do justice to service quality requirements in the nearest future.

Nevertheless, the source coding continues to be of “moving target" nature and the above-mentioned data rates are to be treated as indicative.

Coverage quality

Planning criteria, recommended by Recommendation ITU-R BT.1368-7, are used as a reference, but for coverage assessment network operators often adapt certain criteria to the national situation. An important criterion to be defined is the coverage quality that is considered acceptable. In general, a location probability of 95% is taken as acceptable coverage for rooftop reception. In case of portable reception, percentages ranging from 70 to 95 are taken. It should be noted that location probabilities of less than 95% may well lead to filing of complaints by the audience.

For assessing coverage quality, sophisticated network planning software tools are needed as well as an accurate transmitter database plus terrain and clutter databases.

Shape, terrain and the size of the areas to be covered depend very much on the country. As part of the service requirements, the areas to be covered with a certain programme package should be defined together with the required reception probability and, as far as needed, areas or conditions where a lower probability is considered acceptable.

Radiation characteristics

The required minimum field strength for portable reception and in particular indoor reception (normalized at a reception height of 10 m) is much higher than for rooftop reception.

The radiation characteristics related to outdoor and in particular indoor reception are such that coverage over a large area can in practice only be achieved by means of radiated power distribution and use of Single Frequency Networks.

5.3 HDTV

High-definition television (HDTV) services provide viewers with a significantly enhanced television experience of superior quality of service. The demand for high-definition (HD) services is driven by such factors as:

- The growing number of households with HD-ready and HDTV flat panel displays;
- The apparent decrease in quality of service SDTV broadcast offers on flat-panel displays with increasing screen size;
- The emergence of new HD-capable technologies; and
- The desire to watch high-profile sporting events and movies in HD quality.

The number of households purchasing flat-panel displays is increasing rapidly. Almost 50% of European households have a flat-panel displays, with penetration expected to increase to 87% by 2010.

Nearly all available flat-panel displays sized at 28 inches or higher are HD-ready. As more households become equipped with HD-ready television sets, they will expect to be able to access high-definition television services.

Criteria for coverage quality and radiation characteristics for HDTV are similar as for rooftop and portable reception. The considerations contained in Section 5.2 are also relevant in case of HDTV. HDTV is particularly attractive for large screen flat panel displays. While large screens can also receive the signal via simple indoor antennas, in many cases, indoor reception is used for secondary sets, usually of smaller screen size.

Multiplex capacity

In the case of HDTV, picture quality (quality of service) is the main objective and, consequently, the number of services per multiplex is limited. Initially, a limited number of HDTV broadcasted programmes is likely to be acceptable to viewers. However, future demands to convert all current standard definition TV services into HD quality without extending the number of multiplexes will be a great challenge.

The capacity requirement for HDTV is such that the MPEG-2 compression format is not any more considered as a viable option, although it is technically possible to transmit one HDTV programme in MPEG-2 in a multiplex as has been the case in Australia (DVB-T in 7 MHz channel with 64 QAM multiplex and data rate capacity of 23 Mbit/s, the video data rate chosen in the year 2001 for HDTV was 15.4 Mbit/s). Countries like the USA, using ATSC, also offer single HDTV programme per channel.

For HDTV, a new HD MPEG-4/AVC capable receiver is needed in order to implement more efficient compression system. The following aspects are of particular importance for HDTV:

- HDTV using MPEG-4/AVC compression may require for a good picture quality (quality of service) 10Mbits/s for scanning format 720p; 12 Mbits/s for scanning format 1080i and 20 Mbits/s for scanning format 1080p.
- It will be necessary to carry at least two HDTV services per multiplex to justify the use of spectrum and make an economically viable offering;
- 720p is more frequency efficient than 1080i; 1080i would need 10-20% higher transmission capacity, depending on type of content; and
- 1080p is offering best quality of picture; it is of critical importance to large screen flat panel displays (50 inch and higher) and is to be considered as an option for future deployment as well.

DVB-T and DVB-T2 Multiplex capacity

Second generation DVB-T2 standard has been developed for digital terrestrial TV Broadcasting and is offering, under similar reception circumstances, between 30% and 50% more net data capacity than DVB-T. In addition, it has the following inherent features:

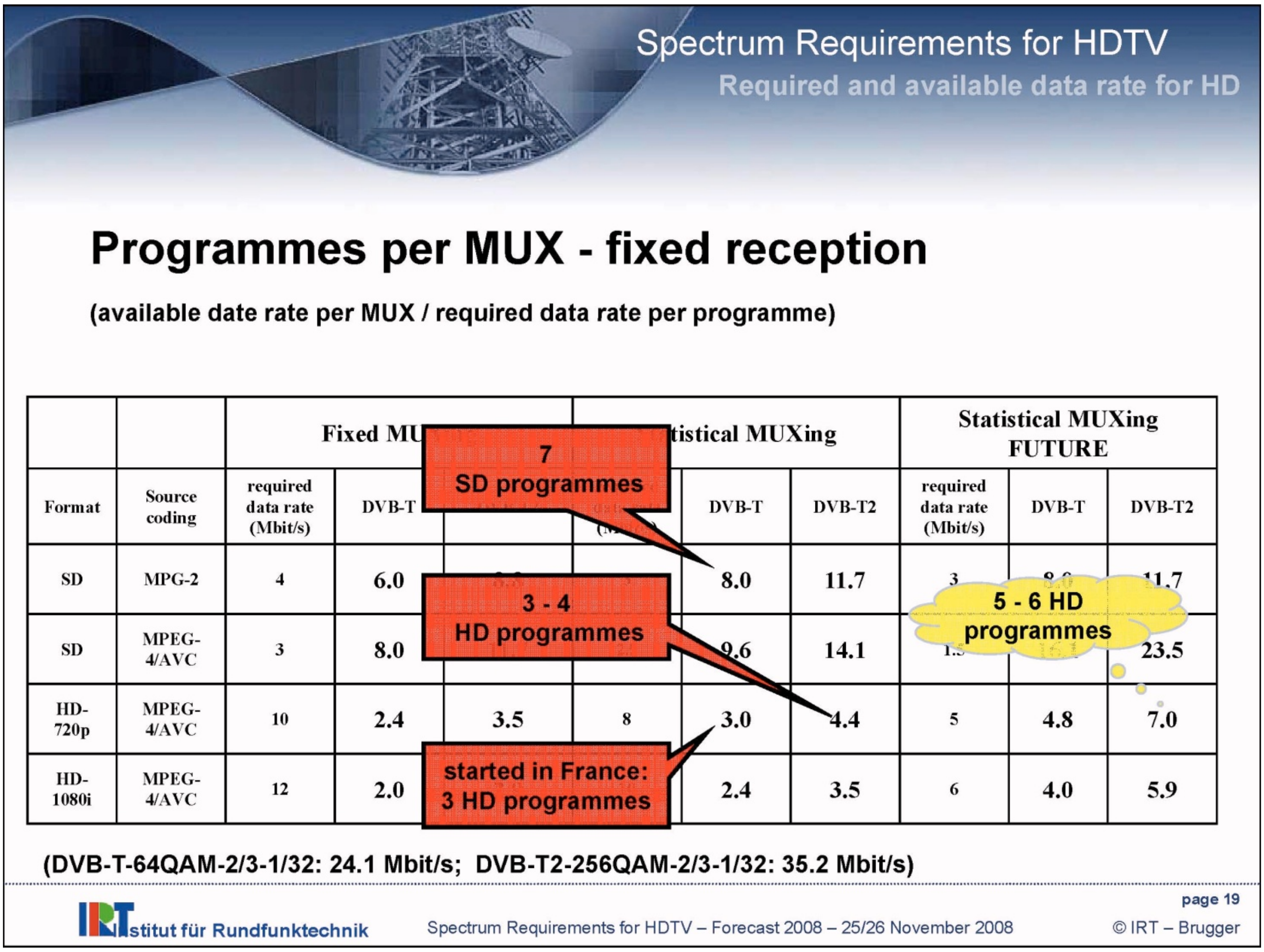
- Improved robustness against interference from other transmitters resulting in better frequency reuse;
- Better SFN performance, distance between adjacent transmitters at least 30% larger
- Focus on fixed reception using existing antennas;
- Backwards compatibility with DVB-T signal not required;
- Compatible with GE-06 Agreement;
- Early consumer products available as from 2010, and
- Mass market quantities of DVB-T2 receivers are expected as from 2012.

Currently DVB-T2 is under intensive testing in UK.

The following comparative Table 1 (courtesy of Dr. R. Brugger, IRT, EBU Forecast 2008) illustrates the number of standard definition/high definition TV programmes per multiplex for fixed reception for:

- DVB-T (64QAM-2/3-1/32, with total data rate per multiplex 24.1 Mbit/s), and
- DVB-T2 (256 QAM-2/3-1/32 with total data rate per multiplex 35.2 Mbit/s)

Table 1



Programmes per MUX - fixed reception

(available date rate per MUX / required data rate per programme)

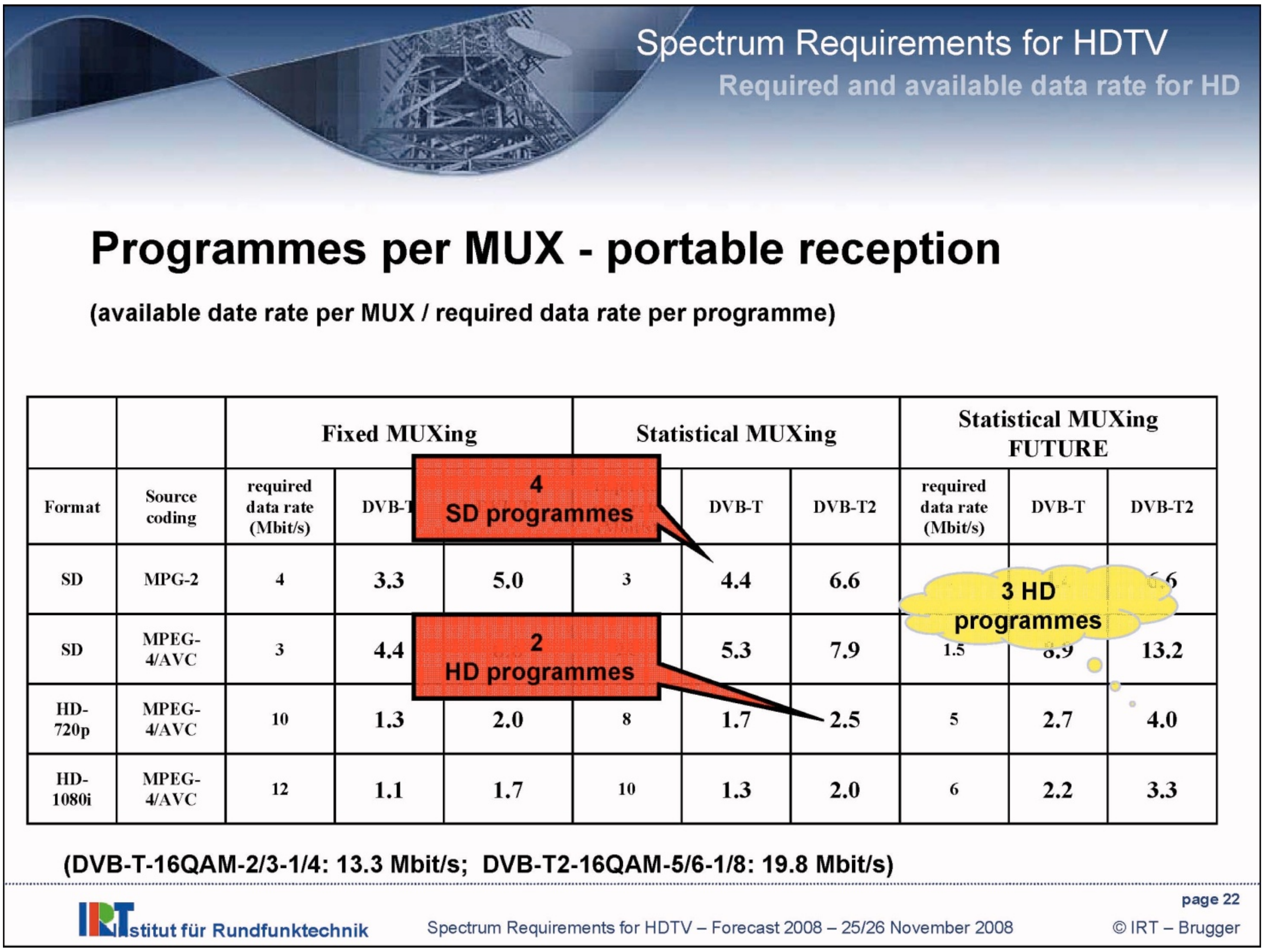
		Fixed MU[illegible]			[illegible]tistical MUXing			Statistical MUXing FUTURE		
Format	Source coding	required data rate (Mbit/s)	DVB-T	[illegible]	[illegible]	DVB-T	DVB-T2	required data rate (Mbit/s)	DVB-T	DVB-T2
SD	MPG-2	4	6.0	[illegible]	[illegible]	8.0	11.7	3	[illegible]	11.7
SD	MPEG-4/AVC	3	8.0	[illegible]	[illegible]	9.6	14.1	[illegible]	[illegible]	23.5
HD-720p	MPEG-4/AVC	10	2.4	3.5	8	3.0	4.4	5	4.8	7.0
HD-1080i	MPEG-4/AVC	12	2.0	[illegible]	[illegible]	2.4	3.5	6	4.0	5.9

(DVB-T-64QAM-2/3-1/32: 24.1 Mbit/s; DVB-T2-256QAM-2/3-1/32: 35.2 Mbit/s)

The following comparative Table 2 (courtesy of Dr. R. Brugger, IRT, EBU Forecast 2008) illustrates the number of standard definition/high definition TV programmes per multiplex for portable reception for:

- DVB-T (16QAM-2/3-1/4, with total data rate per multiplex 13.3 Mbit/s), and
- DVB-T2 (16QAM-5/6-1/8 with total data rate per multiplex 19.8 Mbit/s)

Table 2



		Fixed MUXing			Statistical MUXing			Statistical MUXing FUTURE		
Format	Source coding	required data rate (Mbit/s)	DVB-T	[illegible]	[illegible]	DVB-T	DVB-T2	required data rate (Mbit/s)	DVB-T	DVB-T2
SD	MPG-2	4	3.3	5.0	3	4.4	6.6	[illegible]	[illegible]	6.6
SD	MPEG-4/AVC	3	4.4	[illegible]	[illegible]	5.3	7.9	1.5	8.9	13.2
HD-720p	MPEG-4/AVC	10	1.3	2.0	8	1.7	2.5	5	2.7	4.0
HD-1080i	MPEG-4/AVC	12	1.1	1.7	10	1.3	2.0	6	2.2	3.3

In recent study R. Bruger and A. Gbenga-llori trev_2009-Q4_Spectrum_Brugger.pdf have investigated in concise form the potential of digital terrestrial television to provide a competitive platform for future broadcasting applications. High definition TV (HD) has been assumed as a future standard for all TV applications. The number of programmes that can be accommodated in a multiplex when applying statistical multiplexing, new source coding techniques (MPEG-4) and new channel coding techniques (DVB-T2) have been assessed and the possibilities available within the GE-06 Agreement have been considered.

This investigation shows that with the introduction of MPEG-4 plus DVB-T2 it is possible to provide a competitive offer on the terrestrial platform within the framework of the GE-06 Agreement.

Furthermore, the conclusion can be drawn that broadcasters only benefit from a transition to MPEG-4 and/or DVB-T2 under the assumption that such application of more frequency-efficient techniques can be used by them for an improved programme offer in terms of higher quality (HD) and/or a larger number of programmes.

For these reasons it is considered indispensible that the presently available broadcasting spectrum remains available for broadcasting. Otherwise, any further reduction of broadcasting spectrum would seriously jeopardize the competitiveness of the DTTV platform in not too distant future.

ISDB-T Multiplex capacity

ISDB-T consists of 13 OFDM segments. One OFDM segment corresponds to a frequency spectrum having a bandwidth of B/14 MHz (B means the bandwidth of a terrestrial TV channel: 6, 7 or 8 MHz), so one segment occupies bandwidth 6/14 MHz (428.57 kHz), 7/14 MHz (500 kHz) or 8/14 MHz (571.29 kHz). Television broadcasting employs 13 segments with a transmission bandwidth of about 5.6MHz, 6.5 MHz or 7.4 MHz.

ISDB-T has three transmission modes having different carrier intervals in order to deal with a variety of conditions such as the variable guard interval as determined by the network configuration and the Doppler shift occurring in mobile reception. In Mode 1, one segment consists of 108 carriers, while Modes 2 and 3 feature two times and four times that number of carriers, respectively.

The time interleaving duration in real time depends on the parameters set at the digital-signal stage and on the guard-interval duration, and consequently the values shown in Table 3 below for said parameters are approximate.

Table 3: Basic parameter of ISDB-T system

Transmission parameter	Mode 1	Mode 2	Mode 3
Number of segments	13		
Bandwidth	5.57 MHz (6M*) 6.50 MHz (7M*) 7.43 MHz (8M*)	5.57 MHz (6M*) 6.50 MHz (7M*) 7.43 MHz (8M*)	5.57 MHz (6M*) 6.50 MHz (7M*) 7.43 MHz (8M*)
Carrier spacing	3.968 kHz (6M*) 4.629 kHz (7M*) 5.271 kHz (8M*)	1.948 kHz (6M*) 2.361 kHz (7M*) 2.645 kHz (8M*)	0.992 kHz (6M*) 1.157 kHz (7M*) 1.322 kHz (8M*)
Number of carriers	1405	2809	5617
Active symbol duration	252 μs (6M*) 216 μs (7M*) 189 μs (8M*)	504 μs (6M*) 432 μs (7M*) 378 μs (8M*)	1008 μs (6M*) 864 μs (7M*) 756 μs (8M*)
Guard interval duration	1/4, 1/8, 1/16, 1/32 of active symbol duration		
Carrier modulation	QPSK, 16-QAM, 64-QAM, DQPSK		
Number of symbols per frame	204		
Time interleaving duration	0, 0.1s, 0.2s, 0.4s		
Inner code	Convolutional coding (1/2, 2/3, 3/4, 5/6, 7/8)		
Outer code	RS(204,188)		
Information bit rate	3.65-23.2 Mbit/s (6M*) 4.26-27.1 Mbit/s (7M*) 4.87-31.0 Mbit/s (8M*)		
Hierarchical transmission	Maximum 3 levels (Layer A, B, C)		

* Bandwidth of a terrestrial TV channel.

A mixture of fixed-reception programs and handheld reception programs is made possible through hierarchical transmission achievable by band division within a channel. “Hierarchical transmission” means that the three elements of channel coding, namely, the modulation scheme, the coding rate of convolutional error-correcting code, and the time interleaving duration, can be independently selected. Time and frequency interleaving are each performed in their respective hierarchical data segment.

As described above, the smallest hierarchical unit in a frequency spectrum is one OFDM segment. Referring to Fig. 1, one television channel consists of 13 OFDM segments, and up to three hierarchical layers (Layers A, B, and C) can be set with regard to these segments. If the OFDM signal is transmitted using only one layer, the layer is A. If the signal is transmitted using two layers, the center "rugged" layer is A and the outer layer is B. If the signal is transmitted using three layers, the center "rugged" layer is A, the middle layer is B, and the outer layer is C. Taking the channel-selection operation of the receiver into account, a frequency spectrum segmented in this way must follow a rule for arranging segments. In addition, one layer can be set for the single center segment as a partial-reception segment for handheld receivers of one-segment services. In this case, the center segment is Layer A. Using the entire band in this way is called ISDB-T.

Figure 1

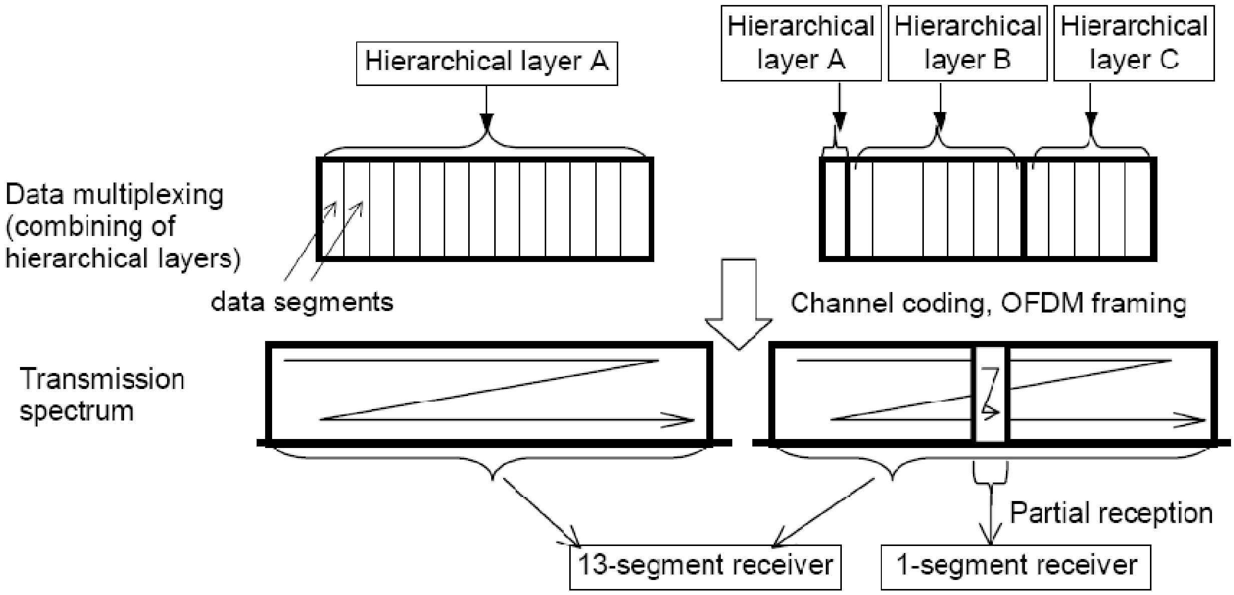


Table 4 presents the total data rate for all 13 segments, considering the ISDB-T parameters, which are defined by the Broadcaster. It can be used by fixed and portable reception:

Table 4: Total Data Rate

Carrier modulation	Convolutional code	Number of TSPs transmitted (Mode 1/2/3)	Data rate (Mbps)			
			Guard ratio: 1/4	Guard ratio: 1/8	Guard ratio: 1/16	Guard ratio: 1/32
DQPSK QPSK	1/2	156/312/624	3.651	4.056	4.295	4.425
	2/3	208/416/832	4.868	5.409	5.727	5.900
	3/4	234/468/936	5.476	6.085	6.443	6.638
	5/6	260/520/1040	6.085	6.761	7.159	7.376
	7/8	273/546/1092	6.389	7.099	7.517	7.744
16QAM	1/2	312/624/1248	7.302	8.113	8.590	8.851
	2/3	416/832/1664	9.736	10.818	11.454	11.801
	3/4	468/936/1872	10.953	12.170	12.886	13.276
	5/6	520/1040/2080	12.170	13.522	14.318	14.752
	7/8	546/1092/2184	12.779	14.198	15.034	15.489
64QAM	1/2	468/936/1872	10.953	12.170	12.886	13.276
	2/3	624/1248/2496	14.604	16.227	17.181	17.702
	3/4	702/1404/2808	16.430	18.255	19.329	19.915
	5/6	780/1560/3120	18.255	20.284	21.477	22.128
	7/8	819/1638/3276	19.168	21.298	22.551	23.234

*1: This table shows an example of the total data rate in which the same parameters are specified for all 13 segments. Note that the total data rate during hierarchical transmission varies depending on the hierarchical parameter configuration.

More detailed information on ISDB-T multiplex can be found in ITU-R Rec. BT-1306-3 (System C) and on the following standards:

ARIB Standard ARIB-STD B-31 Version 1.6 – Transmission System for Digital Terrestrial Broadcasting, November/2005. Available at: www.arib.or.jp/english/html/overview/doc/6-STD-B31v1_6-E2.pdf.

Brazilian Standard ABNT NBR 15601 – Digital Terrestrial Television – Transmission System, December/ 2007. Available at: www.abnt.org.br/tvdigital/norma_eua/ABNTNBR15601_2007Ing_2008.pdf.

5.4 Mobile TV

Mobile television has different meanings. It could be mobile reception of digital television signals of DTTV networks set up primarily for rooftop or indoor reception. It could also mean reception of television on handheld devices such as mobile telephones. The latter has received considerable attention, although concerns have been raised. Is it a mobile communication service with the network owned by telecommunication operators, or is it a broadcasting service with the network owned by broadcast network operators? Or is it a combination of both? Warning: Once considering granting a license to DVB-H operator study in detail the business plan of the incumbent applicants may be useful (recent license revocation in Germany leads to series of questions to be answered by national licensing authorities).

There are several systems for mobile television.

This report will only focus on DVB-T, DVB-H, ,T-DMB and ISDB-T. From the network planning point of view there is no difference between T-DMB and DAB-IP.

The considerations of Section 5.2 can also be applied for mobile reception of transmissions using the DVB-T or ISDB-T system.

DVB-H and T-DMB have both advantages and disadvantages. The main difference is the bandwidth and the frequency bands for which the system is specified. In order to transmit in T-DMB the same number of services as in DVB-H, more DMB multiplexes will be necessary. The choice between the systems will be mainly a matter of available frequency bands and channel raster adapted for that band.

In ISDB-T, Mobile TV programming is transmitted using one segment of the OFDM signal (see Figure 1 above). The segment used today for this purpose is the central segment, although discussions regarding the usage of partial reception of any of the 13 segments for Mobile TV are taking place. This will allow the Broadcaster to transmit 13 separate Mobile TV channels, and Pay TV business models will be possible.

In the case of one Mobile TV channel being transmitted on the central segment, the receiver has to decode the signal and demodulate this segment of the OFDM signal. This application is called “1-seg” or “1-seg technology”.

Because of bandwidth limitations, each 1-seg transmission can handle only low resolution programming targeted to mobile devices.

Handheld devices can be used at indoor and outdoor locations, in stationary position and a high speeds in cars and trains. The receiving antenna has small dimensions, compared with the wave length and many devices use built-in antennas. However these inherent features impose implementation requirements for very high minimum field strength.

Multiplex capacity

Handheld devices have very small screens and DVB-H, T-DMB and ISDB-T use advanced compression systems (MPEG-4/AVC). Therefore the data rate per programme chosen is lower. As the reception conditions are very demanding, most operators tend to choose a robust system variant with the consequence of a limited net bit rate. In that case, 10 to 15 programmes may be accommodated in a DVB-H multiplex. The number of TV services in a T-DMB multiplex is in practice 5 to 6.

In ISDB-T for mobile applications, the multiplex capacity is calculated for one segment of the OFDM. Table 5 below presents the data rate of a Single Segment, considering the ISDB-T parameters (defined by the Broadcaster):

Table 5: Data Rate of a Single Segment

Carrier modulation	Convolutional code	Number of TSPs transmitted *1 (Mode 1/2/3)	Data rate (kbps) *2			
			Guard ratio: 1/4	Guard ratio: 1/8	Guard ratio: 1/16	Guard ratio: 1/32
DQPSK QPSK	1/2	12/24/48	280.85	312.06	330.42	340.43
	2/3	16/32/64	374.47	416.08	440.56	453.91
	3/4	18/36/72	421.28	468.09	495.63	510.65
	5/6	20/40/80	468.09	520.10	550.70	567.39
	7/8	21/42/84	491.50	546.11	578.23	595.76
16QAM	1/2	24/48/96	561.71	624.13	660.84	680.87
	2/3	32/64/128	748.95	832.17	881.12	907.82
	3/4	36/72/144	842.57	936.19	991.26	1021.30
	5/6	40/80/160	936.19	1040.21	1101.40	1134.78
	7/8	42/84/168	983.00	1092.22	1156.47	1191.52
64QAM	1/2	36/72/144	842.57	936.19	991.26	1021.30
	2/3	48/96/192	1123.43	1248.26	1321.68	1361.74
	3/4	54/108/216	1263.86	1404.29	1486.90	1531.95
	5/6	60/120/240	1404.29	1560.32	1652.11	1702.17
	7/8	63/126/252	1474.50	1638.34	1734.71	1787.28

*1: Represents the number of TSPs transmitted per frame
*2: Represents the data rate (bits) per segment for transmission parameters
Data rate (bits): TSPs transmitted × 188 (bytes/TSP) × 8 (bits/byte) × 1/frame length

More detailed information on ISDB-T multiplex can be found in ITU-R Rec. BT-1306-3 (System C) and on the following standards and links:
www.arib.or.jp/english/html/overview/doc/6-STD-B31v1_6-E2.pdf or
www.abnt.org.br/tvdigital/norma_eua/ABNTNBR15601_2007Ing_2008.pdf

ARIB Standard ARIB-STD B-31 Version 1.6 – Transmission System for Digital Terrestrial Broadcasting, November/2005. Available at: www.arib.or.jp/english/html/overview/doc/6-STD-B31v1_6-E2.pdf.

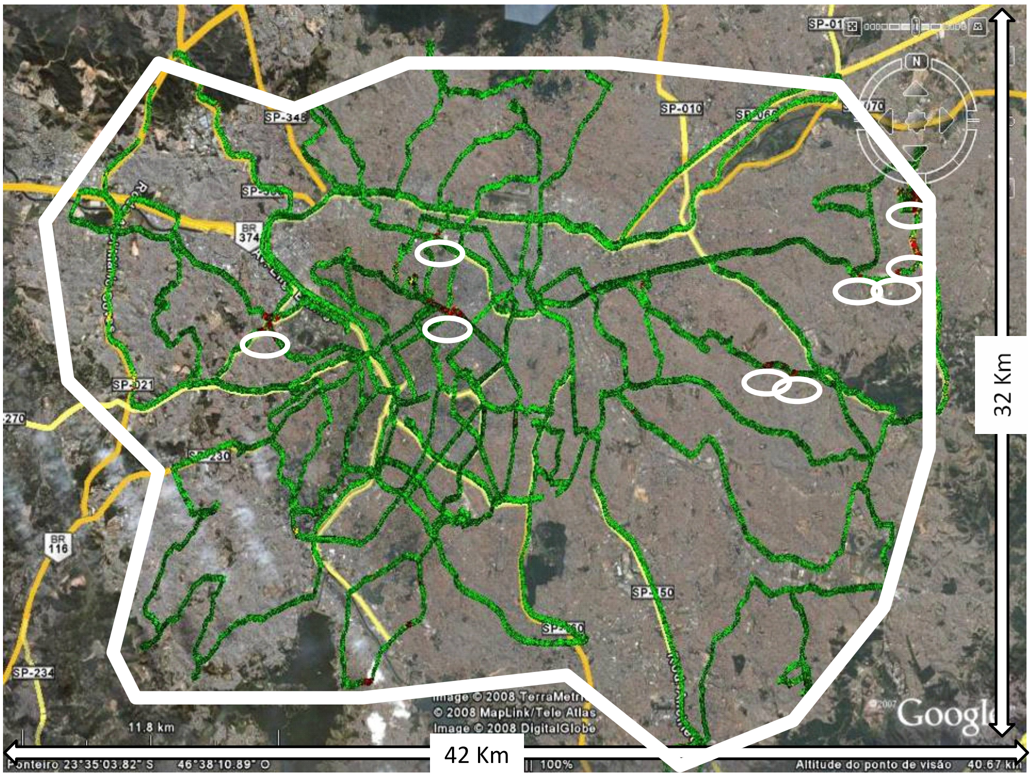
Brazilian Standard ABNT NBR 15601 – Digital Terrestrial Television - Transmission System, December /2007. Available at: www.abnt.org.br/tvdigital/norma_eua/ABNTNBR15601_2007Ing_2008.pdf.

Coverage quality

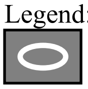
For mobile and handheld reception, a high coverage quality is required. The location probability is often taken as 95% for handheld portable reception and 99% for handheld reception inside a moving vehicle.

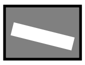
The document ITU-R **6A/99-E** (www.itu.int/md/R07-WP6A-C-0099/en) presents field mobile tests results in Brazil. In São Paulo city, for example, the mobile field tests results are shown in Figure 1 below. The tests were made in 331 measurement points, 258 outdoor and 73 indoor sites. São Paulo is the largest city of Brazil having large concentration of tall buildings in several parts of the city, similar to the landscape of New York and Tokyo. The mobile signal is transmitted from single station. This reference station has horizontal EIRP of 130 kW and total EIRP of approximately 200 kW and omnidirectional antenna. In said Figure 1, the green points show that the reception of the mobile signal is with good quality and the red ponts with bad quality, most of them in tunnels. .To identify it in a black and white print version, the white contour line shows the area where the mobile signal is with good quality, except in some points in the small white circles, where the signal has bad quality

Figure 1: ISDB-T Mobile performance of mode 3, guard interval 1/16, modulation QPSK, code rate 1/2 and time interleaving of



Legend:


Small circle: Where points inside has bad signal (most of them in tunnels)


White contour line: where the signal has good quality

Radiation characteristics

Even with a robust system variant, the field strength requirements are high because of the poor receiving antenna performance and the reception conditions (indoor, outdoor, in a vehicle with or without external antenna). The most demanding reception conditions are:

- In Band III; 16 QAM and handheld reception inside a moving vehicle without connection of the receiver to an external antenna;
- In Band IV and V (plus 1.5 GHz for some countries); 16 QAM and handheld indoor reception.

In practice network roll-out will start with high power transmitters near towns for coverage of urban areas. As far as required, Single Frequency Networks with a dense transmitter raster will be installed to improve coverage. More information on network aspects for DVB-H and T-DMB can be found in EBU Tech 3327 and for ISDB-T can be found in the Recommendation ITU-R 1368-7 - Planning criteria for digital terrestrial television services in the VHF/UHF bands.

5.5 Interactive TV and data services

Multiplex capacity is generally used for video and related sound services. Sometimes a package of radio programmes may also be included. In addition, the multiplex may contain data for a variety of services including:

- Electronic Programme Guide
- Service Information

- Interactive services
- Teletext
- System Software Update (SSU)

The data rate allocated to the above mentioned services varies considerably from case to case.

Interactive services

There are two types of interactive television services:

- Local interactive services, where the information is stored in the receiver (teletext is an example);
- Remote interactive services, where information is sent to the programme provider via a return channel, this information can include a reaction to a programme (e.g. voting) or a demand for certain programmes (video on demand or pay per view).

Remote interactive TV has long been seen as an important feature of digital television, however remote interactive TV applications are limited in many countries. Remote Interactive services require a return path. If the return path is provided by wired or mobile telecommunication systems, interactive services have no direct impact on the terrestrial digital television network. System for an in-band return path has been specified, the so-called DVB-RCT, but no commercial applications reported. Local interactivity, however, is popular. The Teletext (ITU-R BT.653-3) continues to be an important part of the digital television service offer.

Basic interactive services, like Teletext, can be used with standard DVB-T receivers. For more advanced interactive services, receivers should be equipped with software layer called Middleware in addition to the operating system. Examples of middleware are the Multimedia Home Platform (MHP), Ginga (for more information see ITU-T Recommendation H.761 and ITU-D Doc. 2/229), and Multimedia and Hypermedia information coding Expert Group (MHEG) systems.

In a number of countries, combined DVB-T/ IPTV boxes with hard disks are offered to consumers. The most popular programmes can be received off-air via digital terrestrial television networks, while IPTV networks provide additional information, on-demand programmes and special interest programmes. Programmes of choice can be automatically downloaded on the hard disk. In this way wide-band remote interactive services are rendered. In order to show and select the stored programmes, each programme should be accompanied by metadata.

Interactive multimedia services

Interactive DTTV may become viable delivery media for provision of a wide range of modern information and communication societal services to the population of developing countries. It can be achieved through encapsulation of multimedia data streams (including web and web-type services data) into TV broadcasting digital flows. The reception of the above services will be done with the help of digital TV broadcasting STBs and their data displayed on the TV-set screen. The same STBs with their software and hardware are supporting the return path channels either on PSTN lines (on the basis of built-in dial-up modems), on xDSL, or on home cable lines HFC (Hybrid Fiber Cable) on the basis of DOCSIS standard (built on or external DOCSIS modems connected with the STBs by Ethernet interface).

Enhanced TV and interactive TV are principally new TV broadcasting services that can only be provided on the basis of digital broadcasting. The concept of enhanced TV envisages pay services with coded signal that requires using smart cards and conditional access systems. Leasing equipment from dedicated operator may enable interactive services to the population under subscription packages. Moreover the possibility of free reception of societal programmes package (both national and regional) by the population remains possible.

Enhanced TV envisages the technology of pseudo-interactive (locally build in the receiver) DTTV services The without a return path channel. These include various information services and reference materials, such as TV – the press, weather forecasts, ratings, advertisement channels, etc. During the transition to digital broadcasting such services may be provided at once to populated areas where there is a shortage of telephones and where it is yet impossible to organize a return path channel for full-scale interactive service.

In regions with sufficient telephone penetration interactive systems may be deployed on the basis of a return path channel via PSTN line. A return channel can support various e-applications (commerce, government, employment, health, education, agriculture, polls, ratings, cirtual CD, web games etc.). At the same time high data-rate access to the Internet on dedicated DTTV channels may be provided. Towards this end a TV viewer may not need a PC as in this case its function will be performed by the STB for digital broadcasting: it will display web pages on the screen organized in accordance with "carrousel" principle after appropriate re-formatting and re-scaling of text and graphic objects of web pages in a way allowing their display on the screen of a standard definition TV set. The web browser is operated with the help of a cordless keyboard. Connection does not require any additional time, as the Internet channel is permanently available. In fact this service is a factor of new quality of life, as television becomes a powerful information gateway concentrating most advanced information technologies that enable any person regardless of his/her age and education/social status to be an integrated member of the global information infrastructure without buying a PC. The digital TV broadcasting STB supports the Internet access and e-mail functions.

At the next stage of deploying digital TV broadcasting system it becomes possible to extend the interactive services to remote rural areas with insufficient PSTN line penetration via wireless return channel.

Integrated interactive multipurpose information system on the basis of digital TV broadcasting

The said e-applications may form an integrated interactive multipurpose information system implemented on the basis of a single user's interface (browser) and a uniform interactive platform. Thus a broadcasting operator may become a provider of the service system to corporate and individual users on basis of data formation centers of corresponding information services, including specialized servers and devices for encapsulation of the said services in TV broadcasting signals. Server software represents a multifunctional software package including, in particular, billing modules, modules of interoperation with banking payment systems, advertising management, mediametrics collection and processing of return (interactive) channels data, etc. The user part of the software for such a system (browser) is installed in the digital broadcasting STBs.

Such system could generate additional revenues for the operator via subscription fee charged for conditional access system (implemented through STB smart cards). However it is advertisers' payments that constitute the most important source of revenue for the operator of an interactive information system. Advertising in interactive information systems radically differs from traditional linear advertising in analog broadcasting. Its main distinction lies in its target nature (different groups of users get different advertisements) and in the built-in function of measuring the audience (mediametrics). Actually STBs can support the following functions:

1. Assignment of a consumer index to the subscriber. When a subscriber is switched in the system a questionnaire is displayed on the screen with a number of items referring to the subscriber's social status, age, sex, revenue, interests in various spheres, goods and services of interest, etc (such poll may be repeated over certain periods of time, e.g. annually, to fix the changes if any). The index is forwarded to the operator' server and further on is used to identify the advertising materials to be forwarded to this subscriber.
2. Mediametrics (measurement of the audience) of TV programs. An STB registers each switch over from one TV channel to another and certainly the viewing time in each channel. Periodically the obtained viewing data are forwarded to the operator's server. The function allows calculating the exact rather than statistical rating of TV programmes.
3. Advertising mediametrics. Each payment for goods and services effected by a subscriber with an STB (supporting the e-commerce function) is registered and the information about the type of goods or services bought is transmitted to the operator's server where the connection between the purchase of the goods and services and their advertising supplied to the subscriber earlier is analyzed. This function helps evaluating the effectiveness of advertising materials.

Interactive information system may provide data of vital importance both for TV companies (program ratings) and advertisers (much higher effectiveness because of target ratings obtained).

5.6 Briefing on service developments and network evolution

Service developments

In general, it can be reported that digital terrestrial television in pure Free-To-Air (FTA) offer, or combination of FTA with pay per view (PPV) TV offer, is becoming very popular.

Due to widening presence of flat panel displays in growing number of households, there is a rising demand for high quality video.

HDTV is expected to become a future norm for TV viewing in the living room. A number of countries have already begun HDTV transmissions. Cable TV, satellite TV and IPTV are less restricted in capacity than digital terrestrial networks and are more suitable for HDTV transmissions of highest service quality. Digital terrestrial networks may offer HDTV while SDTV may be mainly used for secondary sets, recreational homes and handheld devices as is the case in Australia.

Consumer demand for mobile TV still needs to be proven.

Interactive TV and, in particular, use of on-demand and time-shifted services via PVRs or IPTV networks (e.g. TV Anytime) is expected to be of increasing importance. Innovative interactive applications are yet to be deployed over DTTV. With the development of Home Networks, consumer demand for integrated media devices and interactive data services is expected to increase even more. This may lead to a decreasing need for linear (direct) broadcasting, and an increasing need for content that could be downloaded.

Digital terrestrial television networks will face increasing competition due to the service offerings on digital cable TV, IPTV and satellite TV platforms. Digital terrestrial television is, however, a cost effective way to distribute a limited package of popular programmes and to achieve near universal coverage. Additional content and special interest programmes may be supplemented using IPTV networks, where available.

Service and network evolution

For each type of service in a digital terrestrial television network basic choices have to be made amongst three interdependent parameters: multiplex capacity, coverage quality and radiation characteristics. The choice will have a major impact on the transmitter network.

Television services aimed at fixed reception with rooftop antennas require moderate field strength levels. The choice is often made for high coverage probability over large areas and a relative high net data rate of the multiplex.

Television services aimed at portable reception with small antennas at indoor and outdoor locations require considerably higher field strength levels than rooftop reception. Choices are often made for a more robust DTTV system variant resulting in lower net data rate of the multiplex, moderate to high coverage probability and transmitter network of higher density than one intended for rooftop reception. Services generally target urban areas.

MPEG-4/AVC is the dominant choice of countries, enabling better spectrum efficiency for both SDTV and HDTV in particular (HDTV requires a high net data rate per multiplex). An advanced transmission system DVB-T2 has been developed and standardized with the first receivers expected to be on the market as from 2010.

Mobile TV requires very high field strength levels and a very robust DVB-T, ISDB-T or other System variant is likely to be chosen and hence a limited net bit rate per multiplex. Mobile TV systems like DVB-H, T-DMB and ISDB-T make use of MPEG-4 compression. A high coverage probability is needed. The network generally consists of high power transmitters near towns complemented by transmitters in SFN.

Interactive television could use a significant part of the multiplex capacity. For remote interactivity a return path is needed using PSTN or wireless telecommunication systems, broadband access technology inclusive

5.7 Regulatory environment

Regulatory decisions regarding the use of the frequency spectrum are taken by national Regulatory Authorities, on the basis of international Treaties, Standards and Recommendations. To this purpose, national administrations work together in international organizations, such as the International Telecommunication Union (ITU) on world-wide level, and with regional organizations concerned (e.g. APT, ASBU, CEPT, CITEL, etc).

Within the European Union (EU), the spectrum policies of the European Commission (EC) are of great importance to national administrations.

The Section here-after deals with the main international regulatory provisions for use of the bands allocated to broadcasting service.

Service allocations in the Radio Regulations

The ITU Radio Regulations form a treaty between ITU member states and are reviewed at regular intervals by World Radio Conferences (WRC). The last WRC (WRC-07) was held in 2007 and the next one is planned in 2012. The Radio Regulations prescribe the use of frequency bands and give procedures for managing the use of these bands.

A recently appearing tendency to regulate spectrum on service and technology neutral basis may lead to a reallocation of frequency bands for several types of services and to a need to review existing ITU definitions (e.g. broadcasting, mobile and fixed services). The market based approach in spectrum management is of great concern for services that are not only based on economic values, but also on cultural and societal values, such as broadcasting. Such approach may also lead to the use of the same frequency band by services with very different technical characteristics. Preventing unacceptable interference therefore would need careful consideration.

Band allocations

Band III (174-230 MHz) is allocated in Region 1 to broadcasting services and, in some countries, to mobile services. Contrary to one or two decades ago, there is little interest for mobile radiocommunication services in Band III.

Band IV and V (470-862 MHz) is allocated to broadcasting services and, as a result of decisions made at WRC-07, for mobile services in the frequency range 790-862 MHz (TV channels 61 to 69) from 17 June 2015, mainly for Region 1.

This date corresponds to the end of the analogue / digital broadcast transition period as established in the GE-06 Agreement. However, in 65 countries, including 22 European countries, mobile radiocommunication services are allowed immediately after WRC-07 under the condition that broadcasting services (or other services using the band in accordance with the Radio Regulations) in neighbouring countries will be protected.

It should be noted that within the mobile service allocation, international mobile telecommunication (IMT) services have been identified as one of the possible uses. IMT services include both IMT 2000 (3G technologies, UMTS, CDMA 2000, WiMAX) as well as IMT advanced services (4G). At the WRC-07, national administrations decided to merge IMT 2000 and IMT advanced services into a single category.

WRC-07 agreed that broadcasting services in GE-06 should be protected from mobile services and that countries planning to implement mobile services in the frequencies between 790-862 MHz shall coordinate with neighbouring countries prior to implementation. Furthermore, WRC-07 calls on the ITU to study compatibility between mobile and broadcasting services in the frequency range 790-862 MHz (ITU JTG 5-6). The results of these studies will be presented at WRC-12.

In addition Bands IV and V are allocated to the following other services:

- Radio astronomy (channel 36), in some countries;
- Radio navigations services (645-862 MHz), in some European countries;
- Fixed communication services in 790-862 MHz;
- Services ancillary to broadcasting (such as radio microphones) provided that broadcasting and mobile services are protected, in some countries.

The Band 1452-1492 MHz is allocated to broadcasting and satellite broadcasting and the use is, according to the Radio Regulations, limited to digital audio broadcasting.

Frequency Plans

For most broadcasting bands international a-priori frequency Plans have been established, such as the GE-06 Agreement. The main conditions for a successful frequency Plan are:

- Equitable access to the frequency band for all countries concerned;
- Avoidance of unacceptable interference; and
- Flexibility for future developments.

Frequency Plans define the rights of the participating countries for use of transmissions of which the technical characteristics are described in detail;

- Procedures for the execution of an Agreement;
- Procedures for modifications of the frequency Plan;
- Procedures for notification of operational transmissions.

Bands III, IV and V

The use of Band III, IV and V for broadcasting and non-broadcasting services is regulated by the GE-06 Agreement. Band III has been planned for digital radio (T-DAB) and digital television (DVB-T). Results of GE-06 are often expressed in the number of “layers”. “Layers” are not defined in GE-06, but are in general understood as the number of channels that can be received in an area. Most countries achieved three T-DAB and one DVB-T “layer” in Band III. Almost all European countries have adapted a 7 MHz channel raster in Band III. Bands IV and V has been planned for DVB-T in 8 MHz channel. Most countries achieved seven or eight DVB-T “layers” in Band IV and V.

The procedures of the GE-06 Agreement make a flexible implementation of the Plan possible.

The main provisions in this respect are:

- Plan entries can be used for broadcasting transmissions with different characteristics than specified in the Plan entry, provided that the interfering field strength of the Plan entry, calculated at a great number of points, is not exceeded; the so-called conformity check ;
- Plan entries can be used for different applications of broadcasting or mobile services provided that the band is allocated to the relevant service in the Radio Regulations and that the power density limit of the Plan entry is not exceeded; and
- Plan entries can be modified after agreement of countries that are potentially affected by the change. It should be noted that the modification procedure can take a considerable time before all agreements have been reached. If after about 2 ¼ years the necessary agreements have not been reached, the proposed modification will lapse.

The GE-06 Agreements contains two frequency plans, an analogue TV Plan and a digital broadcasting Plan. These two Plans are not mutually compatible. After a transition period, the analogue TV Plan will cease to exist and analogue television transmissions are no longer protected. The transition period ends on 17 June 2015. However in a number of African and Arab countries analogue television in Band III needs to be protected until 17 June 2020.

5.8 Digital switch-over (DSO)

Digital switch-over (DSO) is a complex process that takes years. National governments need to adopt a clear strategy for the transition from analogue to digital television that is supported by all entities concerned. A number of elements that should be included in the strategy are:

- Date for analogue switch-off;
- Coordination of frequencies with neighbouring countries for digital television during the transition period;
- Licensing process for digital terrestrial television;

- Agreements regarding termination of analogue television licenses;
- Provisions for simulcasting;
- Agreements with consumer equipment manufactures ensuring that sufficient number of adequate digital receiving equipment is available on time;
- Provisions to enable low income households to procure digital STB/receivers; and
- Communication campaigns to inform and assist the public.

The manner in which digital terrestrial television is introduced and the time period necessary to complete the process depends on the market and differs to country. The simulcast period, when broadcast services are delivered in both digitally and analogue form in given area, depends on the switch-over strategies adopted.

After analogue television has been switched-off, the spectrum released becomes available for new services.

This released spectrum is often called the “Digital Dividend”.

Analogue switch-off (ASO)

Some national governments have promoted digital switchover through loans or grants, subsidized set top boxes, or temporary reductions in license fees paid by broadcasters. EC for example has opened enquiries into digital switch-over funding in a number of member-states where it believes that EC state aid rules have been violated. In general, EU member-states can make funding available on condition that it does not favour one specific delivery platform (technological neutrality principle).

Licensing

National administrations prepare legislation taking into account ITU and regional agreements (among EU member-states, CEPT agreements and EC policies and directives). On the basis of national legislation licenses for digital television are granted. The licensing processes for digital terrestrial television vary considerably. In some countries, network operators are granted licenses, while in others, licenses are granted to content providers, multiplex operators and network operators. Selection of applicants is sometimes done on the basis of auctions, in other cases by means of comparative tests (“beauty contests”). In most cases, public broadcasting transmissions are licensed by priority. License costs differ considerably, in some cases a fee is required that covers the costs of the licensing process by the regulator, in other cases “administrative pricing” of spectrum is applied where the fee is related to the market value of the part of spectrum concerned.

5.9 Digital dividend

Many interpretations exist for the term “Digital Dividend”. However, for the countries in the European Union, the definition used by the European Commission and its advisory body the Radio Spectrum Policy Group (RSPG) is most relevant. The Digital Dividend is, according to the RSPG, to be understood as the spectrum made available over and above that required to accommodate the existing analogue television services in a digital form in VHF (Band III: 174-230 MHz) and UHF (Bands IV and V: initially 470–862 MHz, being subsequently modified by WRC-07 to 470-790 MHz).

In its Communication on “EU spectrum policy priorities for the digital switchover in the context of the upcoming ITU Regional Radiocommunication Conference 2006 (RRC-06)”, the European Commission identified three categories:

1) Spectrum needed for the improvement of terrestrial broadcasting services: e.g. services with higher technical quality (notably HDTV), increased number of programmes and/or enhancement of TV experience (e.g. multi-camera angles for sports, individual news streams and other quasi-interactive options);

2) Radio resources needed for “converged” broadcasting services which are expected to be primarily “hybrids” of traditional broadcast and mobile communication services;

3) Frequencies to be allocated for new “uses” which do not belong to the broadcasting family of applications. Some of these potential new “uses” of the spectrum dividend are future services and applications which are not yet marketed or are existing but do not yet operate in these frequencies (e.g. extensions of 3G services, short range radio “broadband” applications).

In most developing countries, the existing analogue TV services can be accommodated into one DVB-T or ISDB-T multiplex. However, countries with five or more analogue TV services and using DVB-T or ISDB-T with a robust modulation may need two DVB-T or ISDB-T multiplexes for broadcasting their existing analogue TV services in digital delivery SDTV format.

For a successful introduction of DVB-T or ISDB-T, more multiplexes are needed than the ones containing the current analogue TV programmes. However, according to the RSPG definition, the multiplexes not needed to transmit the existing analogue services in digital format, are falling into the category of digital dividend.

5.10 Changes to networks

As a consequence of the developments described in preceeding Sections 5.1, 5.2, and 5.7 changes to terrestrial television networks may be needed.

Network changes can relate to one or more of the following network elements:

- Radiation characteristics;
- DTTV system;
- Transmitting sites; and
- Multiplexes.

Transmitting station and network layout:

a) Transmitting site

Reserve (stand-by) transmitter in n+1 configuration be used in case of maintenance or transmitter breakdown. The reserve transmitter should then be adjusted to the frequency with same power of the transmitter it replaces.

Another often stand-by configuration is formed by installing stand-by units per transmitter such as a double driver stage. The RF power amplifier, in case of solid state transmitters, has a built-in redundancy due to the parallel operation of a number of amplifiers. In some cases, the antenna is split into two parts and each part is fed by an antenna cable. In this way, part of the antenna installation can be switched off while the station is still operational, albeit on reduced radiated power.

b) Transmitter networks

Digital terrestrial television transmitter networks consist in general of the following parts:

- Central multiplex centre;
- Central monitoring and operations centre;
- Distribution links (radio relay, fibre optic);
- Main transmitters;
- Fill-in transmitters (gap fillers).

The transmitters can be operated as Multi Frequency Network (MFN), as Single Frequency Network (SFN) or as a combination of both. The latter can consist of main stations as MFN and a main station and a number of low power stations as SFN. In SFN, coverage is achieved by means of power distribution over several stations. The total power of the stations in the SFN is less than the power of one station that would be needed to coverage a similar area. Moreover, reception probability is improved by simultaneous reception of multiple useful signals. Operation of a SFN is complex, in particular regarding the synchronization in transmitter timing, and is also more costly.

In a MFN configuration, it is possible to broadcast local programmes per site and with a higher bitrate because a long guard interval is not needed.

Fill-in transmitters are usually fed off-air by a main transmitter and the signal is retransmitted at a different frequency (MFN). In a SFN, it is also possible to feed a fill-in transmitter off-air and retransmit at the same frequency, but care must be taken to ensure a sufficient isolation between incoming and outgoing signal.

Sufficient isolation is in some cases difficult to achieve and fill-in transmitters in SFN are then fed in the same way as main transmitters by radio relay or fibre optic link.

5.10.1 Radiation characteristics

Reasons for change

Changes to the radiation characteristics of a transmitting station may take place for a variety of reasons such as:

- Introduction of new services ;
- Introduction of sub-bands and guard-bands ;
- Operational reasons;
- Coverage improvement.

Operational reasons for changing characteristics of digital TV stations could occur when the roll-out of TV networks is done under time pressure. It is not always possible to acquire the required local planning licenses in time or to have transmitters available at the required power level. Therefore, temporary installations or even stations, with restricted power or antenna height may be necessary.

It could also occur that antenna installations cannot handle the power requirements of new digital transmitters and that antennas need to be replaced.

It may turn out that the coverage of a station is unsatisfactory or becomes unsatisfactory as a result of an increase in interference due to the roll-out of digital TV stations in neighbouring countries. Then a more powerful transmitter or improved antenna diagram may be needed to be deployed.

Frequency

A frequency change requires the retuning of the transmitter and antenna filters. In the case of a SFN, all transmitters in the SFN must change frequency and preferably simultaneously. The antenna pattern is frequency dependent and can be different for the new frequency.

In addition, the new frequency may require restrictions in other directions than those used by the former frequency as a result of international agreements. In order to comply with these restrictions, the maximum radiated power may need to be reduced. If the new frequency is in another part of the band, propagation characteristics will be different.

A frequency change will therefore most likely result in coverage modifications which, in some areas, could result in coverage problems. In these cases, viewers in the areas concerned have to be informed and advised timely on ways to improve their reception.

Power

Increasing radiated power, as far as allowed by relevant International Plan (e.g. GE-06 Agreement) and local planning licenses can be implemented in different ways.

Antenna:

a) Horizontal radiation pattern

The antenna pattern is influenced by the antenna design and construction and by the frequency. The basic radiating element is a panel with dipole arrangements. In general a transmitting antenna consists of several tiers of panels. The number of panels in a single tier depends on the support structure and the required horizontal radiation pattern. Non-directional antennas located at the top of the mast have often four panels per tier.

Newly designed antenna constructions have considerably improved radiation characteristics throughout the frequency band.

b) Vertical radiation pattern

The vertical radiation pattern is of particular interest for coverage close to the transmitter. Bigger number of tiers leads to increased antenna gain, but also to more problematic reception close to the transmitting site.

Some network operators do not install antennas of more than eight tiers if the site is located in an urban area. With more tiers the necessary null-fill can only be realized at the costs of the additional gain.

Even without changing the number of tiers, the replacement of an antenna almost always changes the angle of the "nulls" in the vertical diagram, resulting in a location shift of areas with lower field strength close to the transmitter.

Areas of high field strength near the transmitter are also of concern. In areas where maxima occur in the pattern close to the transmitter, the field strength could be so high that it causes interference to consumer and professional equipment. Very close to the antenna there may be a health danger. There are different electromagnetic compatibility regulations per country; field strength limitations and hence limitations in the radiated power may be necessary.

The main beam of the vertical antenna radiation pattern should be directed towards the coverage area (and not beyond). In particular, in case of high antenna heights or relative small coverage areas a beam tilt will be necessary. This beam tilt has the additional advantage that less power is radiated towards the horizon and thus less interference created towards other transmissions.

c) Polarization

Horizontal polarization causes less ghost images (delayed signal reflections) in reception compared with vertical polarization. Therefore with analogue TV most antennae are horizontally polarized. While ghost images are not a problem in digital TV, most countries have opted for horizontal polarization because of the existing base of horizontally polarized rooftop antennae and the wish to reuse existing transmission installations as much as possible. If reception at low receiving heights is important and the receiving antennae are mainly vertically polarised, e.g. in case of indoor and mobile TV reception, vertical polarization may be adopted.

d) Operational aspects

Antenna changes are costly if new antennas or antenna combiners need to be installed. Work on antennas needs often to be done at elevated locations. Due to weather conditions, antenna maintenance and construction may be restricted to appropriate season. There is limited space on antenna masts. For new antennas, compromises may have to be made regarding height and aperture. In some cases, a temporary antenna with smaller aperture (and consequently lower gain) may need to be installed until another antenna has been removed. If the lower gain cannot be compensated by a higher transmitter power a reduced coverage will be the result.

Evidence suggests that installation errors can be made on the top of high antenna masts/towers where very difficult working conditions prevail. It is recommended to measure antenna radiation characteristics by specially equipped helicopter for verification of horizontal and vertical radiation patterns (less than an hour would be adequate). As a rule of the thumb both patterns are to be verified before putting relevant DTTV transmitter into operation. Around 30% errors have been detected by helicopter antenna verification measurements in BBC analogue TV broadcasting network alone.

While creating graceful degradation effects at analogue TV broadcasting coverage area such error rate can not be tolerated for DTTV broadcasting – such workmanship omissions would create loop-holes in the coverage area – viewers' complaints will be inevitable.

e) Antenna height

Increasing antenna height is generally a frequency efficient way to improve coverage. It allows the coverage area to be enlarged, but, beyond the horizon, the interfering field strength to other service areas is marginal. Increasing antenna height is, however, not a trivial matter and may not be possible in many cases due to practical or regulatory reasons.

Furthermore, in many countries existing transmission installations are used mainly for digital TV for reasons of cost savings and the inability to increase antenna height. In some countries, however, more dense digital TV networks are used (as SFN) in order to improve indoor and mobile reception.

In these cases, the coverage area per transmitter is smaller than it was with analogue TV, therefore antenna heights could also be lower. In case of high antenna heights and relative small coverage areas, care should be taken with the null-fill in the vertical radiation pattern and an adequate beam tilt will be needed.

5.10.2 DTTV system

The choice of DTTV compression or transmission system depends on the kind of service that need to be provided. These requirements may change over time. It may also be necessary to adopt a more efficient compression or transmission system if the number of multiplexes is reduced or cannot be extended, and the requirements for broadcasting services exceed the capacity of the available frequency band. This is of paramount importance if Bands IV and V are partitioned and the required services have less spectrum available.

The options

The DVB-T system has the choice of 2k or 8k Fast Fourier Transform (FFT) sizes, three types of carrier modulation and five code rates; in total, there are 120 possible variants.

With a proper choice of modulation and code rate a robust variant can be achieved with low required field strength, but also a low bit rate.

Alternatively, a high multiplex capacity can be chosen, but in that case a high field strength is required. The guard interval is important for Single Frequency Network.

In addition there is a choice for non-hierarchical modulation and hierarchical modulation. In the latter case, a choice also has to be made between three possible modulation parameters.

Similar considerations are valid for ISDB-T system.

Changing DVB-T, ISDB-T or other System variant is a simple adjustment in the transmitter. The transmitter with the lowest net bit rate of a network determines the multiplex capacity of that network, therefore all transmitters of a network have generally been adjusted to the same DVB-T, ISDB-T or other System variant. The bit rate of the MPEG Transport Stream, the incoming signal to the transmitter, should not exceed the bit rate of the DVB-T, ISDB-T or other System variant for which the transmitter has been adjusted.

In DVB-T2 the use of highest-order constellation 256QAM for example increases the gross data rate to 8 bits per OFDM cell, thus increasing spectral efficiency and capacity transported for a given code rate. Similar considerations are applicable as for the DVB-T above.

FFT size

The 2k and 8k variants refer to the number of OFDM sub-carriers in the digital signal. There is a trend to use 8k only. 2k has an advantage for mobile reception because interference due to the Doppler effect occurs at four times higher speeds than with 8k. With 2k, however the guard interval, important for SFN operation, is four times shorter than with 8k. The DVB-H and ISDB-T system also has a compromise variant of 4k.

Carrier modulation and code rate (DVB-T and ISDB-T)

In the case of portable reception and in particular indoor reception, field strength requirements are very demanding and the trend is to use 16QAM with relative low code rate (2/3 or ½). For rooftop reception 64 QAM and a relative high code rate (2/3 or 3/4) is often chosen. As indicated in Section 2.2, a compromise has to be found between multiplex capacity, coverage quality and wanted field strength. In practice, different compromises are made: 16QAM is also used for networks planned for rooftop reception and 64QAM for networks planned for indoor reception. There are cases known where a very high number of services need to be broadcasted over a small area and 64QAM with a code rate of 7/8 is used providing 31.6 Mb/s.

Hierarchical modulation (DVB-T and ISDB-T)

Hierarchical modulation is not used much in practice. It allows for the transmission of two independent multiplexes by one transmitter (one frequency) with different transmission quality at the costs of some overhead capacity. A high priority multiplex can, for instance, be used to broadcast a limited number of main services for indoor reception in a large area. The low priority multiplex can be used to broadcast a larger number of services for indoor reception near the transmitter but for rooftop reception in the country side.

Compression and multiplexing

Encoding and multiplexing takes place at a central point and is a relative expensive part of the transmission chain. Changing or improving compression or the multiplex system has no direct impact on the transmitter stations and on coverage. Statistical multiplexing is often used and compared to a constant bit rate per service, it provides a way to increase multiplex capacity while maintaining picture quality.

Upgrading encoders

Experience has shown that the efficiency of encoders improves over the years until the technology is mature. Upgrading or replacing encoders of the same compression system will result in more services in a multiplex or the same number of services but with a higher quality.

Use of MPEG-4

MPEG-4 is an improved future-proof compression system, known as MPEG-4/AVC, ITU-T Rec.H.264 and MPEG-4/AVC Part 10. Compared to MPEG-2, MPEG-4 is achieving coding efficiency improvement of at least 1.5 times. In cases where MPEG-4 is used to provide an increased number of services in a multiplex, an additional advantage is obtained with statistical multiplexing. MPEG-4 already is in use for both SDTV and HDTV transmission and reception.

Transmission system

The process of modulation and error coding takes place in the driver of a digital TV transmitter. A transmitter may already be equipped for different transmission systems. If not, a change of transmission system, for instance replacing DVB-T by DVB-T2 or DVB-H requires a software change or replacement of the driver modules in the transmitter. A change of transmission system has a minor direct impact on the network. However, the service for which the new system has been implemented may have very different requirements (e.g. mobile TV) and adequate receivers are needed.

For terrestrial HDTV transmissions, MPEG-4 compression is used, for example the ISDB-T System in operation in Brazil is based on MPEG-4.

When HDTV introduction is planned with DVB-T/MPEG-4, no more than two HDTV services can be accommodated in a multiplex if it is required to show critical material on large flat panel display screens. With medium size screens and when the viewing distance is more than three times the screen height, three HDTV services in a multiplex may be delivered.

It is expected that MPEG-4 encoders will improve over the years (as did MPEG-2 encoders).

If DTTV introduction is foreseen in 2010 or later, use of enhanced DVB-T2 system might be considered.

Introduction of a new transmission system for existing services can only be done, without service interruptions, by means of parallel (simulcast) transmissions of the existing and the new system. When all receivers are equipped with the new system, the transmissions carrying the old system can be closed down and the multiplexes realocated to broadcasting of new services. This process will be shortened if, after a certain date, the Regulatory Authority concerned imposes an obligation that only the consumer equipment being able to receive the new and the old system, will be allowed to be on sale.

If no multiplexes are available for parallel(simulcast) operation of a new transmission system such as DVB-T2, because, for example, spectrum in Bands IV and V has been allocated to other non-broadcasting services, one or both of the following ways may be considered:

- Source new frequencies based on GE-06 procedures but bare in mind that these frequencies may be constrained in certain cases;
- Free one multiplex by moving the services from this multiplex to other multiplexes whereby making use of advantages of more mature technology and introduce in the liberated multiplex the new HDTV services based on most advanced technology (e.g. , statistical multiplexing, DVB-T2/MPEG4).

Transmitting sites

In general, television network roll-out starts with main stations to cover the majority of the population on so called "island principle" In later years, the network is extended to cover less densely populated areas and to improve coverage by means of fill-in stations.

Number of analogue fill-in transmitters in mountainous areas and cities were set-up in order to resolve reception problems due to ghost images. With digital TV, ghost images are not a problem. Therefore many cases the digital terrestrial television networks might need fewer fill-in stations.

Coverage extension

After the main agglomerations have been covered by relatively few stations, each additional station is expensive in term of costs per inhabitant. Public broadcasters have an obligation for universal coverage and will need to extend coverage of their programmes to nearly the whole country. In some countries the universal coverage obligation is not restricted to terrestrial television and satellite TV is accepted for coverage in rural areas. Commercial broadcasters without a public service mission may not wish to cover a whole country and restrict the terrestrial network to cover main agglomerations with dense population.

In general, existing sites will be reused and the investment costs of digital TV may be limited to replacing the analogue transmitter by a digital one (often of lower power) and reusing the antenna originally installed for analogue TV. Depending on the characteristics of the Plan entry the antenna diagramme may not be optimal for digital TV e.g. when power restrictions imposed for digital TV are in different directions (azimuts or bearings) than was the case with analogue TV.

In the case of a SFN, the distance between transmitters in the SFN requires special attention. If at a reception point the relative delay time between two transmitters in the SFN exceeds the length of the guard interval, self interference of the SFN may occur.

Coverage improvement

Inside a coverage area, reception probability could be marginal or below acceptable limits because of terrain, buildings, forests, etc.. There are limitations in the accuracy of coverage predictions; some of these areas of poor reception are only discovered after complaints by viewers. With detailed terrain and clutter data and well tested propagation prediction methods it may be possible to predict coverage with an accuracy of a few dBs compared to measurements in some situations. Good reception is a statistical feature and depends on many variables including interference field strengths exceeded for 1% of time. An accurate transmitter database with all wanted and potential interfering transmitters is also a prerequisite. Even when predicted coverage meets the standards, complaints may be received.

In making coverage predictions it is always assumed that viewers use proper receiving equipment that complies with frequency planning standards. Section 5.7 deals with receiving equipment and how reception can be improved on the receiving site.

If indoor reception or mobile reception is required, the power specified may not be sufficient to cover a large area with one transmitter, as would be the case with rooftop reception. Power distribution by means of an SFN may be necessary. If the SFN becomes dense, the chance increases that at certain locations two or more signals of equal field strength are received, the so-called zero dB-echo. DVB-T or ISDB-T receivers show decreased sensitivity in these cases, ranging from about 5 to 10 dB (in case of 64QAM2/3) if the signals have equal strength. If the time difference is small (< 0.5 μs) additional problems may occur with the synchronization of receivers.

Zero dB-echo could affect relatively large areas particularly in flat terrain. If a dense SFN is used, it is important that the planning software takes into account the zero dB-echo. With proper network planning, the zero dB-echo area can be minimised or shifted to less populated areas.

Multiplexes

In the GE-06 Agreement, for example, most countries have rights for seven or eight DVB-T “layers” in Bands IV and V and one in Band III. “Layers” are not defined in GE-06, but are generally understood as the number of channels that can be received in given area. In most countries, current licenses do not yet cover all layers provided by the GE-06 Agreement. More layers may be licensed when:

- Analogue TV has been switch-off (including in neighbouring countries) and restrictions to layers removed;
- Decisions have been made about new broadcasting services or other non-broadcastingservices;
- New technology is mature enough to be implemented; and
- Market requirements are clearer.

There is a certain tendency to concentrate digital terrestrial television in Bands IV and V and to use Band III for radio or multimedia services using a system from the DAB family.

Use of common sites

Use of common sites for transmission of existing and new multiplexes has the advantage that existing infrastructure and facilities, like distribution links, transmitter buildings, masts, antennae and reserve transmitters, can be used. Furthermore significant investment has been made already: road access, high voltage power supply, stand-by power supply, water, land appropriation for the site, buildings and staff.

When engineering and installing a broadcasting site, it is advantageous to take into account future extensions. It is often far more expensive to modify links, buildings, masts and antennas at a later date.

Use of common sites may be complex when different network operators make use of the site.

Priority rules have to be made for use of limited space in buildings and masts. Common use of antenna combiners and antennas also requires clear agreements on responsibilities, costs and maintenance. Common use of antennas may be an advantage for economic and operational reasons; however, it does not always provide optimal coverage.

When additional multiplexes are intended for a different kind of network, common use of sites is only partially possible. If a dense digital TV network is required additional sites are necessary and antennas at existing sites may be too high, or have different polarization than required.

Use of different sites

Different network topologies may be necessary if:

- Several operators make use of the same frequency band;
- Some multiplexes make use of dense networks.

Adjacent channel interference may occur around non co-sited stations and use of the first, second, or third adjacent channel on both sides of the wanted channel or the image channel.

The non co-sited station could be a broadcasting station, but also a mobile base station. Even mobile terminals could cause adjacent channel interference at very short distances.

Adjacent channel interference is a local problem. Number of solutions for adjacent channel interference are possible.

If different network operators are involved, the question will arise as to who will have to pay for these provisions.

6 Economic aspects

Broadcasting chain is unique at every level. Its concept, architecture and deployment differs to such an extent that it is extremely unlikely to spot “twin” arrangements. There are no identical TV production centres, contribution/distribution networks, and multiplexes/transmission networks. The variations of technology options and solutions are such that every component of the broadcasting chain may have its own specific design, specifications and cost. Price information has been always of confidential nature and contracts are signed based on tedious negotiations. Discounts could be granted for large scale delivery, established long-term business relations, etc. Planning, warranty, installation and testing, staff training, and aftersales service clauses will have an impact on the total of every contract signed. Even if cost information available, it will be of value in a concrete context.

Not withstanding with the studies mandated to be carried out by this study question, this Report is unable to provide answer to the cost implication issues.

Information on business models, cost and funding, evaluation of risk factors, analysis of cost/benefit issues, which foster an enabling environment, might be provided by actual case studies yet to be carried out by the BDT while assisting ITU members in the transition to digital terrestrial broadcasting.

Availability of such country case studies may be very useful in order to assess the cost incurred and analyze the cost benefits versus risks.

Digital Switchover cost impact

Digital switchover will affect almost all households and entail compulsory costs for consumers. It also entails costs for non-domestic users of television services. This may include the cost of upgrading community TV reception antenna systems that are used in blocks of flats, hotels and in residential care and nursing homes. For the broadcasters and multiplex operators, there are capital investment costs incurred for deployment of the digital network and any associated costs for implementing digital switchover as stipulated in their broadcasting licenses. Commercial services broadcatalsters will also have to develop strategies to deal with the negative impact on their revenues by the extended choice and access to multi-programme services.

Cost for consumers

When digital switchover takes place, all households that wish to continue to receive television services and who have not yet switched to digital television will need to obtain at least a STB.

Currently STBs to receive DTTV services are available for around 70 USD. The price may be expected to fall further by switchover. However, in addition to the cost of STB/receivers, consumers who opt for DTTV may also face other costs.

Households with second or additional sets will need to obtain equipment to adapt all television sets they wish to use after switchover. If they do not opt for an integrated digital television (with an in-built digital tuner) the costs will include a STB. Costs may also include supplementary cables for VCRs and new indoor aerials;

Households with video-recorders may require purchase of additional SCART cables.

Households with video-recorders who wish to record a different television channel to the one to which their television is tuned will need to replace their video recorder (or buy an additional STB to adapt the video recorder).

Households who opt for DTTV (for first or subsequent sets) may have to upgrade aerials for digital switchover. The costs of a new outdoor aerial can vary depending on what needs to be done and regional variations. The range may be from 150 to 600 USD.

Households in blocks of flats may be required to pay additional service charges to meet the costs of upgrading the system for digital reception.

In the period up to and after the start of switch-over the price of DTTV equipment is assumed to fall due to the large scale sales as the country begins to implement plans for digital switchover. The increased demand for digital television also may open the way for cheaper access to basic services on satellite and cable.

Non-domestic users cost

A large number of businesses make use of television broadcasting via analogue networks. In order to continue receiving television services after the switchover, reception equipment and relevant systems will need to be upgraded. In some cases equipment will need to be replaced ahead of its normal replacement cycle.

Communityl TV antenna systems replace the need for individual aerials which may be less effective due to the location and position of the building. The costs of updating communal TV systems for digital television services will vary depending on the type of building, its location and whether the landlord and residents opt to upgrade the system for DTTV only or whether they wish instead to invest in a new system that is capable of providing satellite or cable delivery. For systems being in good condition the cost varies between 1200 – 2000 USD per system.

Cost for Public Service Broadcasters

The process of achieving digital switchover will have a number of implications for public service broadcasters:

- they will need to contract (as multiplex operators or indirectly via other multiplex operators) the transmission network companies to deploy and configure the DTTV network and to increase DTTV coverage with multiplexes carrying public service channels so that the coverage matches existing analogue coverage;
- digital take up may strongly affect their future advertising revenue.

Cost/benefit analysis

Cost/benefit analysis is to be carried out separately for each developing country taking into account its infrastructural, economic, social, demographical, technological and other aspects and on the basis of relevant databases. Furthermore some common approaches may be used and applied, which could be of interest to the cost/benefit analysis specialists from the national administrations and relevant stake-holders.

7 Viewer concerns

It may be necessary for viewers to take action after certain network changes, in order to receive new or improved services, or to continue to receive existing services.

External factors can cause reception quality to deteriorate. These factors include the increase of interference levels when launching new digital TV services and local interference from other services that make use of the same band.

It should be noted that viewers may have reception problems should their reception quality decrease despite maintaining reception quality above the agreed standards. In most cases, viewers can take measures to improve reception quality, however the broadcast community must provide information and relevant assistance.

Improvement of reception

Elements in the receiving installation important to achieve high-quality reception are:

- Location of the receiving antenna;
- Directivity and gain of the receiving antenna;
- Antenna cable loss;
- Match between antenna and receiver;
- Receiver sensitivity ; and
- Receiver selectivity.

The receiver characteristics depend on the design and implementation of the receiver. In general receivers comply with the EICTA specifications. Although some characteristics, e.g. selectivity, may be improved in the future, the viewer cannot improve the receiver. To improve reception, attention should be directed to the antenna and, in particular, its location, directivity and gain all of which are frequency dependent. Active antennas, antenna amplifiers and diversity reception can also help improve reception.

Antenna location

The receiving antenna height is a very important factor. In principle rooftop antennas should be placed above local clutter. Indoor reception can be improved by locating the antenna at a high position in the room, on a higher floor or outside. Even antennas of small dimensions, mounted outside at a height of, for example 3 meters, give a considerable improvement to reception probability compared to indoor reception.

Field strength distribution can be divided in macro and micro variations. Macro variations relate to a small area of, for example 100 by 100 meters, and the location probability requirements refer to such an area.

Micro scale variations relate to the receiving location with dimensions of a few wave lengths and are mainly caused by multipath due to reflections on nearby objects. The receiving antenna should be located at a position where the field strength is maximal. However, micro variations are frequency dependent and it may be difficult to find an optimal position if several frequencies must be received and the average field strength levels are near the minimum required value. For rooftop antennas the position is determined at the time of installation and the choice is limited by the construction of the roof. Portable antennas can, in principle, be placed at an optimum location for each frequency channel. However, it does not contribute to the pleasure of watching television if the antenna position has to be changed each time a different frequency channel is selected.

Directivity and gain

The effective antenna aperture is a function of the wave length and the gain compared to a half wave dipole. Very small antennas, like built-in antennas of handheld receiving equipment have very poor gain. On the other hand, directional rooftop antennas have large dimensions and a considerable gain.

In practice, rooftop or portable antennas can have poor characteristics, in particular with regard to directivity and gain as a function of frequency. It would be helpful for the public if adequate information on receiving antennas could be provided.

Reception can be improved by using an antenna with a better gain. In case of rooftop reception this can be realized by an antenna with more elements to achieve better directivity and gain and an antenna amplifier to compensate for the cable loss.

Portable reception can be improved by means of a small directional antenna to obtain more gain or an active antenna to achieve a lower noise figure and better matching with the receiver.

By means of a telescopic antenna, handheld reception can be improved at locations where reception would otherwise be poor.

Diversity reception

Mobile and portable reception can be considerably improved by the use of antenna diversity. Handheld television devices are too small to include more than one antenna. An antenna diversity system reduces the effect of fast fading and consists of two or more antennas and a dedicated receiver. The outputs of the antennas are combined using certain weight factors and are decoded using the standard decoding algorithm. The application of antenna diversity has the following advantages compared to reception with a single antenna:

- Reduced required field strength (6 to 8 dB);
- Better reception at higher speeds;
- Less reception problems when people are moving around the antenna;
- Less problems with receiving several multiplexes; and
- Easier finding of optimal position for a portable receiving antenna.
- Despite these advantages, diversity antenna reception equipment is not widely available for use.

Retuning receivers

After a frequency change or bringing into use of a new frequency, receivers need to be retuned. Some receivers perform background scanning in the standby mode and are therefore automatically adjusted to new frequencies. However, in most receivers retuning is performed manually by activating an automatic frequency search via a menu. Experience shows that retuning is difficult for many viewers who must take the following actions:

First step:

- Go to menu
- Select “installation”, and
- Execute “Reset default values”.

Second step:

- Go to menu
- Select “installation”, and
- Execute “Automatic transmitter search”.

After both steps, it may be necessary to restore the preferred order of services or to delete services that are not appreciated.

Good communication is essential for announcing, informing about and performing frequency changes.

Replacing consumer TV reception equipment

New receiving equipment is necessary in case of countrie’s decision to change its system:

- New compression system (e.g. MPEG-4);
- New transmission system (e.g. DVB-T2; DVB-H); and
- New television system (e.g. HDTV).

However in case of the ISDB-T of Brazil, its future-proof system already incorporates both MPEG-4 and HDTV. Therefore such replacement of receiving equipment is not at all needed.

The replacement cycle of modern electronic devices is rather short.. In general, it is assumed that digital TV receiving equipment has replacement cycles exceeding six years. However, it could be expected, as in analogue television, that a replaced STB or integrated digital TV receivers continues to be used in other rooms or in recreational premises. Furthermore, digital television tuners are used in several devices such as Personal Video Recorders (PVR) and Personal Computers (PC).

As a rule of the thumb receiving equipment incorporating new compression or transmission systems is likely to be more expensive than equipment with mature technology. Forcing viewers to replace receiving equipment may not be appreciated and may only be acceptable if new and attractive services of enhanced quality be offered.

Communication

Viewers need to be informed about reception possibilities, network changes and the impact that may have on reception and the actions that have to be taken.

The following tools can be used for communication with viewers:

- Website;
- Telephone help desk;
- Advertisements;
- Information via local dealers;
- Information channel in multiplex; and last but not east
- Teletext pages.

8 Conclusions and recommendations on DTTV transition

Digital terrestrial television network evolution in Bands III, IV and V will be driven by a wide choice of services that will include HDTV, mobile TV, interactive and data services, and portable reception. Service offerings will differ from country to country based on local needs and demand.

Strategic decisions on SDTV and HDTV broadcasts and choice of services, which will shape the DTTV broadcasting in the next 30 years or so, are to be taken well in advance of the Analogue-Switch-Off date. After that deadline Bands III, IV and V spectrum may be redistributed for other services and lost for the broadcasting purposes in some countries of Region 1. National Administrations may face the “Now or Newer” dilemma particularly for the introduction of HDTV broadcasting and broadcasters are to be well aware of this possibility.

a) Broadcast industry must work together

For each service it will be necessary to make choices regarding such issues as the type of reception (rooftop, indoor, outdoor, mobile, handheld), the area to be covered and the system to adopt (DVB-T, DVB-H, DMB, ISDB-T and others). A trade-off between multiplex capacity, coverage quality and radiation characteristics will be needed; the compromise made is would have an impact on the service quality, number of potential viewers and transmission costs. In addition a choice needs to be made about the type of network (use of existing sites and/or new or additional sites, SFN versus MFN, etc.).

Broadcasters and/or network operators should discuss these issues and, where appropriate, make agreements with receiver manufactures to ensure that adequate types of receivers are available in sufficient quantities and on time.

b) Regulatory framework needs to be clearly defined

The use of Bands III, IV and V is heavily regulated by international agreements such as the ITU Radio Regulations and the GE-06 Agreement. The European Commission has put forward distinct policies about the use of Digital Dividend, favouring a market-led approach to its allocation.

The possibility exists to use parts of Bands IV and V for non-broadcasting services, such as mobile communication systems (UMTS). At the last ITU World Radiocommunications Conference (WRC-07) many countries have agreed to open channels 61 to 69 for such services. However, compatibility studies between digital broadcasting and non-broadcasting services are currently being carried out given the serious concerns about the interference impact of mixing broadcast services with two-way transmissions.

The results of these studies see Agenda item 17 of WRC-07 will be presented at the next ITU World Radiocommunications Conference in 2012 (WRC-12).

c) Broadcast community needs to follow developments regarding the application of the "Digital Dividend" with utmost care

Decisions made by national administrations to reserve a sub-band for particular services would require re-planning and result in changes and restrictions to existing and planned services. Such developments should be followed carefully and consequences in costs and coverage should be analyzed. Furthermore, as long as no clear national decisions are made about the use of the channels 61 to 69, implementation of digital terrestrial television in these channels should be avoided as far as possible.

Some developments on the use of low-power or license-exempt applications in Bands IV and V are of considerable concern and should be followed carefully to prevent interference caused to digital terrestrial broadcasting services.

d) Viewers need to be informed about network changes

Introduction of new services or modifying networks is complex and requires careful preparation.

Changes may be needed to radiation characteristics, system variants and compression or transmission systems and additional transmitting sites and additional multiplexes may have to be installed. Most of these network changes will affect viewers and their ability to receive television services. Furthermore, existing receiving antennas may not be suitable for new services due to the frequency range for which the antenna has been designed or because of its bearing.

Excellent communication to the public to prepare them for network changes is essential. Most network changes will have at minimum an impact on a few households and may have an effect on all households. Accurate coverage predictions are important in order to judge the effect of network changes in the area concerned and to inform the public about the opportunities for receiving new services or to retain reception of existing services.

e) Improve reception through enhanced receiving antennas

Reception can be improved at a receiving location by use of better receiving antennas, whether for roof-top, indoor or handheld reception. Extendable antennas can improve handheld reception while so-called "active" antennas are best for indoor reception and use of antenna amplifiers and antennas with more directivity and gain can improve rooftop reception. The use of an active antenna is facilitated by the integration of a switchable 5 V power supply on the antenna output connector in DTTV receivers.

f) Plan carefully for the future

When replacing transmitting antennas, the new antennas should be of a modern design with generally improved frequency dependent characteristics.

Single frequency networks (SFNs) are an efficient way to provide coverage for portable (indoor) and mobile reception over large areas. However, SFN planning is complex and great care is needed to avoid self interference and so-called '0 dB echo' interference.

If additional multiplexes are expected to be introduced in the future, it is advantageous to take extra space and capacity into account in the design and layout of transmitter buildings, antennas and power supply. Later extensions to the network risk generating high costs as existing equipment is made redundant and replaced.

Networks will need to evolve in the future to meet the service requirements of each market. It is up to the broadcast industry to ensure that all stake-holders are prepared to meet these challenges.

9 Digital Terrestrial Audio Broadcasting(DTAB): advantages, technical platforms, possible approaches for implementation, specific features and phases of migration

9.1 Advantages of DTAB

For listeners, digital radio holds the promise of improved reception and better audio quality, and digital transmission systems have the potential to provide a more diverse range of enhanced radio services than is possible in analogue. Growing number of countries are selecting appropriate DTAB standard for deployment with focus on attractive recent standard developments like DRM and DAB+ (e.g. the later two to three times more spectrum efficient than DAB).

This powerful new technology wave enables a reach multimedia experience offering enhanced opportunities for advertisment and sponsorship to commercial broadcasters through text, images, and additional data services, but is requiring substantial investment to adapt the broadcasting chain to the digital technology.

The crucial advantage of digital terrestrial audio broadcasting (DTAB) over analogue audio broadcasting is the capacity of digital radio to deliver data services. Such data carrying capacity may provide for the following services:

- news;
- local information (different data for different regions in one broadcasted data stream);
- weather information, in particular, special data on weather conditions for agriculture including local weather conditions updates;
- employment assistance data (different data for different communities in one broadcasted data stream);
- market data/updates (current prices at different local markets in one broadcasted data stream);
- traffic information including local traffic conditions updates;
- financial reports/updates;
- variety of subscription data services.

For developing countries DTAB may become a viable mean of provision of data services to the population. The role of DTAB especially grows in cases when the corresponding territory is not covered by TV broadcasting or in cases of low quality reception. Further to the portability of receivers together with the mobile reception of classic analogue sound proadcasting, the DTAB has inherent advantages such as: enhanced capacity of reception of data services, gradual reduction of the price of receivers (which currently is not low enough yet but is decreasing with the growth of DTAB receivers mass production).

9.2 DTAB deployment

DTAB has been deployed in some countries (e.g. Austria, Germany, Italy, Korea, Singapore, Switzerland, nine million DAB radios in UK, USA, etc.). It has replaced entirely the FM analogue broadcasting in Sweden where the FM analogue broadcasting has been already switched off. By national decision every new car in France shall have a digital radio in T-DMB digital standard adopted by this country (variant of DAB) as from 2012..

However the commercial radio industries in Germany and Switzerland have both rejected proposals in July 2009 that they should invest in developing DAB digital radio system in their countries to replace existing analogue AM/FM transmissions. Their argument against TDAB is that the significant investment required simply did not justify the lengthly wait for a financial return, based on evidence from other European countries that have already introduced DAB radio. Both German and Swiss commercial radio industries have warned that a phasing out of FM technology would lead to lower revenues, reduced investment, exceeded entrepreneurial risk, and fewer jobs in their companies, thus reducing diversity of media voices in their countries.

On wider perspective, taking into account the current finacial crisis, it will be very difficult to convince the biggest investor in the broadcasting chain together with the regulatory authorities, public and commercial broadcasters, and entire broadcasting industry to take the risks of decision for such large-scale transition to digital in nearest future. Perhaps “one at a time transition” strategy would be wiser therefore analogue sound broadcasting transition to digital terrestrial audio broadcasting might be expected to be initiated at large international scale after thecompletion of DTTV switch-off . In this respect it might be helpful for ITU Members to consider the possibility of replanning the Geneva 84 Plan in an appropriate time-frame in similar way as it was done with the replanning of both Geneva 61 and Geneva 89 Plans for the transition to digital terrestrial television by corresponding Geneva 06 Plan and Agreement.

9.3 DTAB technologies

Kindly reffer to ITU-R Report BT-2140 (www.itu.int/publ/R-REP-BT.2140/en) for detailed information on DTAB standards.

The following table illustrates the range of bands and channel widths used by the various technologies.

Spectrum use by technology		
Technology	**Service requirements**	**Preferred band**
Eureka 147(DAB), and DAB+	Wideband - multiplexed 1.5 MHz channel per ensemble	VHF Band III *, L-Band
DRM	Narrowband 9-18 kHz per channel	MF, HF
IBOC (HD Radio) - AM - FM	Narrowband 20 kHz per channel 200 kHz per channel	MF VHF Band II
ISDB-TSB	Wideband - multiplexed 0.4 or 1.3 MHz per channel	VHF Bands II and III, UHF
DVB-T	Wideband – multiplexed 7 MHz per channel	VHF Band III, UHF

*) Note: Some European countries use mixed multiplexes of of both DVB-T and DAB.

Different digital radio technologies are designed to use different spectrum bands in order to achieve particular performance. For example, the IBOC system is specifically designed to provide digital broadcasting capability within the licensed existing frequency allocation, and consequently uses the MF Band-AM and/or VHF Band II. DRM is designed to provide very wide area coverage with digital broadcasting services, and is consequently designed to use part of the spectrum already allocated in the MF-AM and HF Bands.

9.4 Approaches to implementation of DTAB

Range of approaches have been taken by national Regulatory Authorities towards implementation of digital radio. These approaches reflect range of factors, predominantly country specific, such as the structure of the broadcasting market, technical or spectrum constraints, and in particular the policy and strategy for the introduction of digital radio, public reaction to it, etc.

Possible approaches to DTAB implementation may be categorised into three main categories:

Full conversion

A "full conversion' approach would imply that all incumbent broadcasters by be obliged to transform the existing analogue radio services into digital with the aim of switching-off the analogue service at some point linked to the take-up of digital receivers. This approach would be based on the assumption that digital radio was primarily a replacement technology for analogue radio and would most likely involve the hand back of analogue radio digital spectrum after the designated switching-off date.

A "full conversion' approach would require sufficient spectrum to accommodate the transition to digital of all incumbent analogue broadcasting services as from commencement or soon thereafter.

Market-based approach

Under the "market-based" approach towards implementiion of digital radio, there would be limited regulation applied to broadcasting service, primarily in areas such as taste and decency and other content-related requirements, technology standards, spectrum allocation and the level of interference. Essentially, the frequencies would be licensed by auction or beauty contest, and there would be no requirement to deliver a particular type of service. No specific requirements and obligations would be imposed for the conversion of existing analogue services into digital ones.

Managed introduction

"Managed introduction" approach would be situated somewhere between the "full conversion" and "market-based" approaches. While full replication of analogue services would not necessarily be envisaeged at the start of digital rollout, a longer term objective would be to ensure conversion of any analogue service into digital until analogue switch off. Priority access to digital capacity could be provided to incumbent analogue broadcasters, possibly on a voluntary basis, who will replicate their analogue services and facilitate the development of innovative services.

The "managed introduction" approach may be better able to address the current limits of available spectrum and to provide for future frequency allocations as spectrum becomes available.

A "full conversion" model would focus on the migration from existing services into digital ones. Spectrum constraints may limit the potential of non-commercial broadcasters to fully exploit the opportunities of the digital platform if spectrum capacity available is substantially used to provide for simulcast services.

"Managed introduction" approach enables greater flexibility to non-commercial broadcasters in migrating from analogue to digital.

9.5 Choosing the approach

Before choosing the approach a number of issues would require carefull consideration, including:

- whether the public interest would be served by an early implementation of digital radio services ;
- what factors prevail in selecting digital technology and in allocating spectrum for service delivery;
- whether digital radio can be treated as a supplementary or a succeeding technology;

- the extent to which digital radio should be regulated upon the start and over defined time frame;
- the role of the incumbent public, commercial, community, regional, national and other radio broadcasters; and
- the scope for the provision of new services and the participation of service providers.

9.6 Specificl features of DTAB

In sharp contrast to analogue audio broadcasting, the DTAB involves the multiplexing of a number of separate audio and data streams to be broadcasted. Unlike existing analogue radio services, therefore, number of radio providers will have their services broadcasted over a single transmission facility. The multiplex delivery of radio programmes makes them more equitable to the audience, but it also erradicates the community broadcasting option.

Licensing

The ability of DTAB to deliver a large number of different services through multiplex over single channel leads to new possible approaches to service planning, and in particular, to the introduction of the multiplex operator into the radio broadcasting chain. The later provides for separation of the licensing of content from carriage, i.e. two-tier licensing regime with separate licenses for content providers and for multiplex operators. In case of such approach to licensing the multiplex operators are getting the ability to manage data bit rate capacity between services, which means the flexibility to respond to market demands. But at the same time interests of content providers also should be protected i.e. content licenses should provide licensees with access to multiplex capacity regardless of who controls the multiplex. In particular such access should be guaranteed for providers of socially valuable Information Society related content i.e. for broadcasters of public service broadcasting radio programs (national services) and other non-commercial broadcasters. The following approaches are possible:

- To issue of content licences with guaranteed access rights to multiplex capacity. For example, a content licence could provide guaranteed access to 128 kbit/s of capacity in a certain licence area, with rights to negotiate a lower or higher allocation at the discretion of the content licensee. This would require sufficient numbers of multiplexes to accommodate all licensed services and the national broadcasters. Consideration could be given to allocation of a dedicated multiplex for transmission of the nation-wide and other non-commercial broadcasting services. Such an access right might also be achieved by obligating multiplex licensees to operate in accordance with some third party access regime.
- To impose 'must carry' obligations on multiplex licensees to accommodate a certain minimum number of particular categories of services. Such obligations could be imposed on every multiplex licence holder, or on a case-by-case basis recognising local demand conditions. The price paid for such a multiplex licence could be expected to reflect the constraint on commercial flexibility and profitability in service delivery.

Spectrum allocation

In the case of digital terrestrial radio (sound broadcasting), it seems likely that services will be delivered via multiplex operations. The spectrum allocation process is therefore likely to relate to a group of services rather than a single service. Individual operators may be given or may buy access to a bit rate or bit rate range capacity.

DTAB service and simulcasting

In the early stages of digital radio, it is likely that (in the absence of regulatory obligations) the content on digital radio will be a simulcast of analogue services. In the medium term, however, consumers may benefit from a differentiation of content on the digital platform, particularly if customer equipment enables listeners to access the analogue services over the same device.

Up to date, no evidence suggests that that there is a regulatory framework for digital radio services that either obligates for or prohibits simulcasting. Rather, most countries have a mixture at varying degree of analogue simulcast with unique-to-digital services.

If the administration chooses to pursue full conversion approach to DTAB, a simulcast requirement may be appropriate. This would aim to prevent digital divide for listeners who choose not to convert immediately to digital from being disadvantaged by the migration of premium analogue content to digital. In an introduction model which contemplates digital and analogue services operating alongside for certain period, however, a simulcast requirement may represent a heavy financial burden to broadcasting operators, would entail inefficient use of limited spectrum and may limit the potential deployment of new services thus failing to attract consumers to embrace digital radio delivery.

DTAB platforms present the opportunity for radio broadcasters to offer a range of new services, including additional audio streams, data services and potentially video services. Internationally, the introduction of digital radio has often been accompanied by regulatory measures designed to achieve a balance between introduction of these new services and retaining the primary focus of digital radio platforms on audio-based entertainment.

Multiplexes could be limited for use for example of 10 per cent of multiplex capacity to provide program related data services, while an additional 10 per cent could be allowed for the delivery of non-program related ancillary data services.

9.7 Phases of migration to digital terrestrial audio broadcasting

Phase One: The Introduction of DTAB

- Existing regulations should be reviewed to ensure that they reflect the implications of DTAB, in particular two-tier licensing regime, which separately licenses content providers from multiplex operators,
- Special frequency channels will be allocated to the current broadcasters to provide for the simulcasting in digital format.
- Special multiplexes or special multiplex capacity will be allocated for broadcasters of public radio programs (national services) and other non-commercial broadcasters supporting Information Society related content.
- Multiplexes will be limited to use fixed percentages of multiplex capacity to provide program related data services and non-program related ancillary data services.
- Call for applications will be issued with obligation for guranteed minimum data stream of the multiplex capacity, which content license holder will be obligated to provide for.
- Frequency channels for use by commercial DTAB networks shall be granted against intial and annual licence fee. Broadcasters should be made aware of the annual fee applied per frequency channel.
- Start up phase of DTAB will be closely monitored in terms of coverage, reception quality and interference.
- Stakeholders' group to co-ordinate the transition process will be set up.
- Infrastructure sharing possibilities in national legislation shall be explored.

Phase Two: The Simulcast Period

In case of "full conversion" approach to DTAB the date for the commencement of Public Service Broadcasting simulcasting is to be defined so that :

- Public Service Broadcastes will be encouraged to establish a migration Plan to digital. Discussions will be undertaken with broadcasters, in order to encourage the establishment of a date when all current free-to-air broadcasts are also delivered to the audience as digital transmissions.
- National Public Service Broadcasts in particular shall be transmitted as must carry and free-to-air on appropriate DTAB platform/s available.

Phase Three: Analogue Cut Off

In case of a "full conversion" approach to DTAB the date of analogue cut off (not later than) is to be defined and communicated to the audience well ahead of time.

This phase will involve the switching off of all analogue terrestrial audio broadcasts. Before the analogue cut off all current broadcasters shall have migrated to a digital platform. The time required will therefore be dependent on the migration option selected by the broadcasters and the market readiness for full delivery of DTAB.

10 Other implications

Switching over from analogue to digital will impose intensive up-to-date on-the-job training of the staff over the whole broadcasting chain.

Furthermore, curriculum adaptation will be urgently needed in universities, colleges and schools whose graduates will be amongst the potential applicants for jobs in broadcasting chain requiring skills adapted to the needs of changing digital environment.

11 Glossary of terms and abbreviations being most frequently used:

720p/50	An HDTV format with 720 horizontal lines and each line with 1280 pixels, progressively scanned at 50 frames per second, as specified in SMPTE 296M-2001 and EBU Tech3299
720p/50-60	An HDTV image format with 1280 horizontal pixel x 720 vertical lines progressive scanning at 50 or 60 frames per second.
1080i/25	An HDTV format with 1080 horizontal lines and each line with 1920 pixels, interlaced scanned at 25 frames per second or 50 fields per second as specified in SMPTE 274 and ITU-R BT.709-5
1080i/25-30	An HDTV image format with 1920 horizontal pixel x 1080 vertical lines interlaced scanning at 25 or 30 frames per second or 50 or 60 fields per second.
1080p/50	An HDTV format with 1080 horizontal lines and each line with 1920 pixels, progressively scanned at 50 frames per second as specified in SMPTE 274 and ITU-R BT.709-5
BMC	Broadcast Technology Management Committee of EBU
ACO	Analogue Cut Off
BER	Bit Error Ratio
CA	Conditional Access
CATV	Cable Television
CCD	Charge-Coupled Device
CMOS	Complementary Metal-Oxide Semiconductor
CRT	Cathode Ray Tube
DAB-IP	DAB – Internet Protocol
DCT	Discrete Cosine Transform
DSO	Digital Switch Over
DTAB	Digital Terrestrial Audio Broadcasting
DTTV	Digital Terrestrial Television
DV	(Sony) Digital Video compression format
DVB	Digital Video Broadcasting (the name of the standard) www.dvb.org/
DVB-H	Digital Video Broadcasting – Handheld (the name of the standard)
DVB-T	DVB – Terrestrial
DVB-T2	State of the art terrestrial transmission system taking advantage of advanced modulation and forward error correction techniques. It is set to deliver 30-50% performance premium over DVB-T.
DVI	Digital Visual Interface
EBU	European Broadcasting Union
EPG	Electronic Program Guide
FTA	Free-to-Air
GE-06	GE-06 Agreement, Geneva 2006
GoP	Group of Pictures
HD	High-Definition
HDCP	High-bandwidth Digital Content Protection
HDMI	High-Definition Multimedia Interface

HDTV	High-Definition Television
ICT	Informational and Communicational Technologies
ISDB-T	Integrated Services Digital Broadcasting – Terrestrial
ITU	International Telecommunication Union www.itu.int
ITU-T H.262	identical to MPEG-2
ITU-T H.264/AVC	identical to MPEG-4 Part 10
LCD	Liquid Crystal Display
MC	Multi-Channel
MER	Modulation Error Ratio
MHEG	Multimedia and Hypermedia Experts Group - a multimedia presentation standard
MHP	Multimedia Home Platform
MISO	Multiple Input Single Output - smart antenna technology in which multiple antennas are used at the source (transmitter). The destination (receiver) has only one antenna. The antennas are combined to minimize errors and optimize data speed. MISO is one of several forms of smart antenna technology, the others being **MIMO** (multiple input, multiple output) and **SIMO** (single input, multiple output)
MPEG	Moving Picture Experts Group www.chiariglione.org/mpeg/
MPEG-2	Motion Picture Expert Group – 2 (the name of the standard)
MPEG-4	Motion Picture Expert Group – 4 (the name of the standard)
MPEG-4/AVC	Refers to ISO/IEC 14496-10, 2003. Information Technology – Advanced Video Coding: A codec for video signals that is also called AVC and is technically identical to the ITU-T H.264 standard. 14496-10. Geneva: ISO/IEC.
MUX	Multiplexer
OLED	Organic Light-Emitting Device (Diode)
OpenTV	Interactive television technology offering a variety of enhanced applications including EPG, HD, VoD, PVR, and home networking.
PDP	Plasma Display Panel
RF	Radio Frequency
SD	Standard-Definition
SDTI	Serial Data Transport Interface
SDTV	Standard Definition Television
SMPTE	Society of Motion Picture and Television Engineers (USA)
UHF	Ultra High Frequency
VHF	Very High Frequency

12 Recommended web sites for further information

Extensive and valuable further information could be found for more detailed reading at the following web sites:

DigiTAG:	www.digitag.org
DVB:	www.dvb.org
EBU TECHNICAL:	tech.ebu.ch
French Regulator CSA:	www.csa.fr
UK Regulator Ofcom:	www.ofcom.org.uk

Annex 1

European Membership Case Study

EUROPEAN COMMISSION
Information Society and Media Directorate-General

Electronic Communications Policy
Implementation of Regulatory Framework (I)

Brussels, 14 January 2009
DG INFSO/B2
COCOM09-01

COMMUNICATIONS COMMITTEE

Working Document

Subject: **Information from Member States on switchover to digital TV**

This is a Committee working document which does not necessarily reflect the official position of the Commission. No inferences should be drawn from this document as to the precise form or content of future measures to be submitted by the Commission. The Commission accepts no responsibility or liability whatsoever with regard to any information or data referred to in this document.

European Commission
Information Society and Media

Information on switchover to digital TV in EU Member States

Information on roll-out dates of DTTV and switch-off dates for analogue terrestrial TV was first published in a Commission services' working document as an Annex to the 2005 Communication on accelerating the transition from analogue to digital broadcasting[1]. Part 2 of the current document provides a synthesis of updated information from Member States regarding roll out of digital terrestrial TV[2]. Updated information on switch off of analogue terrestrial TV is displayed in Part 3.

All Member States have updated their information in summer/autumn 2008.

This document will be published on the Commission's website at
ec.europa.eu/information_society/policy/ecomm/current/broadcasting/switchover/national_plans/index_en.htm

The Commission has asked the Member States to report on switchover and has provided a checklist of items that could be included in published national switchover plans[3]. These plans have also been published on the Commission's website at the same address (see Part 4).

Roll out of Digital Terrestrial TV in Member States

Country	Date	Other details
AT	Started 26.10.2006	MUX A: 87% coverage of population by the end of 2007; 91% by the end of 2008; 95% by 2010 MUX B: 81 % by the end of 2007 (unchanged since) MUX C (regional): 16 licenses issued in November and December 2008; services to be launched soon. MUX D (DVB-H): four main cities covered since June 2008; 50% coverage of the population at the end of 2008
BE	Flanders: fully rolled out since mid 2004 Wallonia and Brussels capital area: fully rolled out since end 2006	90% coverage of BE by end 2006 80% coverage of Wallonia and Brussels capital area
BG	Digital TV broad-casting started on 26.05.2003 in Sofia – one multiplex, maxi-mum six programs	2 single frequency transmitters operating in TV channel 64, 6 TV programs; covering the Sofia region.
CY	2010	The Republic of Cyprus has decided to grant two nationwide licenses for DTTV network/multiplex operators. One license will be granted to the public broadcaster in order to use 1 MUX to transmit its programs. The second license will be auctioned. It will include two MUXes during the switchover period and five MUXes after the switch off. These processes are currently underway and it is expected that both licenses will be granted by 2009. The roll out of DTTV and availability of services will commence as soon as possible and no later than 2010.

---

1 Commission services working document Annex to the 2005 Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions on accelerating the transition from analogue to digital broadcasting {COM(2005)204 }

2 This document covers only regular permanent broadcasts. It does not cover information about transitory and pilot test broadcasts.

3 See Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions on the transition from analogue to digital broadcasting (from digital 'switchover' to analogue 'switch-off'){COM(2003)541}

Country	Date	Other details
CZ	Launch of DTT services started in October 2005.	Started (21 October 2005) in Prague and Brno and their near surrounding areas. Two networks have been gradually put into operation on temporary basis prior to preparation and approval of a national switchover plan. One of them has reached approximately 40% penetration of population covering Prague, Brno, Ostrava, Plzen, Domazlice, Usti nad Labem and their surroundings. Since May 2008 switchover development in the Czech republic has been based on the national switchover plan approved by the government.
DK	Launch of service April 2006	Public Service: MUX 1 launched in 2006 with outdoor coverage in the whole country and partial indoor coverage. MUX 2 to be launched by 1 November 2009. A commercial gatekeeper has been appointed to launch MUX 3-5 at the latest by 1 November 2009 and MUX 6, including DVB-H, by 1 November 2010. MUX 6 will be used for testing and research 1 November 2009 until 31 October 2010.
DE	DVB-T: coverage: 95 percent of population with public broadcasting and 60 percent of population with private broadcasting in addition.	May 2008 termination of DMB-services on all sites.
EE	Regular DTT broadcasts started 2004	MUX 1 carries 7 freeview channels (two public - ETV, ETV2 & five commercial – Kanal2, TV3, TV6, K11, Kalev Sport) and covers 99% of territory from August 2008. MUX 2 & 3 are dedicated for pay services, including the first local digital pay channel Neljas TV, coverage is more than 90% of the territory.
EL	Since January 2006, one MUX of the national broadcasting organisation is operated and offers four programs of DTT[4]	The national level coverage is roughly 50% of the population and 30% of the geographic cover. Up to end of the current year, it is forecast that the above percentages will be increased up to 60% and 40% respectively.
ES	Since 2000	Coverage 85% of population currently, 88% by July 2008, 90% by December 2008, 93% by July 2009 and 98% for PSB(RTVE) before 3 April 2010.

4 The Greek Administration has issued the new Broadcasting Law (3592/19-07-07 OFFICIAL JOURNAL OF THE HELLENIC REPUBLIC 161) and therefore it has been harmonised with the Directives 2002/21/[EC], 2002/22/[EC] and 2002/77/[EC], at the part that they concern the provision of radio-television services. The aim was the plurality and objectiveness of the information, and the equality of the transmission of the information and news to be guaranteed.

Based on the above mentioned Law, the Administration has the appropriate vehicle to proceed in licensing of DTT and digital radio. Besides, the Administration has determined the process and the terms to proceed from analogue to digital broadcasting.

It is foreseen also, that by the end of 2008, a nation wide digital frequency plan will be available and it will be the appropriate tool for the DTT realization.

With regard to the current situation, a MUX of the national broadcasting organisation is in operation, which offers four programs of DTT.

<table>
<tr><th>Country</th><th>Date</th><th>Other details</th></tr>
<tr><td>FR</td><td>Started on 31 March 2005</td><td>Coverage 50% of population by September 2005, 65 % by October 2006, 85% by 2007, 95% by 2011</td></tr>
<tr><td>HU</td><td>From 2008</td><td>Government accepted the National Digital Switchover Strategy in March 2007.
misc.meh.hu/letoltheto/english_kormhat.pdf
misc.meh.hu/letoltheto/english_DAS.pdf
Parliament accepted the act on the rules of broadcasting and digital switchover in June 2007.
www.meh.hu/misc/letoltheto/eng_2007_74_tv_das.pdf
The national Communications Authority entered into a contract with Antenna Hungaria Zrt. on 5 September 2008. The contract includes the following conditions for coverage:</td></tr>
<tr><td colspan="2"></td><td>
<table>
<tr><td>year
Multiplex coverage %</td><td>2008</td><td>2009</td><td>2010</td><td>2011</td><td>2012</td><td>2013</td></tr>
<tr><td>A</td><td>59</td><td>88</td><td>95</td><td>96</td><td></td><td></td></tr>
<tr><td>B (in that case DVB-T)</td><td>20</td><td>45</td><td>65</td><td>85</td><td>94</td><td></td></tr>
<tr><td>B (in that case DVB-H)</td><td>16</td><td>30</td><td></td><td></td><td>50</td><td></td></tr>
<tr><td>C</td><td>59</td><td>88</td><td>95</td><td>96</td><td></td><td></td></tr>
<tr><td>D</td><td></td><td></td><td></td><td></td><td>96</td><td>97</td></tr>
<tr><td>E</td><td></td><td></td><td></td><td></td><td>95</td><td>96</td></tr>
</table>
</td></tr>
<tr><td>IE</td><td>DTT services launch in Q3 2009.</td><td>The Broadcasting (Amendment) Act 2007 has provided for the development of DTT services in Ireland.</td></tr>
<tr><td>IT</td><td>Since second quarter 2008.</td><td>2 Public Services Coverage >70% of population (DVB_T)
3 Private Services Coverage >70% of population (DVB_T)
4 Private Services Coverage >50% of population (DVB_T)
2 Private Services Coverage >70% of population (DVB_H)</td></tr>
<tr><td>LT</td><td>30 June 2006</td><td>Start in Vilnius, by end 2007 in the five biggest cities, by beginning of 2009 one network should cover 95% of the territory. At the beginning of 2008, four digital TV networks were in operation. The completion of networks is scheduled for the end of 2010.</td></tr>
<tr><td>LU</td><td>DTTV start on 31 August 2006
Complete switch-off of analogue TV on 31 August 2006</td><td>Currently one VHF TV channel has been converted as well as two UHF TV channels.</td></tr>
<tr><td>LV</td><td>Since 2007 digital terrestrial broadcasting started in test mode.</td><td>Planned to introduce digital terrestrial TV in steps by regions</td></tr>
<tr><td>MT</td><td>Commercial operations started 2005. Nationwide coverage achieved.</td><td>The process leading to award of spectrum for the purposes of general interest objectives is currently underway.</td></tr>
</table>

Country	Date	Other details
NL	Available since 2003 in the western parts of NL. From 11 December 2006 PSB available in the whole country.	KPN provides mobile TV over DVB-H since 05 June 2008.
PL	Launch of service is expected in 2009. Tender will be announced in the near future.	The National Switchover Strategy is currently under review process.
PT	Launch of service until the end of August 2009	MUX A (FTA) Licence granted in December 2008.
RO	Not yet started	Pilot transmissions in Bucharest (started March 2006) and in Sibiu (since November 2006). Implementation strategy to be finalised by the end of 2008.
FI	Available since 2001/2002; full network rollout autumn 2004 to autumn 2005	Coverage 99,9% (Aug 2005)
SE	since 1999/2000;	Multiplex 1 carrying the PSB channels covers 99,8% of permanent households. Multiplexes 2-4 cover 98% of households. A fifth multiplex covers approximately 70 %, but is planned to be extended. A sixth multiplex is planned to start transmitting by the end of 2008. Licenses have been issued for the sixth multiplex requiring transmissions with MPEG 4.
SI	Roll out 2006-2010	MUX A: 80% coverage of population by the end of 2008; 95% by 2010 MUX B: 70% coverage of population by 06/2010 MUX C: used for HDTV only; a public tender planed for 2009
SK	Full switch-off: end of 2012	The selection procedure is still running in Slovak Republic. The invitation for tender was published on 20 August 2008 together with the deadline for submission offers which is 20 November 2008. This is common selection procedure for MUX1 and MUX2. It is expected to issue the licenses after evaluating all submitted offers not later then in 1st Q of 2009. Expected coverage of the all citizens of the Slovak Republic is 45% as minimum after one year after issuing of the license for MUX1 (channels above 60). Switch-off of analogue transmitters using frequencies for digital MUX2: on 31 December 2011 at the latest Switch-off of analogue transmitters using frequencies for digital public multiplex (MUX3): on 31 December 2011 at the latest Switch-off of remaining analogue transmitters: on 31 December 2012 at the latest
UK	Since 1998	87% of households have digital TV [March 2008]

Switch off dates of Analogue Terrestrial TV in Member States

Country	Date	Other details
AT	End of 2010 envisaged (full switch-off)	Main high power analogue transmitters already switched off. Low power transponders are in the process of being switched over to digital.
BE	November 2008 in Flanders November 2011 in Wallonia and Brussels capital area	
BG	2012	Start of DBV-T – mid 2008, analogue switch-off 2012 according to the Plan of Introduction of DBV-T in the Republic of Bulgaria, adopted by a decision of the Council of Ministers on 31 January 2008. For the successful realisation of the transition to digitisation, a package of regulatory measures, amendments of and supplements to the Bulgarian legislation are needed namely the Electronic communications Act and the Radio and television Act. Both are in a discussion process in the Bulgarian Parliament.
CY	1/07/2011	All analogue transmissions will be switched off, nationwide, on the 1 July 2011.
CZ	June 2012	The first region Domazlice was switched-off on 31 August 2007 as an experimental measure prior to approval of a national switchover plan. The national switchover plan was approved by the Czech government on 28 April 2008 and came into force on 15 May 2008 (*www.ctu.cz/cs/download/sb051-08.pdf*). The switchover plan determines ASO in details, sets 11 geographical areas which will be digitised step by step due to lack of accessible spectrum, conditions for analogue TV transmitters switching off etc. According to the plan – the network for PSB will cover 95% of population to 31 December 2010, – by 11 November 2011 the main phase of ASO will be completed i.e. analogue transmitters switched off (except for two regions) and DTT network coverage of population will be the same as previously provided by analogue terrestrial television, in the final stage four DTT networks in operation, four MUX receivable countrywide (coverage 70-95 % of population), full analogue switch-off in June 2012.
DE	End of 2008	Commenced in Berlin in 2003; will be continued through specific areas and completed before end of 2008[5]
DK	End of October 2009	Nationwide switch off

5 See www.ueberallfernsehen.de/

Country	Date	Other details
EE	1 July 2010	The first region – the island Ruhnu was switched off on 31.03.2008. Nationwide switch off will be held on 01.07.2010
EL	after 2010	2012 may be feasible
ES	3 April 2010	The first area (Soria) to be switched off in July 2008. Gradual switch off the analogue transmitters from 30 June 2009 in accordance with the transition plan. Target PSB (RTVE) coverage: 98%
FI	31 Aug 2007	
FR	30 Nov 2011	Gradual switch off from 2009, depending on the coverage of digital TV and the rate of equipped households
HU	End of 2011	Gradual switch off of the analogue transmitters. The possibilities for earlier switch off of the analogue systems are investigated.
IE	No decision yet.	
IT	According to a new law the switch off at national level is postponed to 31 December 2012.	Switch-off by technical areas, in eight half-year periods. Sardegna is the first region to be totally switched-off, from 15 to 31 October 2008. The second region, Valle D'Aosta, will be switched-off in the 1st half of 2009.
LT	29 October 2012.	Resolution No. 970 issued by the Government of the Republic of Lithuania on 24 September 2008.
LU	31 August 2006	One analogue VHF channel and two analogue UHF channels have been switched off on 31 August 2006.
LV	1 December 2011	Regulations issued by the Cabinet of Ministers on 2 September 2008. Switch-off by regions, finished 1 December 2011 The strategy for the introduction of DTT services in Latvia was approved on 11 October 2006 by the Latvian Cabinet.
MT	31 December 2010	Nationwide coverage
NL	11 December 2006	'Big bang' switchover from analogue to digital terrestrial television in one night. Only PSBs were concerned, no commercial broadcasters were operational in analogue terrestrial TV.
PL	2015 (final date)	Earlier date possible according to the market situation.
PT	No decision yet	2010-2012 (tentative)
RO	31 December 2012 (current assessment)	Implementation strategy to be finalised and adopted by the end of 2008
SE	October/December 2007	The last analogue terrestrial transmissions were switched off in October 2007. The switchover was carried out during a period of two years on a regional basis.
SI	End of 2010 or earlier	Gradual switch off local areas when similar penetration as by analogue terrestrial broadcasting coverage is reached.

Country	Date	Other details
SK	end 2012	Gradual switch-off of the transmitters in accordance with the national strategy. There is a plan to switch off all analogue TV transmitters before 31 December 2012. This is in accordance with the Slovak technical plan for transition from analogue to digital TV transmission.
UK	2012	Switch-off by region, from 2nd half 2008 to 2nd half 2012[6]

Detailed information on Member States' switchover plans

Member States information on their switchover plans is published on the Commission's website at

ec.europa.eu/information_society/policy/ecomm/current/broadcasting/switchover/national_plans/index_en.htm.

6 For details see www.digitaluk.co.uk/when

Annex 2

The Brazilian Case Study

The digital terrestrial television broadcasting channel planning and the deployment of the DTTB in Brazil.

1 Introduction

This chapter presents the work that has been conducted by the National Telecommunications Agency (Agência Nacional de Telecomunicações - Anatel) related to channel planning regarding the introduction of the Digital Terrestrial Television Broadcasting (DTTB) in Brazil and the stages for its deployment. The text consolidates three contributions (RGQ11-1/2/93-E, 95-E and 185-E) submitted by the Brazilian Administration to the Rapporteur's Group on Question 11-1/2 during the meetings held on September 8th 2003 and May 31st 2004, both in Geneva. The Rapporteur´s Group Meeting of September 2003 "proposed that the contributions of Brazil should be documented on the ITU Web site as a case study on the introduction of digital terrestrial TV broadcasting"(2/REP/012-E). This proposal was approved in the Plenary Session of the Study Group 2 on September 11th 2003. As a result of these decisions, this Annex presents the methodology, the results and the current work Anatel is undertaking on the completion of the DTTB channel planning. In addition, it is important to observe that the country's channel planning is not related to any specific DTTB standard, since it contemplates the particularities of each existing DTTB standards.

2 Methodology applied for digital terrestrial television channel planning and its respective results

This section describes the methodology applied by Brazil to prepare its channel planning for the deployment of the DTTB in the country and its results. The applied methodology is independent of the DTTB standard adopted. A working group under the coordination of Anatel and representatives from the Brazilian TV networks has been working on digital terrestrial television channel planning since 1999.

2.1 Digital television channel planning strategy

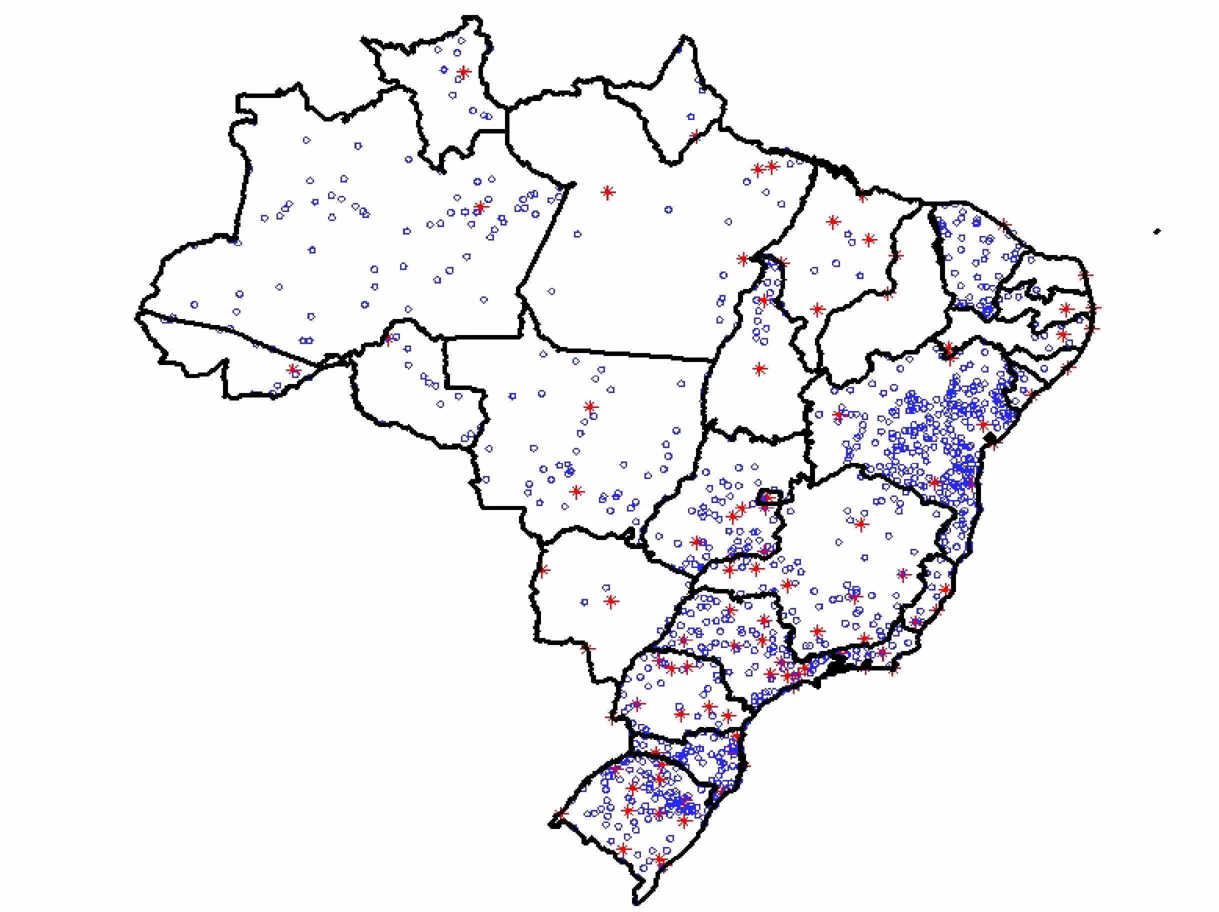
When it comes to coverage, Brazilian TV networks present quite different characteristics among themselves. They can be either regional networks or national networks, which encompass regional networks, or eventually independent full TV station with strict local penetration. Figure 1 indicates the distribution of full TV stations (in stars) and relay stations (in circles) of a particular Brazilian network with distributed generation and national penetration.

The preparation of the Basic Plan for DTTB began in September 1999. Since then, specific premises have been established. They are as follows:

- digital television will replace existing analogue TV by using UHF (channels 14 to 69) frequency bands;
- the main objective of channel planning is to assure that digital television stations will have service areas similar to their corresponding analogue stations service areas;
- during the initial phase called the 'transition period', analogue and digital channels will perform simultaneous broadcast (simulcasting);
- digital television planning will be carried out in three phases: "Phase 1" only for those cities where active full TV stations are in place and, in a later stage; "Phase 2" for those cities whose population is over one hundred thousand inhabitants with only television relay stations; and "Phase 3" for

others cities with television relay stations; whenever is possible, digital stations will have to operate on the maximum power of its class[7].

Figure 1: Network with distributed generation and national penetration (Phases 1 and 2)



Because of the preparation for the Basic Plan for Digital Television Channel Distribution (PBTVD[8]), Anatel has suspended, from October 1999 to April 2005, allocation of new analogue channels, and changes of the technical characteristics in the existing channels in regions of Brazil under heavy spectrum usage. From February 2002 to April 2005, the same policy was applied to the remaining regions. After the publication of the PBTVD, item 1.3.3, Anatel resumed activities on the analogue channels allotment plan, proceeding with the inclusion of new analogue channels. It's important to observe that PBTVD will continue to use the frequency band currently allocated to analogue transmission.

---

7 Brazilian TV Stations are classified into Special, A, B or C Class according to the ERP (Effective Radiated Power) that they are authorized to transmit by Anatel. The ERP limits for each class are defined in the national technical regulation for television broadcasting.

8 Basic Plan for Digital Television Channel Distribution (PBTVD) is the official name designated for the Digital Television Allotment Plan in Brazil.

2.2 Phases of digital television channel planning

The channel plan studies were divided in three phases. The first phase focused on making digital channels available to broadcast simultaneously with a specific and already existing analogue channels, those authorized to provide television service on municipalities where at least one generator station covers.

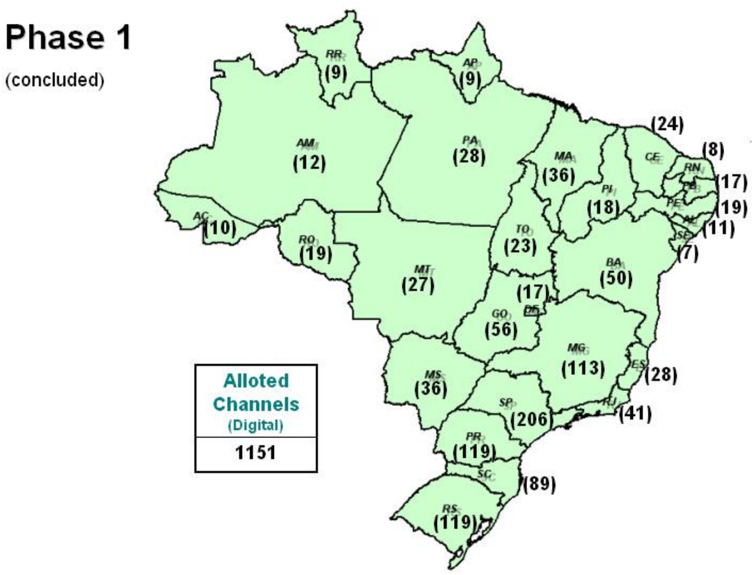
The second phase focused on the availability of digital channels for simulcasting in municipalities with population above one hundred thousand inhabitants and that are covered only by relay stations. This phase also included a review of the first phase, in order to meet the demand in all municipalities to which authorizations to install new television operating networks were granted after the beginning of the first phase.

In the year of 2006, Brazilian government initiated the third phase of digital channel planning studies. This phase deadline is June 2011. It includes the allotment of digital channels for the relay stations on the remaining cities and a digital channel revision on the previous phases allotment plan.

2.3. Channel planning results

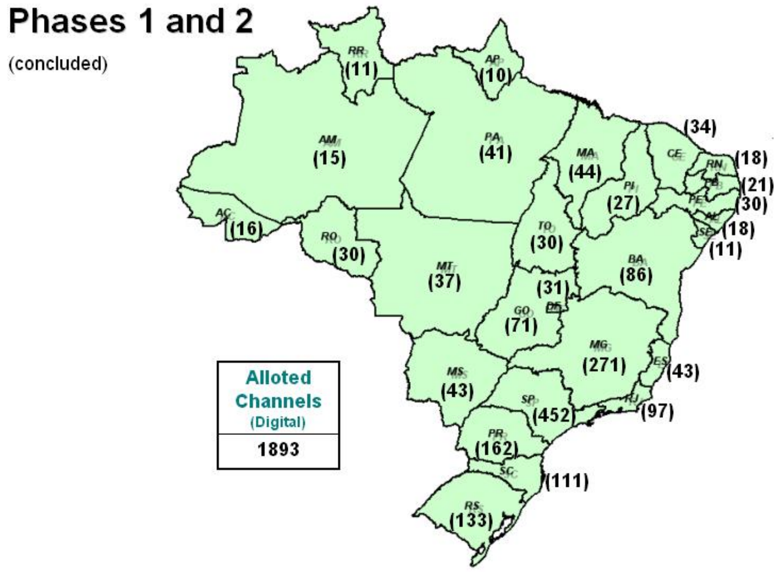
The first phase, concluded in September 2002, made available 1 151 digital channels in 164 municipalities, as presented in Fig. 2.

Figure 2: Digital channels available after Phase 1



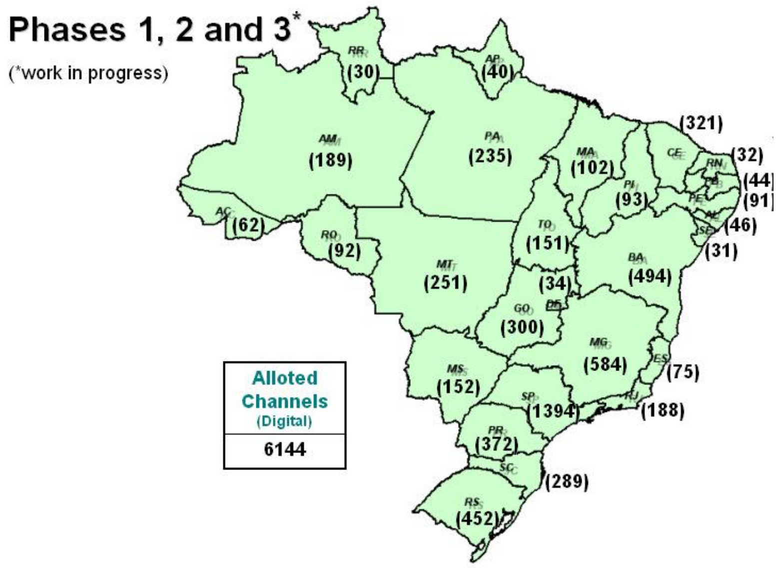
The second phase, concluded in March 2003, made further allocation of 742 digital channels in 132 municipalities. As a result of the conclusion of both Phases 1 and 2, 1893 channels were made available for the introduction of Digital Terrestrial Television Broadcasting (DTTB) in Brazil as presented in Fig. 3.

Figure 3: Results obtained after the conclusion of Phase 2 – Digital channels



After the conclusion of the third phase, which is currently in progress, it's planned to have 6 144 digital channels in Brazil, as presented in Fig. 4.

Figure 4: Digital channels allotted after the conclusion of Phase 3



The Basic Plan for Digital Television Channel Distribution (PBTVD) has been successful in assuring that the service areas of digital television stations is similar to its related analogue stations. The PBTVD encompasses 296 Brazilian municipalities, whose total population is approximately 110 million inhabitants. These municipalities are covered either by a generator television station service (main broadcasting transmitting stations – primary service) or if their population is over one hundred thousand inhabitants and at least by one operating relay-station (known also as repeater-components of the secondary rebroadcasting service) in the city. Only in service analogue channels were taken into account for the channel planning. Therefore, up to August 2008, 2 157 digital channels have been made available by the National Telecommunications Agency (Agência Nacional de Telecomunicações - Anatel) and there will be more than 6 100 digital channels in Brazil until 2013. Thus, more than 12 200 channels, analogue or digital, will be available during the "simulcast" period from 2013 to 2016.

3 Legislation and Regulatory adjustments for the deployment of Digital TV in Brazil

In order to deploy the Brazilian System of Digital TV (SBTVD), adjustments to the legislation and to the regulatory framework were needed. This process had five important stages, as listed below.

3.1 Phase 1: Creation of the Brazilian System of Digital Television (SBTVD)

The creation of the Brazilian System of Digital TV (SBTVD), was initiated by the Decree 4.901, of 26 of November of 2003, which:

- Established the aims of the Brazilian System of Digital Television (SBTVD).
- Created the Development Committee of the SBTVD with the scope of studying and elaborating a report[9] with proposals for:
  1 The definition of the reference model for the Brazilian system of digital television.
  2 The standard of television to be adopted in the Country.
  3 The form of exploitation of the digital television service
  4 The period and framework of the transition from analogue to digital system.
- Created an Advisory Committee and a Steering Group, which jointly compose the SBTVD, along with the Development Committee.

3.2 Phase 2: Digital Technology updates in regulatory documentation

The Phase 2, which was based on digital technology updates in the regulatory framework, was approved by Anatel Resolution N. 398, on April 7th 2005[10]. This Regulatory document presents technical aspects of sounds and video broadcasting and television retransmission, with the purpose of:

- Ensuring the quality of the signal in the coverage area.
- Preventing harmful interferences over currently authorized, and already installed, telecommunication stations.
- Establishing the technical criteria of viability projects designing, especially those regarding to inclusions in channel allotment plans, and modifications on technical installations.

The revision of the technical regulation for television broadcasting also included the procedure for calculation of viability involving channels of Digital TV[11] and the adoption of Recommendation UIT-R P.1546[12].

3.3 Phase 3: Creation of Basic Plan for Digital Channel Distribution (PBTVD)

The Phase 3 startup occurred with the publication of Anatel Resolution 407, on June 10th 2005[13]. This document approved the Brazilian Digital Television Channel Allotment Plan, officially named as Basic Plan

9 sbtvd.cpqd.com.br/cmp_tvdigital/divulgacao/anexos/ 76_146_Modelo_Ref_PD301236A0002A_RT_08_A.pdf

10 www.anatel.gov.br/Portal/documentos/biblioteca/resolucao/2005/res_398_2005.pdf

11 www.anatel.gov.br/Portal/documentos/biblioteca/resolucao/2005/anexo_res_398_2005.pdf

12 www.anatel.gov.br/Portal/documentos/biblioteca/resolucao/2005/anexoii_res_398_2005.pdf

13 www.anatel.gov.br/Portal/documentos/biblioteca/resolucao/2005/res_407_2005.pdf

for Digital Channel Distribution - PBTVD[14], referred to in item 1.2.3, Fig. 33. It also allocated, considering the guidelines discussed on item 1.2.1, 1893 digital television channels in 306 localities. In sum, in 2005, the Basic Plan of Distribution of Television Channels (PBTV) contained a total of 473 generator TV stations (analogue stations), 9845 relay TV stations and 1207 stations in cities where its populations were more than one hundred thousand inhabitants

3.4 Phase 4: Definition of the Digital Terrestrial Television system and the transition period guidelines

The Phase 4 started with the Decree No 5,820, on June 29th 2006[15], defining that the SBTVD-T would adopt, as a base, the standard of signals desigatned by ISDB-T (Integrated Services Digital Broadcasting-Terrestrial), also incorporating the technological innovations approved by the Development Committee. Beyond those definitions, the document presented the guidelines for the transition period from analogue to digital TV. The Decree also laid down the following points:

- Creation of the SBTVD Forum[16];
- Made possible:
- Simultaneous fixed, mobile and portable transmission.
- Interactivity.
- High Definition (HDTV) and Standard Definition Television (SDTV).
- Defined the assigned of one digital channel for each existing analogue channel, regarding the transition period. The preference is for the digital channel allocation in the UHF band (channels 14-59), rather than in the VHF band - high (channels 7 - 13).
- Deployment sequence, first starting with the TV stations.
- Established that, after signing the assignment contract, the installation projects must be submitted by the broadcasting companies to the Ministry of Communications within 6 months. Afterwards, the digital transmissions should start within 18 months.
- Defined that, after July 1st 2013, only digital technology television channels will be granted by the Ministry of Communication for television broadcasting.
- Defined the date of June 29th 2016 as the switch-off date of analogue transmission.

Creation of 4 (four) digital public channels for the national Government.

3.5 Phase 5: Establishment of conditions for assignment contract of the additional channel for the digital and analogue simultaneous transmission

The Ministry of Communication (MC) ordinance Nº 652[17], which has been published on the 10th of October, 2006, initiated Phase 5 by establishing the assignment contract conditions for the additional channel, which shall be used during the digital and analogue simultaneous transmission period (Simulcast). It has also included the schedule for the transition, as defined below:

- The assignment contract will observe the PBTVD.
- The digital channel will have to:
  I Provide the same coverage as its analogue counterpart;
  II Provide efficient management of the analogue and digital transmissions;
  III Prevent interferences.

[14] www.anatel.gov.br/Portal/documentos/biblioteca/resolucao/2005/anexo_res_407_2005.pdf

[15] www.planalto.gov.br/ccivil/_Ato2004-2006/2006/Decreto/D5820.htm

[16] www.forumsbtvd.org.br

[17] www.mc.gov.br/sites/600/695/00001879.pdf

Figure 5: Transition period in Brazil (analogue to digital television)

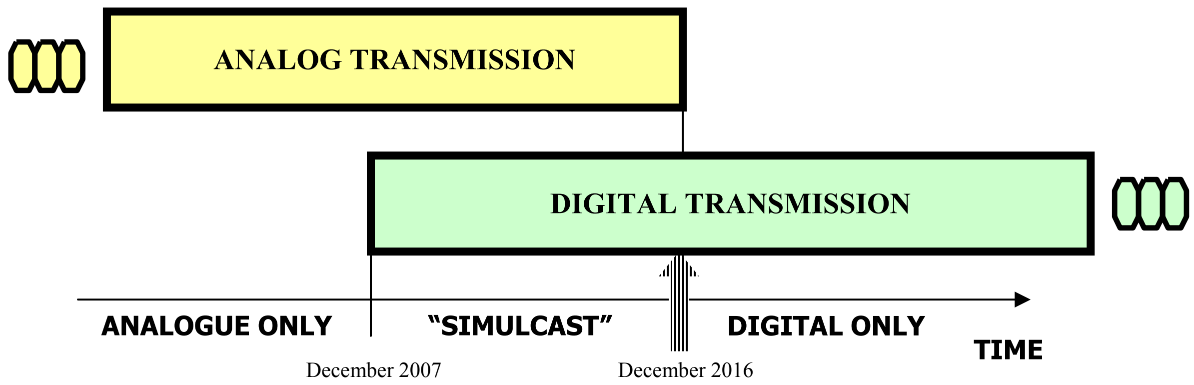


Table 1 presents the planning phases for assignment contracts of additional channels and the schedule for their commercial deployment[18]

According to the plan, migration priority is given to generator TV stations and, later, to the relay stations located in Federal and State Capitals. The signing of assignment contracts by relay station operators in the remaining cities will take place at the last stage.

After the assignment contract is signed, the TV Broadcaster may start to test and then commercially deploys the system.

18 www.forumsbtvd.org.br/cronograma.php

Table 1: Schedule for the assignment contract and commercial deployment of Digital TV

Phase of planning (Item 1.2.3)	Station TV type	Cities (Group)	Assignment contract schedule	Commercial deployment schedule
Phase 1	TV stations	São Paulo (SP)	Up to 12/29/2006	12/29/2007
Phase 1	TV stations	Belo Horizonte, Brasília, Rio de Janeiro, Salvador e Fortaleza (G1)	Up to 11/30/2007	Up to 01/31/2010
Phase 1	TV stations	Belém, Curitiba, Goiânia, Manaus, Porto Alegre e Recife (G2)	Up to 03/31/2008	Up to 05/31/2010
Phase 1	TV stations	Campo Grande, Cuiabá, João Pessoa, Maceió, Natal, São Luis e Teresina (G3)	Up to 07/31/2008	Up to 09/31/2010
Phase 1	TV stations	Aracaju, Boa Vista, Florianópolis, Macapá, Palmas, Porto Velho, Rio Branco e Vitória (G4)	Up to 11/30/2008	Up to 01/31/2011
Phase 1	TV stations	Other Cities with TV Stations (G5)	Up to 03/31/2009	Up to 05/31/2011
Phase 2	Relay stations	Cities of the Groups SP, G1, G2, G3, G4 (Capitals and Federal District)	Up to 04/30/2009	Up to 06/31/2011
Phases 2 and 3	Relay stations	Other Cities with Relay Stations	Up to 04/30/2011	Up to 06/30/2013

4 The Brazilian Digital Television System (SBTVD) Forum

After the release of Presidential Decree 5,820, the role of private organizations in the development of DTT was intensified, mainly because of the SBTVD Forum.

The Forum is a nonprofit entity, whose main objectives are supporting and fostering the development and implementation of best practices to the Brazilian digital television broadcasting success. The most important participants of broadcasting, reception-and-transmission-equipment-manufacturing, and software industries are part of this Forum.

The Forum's main tasks are: to identify and harmonize the system's requirements; to define and manage the technical specifications; to promote and coordinate technical cooperation among television broadcasters, transmission-and-reception-equipment manufacturers, the software industry, and research-and-education institutions; to propose solutions to matters related to intellectual property aspects of the Brazilian DTT system; to propose and develop solutions to matters related to the development of human resources; and to support and promote the Brazilian standard in the country and overseas.

Besides the private sector, federal government representatives also participate in the Forum. And such participation is considered very important, since it allows those representatives to closely follow the discussions taking place, while strengthening the relationship between forum members and public regulators.

4.1 Objectives

The Forum of Brazil's Terrestrial Digital TV Broadcasting System was formally instated in December 2006. The Forum's mission is to help and encourage the installation or improvement of the digital sound and video transmission and receiving system in Brazil, promoting standards and quality that meet the demands of the users.

The purpose of this Forum is to propose voluntary or mandatory technical norms, standards, and regulations for Brazil's terrestrial digital television broadcasting system, and, in addition, to promote representation, relations, and integration with other national and international institutions.

4.2 Structure and Composition

There are three membership categories: Full Members, Effective Members, and Observers. The Full Members, who have the right to vote and the obligation to pay annual dues, belong to the following sectors:

a) Broadcasting stations.

b) Manufacturers of receivers or transmitting equipment.

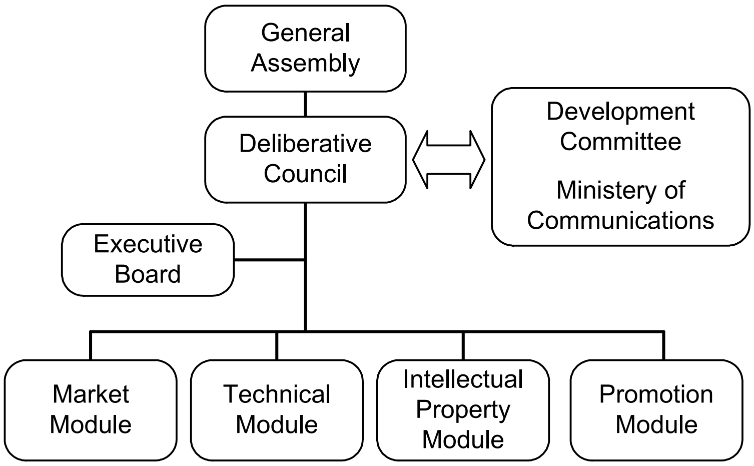
c) Software industry.

d) Teaching and research institutions that carry out activities directly involving Brazil's digital TV system.

Effective Members come from sectors that are different from those mentioned previously, but they must also pay annual fees dues. The Observer Members are those who, when formally invited by the Council, accept to enter the Forum, without any voting rights and without the obligation to pay annual fees dues.

The Deliberative Council is comprised of 13 councilor members elected by the General Assembly. The Council shall be able to draw up general policies of action, strategies, and priorities, adopt the results of the work, and refer them to the Development Committee of the Federal Government.

Figure 6: Brazilian digital TV Forum



4.3 Modules Assignments

The Forum is comprised of four modules that address different aspects of the Digital TV implementation task.

Market Module

The Market Module must identify the needs, wishes, and opportunities of the market, defining functional requirements, time limits for availability, and costs, and coordinating the relationship between the various sectors represented in the Forum.

This module checks conformity with the technical specifications and requirements that are drawn up and analyzes and proposes solutions to issues related to planning the implementation of terrestrial digital television.

Technical Module

The Technical Module coordinates the efforts relative to the technical specifications of Brazil's digital TV system and research and development activities, identifies specification needs, and defines the availability of technical solutions referring to the generation, distribution, and reception of the digital TV system, including high definition, standard definition, mobility, portability, data services, interactivity, content protection, and conditional access.

This module also coordinates the efforts to harmonize technical specifications with other national and international institutions.

Intellectual Property Module

The Intellectual Property Module must coordinate efforts in the search of solutions regarding intellectual property, drawing up policies and practices to be adopted among the members and proposing the legal advise on these issues to the competent institutions.

This module also helps and monitors the negotiation of royalties linked to the incorporation of technologies along with their holders and informs the council about the costs involved in the techniques being adopted or incorporated.

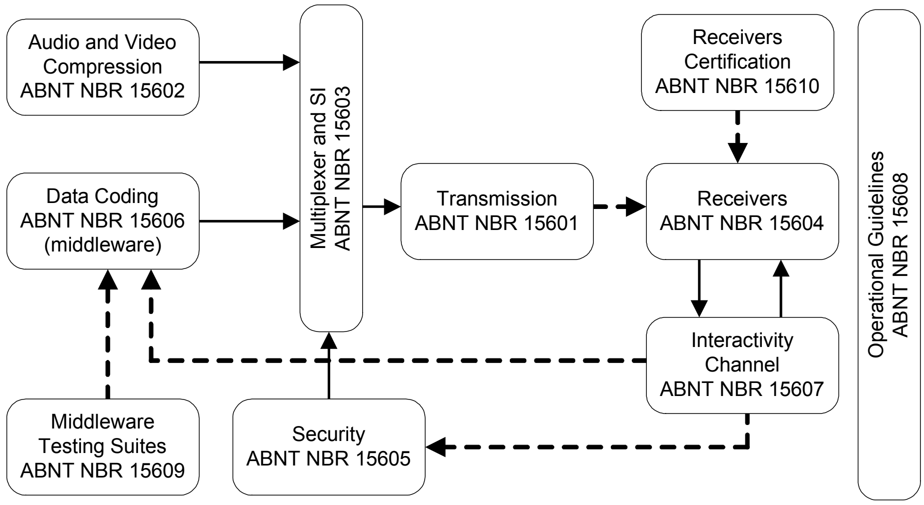
Promotion Module

The Promotion Module coordinates efforts to promote, distribute, and disseminate Brazil's system. This module must promote seminars and courses; publish newspapers, bulletins, and other carriers of information. The Promotion Module is also responsible for organizing the common activities of broadcasters and industries aimed at increasing the awareness about the advantages of the Digital TV system.

4.4 Outline of the Technical Standards

Standardization activities, performed by the Technical Module, are divided among eight subgroups of specialist volunteer members, which work in the sectors of the broadcasters, consumer electronics, transmitters and software industries and universities. The working groups are organized as below.

Figure 7: Brazilian standardization structure



The standards for the digital terrestrial television, showed in the Fig. 37, are listed below:[19]

- ABNT NBR 15601:2007 – Transmission system
- ABNT NBR 15602:2007 – Video coding, audio coding and multiplexing
- ABNT NBR 15603:2007 – Multiplexing and service information (SI)
- ABNT NBR 15604:2007 – Receivers
- ABNT NBR 15605:2007 – Security issues (under approval)
- ABNT NBR 15606:2007 – Data coding and transmission specification (partial)
- ABNT NBR 15607:2007 – Interactive channel (partial)
- ABNT NBR 15608:2007 – Operational guidelines
- ABNT NBR 15609:2007 – Middleware test suit (internal working document)
- ABNT NBR 15610:2007 – Tests for receivers (internal working document).

5 Current Status of the DTTV deployment

On December 2nd, 2007, the first official implementations of the Brazilian DTTV system began commercial operations in the city of São Paulo and, by mid-2008, there were already 10 commercial broadcasters operating in this city. Although tests were already being conducted since May, 2007, the government chose the December date as the official date of the system launch.

According to the schedule established by the government, all analog TV broadcasters must also be transmitting digital until 2013. Furthermore, the switch-off of the analog systems is schedule to take place in 2016.However, in 2008, the actual deployment of DTTV transmissions in Brazil was moving ahead of the schedule. Stimulated by the increasing interest in the new technology, many broadcasters have been investing earlier than required by law and have been starting digital transmissions sooner than expected. The accelerated implementation was also due to the tax-reduction incentives offered by the government, and to the new applications made possible by the DTTV system, such as portable reception.

19 www.abnt.org.br/tvdigital/TVDIGITAL.html

In the first six months after the official commercial launch, DTTV transmissions in Brazil is a reality in São Paulo, Rio de Janeiro, Belo Horizonte and Goiânia, and 10 other cities were scheduled to get digital broadcasting yet in 2008. By the third quarter of this year, DTTV signals already covered over 21 million people, and were expected to reach 30 major cities and state capitals by the end of 2009.

The robustness of DTTV signals, as well as the superior video and audio quality provided by the technology, represents a big step forward in the technical quality on content access of lower income population. The market penetration of television devices in Brazil and its close relationship with the general population are clues to enable us to devise the huge market that DTTV will offer in the next few years.

5.1 DTTV market in 2008

In the third quarter of 2008, there were already over 30 different DTTV receivers available in the market, with functionalities and designs aimed to different economic segments and user preferences. Among those models, there could be found portable reception devices (1-Seg), including portable TVs, computer USB tuners and cell phones. For fixed reception, consumers could choose between standard definition and high definition devices, although all broadcasters have been transmitting in high definition (1080i). There were already over 50 h a week of original HDTV programming, and a growing demand from viewers.

Since the commercial start of DTTV in Brazil, consumers were able to see a significant fall in the prices of reception devices, with the proliferation of additional manufacturers and models. As an example, by the third quarter of 2008, portable one-seg receivers for computers could be found for prices around US$ 100, while high-definition fixed-reception set-top devices could be found in the US$ 180 to US$ 300 price range. It was not unusual to find special offers to lower income consumers that split the price of the receiver in up to 12 monthly instalments.

By that same time, the industry had already provided many solutions for the high-end DTTV market, such as full-HD displays with integrated digital tuners. Many manufacturers offered displays with integrated receivers, with sizes ranging from 32 to 52 inches, for a price to the consumer starting at around US$ 1.500.

Since the beginning of transmissions, market prices for DTTV receivers have been falling gradually, as the market moves from the early adopters to the ordinary consumers. That expected movement has been regarded by broadcasters and industry as proof of the successful introduction of DTTV. It’s a trend that is expected to intensify with the beginning of transmissions in other cities. As of mid-2008, manufacturers have been preparing for Christmas, when a surge in demand for reception devices is expected. The general expectations are that the demand for DTTV receivers and integrated TVs will grow steadily over the following years.

6 Conclusion

The opinion of the majority of the concerned entities is that the introduction of digital TV in Brazil has been very successful. The better images and sound quality, the portable TV with in-band “one-seg” technology, the future interactivity with the user and the digital convergence are the most evident benefits of the new technology. Nonetheless, keeping terrestrial television a free and open service, providing ways for the social inclusion of a growing number of citizens, as well as offering them an important mean of entertainment, education and cultural integration, at local, regional, and national levels, are not less important objectives for system that has been prepared to serve a vast country such as Brazil, both in territorial and demographic senses.

One of the first steps on the transition process was the development of the Digital Television Channel Plan, conducted by the National Telecommunications Agency (Agência Nacional de Telecomunicações - Anatel) since 1999. At the end of the channel planning process, not later than 2013, it is expected that more than 6 100 digital channels have been assigned. In the full “simulcast” period, from 2013 to 2016, more than 12 200 analogue and digital channels are supposed to be in operation. This fact illustrates the magnitude of the task that has been assigned to Anatel, and that has been so far successfully executed by the Agency.

An important cornerstone of the successful introduction of the digital terrestrial TV in Brazil was the creation of the Brazilian Digital Television System Forum, or SBTVD Forum, in 2006. The Forum, whose members are TV network operators, equipment manufacturers, the software industry, education and research institutions, plus some other invited institutions and individuals, has had an important role in supporting and fostering the development and implementation of digital television in the country. It is also responsible for defining the best practices for the deployment of the system. By working close with the Japanese experts on the ISDB-T standards, the Forum has created a vast knowledge base about the implementation of DTT, and has contributed to the formation of a large number of professionals with competence on the subject.

Annex 3

Case Study for the schedule of introduction of DTTV in France

1 Preamble

The **Conseil Supérieur de l'audiovisuel (CSA)**, which is the French regulator for audiovisual, was established by Decree No. 89-518 of 26 July 1989 on the organization and functioning of CSA (www.csa.fr). CSA issues licences for private TV and radio broadcasting over terrestrial radio relay, and agreements are established for such licences. Television and radio broadcasting over frequencies that are not assigned by CSA (cable, satellite, ADSL, Internet, telephone, etc.) also comes under CSA's responsibility (agreement or declaration).

With responsibility for the procedures for deploying digital television over all French territory in fixed terrestrial (DTT) and mobile terrestrial (PMT) form, CSA has established a detailed schedule in order to ensure that the deployment of digital terrestrial television (DTT) is completed by 30 November 2011 for all French people in accordance with the legislation in force. That legislation deals with around 13 000 frequencies assigned to around 4 000 transmitters.

Note: French territory includes entities in Regions 1, 2 and 3 as defined by the ITU-R Radio Regulations (international treaty).

2 Schedule for digital terrestrial television (DTTV)

31 March 2005: Commencement of deployment of DTTV (17 sites).

10 May 2006: 50% of the population of Metropolitan France are covered by DTTV. Adoption of a list of new stations licensed for 31 March 2007, i.e. 115 sites before the end of 2007, which should result in 66% coverage of Metropolitan France by October 2006 and 70% in March 2007, with an objective of 85% by the end of 2007.

4 January 2007: Programme adopted by CSA for 2007 for the opening of 37 new zones that should allow 80-85% of the population to be covered by the end of 2007.

22 July 2007: CSA establishes the conditions governing the introduction and deployment of DTTV (DVB-T).

11 December 2007: Consultation of the different players potentially involved in DTTV further to Law 2007-309 of 5 March 2007 on the modernization of audiovisual broadcasting and television of the future.

15 April 2008: Contribution by CSA for the establishment of a national plan for discontinuing analogue broadcasting and changing over to all-digital. Further to the consultation of potential DTTV players launched on 11/12/07, CSA received 80 contributions. Based on those contributions and its own studies, CSA adopted an opinion which it transmitted to the Prime Minister. In summary, discontinuation of analogue TV must take place gradually based on geographical zones, with the guarantee of continuity of service without programme loss for TV viewers.

July 2008

– 23.2% of homes are equipped with **HDTV** (high resolution image transmitted by ad hoc equipment: HD-DTTV/MPEG-4 adapter, Blu-Ray reader, etc.); studies foresee extensive spread, with 51% in 2010 and 93.2% in 2017. CSA has authorized three HD channels at the end of 2007 and two HD channels in 2008. Industrialists have decided to ensure the widespread use of the MPEG-4 standard as from the end of 2012.
– 22 July 2008: Programme for the extension of DTTV in 2009; first phase: 71 new DTTV zones for the summer of 2009 at the latest. By the end of 2009, around 92% of the population of Metropolitan France should have DTTV coverage.

October 2008

– On 1 October, CSA posted **DTTV coverage interactive digital maps** on its website to allow TV viewers to visualize the coverage of each DTTV channel. Those maps will be updated regularly with the bringing into service of new transmitters.

– Under Articles 99 and 105 of Law 2007.309 of 5 March 2007 on the modernization of audiovisual, the **Digital TV Observatory** (OTVnu) was set up by the government at the end of 2007 under the auspices of CSA to **measure the level of TV equipment in French homes**. The Observatory published its first results on 2 October. At the end of the first quarter of 2008 and based on 25 284 000 homes equipped with TV sets, regarding the deployment of digital TV (DTTV, satellite, ADSL, cable): 58.7% of homes have at least one digital access, 30% of those homes are entirely digital and 53.7% possess at least two TV sets; 8 million homes, or 31.7%, have at least a DTTV adapter. The percentage of the population with digital TV coverage as at 31 March 2008 was 83.3%. In addition, with regard to analogue TV reception: 70.1% have digital access on at least one of their sets and 29.1% receive analogue TV only. In summary:

Digital access: 31.7% wireless access with DTTV adapter (8 million), 14.6% digital satellite through subscription (3.69 million), 13.2% ADSL (3.35 million), 6% digital cable through subscription (1.5 million). Free digital satellite is not covered by this study, but it is estimated that 500 000 households use this means of reception.

Digital and analogue access: 31.7% DTTV (8 million), 33.8% other digital access (8.54 million), 29.1% analogue terrestrial wireless access (7.35 million), 8.5% analogue cable (2.15 million). It is estimated that 1.5 million households receive analogue TV free via satellite.

– Action No. 20 of the plan FRANCE NUMERIQUE 2012 (www.francenumerique2012.fr) recommends that resources be made available for the new TV services. This means setting France the objective, by 30 November 2011, of 13 multiplexes: 11 for DTTV (simple or high definition) with a coverage of 95% of the population, and 2 for PMT with a coverage of 70% of the population.

25 November 2008: DTTV extension continues with the opening of 77 new transmitters on dates set between 30 November and 19 December 2008. The 77 new zones will add to the 55 localities already brought into service in 2008, thus by the end of 2008 nearly 53 million people, or almost 87% of the population of Metropolitan France, will have DTTV coverage.

8 December 2008: CSA opinion on the future schedule for the changeover to all-digital.

More up to date information could be found via trev_2009-Q4_Spectrum_Brugger.pdf (reference Section 2.1)

3 Schedule for terrestrial mobile television (PMT)

The first tests for the different terrestrial PMT standards commenced in 2005, followed by testing of the chosen DVB-H standard in 2006 and 2007; that testing is continuing.

17 January 2007: Public consultation by CVSA regarding arrangements for the launch of PMT.

14 June 2007: Analysis by CSA of the 47 contributions received following the consultation of 17/1/07.

6 November 2007: Pursuant to Article 30-1 of the law of 30/9/86, CSA launched a call for candidacies for PMT (with possible interactivity) with national coverage for **a multiplex** of 16 channels with 3 reserved for the public service.

1 April 2008: Issue of call for candidacies for the PMT interactive services further to the consultation of 6/11/07.

27 May 2008: From the 36 receivable files submitted further to the consultation of 6/11/07, **CSA retained 13 candidates for PMT.**

28 July 2008: CSA foresees the commercial launch of PMT **in the first quarter of 2009.**

6 November 2008: Analysis of the 15 contributions received for **interactive PMT**. The resources foreseen comprise six blocks of 20 kbits/s for the services under Article 30-7 of Law 86-1067: access for electronic communication to the public allowing simultaneous reception by an entire segment of the public (ESG, traffic, weather, etc.). In addition, for the data associated with the programme (Push, VoD, Music, etc.), 10 kbits/s, modifiable as required, are planned.

NOTE: The Council of Europe set up the **European Audiovisual Observatory** in 1992 (www.obs.coe.int). In its communication of 15/10/08, the Observatory estimated that in 2008 a total of 6 500 TV channels are available in the 27 countries of the EU and 2 candidate countries (Croatia and Turkey). The Observatory's MAVISE database set up in 2007 at the initiative of the European Commission through its Directorate General Communication (mavise.ubs.coe.int) contained, as at 15/10/08: 4 663 listed channels, of which 381 are national terrestrial (analogue or digital), 2 473 use cable, satellite and IPTV, and 1 809 are regional or local. MAVISE, to which access is free, is continuously updated and in December 2008 contained 5 157 TV channels, 4 000 TV companies, and channel offers from over 150 packages. It may be noted that the Observatory's PERSKY database contains the directory of TV channels in Europe.

Annex 4

EBU HDTV Receiver Requirements
EBU Tech 3333

EBU Committee First Issued Revised Re-issued

DMC 2009

Keywords: HDTV Receiver, Set-top-box, Functional Requirements

1 Scope

This document represents the minimum HDTV receiver requirements of EBU members (the broadcasting organisations) and has been discussed in detail with DIGITALEUROPE (EICTA) representatives. Media industries developing stand-alone receiver (set-top boxes - STB or integrated receiver decoders - IRDs) or receivers with integrated digital televisions (iDTVs) are encouraged to comply with this set of requirements in order to allow interoperability between EBU Members' broadcasts and the receiver device.

Note 1: EBU Members may require additions or changes to these requirements to meet particular national demands (e.g. language).

Note 2: The sections on Audio of this document received substantial contribution from EBU project P/Loud and D/MAE; the sections on LAN/Networking and CE-HTML have been provided in cooperation with the EBU project D/CH.

2 Normative references

The technical requirements or specifications contained in this document refer to standards developed by standard-settings organisations such as DVB; ETSI; DIGITALEUROPE, MPEG; ISO; CEI and CEN. In particular:

– EBU Tech 3299 EBU Tech 3325
– ETSI TS 101 154 v1.9.1 ETSI EN 300 421 v1.1.2 (DVB-S)
– ETSI TS 102 323 v1.3.1 ETSI TS 102 366 v1.2.1
– ETSI EN 300 429 v1.2.1 (DVB-C) ETSI EN 300 744 v1.6.1 (DVB-T)
– ETSI EN 300 468 v1.10.1 ETSI EN 302 755 v1.1.1 (DVB-T2)
– ETSI EN 300 743 v1.3.1 (DVB subtitling) ISO/IEC 14496-3
– ETSI EN 302 307 v1.1.2 (DVB-S2) ISO/IEC 14496-10 (2005)
– ETSI TR 101 211 v1.8.1 ITU-R Rec. BT 601
– ETSI TS 102 114 v1.2.1 ITU-R BS.775
– IEC62216-1 IEC 60169-24
– ITU-R Rec. BT 709 Dolby Technical Bulletin Number 11
– IEC 60169-2 DLNA Guidelines 1.5
– CEA-861-D HDMI 1.3a
– DVB TM-GBS0275

3 Informative references

HDready (1080p) DIGITALEUROPE HDTV (1080p) www.digitaleurope.org www.swisstxt.ch >Download > Multimedia Solutions >Teletext - recommendations for the minimum functions of teletext decoders

4 Video

4.1 Image formats

The following image sampling structures shall be supported (see TS 101 154 V1.9.1, which defines further formats beyond those listed here).

– 1920 x 1080, interlaced, 25 frame/s (50 fields)
– 1920 x 1080, progressive, 25 frame/s
– 1440 x 1080, interlaced, 25 frame/s (50 fields)
– 1440 x 1080, progressive, 25 frame/s
– 1280 x 1080, interlaced, 25 frame/s (50 fields)
– 1280 x 1080, progressive, 25 frame/s
– 1280 x 720, progressive, 50 frame/s
– 1280 x 720, progressive, 25 frame/s (carried as 720p/50 with pic_struct=7) (frame doubling). (See ISO/IEC 14496-10).

Note: receiver supporting IP streaming (e.g. Hybrid Receiver), should support native 720p/25.

– 960 x 720, progressive, 50 frame/s
– 720 x 576, interlaced, 25 frame/s (50 fields)
– 704 x 576, interlaced, 25 frame/s (50 fields)
– 544 x 576, interlaced, 25 frame/s (50 fields)
– 480 x 576, interlaced, 25 frame/s (50 fields)

The following Profiles shall be supported:

– MPEG-2: MP@ML;
– MPEG-4 - H.264/AVC: MP@L3, MP@L4.0; HP@L4.0

The receiver shall be able to decode the SVC baseline layer (see TS 101 154 v1.9.1) 1080p/50 & SVC (**): The receiver shall not crash when 1080p/50 is received either as H.264/AVC or SVC. The receiver shall not crash when any other image format with SVC is received. *

Note: It is expected that new compression/sampling formats or elementary streams with the same coding format and higher levels, such as 1080p/50, will be broadcasted in the future. Current receivers should be designed such that they exploit available information from (P)SI and elementary streams in a way that they safely detect such situations and behave in a stable way in the presence of such signals, e.g. by presenting information to the user through the GUI.*

*Note**: DVB TM-AVC has approved the addition of HP@L4.2 and SVC (includes the 1920x1080p/50-60 image format) to TS 101 154 V1.9.1.*

4.2 Random Access Points

Receivers must support random access points of maximum 5 seconds (see ETSI TS 101 154).

4.3 Overscan

An IDTV receiver shall utilize the appropriate overscan flag as defined by ISO/IEC 14496-10 (2005).

A STB receiver shall convey the flag to the display through the AVI_infoframe (HDMI).

Note: see EBU Tech 3325 as background information on overscan.

4.4 Scaling between HD and SD

SD to HD up-scaling shall use the centre 702x576 pixels unless this would cause misalignment of SD video and graphics.

HD to SD down-scaling shall use the whole HD image to the centre 702x576 SD image format.

4.5 Video Display Characteristics

4.5.1 Frame Cropping information

Shall only be used to crop 1088 to 1080 lines. If there is no crop information the receiver shall discard the bottom 8 lines of a frame.

4.5.2 Format switching

The receiver shall not crash and must continue operation after format switching (event-based and channel-hopping). Disturbance/distortions to the image should be minimal (e.g. freeze or black frame duration <= RAP, depending on GOP length).

4.5.3 Output format

The default output resolution is HD resolution (either 720p/50 or 1080i/25).

A mode shall be available that allows the output to follow the input format.

It shall be possible to manually switch between 720p/50 and 1080i/25.

Enhanced receivers may also allow switching the output to 1080p/50.

4.5.4 Active Format Descriptor (AFD)

(See EN 2216-1, chapter 6.4.3). It is recommended that receivers with HDMI output provide at least one of the following methods of processing aspect ratio and AFD information for video output on HDMI:

- Provide a reformatting function for the video to match the aspect ratio of the display based on AFD, aspect ratio and user preference as per section 6.4.3.5, EN 2216-1 for 16:9 displays) of the E-Book.

  Support for scaling to 4:3 aspect ratio for HDMI is optional (since consumer HD displays are 16:9). Aspect ratio signalling in the HDMI AVI Infoframe bits R0 - R3, M0, M1 (see CEA-861) shall be set in accordance with the properties of the video on the output.
- Pass the video to the HDMI output unprocessed with respect to AFD and aspect ratio scaling, and pass AFD and aspect-ratio signalling in the video to the HDMI output as part of the AVI Infoframe bits R0 - R3, M0, M1 (see CEA-861).

Note: HD broadcasts are always in 16:9 aspect ratio.

4.5.5 Colorimetry

A receiver shall signal the appropriate colour space to the display via the HDMI AVI Infoframe. The default colour space shall comply with ITU-R Rec. BT 709-5.

When converting SD to HD, a receiver should apply a colour transformation from ITU-R BT. 601 colourspace to ITU-R BT.709-5 colourspace. The colourspace shall be signalled via the HDMI interface.

4.6 Decoding compliance

4.6.1 Minimum bit-rate (e.g. static pictures)

The receiver shall respect MPEG timing models in ES buffer occupancy. The minimum bit-rate is defined by the shortest syntax according to ISO/IEC 14496-10 for a uniform sequence with maximum redundancy.

5. Audio

HD IRD shall fulfil the minimum decoding requirements for standard definition (SD) according to ETSI TS 101 154. For audio, the HD receiver shall provide at least one stereo decoder MPEG-1 Level 2. The receiver should support audio bitrates of up to 192 kbit/s per single audio channel and up to 384 kbit/s for two-channel stereo. In the case of transmitted stereo, the HD receiver shall support linear PCM at the digital output interface. In the case of a transmitted 5.1 audio signal, the HD receiver shall provide a downmix of the multichannel audio signal. The HD receiver shall provide support for 5-channel plus LFE (Low Frequency Effects), i.e. 5.1-channel surround sound corresponding to the loudspeaker layout described in ITU-R BS.775. In the case of simulcast, i.e. transmitted stereo and 5.1 audio signal, the HD receiver shall provide the transmitted stereo at its analogue and digital stereo output interface.

In this document the following notation is used:

– **System A**: Dolby Digital Plus or E-AC-3 (DD+) transcoded to Dolby Digital or AC-3 (DD)

– **System B:** HE AAC transcoded to DD or DTS

  The audio may be carried by **System A** and/or by **System B**, as determined for the relevant network.

– **Both System A and System B** shall be supported for networks where there is no mandatory operator acceptance of IRDs.

– **Either System A or System B** may be required for networks where an operator is in charge of specifying the functionality of the IRDs and ensuring that the minimum requirements are met.

In addition to these requirements for mono/stereo output, HD IRD shall provide outputs for multichannel audio, as in Table 1 below:

TABLE 1: Audio Requirements for System A and System B

Status Comment

DD streams at all bitrates and fs=48 kHz according to ETSI TS 102 366 v1.2.1

Mandatory

Decoding

DD+ from 32 kbit/s to 3024 kbit/s and fs=48 kHz= according to ETSI TS 102 366 v1.2.1. Other samples rates may be required by local specifications

Mandatory

Transcoding

DD+ to DD according to ETSI TS 102 366 v1.2.1

Mandatory At fixed rate of 640 kbit/s

Metadata

A complete set of Dolby metadata

Mandatory The HD IRD shall use metadata, where provided by the broadcaster, to control for example the stereo down-mix from multi-channel audio, and shall use it, or pass it through, when providing bitstream output of Dolby Digital.

Examples of metadata parameters of use are down-mix coefficients, “dialnorm”, compression modes, etc.

Pass-through of native DD and DD+ bitstreams

Mandatory In order to guarantee compatibility with legacy multichannel audio receivers, the following mechanism should be implemented. If an HDMI sink device indicates in its E-EDID structure that Dolby Digital decoding is supported, but Dolby Digital Plus decoding is not supported, the IRD shall transcode Dolby Digital Plus streams to Dolby Digital prior to HDMI transmission.

System A

HDMI Audio output

DD+ transcoded to DD according to ETSI TS 102 366 v1.2.1

Mandatory Fixed bit-rate of 640 kbit/s

PCM stereo from the decoded or downmixed bitstream

Mandatory When an HDMI Sink device indicates in its E-EDID structure that it only supports Basic Audio (i.e. two-channel L-PCM from the original stereo signal or from a stereo down-mix from the multi-channel signal), then the HDMI output will provide Basic Audio. This feature would then take precedence over the requirement of DD, DD+ and HE AAC multi-channel in the table above whenever the Sink device indicates that only Basic Audio is supported. The volume control settings of the HD IRD shall not influence the audio playback level on this interface.

PCM MCA from the decoded bitstream

Optional The volume control settings of the HD IRD shall not influence the audio playback level on this interface.

Pass-through of DTS bitstream

Not applicable

DD+ transcoded to DD according to ETSI TS 102 366 v1.2.1

Mandatory Fixed bit-rate of 640 kbit/s

PCM stereo from the decoded or downmixed bitstream

Mandatory The volume control settings of the HD IRD shall not influence the audio playback level on this interface.

Pass-through of DD bitstream

Mandatory

S/PDIF

Audio output

Pass-through of DTS bitstream

Not applicable

Status Comment

HE AAC Level 2 (mono, stereo) at fs=48 kHz according to ISO/IEC 14496- 3 and as constrained by ETSI TS 101 154 v1.8.1

Mandatory

System B

Decoding

HE AAC Level 4 (MCA up to 5.1) at fs=48 kHz according to ISO/IEC 14496-3 and as constrained by ETSI TS 101 154 v1.8.1

Mandatory

Transcoding

HE AAC Level 4 (MCA up to 5.1) at fs=48 kHz according to ISO/IEC 14496-3 and as constrained by ETSI TS 101 154 to DD according to ETSI TS 102 366 v1.2.1 or DTS according to ETSI TS 102 114 v1.2.1.

Mandatory If DD, at fixed rate of 640 kbit/s. In the case of DTS, fixed bit-rate of 1509 kbit/s

Dynamic Range Compression parameters according to ISO/IEC 14496-3 and “Transmission of MPEG -4

Ancillary Data" as specified in Annex C of ETSI TS 101 154 v.1.8.1

Programme Reference Level according to ISO/IEC 14496- 3 etadata

Mixdown parameters according to ISO/IEC 14496- 3 and "Transmission of MPEG -4 Ancillary Data" as specified in Annex C of ETSI TS 101 154 v.1.8.1

Pass-through of native HE AAC bitstreams

Optional

MCA HE AAC bitstream transcoded to DD according to ETSI TS 102 366 v1.2.1 or DTS according to ETSI TS 102 114 v1.2.1.

Mandatory For DD, a fixed bit rate of 640 kbit/s. For DTS, a fixed bit-rate of 1509 kbit/s.

If an HDMI sink device indicates in its E-EDID structure that DD or DTS is supported, but HE AAC decoding is not supported, the IRD shall transcode HE AAC streams to DD or DTS prior to HDMI transmission.

PCM stereo from the decoded or downmixed tstream

Mandatory When an HDMI Sink device indicates in its E-EDID structure that it only supports Basic Audio (i.e. two-channel L-PCM from the original stereo signal or from a stereo down-mix from the multi-channel signal), then the HDMI output will provide Basic Audio. This feature would then take precedence over the requirement of DD, DD+, HE AAC multi-channel and DTS in the table above whenever the Sink device indicates that only Basic Audio is supported.

The volume control settings of the HD IRD shall not influence the audio playback level on this interface.

PCM MCA from the decoded bitstream

Optional The volume control settings of the HD IRD shall not influence the audio playback level on this interface.

HDMI Audio output

Pass-through of DTS bitstream

Optional

S/PDIF

Audio

PCM stereo from the decoded or downmixed bitstream

Mandatory The volume control settings of the HD IRD shall not influence the audio playback level on this interface.

Status Comment

MCA HE AAC bitstream transcoded to DD or DTS

Mandatory For DD, a fixed bit rate of 640 kbit/s. For DTS, a fixed bit-rate of 1509 kbit/s

Pass-through of DTS bitstream

Optional

Audio Stream Mixing

Optional

Audio Description

Mandatory

Mandatory only for Broadcast-Mix according to DVB EN 300 468 v1.10.1 (supplementary audio descriptor). The receiver should provide a separate audio output (headphone socket preferred) which is switchable to audio= description and which is separately adjustable (if headphone). According to the needs of the users, the receiver mix audio description shall be available at the digital output interface. The receiver mix audio description is described in TS 101 154 V1.9.1 Annex E. An alternative is provided by the DD+ stream mixing, which is implemented as part of DD+

Adjustment of video/ audio delay

Mandatory The HD IRD shall support the possibility to adjust the audio-delay on the S/PDIF output (if available) from 0 to 250 ms and it should be adjustable in 10 ms steps.

Audio handling when changing service or audio format

Mandatory The HD IRD should gracefully handle change of service or audio format at the audio outputs without significant disturbances to the end user. The HD IRD shall not store volume control settings for individual TV or Radio channels independently.

Internal digital audio reference level

Mandatory The HD IRD shall have an internal digital audio reference level equivalent to the Dolby dialogue normalization reference level of –31 dBFS (equivalent to –20 dBFS Leq for the analogue outputs). The HD IRD shall adjust the output level of all audio decoders to match the internal reference level so that perceived programme loudness is consistent for all audio-coding schemes. For HD IRD featuring DD and DD+, this should be consistent with Dolby Technical Bulletin 11: Requirement Updates for DD and DD+ in DVB Products. HD IRD featuring DD or DD+ decoding shall include the PCM Level Control feature described therein.

For example, for MPEG -1 Layer 2 audio streams that have an average loudness of about -20 dBLeq, the IRD shall apply an attenuation of 11 dB for the digital output to match the internal reference level. For information HE AAC has a reference level of -31.75 dBFS. It shall be possible to change the applied gain reduction for the

MPEG Layer 2 audio according to future loudness standardization by means of a downloadable software update.

Lip Sync

Mandatory HD IRDs shall not introduce a differential delay of more than 5ms between audio and video. An IRD shall support HDMI v1.3 including "Auto-LipSync". The receiver/player should delay the audio on the analogue output (intended for amplifiers) and S/PDIF output by the corresponding amount of time, which is needed to compensate for the different decoding delay of audio and video. Section "Adjusment of video/audio delay" specifies the accuracy required. This delay shall not be applied to audio conveyed through HDMI (even if the audio is decoded and mixed down to stereo PCM).

Miscell-aneous Require-ments

Radio Services

Mandatory Support of the codecs mentioned above.

6 SI and PSI

6.1 Multiple video compression

The receiver shall present the H.264/AVC video if there is a choice between AVC and MPEG-2 in the PMT.

6.2 Logical channel number

The receiver shall interpret the HD simulcast and logical channel number descriptors according to IEC62216 (2009 version). The decision to interpret the presence of a HD_Simulcast_LCN as a substitution depends on quality reception condition and is made only at the scanning step. LCN conflicts shall be handled gracefully by the receiver.

6.3 HD_simulcast_LCN

The receiver should ensure that the quality of the HD service is good enough (e.g. BER after viterbi is quasi error free e.g. 10-7) before taking a switch.

6.4 Linkage descriptor

Receivers shall interpret linkage descriptors with link types of service replacement service (in the SDT) as described in DIGITALEUROPE's draft 'E-book' (rev end 2008) and event simulcast (in the EIT) as described in document EN 300 468 V1.10.1. This specification is currently under finalisation.

Note on event simulcast: broadcasters must ensure that the SD- and HD-events are temporally aligned.

6.5 Service type (content)

Use of 0x0A, 0x16, 0x19, 0x03, 0x0c*, 0x01, 0x02 service types.

Note: platform dependent

6.6 DVB FTA_Content_Management_Descriptor

If the descriptor is available it shall be supported according to the EN 300 468 V1.10.1 and the parameters settings as defined in this document. In the case of absence no restrictions shall apply. Further information can be found in section 9.7.

6.7 EPG

Receivers shall support EIT p/f and schedule, carried in EIT actual and EIT other tables, and shall expose the information to the viewer. Recorders should support CRIDs (TV-Anytime - see document ETSI TS 102 323 v1.3.1, chapter 12) and use them to provide advanced recording functionalities such as series linking, trailer recording and conflict resolution.

6.8 Dynamic switching PMT

Dynamic switching PMT shall be supported. The maximum switching time should not be longer as a manually initiated channel change.

6.9 Dynamic changes of service_names in SDT

Dynamic changes of service_names in SDT shall be supported.

6.10 Service_move_descriptor

Depending on service changings within one platform (i.e. DVB-C) the service_move_descriptor shall be supported.

6.11 Event_id

The receiver shall support automatic PVR recordings by using the EIT actual as trigger (see also 7.7.2).

Note: This functionality requires that the EIT transitions be timely aligned to the event boundaries.

7 Access Services

Receivers shall not simultaneously interpret txt-subtitles and DVB subtitles. The receiver shall give priority to DVB Subtitles.

7.1 DVB Subtitles

DVB-subtitling to EN 300 743 V1.3.1 is mandatory. Different languages shall be selectable. The default is the preferred language at installation. It is mandatory to be able to select or deselect subtitles and for this choice to be maintained across channel changes.

7.2 HD-DVB Subtitles

Mandatory (EN 300 743 V1.3.1). Different languages shall be selectable. Default is preferred language selected at installation. It is mandatory to be able to select or deselect subtitles and for this choice to be maintained across channel changes.

7.3 Clean Audio

Shall be compliant with TS 101 154 V1.9.1 (draft).

7.4 Teletext Subtitles

Mandatory (Teletext-Subtitle EN 300472, internal decoder), and the STB shall render the graphics.

Note: There is no teletext via HDMI.

7.5 RDS/Radio/Radio text plus

Optional DVB TM-GBS0275.

7.6 Hard of Hearing

The receiver shall detect 'normal' DVB Subtitles (component_type=0x14) and Teletext subtitles (component_type=0x02) and when labelled as 'hard of hearing' with component_type=0x24 for DVB Subtitles or teletext_type=0x05 for teletext subtitles. This shall be accessed as a user choice in the subtitling menu. If 'hard of hearing' content is available in both DVB Subtitling and Teletext, only the DVB Subtitling shall be displayed. In case of 'hard of hearing' subtitling mode is selected and no 'hard of hearing' pages are received, the receiver shall use 'normal' subtitling from the same selected language. In case of 'normal' subtitling mode is selected and no 'normal' pages are received, the receiver shall use 'hard of hearing' subtitling from the same selected language.

7.7 Control of recording devices

7.7.1 Source is HDTV Set Top Box

The Set top box should toggle the SCART pin 8 to signal an external recorder when to start and stop recording an event. It shall be possible to have a choice between a time based recording or a recording based on the value of the event_id.

7.7.2 HDTV PVRs

It shall be possible to have a choice between a time based recording or a recording based on the value of the event_id.

8 VBI

8.1 Teletext Services

Mandatory: V1.5. Recommended V2.5.

Recommendation: HD appropriate graphics-generator, decoder memory capacity for a minimum of 10 Teletext pages. The Memory should in all cases store the (4) TOP or FLOF (as appropriate) "colour-linked" pages. If the service does not carry one of these page access methods the previous, the next, the next "nn0" (e.g. page number 240, if currently showing 234) and the next "n00" (e.g. page number 300, if currently showing 234) page number. Teletext should be re-inserted into the baseband video signals on the SCART interface of the STB.

8.2 Wide Screen Signalling (WSS)

Mandatory on all analogue outputs on a STB. The information for the AFD needs to be transformed into WSS for the analogue output on SCART.

Note: This requires that broadcaster AFD does not preclude the translation into WSS

8.3 Signalling over SCART

VCR (2nd SCART).

If there is a second SCART, only DVB and teletext subtitling shall be presented, and not OSD.

9 Content Management

9.1 Common Interface (CI)

Mandatory for STB size receiver and IDTV with screen-size bigger than 30 cm diagonal, optional two CI slots. Optional for small receivers such as USB-sticks or plug-in PC cards. Not required if CI+ implemented.

9.2 CI+

Recommended one CI+ slot, optional two CI+ slots.

9.3 Analogue HDTV/SDTV component output

If Y Pb Pr outputs are available then the receiver shall support the DVB FTA_Content_Management_Descriptor information as specified in section 9.7.

9.4 HDCP on HDMI

Shall be controlled by the DVB FTA_Content_Management_Descriptor information as specified in section 9.7.

9.5 HDCP switchable (via menu in STB)

It shall be possible to enable and disable HDCP for content with no usage restrictions through a user set-up menu. See section 9.7.

9.6 USB, LAN access to audio/video data

Shall be controlled by the DVB FTA_Content_Management_Descriptor information as specified in section 9.7.

9.7 FTA content management according to signalling by FTA content management descriptor

For SDTV broadcasts no restrictions shall apply.

Note: This section follows the principles of ETSI EN 300 468 V1.10.1; however further definitions are made for the management of HD content.

The FTA content management descriptor provides a means of defining the content management policy for an item of content delivered as part of a free-to-air (FTA) DVB Service.

9.7.1 Semantics for the FTA content management descriptor

The content management descriptor is defined in EN 300 468 V1.10.1 Section 6.2.18.

9.7.2 Fundamental requirements for HD content management

The interpretation on how to apply the functionalities of the content management descriptor is currently under discussion. This document will be updated in due time.

10 System Software Update

DVB-SSU Simple profile mandatory (enhanced profile is strongly recommended). Default settings for automatic SW update: active in both stand-by and operate mode. The receiver should support data rates from at least 10 kbit/s*. User shall be able to disable/shift/cancel. The receiver should allow for an alternative software update (e.g. via USB).

**Note: This data rate is used in the French markets; however users should be aware that this low data rate will require longer down-load times. Consequently higher date rates should be applied in broadcasting and should be supported by the receivers.*

Informative note: typical data rates are in the area of 50 kbit/s to 150 kbit/s.

11 API

The receiver should be able to support the different API (e.g. MHP, MHEG, CE-HTML, etc.) from their hardware structure in markets where these services are available. See also appendix A.

12 RF & Channel

12.1 DVB-S

Tuner/demodulator characteristics in accordance with ETSI EN 300 421 v1.1.2. The receiver shall support symbol rates on the incoming carrier in the range 7.5 Mbaud to 30 Mbaud. The receiver shall accept input signals with a level in the range -25 to -60 dBm.

12.2 DVB-S2

RF/IF characteristics as in ETSI EN 302 307 v1.1.2.

12.3 DVB-C

Tuner/demodulator characteristics in accordance with ETSI EN 300 429 1.2.1. RF frequency range from 110 – 862 MHz. National demands may require an extended frequency range.

Receiver performance: Return loss > 7 dB, Noise figure < 10 dB.

The bit error rate before Reed Solomon decoding is used as the quality criterion. The receiver shall have a BER performance better than- 10-4 for the C/N ratios specified below for all specified input levels:

QAM: C/N:

256 - 32.5 dB

128 - 29.5 dB

64 - 26.5 dB

16 - 20.5 dB

12.4 DVB-T

Tuner/demodulator characteristics in accordance with EN 300 744 v1.6.1. Receiver performance as in ETSI EN 62216-1 - E-book 2008 update. DVB-T additions are referenced in the relevant E-book sections.

12.4.1 VHF/UHF S Band, 230 – 470 MHz.

Optional. (ref. E-Book 12.2)

12.4.2 C/N performance

The values given in EN 300 744 v1.6.1, (Annex A1, Table 1; reproduced here for convenience) should perform in the same way or better.

Table 2: Required C/N for non-hierarchical transmission to achieve a BER = 2x10-4 after the Viterbi decoder C/N performance (dB)

Modulation Code rate Gaussian channel Ricean channel

QPSK ½ 3.5 4.1

QPSK 2/3 5.3 6.1

QPSK ¾ 6.3 7.2

QPSK 5/6 7.3 8.5

QPSK 7/8 7.9 9.2

16-QAM ½ 9.3 9.8

16-QAM 2/3 11.4 12.1

16-QAM ¾ 12.6 13.4

16-QAM 5/6 13.8 14.8

16-QAM 7/8 14.4 15.7

64-QAM ½ 13.8 14.3

64-QAM 2/3 16.7 17.3

64-QAM 3/4 18.2 18.9

64-QAM 5/6 19.4 20.4

64-QAM 7/8 20.2 21.3

12.4.3 Noise Figure

Better than 7 dB. (ref E-Book 12.7.3).

12.5 DVB-T2

Work in progress (16/12/2008). Tuner/demodulator characteristics in accordance with ETSI EN 302 755 1.1.1.

13 Connectors and Interfacing

13.1 DVB-T and DVB-T2

IEC 60169-2, 75 Ohm antenna socket.

Mandatory: inline power supply for antenna, DC 5V, 30mA (these are recommended values).

13.2 DVB-C

IEC 60169-2, 75 Ohm antenna socket.

13.3 DVB-S/S2

IEC 60169-24, 75 Ohm antenna socket.

13.4 Connectors for iDTV

Mandatory: S/PDIF (either optical or electrical), HDMI input, Common Interface.

Recommended: Ethernet port.

Optional: headphone audio output (i.e. audio description), SCART input (RGB/CVBS), SCART output.

13.5 Connectors for STB

Mandatory: S/PDIF (either optical or electrical), HDMI output, Common Interface, SCART output (RGB/CVBS), SCART input-output for VCR and loop-through to the SCART output.

Recommended: Ethernet port.

Optional: Y Pb Pr, RF loop-through for DVB-C, DVB-T and DVB-T2, headphone audio output (i.e. audio description).

13.6 Remote control

A remote control is mandatory.

13.7 HDMI

13.7.1 Video

Receivers shall provide an output of signals in YCbCr 4:2:2 format and the coding range as specified in ITU-R BT.601 (SDTV) and ITU-R BT.709-5 (HDTV) with a resolution of at least 8 bit. The appropriate colour space needs to be signalled to the display. The HDMI AVI Info frame (CEA-861-D Table 7) shall be supported.

13.7.2 Audio

The receiver shall support multichannel PCM and bitstream outputs over HDMI.

13.8 HDMI control data

CEC shall support, as a minimum, system audio, stand-by, and one-touch play.

13.9 USB connector

Optional. It shall follow the FTA-descriptor specified in this document.

13.10 Removable Media (USB-Connector)

Optional (It shall follow the DVB_FTA_descriptor as specified in this document).

13.11 LAN-Access (Fast Ethernet, Wireless LAN or Powerline)

Access to a private local area network is optional. An integrated wired or wireless IP-based Interface shall be compliant to Fast Ethernet (IEEE 802.3u) and/or WLAN (802.11g and better). Wirelesses interface support should be WiFi certified. A Powerline interface should support HomePlug-AV including band-stop filtering to minimize RF-interference with radio-services and wireless transmitters in the home.

13.12 Home Networking

Access to Home Networking is optional. The following describes the receiver behaviour when Home Networking is supported:

For the integration in a Home Network (HN), the receiver shall support home networking compliant to DLNA Guidelines 1.5 or higher using UPnP-AV, exposing recorded and live content to the HN as a Digital Media Server (DLNA-DMS) (*).

The receiver shall be able of carrying on the IP interface at least one broadcast service (live or prerecorded) in real time in the original encoding format and resolution. The IP interface should be able to accommodate traffic from the access network as well from the HN at the same time.

The receiver should expose the programme/service guide received on the delivery network on the HN including the option of scheduling recordings by the user (**).

The receiver should provide a Digital Media Player (DLNA-DMP) for the selection, control and rendering of live and stored content from a Digital Media Server (DMS). The Renderer (DLNA-DMR) is part of the Digital Media Player (DLNA-DMP) and should be able to be discovered and controlled by other UPnP Control points in the HN.

Any Digital Rights Management (DRM) and/or Conditional Access (CA) that are integrated in the receiver should support exposing both secure and non-secure content to the HN by following the rules of DVB-CPCM including the DVB FTA_Content_Management Descriptor.

(*) If DLNA Media Profiles are other than those used in the access network, transcoding may not be required.

(**) The exposure on the HN of the programme/service guide should be in accordance with UPnP and/or HTML.

14 Usability

In general it is recommended that internationally agreed icon labelling be applied, instead of textual descriptions.

14.1 Stand-by mode

Mandatory.

14.2 Power Consumption in stand-by mode.

See EU regulations on power consumption.

14.2 Power Switch-Off

It is recommended that STB and IDTV have a physical power-switch.

14.3 Channel change time

Not significantly more than RAP period.

14.4 HDCP control by user

Mandatory. See 9.5.

14.5 Component descriptor display

Mandatory for subtitles and audio descriptions, and audio channels (i.e. different languages). Display of image format changes should be manually selectable.

14.6 Means of selecting an alternate language

Mandatory - see above.

14.7 User controls

The standby, channel, menu, volume and arrow-keys buttons on the device shall be easily accessible to the user.

14.8 Remote control

Buttons should have consistent labelling, using internationally agreed icons wherever possible.

14.8.1 Remote Control Buttons

The following table lists the major functions and buttons preferred on the remote control.

Table 3: Remote Control Button Functions Button function Requirement Comments

Aspect ratio adjustment Optional, for use with SD

Audio description on/off Mandatory, Including sound indicator.

Easily to be identified (i.e. finger sensitive) or on the corner position.

Audio mute Mandatory With icon.

Audio volume up/down Mandatory. May also control the volume of other equipment when configured appropriately.

Back (menu navigation) Mandatory.

Channel up/down Mandatory.

Cursor (menu navigation) Mandatory. up/down/left/right

Exit to video Mandatory.

Guide Mandatory.

Help Recommended

Info Mandatory.

Menu Mandatory.

Numeric, 0 - 9 Mandatory.

OK Mandatory. In centre of cursor keys

On/Stand-by Mandatory.

Picture-in-picture Optional.

Radio/TV select Mandatory.

Subtitling on/off Mandatory, Should cover all channels over channel changing.

Text applications colour keys Mandatory.

Text/TV Mandatory.

Video format Optional, Recommended.

It would be preferable to mechanically protect the less frequently needed remote control buttons by some sort of flap or cover, or alternatively to access their functions in the graphic menu structure.

14.8.2 Audible feedback for buttons on the remote control

It is recommended that the receiver should generate audible tones to provide feedback that a remote control button press has been acknowledged. The user should be able to turn these tones on or off, as desired, in the receiver.

14.9 Display functionalities

14.9.1 Alphanumeric

Optional but recommended for radio services.

14.9.2 Event Name

Optional but recommended.

Appendix A (informative): Signalling for CE-HTML

A.1. Signalling and Application lifecycle

Interactive services related to one or more services are signalled in a DVB-AIT which is carried in the same MPEG-2 TS as the corresponding service(s). HTML-applications shall be started and stopped according to DVB-AIT signalling. Basic lifecycle rules:

- Signalling of applications on broadcasting services is done via broadcast DVB-AIT or SD&S.
- Only those applications signalled in the AIT are allowed to run in the context of the corresponding service (embedding of video, …)
- When an application tunes to a service and is included in its AIT then the tuning is performed and the application remains active. If the new service signals an autostart application then this application is not started.
- When an application tunes to a service and is not included in its AIT then the tuning is performed and the application is killed. If the new service signals an autostart application then this application is started.
- When an application running on a service starts another application which is not signalled in the AIT of this service then the application is started but the service context has to be cancelled (logical tuning to a "null" or "default service"). The new application can then via tuning put itself into a new service context (if not signalled on the new service it will be killed).

A.2. Transport protocols for HTML applications

Interactive services related to one or more services are signalled in a DVB-AIT, which is carried in the same MPEG-2 TS as the corresponding service(s). Standard DVB-AIT signalling is used for transmitting the related URLs via the broadcast channel.

A.2.1 Bidirectional IP connection

For bidirectional IP communication channels standard http and https protocols are used to carry applications.

A.2.2 DSM-CC via Broadcast channel

DSM-CC implementation is required.

Note: IPTV networks will not use the DSM-CC carousel mechanism within the MPEG-2 TS for the transport of any application or data. Only http requests on web servers via the IP interaction channel will be used to load data. The only exception is the carriage of DSM-CC stream events, which will be used for transmitting time critical information via the MPEG-2 TS.

A.3. HTML profile

The HTML profile used by the services is based Open IPTV Forum Declarative Application Environment (DAE) specification based on the CE-HTML standard (ANSI/CEA-2014.A) plus the additions defined by the Open IPTV Forum. The minimum requirements for the browser are given by a compliance list that is still under discussion and will be published later. Scalable Vector Graphics will not be used for the time being.

Annex 5

Matters Related to Consumers' Digital TV Receivers

Annex 5 - Part A
Maximizing the Quality of SDTV in the Flat-Panel Environment

5.A.1 The changing environment

With television screen sizes becoming progressively larger in the home, defects in the transmitted picture quality are becoming more and more noticeable - and also more annoying - for the viewer. Display technology is changing from the CRT to LCD or PDP flat-panel displays. These types of displays - particularly PDP - mask the picture impairments to a lesser extent than CRTs and thus, compared to CRT displays, are apparent "magnifiers" of the impairments. Television is moving to an age where high picture quality is becoming more important.

Many ITU Members have broadcast in PAL or SECAM for the last 40 years; in recent years, digital broadcasts have used the MPEG-2 video compression system. The picture quality delivered in an MPEG-2 channel depends on many factors but a limiting factor is the channel data rate. Most European broadcasters for example use bitrates of 2.5 - 5.0 Mbit/s. But, for a number of reasons, there are circumstances where the programme's inherent picture quality cannot be delivered satisfactorily to viewers using flat-panel displays.

Broadcasters need to review the ways in which they make and deliver television programmes in the light of these new large home displays - indeed, at some stage sooner rather than later, broadcasters will need to improve the picture quality that is delivered to viewers using flat-panel displays.

This Chapter, based on EBU Technical Information I39-2004 [3], describes the steps that broadcasters should take to improve picture quality in the standard-definition TV (SDTV) environment. Of course, in responding to the new age of large displays, some broadcasters may decide to introduce high-definition TV (HDTV) services. This scenario indeed is most far-sighted. However, it is not the subject of this Chapter. The issues associated with a change to HD delivery will be considered later in this Report.

Studies conducted within the EBU have suggested that, in an MPEG-2 SDTV channel (with available encoders and decoders), the more critical kinds of scene content must be delivered at a data ate of 8 - 10 Mbit/s if they are to be reproduced with good "conventional" quality on largescreen flat panels. It is to be noted that in the case of HDTV, a data rate of 15 - 22 Mbit/s is required for good quality TV using MPEG-2 compression – depending on the scanning format used and the acceptable level of degradation relative to the uncompressed HD picture quality. This is a rule of thumb for ensuring high quality for all types of content produced for digital delivery in the flat-panel age, even though such high data rates will not be required for some types of picture content found in average programmes.

If data rates adequately higher than those used today are possible for SDTV broadcasting, a major part of the potential limitation on flat-panel quality is removed. This is the step that will have most effect on critical content impairments. But whether the data rates can be raised or not, there are other steps that can be taken to make the best of the prevailing situation. There are "good practice" steps that are worth taking, whatever the available data rate limit. It is these steps that are the subject of this Annex. In time, practical experience will be gained by Members on which data rates and measures are needed to optimize picture quality on flat-panel home displays, which can then be shared with others. In the meantime, broadcasters should evaluate the extent to which they can adopt the measures suggested in this article. Furthermore, they should consider setting organization-wide picture-quality targets for digital television. Having such a benchmark will make it possible for broadcasters to evaluate the costs of making the necessary improvements, and allow them to plan the appropriate measures needed to achieve these improvements.

5.A.2 Recommendations for best practice:

1) Thorough research on relative performance should be done before buying MPEG encoders. It will be a good investment. The state of the art needs to be reviewed frequently.

2) If the service is a ***green field*** with no legacy MPEG-2 receivers to serve, consider, as most Broadcasters do, using codecs more modern one like MPEG-4/AVC instead of MPEG-2. Make buying the encoder the last thing you do before the service starts.

3) Check if the picture quality limits, due to the delivery mechanism, match the quality limits possible in programme production. If the delivery mechanism is a significant constraint on quality transparency across the chain, programme makers may be wasting their investments in programme production. Broadcasters' public service mission calls for technical quality, which does justice to the high programme quality.

4) Take great care in the broadcasting chain to ensure end-to-end high-quality 4:2:2 signals, and never allow the signal to be PAL or SECAM coded.

5) If possible, preserve 10 rather than 8 bit/sample values for the components in the 4:2:2 signals flowing through the programme production and broadcasting chain.

6) Explain to production staff what kind of production grammar (shot composition, framing and style) will lead to poor quality on large flat panels. Encourage and train them to avoid high entropy unless you can use higher broadcast data rates.

7) Encourage flat-panel receiver manufacturers to develop high-quality standards conversion and scaling electronics, and advise the viewing public about which are the best flat-panel receiver types.

8) For mainstream television programme production in compressed form, use no less than 50 Mbit/s component signals.

9) Do not trans-code between different analogue or digital compression schemes, and use signal exchange technologies such as SDTI and File Transfer which handle compressed signals in their native form.

10) If noise reduction is required it should be introduced before encoding. However, noise reducers should be used with caution after a careful consideration of the options here-after.

11) Set clear organizational broadcast quality goals, and use the professional skills of your staff to keep to them.

5.A.3 Options for optimizing SDTV picture quality in a flat-panel environment

5.A.3.1 The way compression systems work

Before outlining the measures in more detail, it is useful to review the way that digital compression systems work. While yesterday's analogue compression system –"interlacing" - applied itself in exactly the same way to *any kind* of scene content, digital compression systems *adapt themselves* to the scene content. This makes them much more efficient, but also it makes describing the way they perform more complex, and identifying ways to optimize the quality is more complex as well. Nevertheless, worthwhile good-practice elements can be identified if care is taken.

The key element of picture content that affects the way compression systems perform is the degree of detail and movement in the scene (sometimes called ***entropy***). It is mainly this that determines how taxing the scene is for the compression system. Scenes with less detail and movement are "easier" to compress, in the sense that the input is more closely reproduced at the output, but the reverse is true for scenes with a lot of detail and movement - particularly over the whole picture, rather than in just parts of it. The point where "easy to compress" become "difficult to compress" is determined by the delivery data rate (bitrate) limit. When the scene is difficult to compress, the compression system introduces impairments of its own ("artefacts") in the picture.

Programme-makers need to understand the different types of scene content and they way they behave in compression systems.

The most difficult or taxing scenes to compress are those containing high detail and movement over the whole scene. The most taxing or "stressful" type of content is usually material shot originally with video cameras, showing scenes which have an elaborate "canvas". This usually means sports events or light entertainment. These are the kinds of programme that will look worse on the new large displays, because the compressionprocess will introduce its own impairments into the picture - unless the data rate is high enough.

The easiest or least taxing scenes to compress are usually, but not always, cartoons or those shot on celluloid film at 24 pictures per second. This usually means fiction/drama or documentary material. Movie material will usually look "good" on large displays at low bitrates, because the compression process is least likely to introduce artefacts of its own - though film grain can make compression more difficult if it is present, as explained later. The higher the field or frame rate, the higher the entropy. For the same camera shot, 50 Hz interlaced television scenes are easier to compress than 60 Hz interlaced scenes.

Unfortunately "noise" or "grain" in a picture, which may be unintended and unwanted, can also be interpreted as entropy by an encoder, and can thus "stress" the encoder and lead to impairments. The encoder has no way of knowing whether detail is desirable or undesirable, so noise or grain contribute to the overall entropy of the picture. Noisy pictures whose wanted content is "noise-like" may be masked by unwanted picture noise, causing impairments in desirable parts of the picture. ***"Clean" pictures always win twice - they are better to look at, and they are easier to compress.***

Apart from noise itself, creating a PAL or SECAM analogue picture leaves a certain technical "footprint" on the picture. This footprint can pass unnoticed when a viewer first sees the picture, but it can also be interpreted by the digital compression system as more entropy. For PAL, the footprint takes the form of fringes around objects. Thus, PAL pictures can be "stressful" for compression systems. Note also that analogue PAL broadcasts can look poor on flat-panel displays.

5.A.3.2 The need for "headroom"

It is inevitable that television signals will have to go through a number of processes before they reach the viewer in his/her home. Thus, when deciding on the *adequacy* of a set of technical parameters for a television signal, it is important to remember that the full desired picture quality must be available *at the end* of the broadcast chain (and not just at an earlier point). For system-wide adequacy, a safety factor (i.e. ***headroom***) should therefore be added at other points in the chain - to allow the signals to undergo further processing while still "protecting" the chosen parameter values.

The precautions mentioned below should ensure that the picture quality is protected during the many stages of processing that the signals may have to endure, before reaching the viewer's large flat-panel display.

5.A.3.3 The role of sound

The perceived quality of a television programme is influenced by the presence or absence of sound, and by the sound quality itself. The presence of sound appears to have a distracting effect on viewers' perception of the picture quality. So, if broadcasters take care with the sound then, within the limits of home equipment, this should positively help with the image perception too.

5.A.4 Quality and Impairment factors

Picture quality is considered to be made up of a range of ***quality factors*** which affect perception of the quality. These are elements such as "colorimetry", "motion portrayal" (picture rate and scanning format), contrast range, and others. It is the combination of these various elements which defines the perceived picture quality.

In addition, for convenience, there is a range of ***impairment factors*** which also can contribute to picture quality. They are similar to quality factors, but the term is used for impairments added by compression systems or coding. They include elements such as "quantization Noise", "static or dynamic Ringing" (mosquito noise), "temporal Flicker" and "blockiness". Sometimes non-technical analogies are used to describe these elements - for example, the "heat haze" and the "ice cube" effects. These impairments mostly arise when the bitrate is too low for the degree of detail and movement contained in the scene.

Quality factors include those which increase the potential entropy - definition and motion portrayal. At the same time, these very same elements can induce impairment factors to "kick in", because the compression system becomes over-stressed. The process of optimizing the end-to-end broadcast chain is often a case of finding the best balance between these two contrasting factors.

5.A.5 The Broadcasters' objectives

Broadcasters will always want to deliver their material at the lowest possible bitrates they can successfully use. Channel data rate is a precious resource which can be used to provide more multimedia services or more programme channels within a multiplex. However, broadcasters must develop an end-to-end strategy which uses the lowest bitrate that is consistent with acceptable picture quality, or with other constraints.

To optimize the broadcast chain in a 576/50 (conventional quality) transmission environment, broadcasters need to do two things:

a) they must deliver (to the final MPEG-2/MPEG-4 encoder) pictures which have the *minimum entropy* possible, taking into account the programme-maker's intention and the impact the pictures will have.

b) they must use MPEG-2/MPEG-4 encoding arrangements that will result in a *minimum of coding artefacts* being introduced into critical high-entropy content.

Suggestions for a) are considered in the Section immediately below, titled "*Production and contribution arrangements to maximize quality"*. Suggestions for b) are considered in a later Section titled "*Delivery channel arrangements to maximize quality*".

A further Section below, "*Receiver arrangements to maximize quality*", looks at ways in which the receiver manufacturers can improve the perceived picture quality, by designing certain features into the receiver.

While these points can be discussed separately for convenience, always remember that the broadcast chain *as a whole* needs to be considered. The measures taken in production and delivery need to be proportional. ***There is no reason to take special care in production - if poor arrangements are used for encoding, and vice versa.***

5.A.6 Production and contribution arrangements to maximize quality

5.A.6.1 Quality is more than technical parameter values alone

The perceived technical quality of a television picture is not based purely on the technical fidelity of the picture, and the lack of impairments in it. Our impression of picture quality is also determined by our interest in the scene. This means that picture quality is influenced by the professional skills of the cameraman and editor in shot-framing and scene composition.

The "quality factors" of the scene (as described earlier) are also influenced by the professional skills of the cameraman and editor. They are responsible for elements such as colour balance, colorimetry, lighting and the effects of contrast and noise. Control and care not only reflect on the impact of the pictures ... but also upon the entropy of the pictures.

5.A.6.2 Capture

Production staff need to keep in mind the final delivered picture quality. There are two main areas to consider here. The first is the impact that shot composition, framing and style (sometimes called "production grammar"), as well as lighting and camera settings may have on the picture entropy. The second is the influence that production techniques may have on noise or grain levels in the picture.

Production "grammar" influences, among other things, how much visible detail and movement there is in the picture. Camera pans and zooms over *detailed* areas should be avoided if possible, obviously depending on the context of the production. Camera tracking is (for our technical purposes) better than panning. Shooting with lens settings that lead to short depths of field . i.e. with low detail in the background and, hence, lower entropy - may reduce the encoding artefacts in the received pictures.

Production lighting, camera settings and types of equipment can influence the noise level in the picture. Low lighting with high gain settings should be avoided. Although it may not be noticeable to the naked eye, the signal-to-noise ratio is degraded - there is less "headroom" in the signal.

To improve picture sharpness, the camera processing introduces "aperture correction" and/or "contour/detail" correction which amounts to boosting the high frequency end of the spectrum. By improving picture sharpness, it also makes the signal- to-noise ratio worse. In addition, the ´thickness" of the "contours" is magnified and hence is more unnatural when viewed on a large flat-panel display, at a shorter viewing distance in the home. Aperture/contouring correction should be used with caution in any camera. In low-cost cameras (i.e. DV camcorders), the correction circuits are often not as well designed as they could be (to lower costs), and their use should be avoided. In these cases it is better to apply any indispensable "peaking/sharpening" tweaks using subsequent high-quality processing equipment.

Since aperture and detail correction also corrects for (a lack of) "lens sharpness", the best possible lenses should be used to minimize the need for these corrections.

5.A.6.3 Processing

Pure production with no compression, in accordance with ITU-R Rec. BT.601-6, will produce the best quality for delivering to the encoder. However, this may well be impractical.

Nevertheless, 4:2:2 sampling structures should be used throughout the production process.

The use of helper signals such as "MOLE" [4] - which carry information on the first application of compression "coding decisions" along the production chain - could in principle be useful for maintaining quality in production. In practice, we have not been able to identify any organization which has been able to successfully apply them. These technologies are arguably most useful when very high levels of compression are used, rather than the low levels usually used for production. Furthermore, it is difficult to pass the MOLE signal entirely error-free through the production process.

In the production chain, multiple decoding and recoding of compressed signals must be avoided. Compressed video should be carried throughout production in its "native" compressed form (i.e. as it first emerged from the camcorder).

For real-time transfer via the existing SDI infrastructure, the Serial Data Transport Interface (SDTI.SMPTE standard 305) should be used.

For file transfer, the MXF file format should be used as it provides standardized methods of mapping native compressed (and uncompressed) Video and Audio .essence. (e.g. DV/DV-based, MPEG-2 Long GoP, D10 etc).

Compression in mainstream television production to not less than 50 Mbit/s, as explained in EBU Technical Text D84-1999 [5], should be used.

When higher compression rates and low data rates are necessary for high-content-value news contributions, a long GoP should be used. Compression systems like MPEG-4, that are more efficient than MPEG-2 for news feeds should be considered.

If multiple cascaded (concatenated) codecs cannot be avoided in the overall chain, then at least similar encoding and decoding devices should be used to minimize the quality loss.

For file transfer of programme material in non-real time, the original or native compression system should be used at 50 Mbit/s or higher, I-frame only.

Broadcasters are converting to file/server-based systems and, although ever larger storage is possible, these do not have infinite data capacity and some form of compression will still be needed. The bitrate of the compressed signal should not be below 50 Mbit/s. Do not use editing/storage equipment that has its own internal compression scheme that is different from the "native" one used in the capture camcorder.

It may be absolutely necessary to use noise reduction. If so, this should be performed before the first compression process. Noise reduction should not be introduced in the middle of a series of concatenated compression systems.

5.A.6.4 HD production for conventional-quality television

HD production which is down-converted to 576/50/i gives very good quality, particularly if the HD is progressively scanned (e.g. 720p/1080p), but also if the HD is interlaced (e.g. 1080i). This is a very effective future-proof way of preparing high-quality 576/50/i material. There are additional benefits because the material can be archived at HD resolution and used in future years when there are HD broadcast services. Material captured using cameras operating on an interlaced standard includes spatio-temporal aliasing virtually "burnt in" to the picture. If 1080i material is down-converted to 576i, much of the burnt-in alias is lost and, consequently, the signal is cleaner and easier to compress in the 576i signal domain. If the production is 720p/1080/p originated, the alias is absent, so the 576i signal produced can be even cleaner than that sourced from 1080i.

Broadcasters who make HD productions are advised to produce the material in the same format as the production format. Although it might not be practical to archive a 720p/1080p or 1080i signal in base-band uncompressed form, a compressed data rate at 720p/1080p or 1080i should be chosen that will still provide sufficient quality headroom for future repurposing and post productions. Further studies on this subject are required.

5.A.6.5 Wide aspect ratio

The use of aspect ratio should ideally be controlled in such a way that the best quality result is obtained, although the scope for using different aspect ratios will depend on the organization's broadcast policy. However, whatever arrangements are used for shoot and protect areas, 16:9 productions should be shot in the 16:9 production format ("anamorphic 16:9") and not as a letter-box inside the 4:3 production format.

Semi-professional (consumer, or even "prosumer") cameras normally provide only 4:3 aspect ratio sensors but some of them utilize in-built signal manipulation to give the 16:9 aspect ratio. Experience has shown that these internal camera manipulations should not be used. If needed for wider aspect ratios in post-production, a high-quality professional converter should be used to extract the area of interest.

5.A.6.6 PAL/SECAM signals

Do not use video signals that have been analogue composite-coded at some point. The quality headroom is already lost, and nothing can be done to retrieve it. Furthermore, PAL coding adds unwanted artefacts to the picture (sub-carrier fringing effects, and luminance/chrominance cross effects) which can consume compressed data rate because they are interpreted as valuable picture entropy.

5.A.6.7 Primary distribution

The input to primary distribution should use MPEG-2/MPEG-4 MP@ML encoding for transmission. It is important that encoders of a very high quality perform this encoding process, and that the highest possible data rate is used. Statistical multiplexing should be used if more than two programmes are being distributed in the same stream.

5.A.6.8 The final quality check

Production or technical staff should always check on a large-screen display during production, a version of their programme which is compressed to the level used for broadcasting. This is the only way to be sure about the picture quality. This care will pay off in the long term. This check is probably not needed if broadcast data rates of 8 - 10 Mbit/s are being used for broadcasting.

5.A.7 Delivery channel arrangements to maximize quality

5.A.7.1 Choosing an MPEG encoder

The MPEG compression family is arranged specifically to allow encoders to evolve and improve. Only the form of the MPEG-2/MPEG-4 decoder signal is specified, and as long as the signal received conforms to that, the encoder can be as simple or sophisticated as it needs. The system is also intended to be "asymmetric" in the sense that the decoder system is simple, and complexity is loaded into the encoder.

There are a range of technologies available for pre-processing and post-processing in MPEG-2/MPEG-4 encoders. Pre-processing algorithms essentially filter the image before or during compression. This improves the performance by simplifying the image content. Post-processing algorithms identify and attenuate artifacts that were introduced into the encoder.

Noise and other high entropy elements "stress" the encoder and generate impairments, but over-application of pre-processing, denoising and filtering will blur the picture. The best quality will be obtained by finding the optimum balance between them.

More effective pre-processors and noise reducers are obtained by “loop filters” and de-blocking processors within the encoder and the decoder. Indeed these techniques are included in more recent codecs such as ITU-T Rec. H-264 (MPEG-4).

However, they are not included in the MPEG-2 system which is used today for digital broadcasting at conventional quality. Noise reducers and pre-processors can be used in MPEG-2 systems before the encoder. They can be separate from the encoder or controlled by it. In the first case, the user can adjust the weight of the pre-processor and noise reducer to obtain the best picture quality during the set-up stage, even changing them scene by scene.

This cannot usually be done “live” in real time. In the second case, the encoder selects the weight of the preprocessor and noise reducer by measures such as “buffer fullness” (which is related to entropy). The second approach could be more effective than the first because changes can automatically be made at small time intervals, but this may cause resolution pumping as an unwanted side effect.

Nowadays the performance of MPEG-2/MPEG-4 commercial encoders has improved dramatically and this trend is ongoing. Thus, the MPEG-2/MPEG-4 encoder should be the last item of equipment to buy when starting digital broadcasting. The very latest models should be used, and the encoder should be periodically replaced to take advantage of recent improved performance and should be considered as “expendable” investment in the broadcast chain.

The performance of MPEG-2/MPEG-4 encoders also varies significantly from manufacturer to manufacturer. Variations in the performance of equipment available at any given time can be as much as 30%. Users should evaluate all available encoders, either with their own tests or based on reports of the experience of others. As a rule of thumb, the same type of MPEG-2/MPEG-4 encoder used across the broadcast chain provides better overall quality than a mixture of types. It is worth noting that ”two-pass” MPEG-2 encoders offer higher encoding efficiency than “single-pass” encoders, but they suffer higher encoding delay. They can be up to 20% more quality efficient than single-pass encoders, and should be used where the delay is not important.

Statistical multiplexing increases effective encoding performance. The gain is higher in multiplexes of many programmes, but it is still useful in multiplexes of only three or four programme channels. The unchecked application of statistical multiplexing can lead to impairments when particular combinations of content entropies occur. To reduce the effects on premium content, different priority levels can be applied to different programme channels. In this case, a request for data rate from a high-priority channel will be satisfied before requests from low-priority channels.

5.A.7.2 Using new compression systems

If a “green field” service is to be launched, then one of the new more efficient compression systems should be chosen like ***MPEG-4 Part 10*** (also known as ITU-T Rec. H.264 and MPEG-4/AVC) as significantly more quality-efficient than MPEG-2 at conventional quality levels. Tests made by the RAI in Italy suggest that savings of 50% could be made at conventional (SDTV) quality, even with the early implementations of MPEG-4 Part10. Increasing number of broadcasters wish to use the new algorithms, and indeed they encourage more manufacturers to make receivers/set top boxes using them. As a rule of the thumb the European countries without the legacy problemme of early MPEG-2 adoption have decided to choose the MPEG-4 as future proof choice.

It is to be noted that the license costs of using this system needs to be checked by potential users.

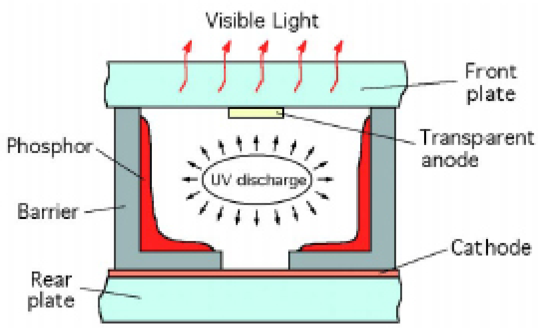
5.A.8 Receiver arrangements to maximize quality

5.A.8.1 Flat-panel technologies

Plasma Display Panel (PDP)

The advantage of the PDP was to have been ease and cheapness of manufacture, as compared to LCD, since it could take advantage of printing, rather than photo-lithography, in its production processes. It has not turned out this simple though, and the benefits of scale are now being felt in new LCD plants which could turn the panel-cost balance on its head.

The PDP manufacturers have invested a lot of money in their factories, and not surprisingly are still confident, in public at least, that there is a good market for their products. Due to high panel costs, these displays initially found a niche as public data displays in airports and railway stations, but have been found to suffer from a lack of brightness when viewed in natural light. Often, when displaying basically static or repetitive information, they exhibit image-sticking and phosphor burn-in.



The heart of a plasma display panel (PDP) is the discharge cell. Sandwiched between two sheets of glass, constrained by barriers, the cell has an anode and cathode. A plasma discharge in the low-pressure helium/xenon gas mixture in the cell generates ultra-violet radiation, converted to red, green or blue visible light by a conventional phosphor. The PDP is therefore self-emissive, but the form of construction leads to a relatively heavy and fragile panel.

A major problem for PDPs has been motion portrayal, with colour fringing becoming visible due to the pulsewidth-modulated greyscale. There is also a difficult trade-off to be made between panel lifetime, and the settings for brightness and contrast. High brightness reduces lifetime but makes the display attractive at the point of sale. Improved contrast can also only be achieved at the cost of reducing the brightness.

The historic advantage of PDPs over LCDs was the ease of making a large panel. Higher resolution was harder but now full HD 1080 i/p resolution large screens PDPs are widely available for sale at affordable prices. Recently PDPs offer1080-line resolution at most sizes an same production facility can make number of panels simultaneously from a single sheet of glass, thus cutting the costs.

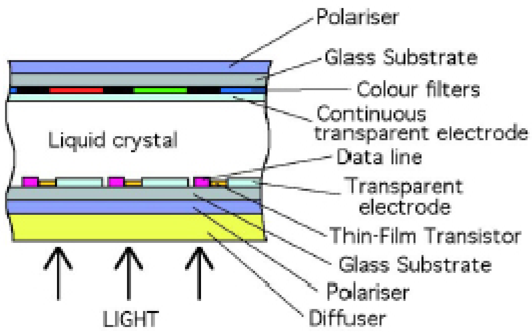
The typical contrast ratio claimed was around 8000:1 accompanied by very good colorimetry with life expectancy around 20000 hours. Very latest models on the market are with 1000000:1 dynamic contrast ratio. Power consumption varies between 350 W and 500 W for 107 cm PDP.

Innovative plasma display technologies enhance further image quality (more colors and gradations), and bring greater energy savings, thinner dimensions, larger screens, new materials and processing technologies, new discharge gas and cell design technologies and double the luminance efficiency with lifetime expanded around 100000 hours. Recently developed 100 Hz, 200Hz, or even better 600 Hz motion portrayal panels are great for good film motion and sports quality reception.

Nowadays plasma panel manufacturers are finding it hard to justify investment in current financial crisis (Pioneer who had already absorbed NEC and Fujitsu/Hitachi are pulling out of plasma panel manufacturing leaving Panasonic as the only Japanese plasma panel manufacturer). Nevertheless Panasonic has made an investment required to bring the next generation of Plasma displays on the market and the Neo PPDs have brought a substantial cut in power consumption with thinner and lighter panels, all increasingly important factors to counter the climate change.

Liquid Crystal Displays (LCD)

LCD technology has the inherent ability to more readily provide displays of higher resolution.



The TFT-LCD basically consists of a layer of liquid crystal sandwiched between polarizing sheets. When a voltage is applied across the electrodes, the polarisation of light passing through the panel is altered, and hence the transmission of the cell can be varied. A colour display is achieved by adding filters, so that a triplet of cells is used for each pixel of red, green and blue. It is, in direct view designs, a transmissive technology, requiring a back-light.

Many of the LCD TVs seen in shops are far from ideal in picture quality. Five years ago, LCD was not seen as a serious contender for the large-screen television market. This was not just due to the yield problems of making the larger sizes, but also due to motion blur caused by slow response speeds, poor colorimetry and viewing angles, as well as higher costs. However, these drawbacks are now being overcome.

Colorimetry improvements have proved relatively simple to implement.

LCD picture quality can now surpass PDP for the first time. Motion blur is greatly improved by a variety of proprietary techniques which aim to speed the transitions between grey levels by modifying drive voltages during the transition. LCDs with higher than 175° angles of view are common practice today. Cheaper LED backlights leading to wider color gamut, now a significant part of the cost of a large display, have been developed, while most common type before was Cold Cathode Fluorescent Lamp (CCFL).

LCD technology is dominating the flat-panel market in terms of volume, with prices falling rapidly following a vast ramp-up of production volumes in different parts of the world - huge resources have been invested into mass production resulting in 47 new fabs built only in the last 2 years before 2009. For example Sharp simultaneously make eight LCD panels at 57-inch size from a single substrate of 2.8mx3m. Towards this end Sharp has invested 3.2bn US$ and this investment has created the last Japanese LCD panel manufacturing facility operational since March 2009. In the future investment in new manufacturing LCD capacity will be through partnerships outside Japan.

LCDs now account for the vast majority of desktop PC screens. Larger screen sizes use up surplus production capacity. With the 42-inch market becoming increasingly competitive, manufacturers are introducing models in 46-47 inch range-to bridge the gap below 50 inches. The inexorable rise in average screen size appears set to continue, which really is the main driver for broadcasters to invest further in HDTV.

LCD may not be the ideal technology for television, but nowadays it is unstoppable. All display sizes and all resolutions can be made and drive circuits are easier than PDP. LCD's have long life around 40000 hours being limited by the backlight's endurance. Generally there is no "burn-in" effect. Contrast ratio in latest LCD TVs achieved is 80000:1, with luminosity around 550 cd/m2, no large area "flicker" and are of relatively light weight. Power consumption of LCD's is as a rule of the thumb one half of that of the PDP's (250 W for 107 cm screen size). However there are some remaining problems such as the natural S-curve transfer characteristic which even after correction results in "stretch of blacks" (causing increased visibility of "noise in blacks"' and of coding artefacts- sometimes dealt with by "clipping" the blacks) as well as the "blur" and "combing" during the de-interlacing, however most new display types are inherently "progressive". Motion portrayal is another remaining problem, but recently developed 100 Hz or even better 200 Hz panels are big things for good film motion and sports quality reception.

Organic Light Emitting Diodes (OLED)

Samsung has produced in the fall of 2008 a 102 cm size flat screen on Organic Light Emitting Diodes (OLED) new technology incorporated into HDTV receiving set with breath taking contrast ratio of 3000000:1. Recently during this year Samsung has made available for sale in the market 117 cm diagonal 40 % thiner and 40 % less power consumption HDTV LED receiver sets with 1000000:1 contrast ratio and motion portrayals of 100Hz and 200Hz. Furthermore Samsung has hinted for 50-inch version end of year 2009, but this company does not expect OLED to become a mainstream product for 4-5 years. Remaining problems of this promising more efficient technology are the display lifetime, the good blue emitter plus the uniformity and low panel production yields, leading to HDTV receiver's price for consumer around three times higher than the LCD type same size. It is estimated that the OLED technology will move up to larger display sizes and that it might have a noticeable impact on the TV industry within next 5-10 years and challenge LCD/PDP technology.

5.A.8.2 Energy Consumption and Environmental Aspects

The said unprecedented TV industry developments have led to production of 6.6 TV receivers with total of 2350 square inches of flat panel displays per second during the year 2008 leading to use of 74 million square inches of special TV-glass by the single manufacturer Philips alone. All this is supplemented by impressive quantity of electronics, enclosures and so on.

Consumer Electronics (CE) represent 16% of the household electricity bill, with TV receivers accounting for the biggest part (40 %). It is estimated that by year 2010 the CE products will be the single largest part of household electricity consumption. Therefore introducing energy efficiency improvements of household appliances will represent substantial cost-effective investments to reduce society's CO2 emissions originating from home electricity use. Estimates show that TV receivers will consume more than 30 Terra Watt Hours during 2030. Every effort will be made to optimize the energy consumption and appropriate regulations/specifications will be imposed leading to balancing the technological push with ecology requirements. It is worth noting that during the year 2007 the LCD TV was twice more energy efficient than CRT TV produced during the year 1999 for the same 32" size. Clearly, the Climate Change dilemma itself will enforce much stricter environmental friendly standards and key innovations in the broadcasting industry.

Obligations for both the Minimum Ecodesign Requirements on Power On/ Standby consumption of TV receivers and the Labeling of Energy Efficiency Class evolving every two years (from 1 to 10 based on Energy Efficiency Index) will be imposed by the European Commission to be applicable within European Union.

5.A.8.3 TV Screen size progress

The average CRT screen size before the demise of CRT was 28". The display manufacturers and broadcasters have conducted extensive surveys to establish the size of flat-screen displays that consumers are likely to purchase.

The advent of flat screen TV's is leading to larger screen sizes in households – most popular LCD size is already 32" and by the year 2010 the size is expected to move up to 42" diagonal. Predictions stipulate that the average TV screen size will be of 60"diagonal in the year 2015 – inclusive 1080 i/p. No doubt-consumer flat-panels are becoming a key driver for HDTV. Furthermore, professional HDTV screen needs will be met by piggybacking on the consumer market for panels as it was done for CRT's. The steady reduction of consumer prices for both PDP's and LCD's at narrow competitive range encourage the viewers – the biggest investor in the broadcasting chain – to acquire large flat screen TV's with expectations to enjoy attractive programmes delivered at home of real HDTV quality.

5.A.8.4 Display pre-processing

The pre-processing of video signals for display on these new panels is a major challenge. Traditional TV manufacturers have never needed to de-interlace interlaced broadcasts, as a CRT can display an interlace signal directly. Similarly, image scaling/resolution changes are accommodated by adjusting the scan size with a CRT. In the case of the new displays, with fixed rasters addressed sequentially, the TV manufacturers need to incorporate de-interlacing and scaling technologies. These technologies are well understood in the professional broadcast environment, but less so by the consumer electronics and PC industries.

There are several chipsets available that claim to do everything necessary. Experience suggests that many of the scaling chips are characterized by poor de-interlacing, and insufficient taps on their scaling filters. They have features to partially mask these shortcomings, but are used with inadequate additional memory. The best way of mapping a picture to such a display is to transmit the signal in a progressive format, pixel mapped to the display. This is one of the reasons for the suggestion in EBU Technical Texts I34/I35 [1][2] that progressive scanning should be used for new HD services. For legacy 576/50/i broadcasting, we were obliged to use interlace scanning, and do the best we can with it.

On a digital flat-panel, the overscan used systematically for CRT displays might be seen as redundant, since the edge of the picture is clearly defined. However, there may be a case for a few pixels overscan:

i) to allow easy scaling ratios,

ii) to mask archive programme content which was not made with a totally "clean aperture" (microphones in shot etc.), and

iii) to cope with unwanted incursions into frame during live programming today.

Another area where most currently-available panels are inadequate is in the presentation of film-mode material carried on an interlaced format (sometimes known as PSF - Progressive Segmented Frame). The pre-processing in nearly all current displays fails to treat film-mode material as such. Instead, it applies a de-interlacer to the signal, thus degrading a signal which, by the progressive nature of flat-panel devices, should in practice be easier to scale and display. ***The broadcast signal should flag "film mode", when appropriate.***

Presentation of pictures with coding artefacts would be improved by adaptive pre-processing that is able to distinguish between picture features and coding-block edges. Better interlace-to-progressive conversion, using two- or three-field spatio-temporal filtering, would also improve the picture quality of currently broadcast pictures.

To scale an image to a particular raster size, the scaling filters need to be carefully chosen to obtain the best final image quality. Therefore the scaling chips should include pre-selected filters, with an adequate number of taps, for the common conversion ratios that they are likely to encounter. A "one size fits all" filter design will not produce the best image quality when scaling from, for example, 720 to 768, if it is optimized for scaling from 1080 to 768.

5.A.8.5 Physical interfaces between equipment and display screen

Digital interfaces, such as DVI and HDMI, offer the possibility of making transparent the transfer of picture data to the display screen. Experience of panels with digital inputs suggests that this will enable the panel to display a clean signal (so much so that coding artefacts become more prominent). The mechanism for this is the lack of an optical output filter on the flat-panel display, compared to the Gaussian spread and hence filtering effect of the CRT spot. This could be mitigated by having many more pixels on the screen than in the source, and appropriate up-conversion filters. This would smooth block boundaries, as well as effectively providing extra bit depth in the display by means of spatial dithering, provided the processing were done to an adequate bit depth.

HDMI - the High-Definition Multimedia Interface [6] - specifies a means of conveying uncompressed digital video and multichannel audio. It can support data rates up to 5 Gbit/s, and video from standard definition, through the enhanced progressive formats to HDTV at 720p, 1080i and even 1080p at 60 Hz and lower, including 50 Hz. This is an appropriate interface for digital connections to flat-panel displays.

Included in the HDMI is HDCP (High-bandwidth Digital Content Protection) [7] to prevent piracy of the uncompressed digital signal. The system encrypts the signal before it leaves the "source" (e.g. the set-top box) and the "sink" (e.g. the display) then decrypts the signal to allow it to be watched. HDCP is a link encryption system. The first products incorporating HDMI interfaces are now available.

The DVI (Digital Visual Interface) [8] is the predecessor of HDMI. It is increasingly used on computers and display products, and uses very similar technology to HDMI, but lacks the audio capability. There is a measure of electrical compatibility between the two, enabling adaptors to be used between the different connectors. The connectivity will be lost if a DVI/HDMI-capable "source" with HDCP enabled does not sense an HDCP-enabled DVI/ HDMI "sink" at the other end. Hence most display manufacturers who are targeting Home Entertainment and Television systems now implement HDCP functionality to their DVI/HDMI interfaces to avoid complaints about picture quality of content.

The advantage of HDMI over DVI will be cable length. Usually limited to about 2m for DVI, 15m (and beyond) should be possible over HDMI.

5.A.9 References:

[1] EBU Technical Information I34-2002: **The potential impact of flat panel displays on broadcast delivery of television.** www.ebu.ch/en/technical/publications/ott/index.php

[2] EBU Technical Information I35-2003: **Further considerations on the impact of Flat Panel home displays on the broadcasting chain.** www.ebu.ch/en/technical/publications/ott/index.php

[3] EBU Technical Information I39-2004: **Maximising the quality of conventional quality television in the flat panel environment - first edition.** www.ebu.ch/en/technical/publications/ott/index.php

[4] Nick Wells: **Transparent concatenation of MPEG compression** EBU Technical Review No. 275, Spring 1998

[5] EBU Technical Statement D84-1999: **Use of 50 Mbit/s MPEG compression in television programme production.** www.ebu.ch/en/technical/publications/ott/index.php

[6] **High-Definition Multimedia Interface** HDMI Licensing, LLC. www.hdmi.org

[7] **High-bandwidth Digital Content Protection** Digital Content Protection, LLC. www.digital-cp.com

[8] **Digital Visual Interface** Digital Display Working Group. www.ddwg.org/dvi.html

5.A.10 EBU guidelines for Consumer Flat Panel Displays (FPDs)

5.A.10.1 Scope

This document describes the requirements of the EBU as to how broadcast programmes should be displayed on modern (non-CRT) consumer television sets. It lists the main technical parameters as well as relevant measurement methods. In addition this document recommends an EBU default parameter set.

Any characterization of a display's performance that references this EBU document shall have been undertaken in full accordance with the measurement procedures outlined below.

5.A.10.2 Background

The diversity of consumer flat panel displays (FPDs) that are currently available has raised concerns over the way that television images are presented to the viewer. Standards for television image capture are aimed at a display with the characteristics typical of a cathode ray tube (CRT). All television programmes produced today in standard definition (SDTV), as well as in high definition (HDTV), comply with these standards. The same is true of all earlier television programmes now stored in broadcasters' archives around the world.

Broadcasters have an obligation towards programme producers to present their productions without distorting their creative intent. Therefore it is essential that manufacturers of consumer television sets should design their displays such that their image rendition adequately reflects the creative values intended by the programme director.

5.A.10.3 Main technical parameters

5.A.10.3a Luminance

On displays of up to 50-inch diagonal, small-area peak white should be adjustable to least 200 cd/m^2 without excessive flare. On larger displays, a lower peak luminance is advisable in most domestic environments. However, more important than the actual peak luminance achieved is the shape of the electro-optical transfer function (EOTF) when set to a realistic peak luminance (the EOTF is defined in section 5d; its gamma value is specified in section 4a).

5.A.10.3b Black level

With a luma signal at black level the luminance level measured from the screen should be adjustable to be below 1 cd/m^2, such that it can match a range of home viewing conditions.

5.A.10.3c Contrast

The contrast obtained will depend on the settings of 3a and 3b, above, which indicates a simultaneous contrast of at least 200:1 (see also section 5c). The contrast figures quoted by a manufacturer should be both the full-screen contrast and the simultaneous contrast, measured as defined below.

5.A.10.3d Frame rate presentation

The display should present images at the frame rate of the source where possible, or at some integer multiple thereof. 60 Hz presentations of 50 Hz input signals and 3:2 pull-down should be avoided.

Television pictures are produced as YC_BC_R digital components with a coding range as defined in ITU-R BT.601 (SDTV) and ITU-R BT.709 (HDTV), i.e. the coding range digital 16 to 235 (8-bit) or digital 64 to 940 (*A5.11.3e. Digital interface (DVI or HDMI) coding range.*

10-bit). Consumer displays with an 8-bit digital interface such as DVI [10] or HDMI [11] shall correctly operate in the 8-bit coding range of digital 16 to 235 for YC_BC_R digital components.

Note 1: HDMI 1.3 allows greater bit depth (deep colour mode). Earlier versions allow increased bit depth when using YC_BC_R 4:2:2 pixel encoding.

Note 2: RGB SDTV and HDTV video signals shall be coded with the video coding range as specified in CEA-861-D [12]

5.A.10.3f HDMI AVI InfoFrame

Because sources (e.g. Set Top Boxes) are expected to set the following bits within the HDMI AVI InfoFrame (described in CEA-861-D [12] Table 7), these should be correctly interpreted by the HDMI input of the display:

Data	Bits	Explanation	CEA-861-D reference [12]
Active Format Info Present	A0	Idicates that Active Format Info is valid	Table 8, AVI InfoFrame Data Byte 1
Bar Info	B1..B0	Provides information about letterbox/ pillarbox when active format information alone is not sufficient	Table 8, Data Byte 1
Scan Information	S1..S0	e.g. display is not to apply overscan	Table 8, Data Byte 1
Colorimetry	C1..C0	e.g. BT.470-2 or BT.709	Table 9, Data Byte 2
Picture Aspect Ratio	M1..M0	e.g. 4:3, 16:9	Table 9, Data Byte 2
Active Format Aspect Ratio	R3..R0	Indicates area of interest within the picture	Table 9, Data Byte 2
RGB Quantisation Range	Q1..Q0	e.g. limited range (16-235)	Table 11, Data Byte 3

The following AVI InfoFrame data may be used to assist input synchronisation:

Pixel encoding	Y1..Y0	e.g. YCbCr 4:2:2, RGB 4:4:4, etc.	Table 8, Data Byte 1
Video Format Ident Code	VIC6..VIC0	e.g. 1080p/50, 1080i/25, 720p/50, 576i/25	Table 3, Data Byte 4

5.A.10.4 Recommended "EBU default" settings

5.A.10.4a Display gamma

The electro-optical transfer function should be a power law (commonly referred to as "Gamma"). The default value of display gamma that is required to match the television programme producer's intent is 2.35 in a "dim-surround" environment [6], as per the measurements reported in section 4.2 in [5]. See also Annex A for further information.

5.A.10.4b Colour primaries and gamut

The colours produced by red, green and blue signals, with each of the others turned off, should be within the EBU tolerance boxes in EBU Tech 3273 [13]. The difference between the gamuts of ITU-R BT.709-5 [2] (HDTV) and EBU (SDTV) [14] systems is so small as to be negligible.

5.A.10.4c Colour temperature

Whilst television pictures are produced in the studio assuming a display with D65 [3] reference white colour, it is acknowledged that many consumer displays are set up for much higher colour temperatures.

To change current broadcast practice would result in an unwanted and undesirable change to the look of the pictures, and so it is proposed that the current status quo be accepted, namely that broadcasters produce pictures for a white point of D65. Consumer displays may actually be set to a white of significantly higher colour temperature, but should always contain a user-selectable setting that conforms to D65. This setting should be clearly indicated and is part of the EBU default conditions.

5.A.10.5 Measurement methods required to characterise the display

5.A.10.5a Luminance

The 100% luminance level is measured on a white patch occupying the central 13.13% part of the picture, both horizontally and vertically, using the test signal described in section 3.5 of EBU Tech 3273 [13] and in ITU-R Rec.BT.815-1 [7]. The measurement should be taken perpendicular to the centre of the screen.

5.A.10.5b Black level

Black level is measured in a dark room, on the black patches in the test signal described in 5a, above. Care must be taken to avoid veiling glare in the measurement instrument, by the use of a mask or a frustrum, as described in EBU Tech 3325 [1].

5.A.10.5c Simultaneous and full screen contrast

Simultaneous contrast is the ratio of the measurements in 5a and 5b, above.

The expression "Full screen contrast" has created confusion within the industry as it is used with different meanings. For the purpose of reporting contrast measurements on flat panel displays, the EBU defines full screen contrast as follows:

Full screen contrast is the ratio of the luminance of a white patch occupying 10% of the width and 10% of the height (i.e. 1% of the screen area) in the centre of a black screen to the luminance measured from a completely black screen (with the set switched on) in a dark room. This is sometimes known as "Full screen (1% patch) contrast".

5.A.10.5d Electro-optical transfer function (Gamma)

The electro-optical transfer function (EOTF) is a definition of how the light output (luminance L_R, L_G and L_B) is related to the broadcast R', G' and B' signals thus:

$$L_X = L_{X0} + s\left(\frac{X' - X_0'}{r}\right)^{\gamma}$$

where:

L_X is L_R, L_G or L_B

L_{X0} is the residual light output at 'black' (this is a combination of the residual light output of the display with the effect of the ambient room lighting),

s is a scaling factor related to peak light output, X' is R', G' or B',

X_0' is the electrical signal representing the effective black level, and

γ is the display gamma, which is specified in section 4a.

The value of r will depend on the coding range (for example, analogue voltage, or 8- or 10-bit digital coding) of the television signals.

Measurements of gamma are made by the method defined in EBU Tech 3273 [13]; see also BBC RD 1991/6 [4].

The EBU would prefer consumer displays to avoid applying overscan on any HD input format (1080p, 1080i, 720p).

However, if a small degree of overscan is unavoidable, it should match the clean aperture, as defined by SMPTE 274-2005 Annex E.4 [8] and SMPTE 296M-2001 Annex A.4 [9].

Further information about overscan is provided in Annex B

5.A.10.7 References

[1] **EBU Tech 3325**: **Methods of measurement of the performance of studio monitors (in preparation)**

[2] ITU-R Rec.BT.709-5: Basic Parameter Values for the HDTV Standard for the Studio and for International Programme Exchange (2002)

[3] CIE (Commission Internationale de l'Eclairage) Standard S 014-2/E (2006): Colorimetry - Part 2: CIE Standard Illuminants

[4] Roberts, A.: Methods of measuring and calculating display transfer characteristics (Gamma)

BBC Research Department Report RD 1991/6.

[5] Roberts, A.: Measurements of display transfer characteristics using test pictures. BBC Research Department Report RD 1992/13.

[6] Hunt, R.W.G: "Corresponding colour reproduction" in *The reproduction of colour*, ed. 6, pp. 173, Wiley & Son, 2004.

[7] ITU-R Rec.BT.815-1: Specification of a signal for measurement of the contrast ratio of displays

[8] SMPTE 274M-2005: Annex E.4 in 1920 x 1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequences for Multiple Picture Rates

[9] SMPTE 296M-2001: Annex A.4 in 1280 x 720 Progressive Image Sample Structure — Analog and Digital Representation and Analog Interface

[10] Digital Display Working Group, 1999-last update, digital visual interface [Homepage of Digital Display Working Group], [Online]. Available: www.ddwg.org/ [June, 20, 2005]

[11] HDMI, 2007-last update, high-definition multimedia interface [Homepage of HDMI], [Online]. Available: www.hdmi.org [March 14, 2007]

[12] CEA 861 –D: A DTV Profile for Uncompressed High Speed Digital Interfaces (2006)

[13] EBU Tech 3273: Methods of Measurement of the Colorimetric Performance of Studio Monitors (1993)

[14] EBU Tech 3213-E: Standard for Chromaticity Tolerances for Studio Monitors (1975)

5.A.10.8 Attachments (Annexes)

5.A.10.8.1 Annex A: Gamma

Television has evolved to give pleasing results in a viewing environment described by colour scientists as 'dim surround' [6].

This outcome includes three invariant components:

– the requirement to match luminance level coding (whether analogue or digital) to the approximately logarithmic characteristic of the human vision system by means of an appropriate nonlinear coding or "perceptual" coding of level. Such a characteristic has the effect of equalizing the visibility over the tone scale of quantizing in a digital signal, or noise in an analogue one. A linear or other non-perceptual based characteristic would require greater dynamic range (bandwidth or bit rate) for the same perceptual quality, with adverse economic consequences;

– the immovable legacy effect of the CRT gamma characteristic on which the entire television system was empirically founded. This legacy consists of both archived content and world-wide consumer display populations;

– gamma is also the characteristic which coding schemes such as MPEG-2 and MPEG4-AVC are designed to match, and any other characteristic will be less than ideal in terms of artefact and noise visibility, to the extent that much of the impairment seen these days on transmitted television material, when viewed on flat screen displays, is caused by the failure of the display to adhere closely to a gamma characteristic, particularly near black.

It has been found that the end-to-end or "system" gamma for images captured in nominal daylight conditions, adapted for the dim-surround consumer viewing environment is approximately 1.2, i.e. definitely not linear.

The system gamma can be expressed as:

System gamma = camera encoding gamma (OETF[1]) x display gamma (EOTF[2])

It has been found from measurement techniques, progressively refined over several decades, that a correctly designed CRT display has an EOTF gamma of approximately 2.35 [5]. This is part of the "immovable legacy effect" of the CRT.

Therefore our system gamma equation is rewritten as

System gamma = 1.2 = OETF gamma x 2.35

Therefore OETF (camera) gamma = 0.51.

Since a pure gamma curve would require infinite gain to be applied to camera signals near black, resulting in unacceptable noise; in practice this curve is modified to consist of a small linear region near black in combination with a reduced gamma curve of 0.45 [2]. Note however, that a "best fit" single power law curve for this characteristic comes out as 0.51, the same as in the calculation above. From the above, since the consumer viewing environment does not, in general, change, and the OETF gamma cannot change (for compatibility reasons and for the continuation of an optimal perceptual coding characteristic), the EOTF gamma must also remain at 2.35, regardless of which new physical display device is used to implement it.

---

[1] OETF: Opto-electrical transfer function

[2] EOTF: Electro-optical transfer function

5.A.10.8.2 Annex B: Issues concerning overscan

The CRT has historically applied overscan of around 5% at each edge. This was required because of the difficulty of aligning the scan geometry at the edges of a screen. Edge artefacts on analogue TV content (and digitised versions of this) have been masked by the presence of overscan in the display.

In the modern all-digital environment, it is expected that edge artefacts are well contained.

Overscan has been applied on early flat panel displays to mimic the appearance of the image on CRTs.

There is an inevitable move towards the broadcast signal containing essential content to the edge of the screen. The consumer should be able to see this complete image, rather than only 80% of the image area.

If the display has greater resolution than the incoming signal, scaling is needed. This scaling should not be confused with overscan.

If a display is a close match to the resolution of the incoming signal, one-to-one pixel mapping will always provide a better picture than scaling by a small percentage.

For SDTV the legacy of the installed base of consumer CRT displays, and the legacy of archive content may prevent any change to existing broadcasting practices for some years to come.

Annex 5 - Part B
HDTV and Progressing Scanning Approach

The advent of flat screen TV's is leading to larger screen sizes in households – most popular LCD size is already 32" and by the year 2010 the size is expected to move up to 42" diagonal. Predictions stipulate that the average TV screen size will be of 60"diagonal in the year 2015 and full strength HDTV 1080p would be preferred by consumers.

Progressive scanning is being presented to the public as a major improvement in the quality by receiver industry.

No any more doubt-consumer flat-panels are becoming de-facto one of the key drivers for HDTV. The steady reduction of tumbling consumer prices for both PDPs and LCDs at narrow competitive range encourage the viewers – the biggest investor in the broadcasting chain – to acquire large flat screen TV's with expectations to enjoy attractive programmes delivered at home of real HDTV quality.

Furthermore, professional HDTV screen needs will be met by piggybacking on the consumer market for panels as it was done for CRT's.

Single world-wide HD video disc progressive scanning format "Blu-Ray Disc" is available on the market as from the year 2008. It is backwards compatible with the DVD and CD formats. The "Blu-Ray Disc" format's playing and personal recording devices are exposing consumers to a quality that is far superior to standard digital terrestrial television broadcast transmissions. "Blu-Ray Disc" player tumbling consumer prices have made the "Blu-Ray Disc" very popular too. Furthermore within less than two years packaged media on HD Blu-Ray discs, such as movies, will dominate the market.

Satellite broadcasting, a leading HDTV delivery system for many households of the world, is increasing bandwidth to better serve viewers with flat panel sets. Cable Television distribution networks also introduce the HDTV innovation. IPTV is providing attractive HDTV content exclusively on pay per view basis. Telco's are also providing HDTV content via VDSL and optical cable directly to households.

Digital terrestrial HDTV broadcasting service is offered to viewers of Australia, Brazil, Canada, China, France, Japan, Korea (Republic of), New Zealand, Singapore, USA. Extensive digital terrestrial HDTV broadcasting testing is on the way in Croatia, Finland, UK.

5.B.1 What if the core display was a 1080p display?

A question considered by the B/TQE Group of EBU in 2004 was: If the world watched video content on 1080p displays, and 1080p DVDs were widely used, would 720p broadcasts look inadequate?

The BBC research, based on series of tests with 170 viewers seems to suggest that if they are at the 2.7 m representative viewing distance for 30-40 inch screen flat panel displays, they would not notice the difference between 720p and 1080p content on the 1080p display, because the eye would already be saturated with detail by the 720p content. But if they watched at closer range (or alternatively at bigger screen), they *would* notice the difference.

But it did seem clear to the said experts group that if: (i) the manufacturers decided to make receivers capable of handling progressive formats up to and including 1080p; (ii) the majority of displays were 1080p and (iii) there were 1080p DVDs in the public hands, then this is what the terrestrial broadcasters would have to deliver.

As already indicated, all the above-mentioned three preconditions of the EBU B/TQE experts group will be fully met as from the year 2010 and will be exceeded by far in the year 2015 with 60 inch average screen size.

Another issue which remains to be explored concerns the extent to which a given progressive input signal can be fully explored in practice by a given flat-panel display. If the three colour primary points are not spatially coincident (as they are not in practice), it may be that to fully exploit a given signal resolution, a higher resolution panel is needed to avoid spatial aliasing effects. In other words, it may be that a 1080p panel is needed in order to fully use the 720p delivery format. At the year 2004, however, the evidence before B/TQE suggested that the best delivery format would be 720p.

Warning to TV Broadcasters: Today, a professional HDTV programme can be produced in any of over 40 different capture/recording formats and converting between them always has shortcomings!!

On 3 of March 2006 Dr. J. A. Flaherty, Senior Vice President Technology, CBS Broadcasting Inc. has stated:

<<Today, Europe needs a more direct path to full HDTV terrestrial broadcasting. Suitable spectrum for terrestrial broadcasting 1920/1080/16:9/24p, 25p, and 50i&p HDTV must be found, even at some sacrifice of today's lesser TV services. Otherwise, Europe's terrestrial broadcasters, starved for spectrum, and thus without HDTV, will, in time, cede their audiences and their future to the worlds' alternative HDTV media. European terrestrial broadcasting deserves a better future, and only Europe can make that future happen. Today, Europe has a new birth of HDTV opportunity in its "Challenge of Choice". Europe needs to adopt full quality high definition for both production and emission and not adopt another evolutionary SDTV or Enhanced1280/720p system on the way to final HDTV**. *Tempus fugit.* European terrestrial broadcasters must become HDTV broadcasters.**>>

5.B.2 Interlaced/Progressive Scanning dilemma

The legacy question here is whether what you already have can be made to work. Interlace scanning can work well with advanced compression and progressive displays – it is just less efficient in transmission, needs complex standards-conversion in the flat-panel display, and has less motion-portrayal quality potential.

It may or may not be most cost-effective to use progressive scanning for programme production, or a mix of interlace and progressive. It may be that interlace production equipment will be cheaper for today. But by specifying a progressive delivery channel, we keep all the production options open, and make ourselves as future-proof as technology allows.

5.B.3 Arguments for progressive scanning

5.B.3.1 Coding gain

In simple terms, anything an interlaced analogue bandwidth-compression system can do in series with a digital compression system, a content-adaptive digital compression system alone can do better, working on the "original" progressive signal.

Thus, one of the advantages of progressive scanning is that we can compress video in a content-adaptive way, rather than partly in a simple systematic way. A system such as interlace never cares what is best for the particular content being seen, or the bitrate available in the channel. ***In the twenty-first century there are better ways to reduce bandwidth than to use interlaced scanning.***

Taken overall, the application of digital adaptive compression must be more “quality efficient” than using interlaced scanning. There must be a “coding gain” associated with progressive scanning and adaptive compression, when compared to using interlace scanning and then adaptive compression.

Quantifying precisely how much this is, or will be, is difficult because it depends on the scene content. It cannot be done in terms of a set of a small number of subjective evaluation results; it has to be seen as the long-term result for the channel efficiency. In practice it seems that most of the coding gain of progressive scanning in a MC hybrid DCT environment comes from the improvement in the effectiveness of the motion compensation stages of compression.

Tests with the ITU-T Rec. H.264 compression system widely known as MPEG-4 AVC Part 10, have established that it compresses progressive images “better” than they compress interlace images. The bitrate required to deliver a “good” quality 720p/50 image has been found to be less than that required to deliver 1080i (interlace) for material which is “critical but not unduly so”.

5.B.3.2 Avoidance of display up-conversion

New LCD, plasma and non-CRT-based projection technologies are different from the CRT technology they replace. It is relatively easy to convert a progressive delivered image to an interlaced form, but it's much more difficult to convert an interlaced image to progressive form to suit it to the new displays.

If you have a choice about whether to broadcast a signal which does, or does not, need de-interlacing in the receiver, all the arguments found support broadcasting a signal that does not need de-interlacing:

1) Firstly because creating whole pictures for a progressive display from an interlace signal is no simple task. Essentially you need different conversion algorithms in the receiver for when the picture is static and for when it is moving. It is complex because you are trying to compensate for information which is not there. Once the upper segment of the vertical/temporal spectrum is taken away by the interlacing, it cannot be recuperated. Certainly there has been much research and development of consumer interlace-to-progressive conversion by the large receiver manufacturers. But, even so, the progress – especially for HD resolution – is not matching its original promise. On sale is seen only equipment with simple “motion adaptive” designs, without motion compensation. While good for still images and for film mode, these methods are less good for television moving images. In television, our core business is moving images.

2) Secondly, if you must have a de-interlacer, it is better to do something once with expensive and complex equipment at the studio output, than to do it a thousand times less well using low-cost equipment in each and every receiver across the land. EBU Group B/TQE assessed de-interlacers that are common in the domestic display environment and found they generally contributed impairment and limited the final quality of an HD-delivered image. However, professional conversion equipment of very good performance has been developed and good de-interlacers are available from a range of manufacturers for studio use.

From all this, the said EBU Group concluded that conversion from interlace to progressive should not be carried out at the receiver if we can avoid it.

5.B.3.3 Improvements in motion portrayal

Though the EBU B/TQE group has not investigated the best forms for HD production those broadcasters in the United States who are using 720p/60 progressive scanning have informed the said group that the greatest reason for their using it is because of motion portrayal for sports content. When there is much movement, progressive scanning looks better, and indeed slow motion replay looks better.

History has taught broadcasters that sport was the major reason for people to buy colour television receivers in the sixties and seventies. For HD, sport will be a “killer” incentive to move to HD. There is every reason to take particular care of sports content for public service broadcasting where it is critical content.

Whether or not progressive scanning is used for production, the choice of progressive scanning for the delivery channel is an advantage. If we choose an interlace delivery channel, we are locked out of fully seeing the advantages of progressive production – they cannot be carried forward to the public. Having a progressive delivery channel allows us the option of using progressive production or not, as circumstances dictate, and this seems the responsible approach.

5.B.3.4 The future broadcast chain will begin and end with progressive scanning

Current picture sources are fundamentally "progressive". The CCD/CMOS at the heart of each camera converts the optical image into electrical form with charges from all the rows of CCD elements transferred into a storage device at the same instant. "Interlaced" or "progressive" images are formed when the signal is "read" out of the chip: indeed, the interlaced signal is formed by discarding information.

We can also note that much electronic graphic programme material is generated in progressive form to avoid the twitter or flicker of fine detail.

Objectively, we will have a broadcast chain which begins and ends with progressive scanning and, given that you have the choice, one can see the use of interlace as an un-necessary limitation on quality built into the chain.

5.B.3.5 Establishing the optimum progressive format

The above experiences led the EBU Technical Committee to recommend that Europe's best interests are served by a progressive delivery channel, of which two are specified by the SMPTE – 720p/50 and 1080p/50.

To reach conclusions on whether one or the other, or both, should be recommended, the B/TQE group went back to first principles to establish what HD brings to the viewer.

Deciding on a proposition for an HD format is not purely a matter of simply citing who uses which system, or drawing three dimensional diagrams of the responses of different scanning formats.

There are too many variables to take into account and, unless actually related to real equipment, these diagrams are misleading.

An appraisal was needed to be done based on the results of controlled tests with real equipment and real people.

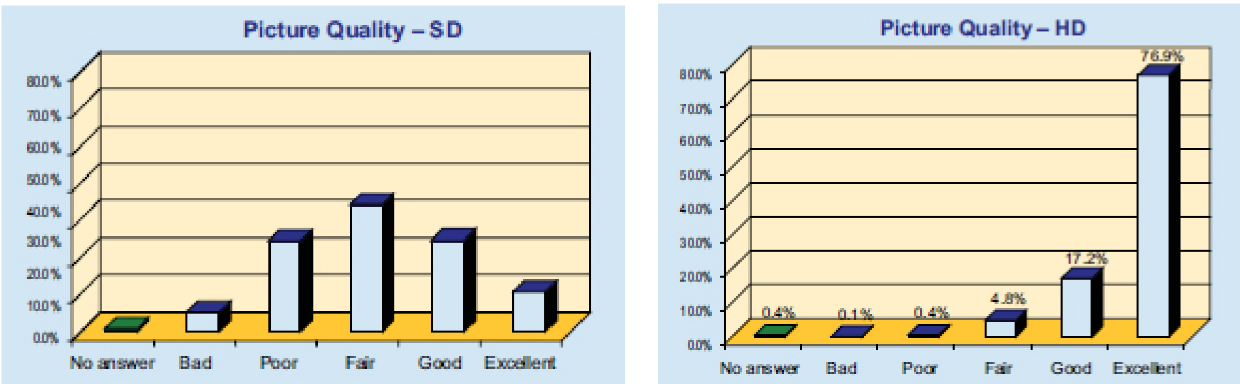
5.B.4 How much quality do we gain with HD?

Overall, of course, the SD image falls short of the equivalent HD-delivered image. For a general idea of the difference, *Fig. 1* shows a comparison made in the year 2004 in Sweden between SD delivered with MPEG-2, and HD delivered using a more advanced coding method. The shots were sections of a complex moving sequence. This was not a scientific test, but it was simply to show the general impact of the order of difference.

Figure 1: Comparing standard-definition and HD images

Fig. 2 shows how SD and HD have been compared by a large population sample in tests in Sweden. In this case, very good quality standard-definition DVDs were compared with HD Digital VHS on adjacent screens. The results showed that the SD picture quality was generally "fair" whilst the HD picture quality was judged as "excellent". If they are seen together, there is about two quality grades difference between HD and SD.

Figure 2: Comparison of SD and HD assessments



This suggests that the critical factor for the viewer's perception of quality is the "context". If the viewer can experience both HD pictures and SD pictures, he or she will evaluate the SD pictures as two grades worse than the HD pictures.

As HD DVDs and HD-capable displays are becoming popular, the viewer will experience this "context", and this in turn will lead to growing pressure on broadcasters to provide matching HD quality.

5.B.5 The balance between requirements for detail and spectrum efficiency

B/TQE believed that a judgment on the optimum delivery format needs to take into account both the requirement to saturate the eye with detail in representative circumstances, and the need to provide the lowest possible delivery bitrates for spectrum efficiency.

The European terrestrial airwaves, in particular, are highly congested and all broadcasters arguably need to be as spectrum-efficient as possible but without annoying rtefacts. There is no doubt that whatever the compression system used, the delivery bitrate for a 1080p/50 signal would be higher than for a 720p/50 signal. If a 720p/50 delivery signal is adequate, it is argued, it would be responsible to use it, rather than use a higher scanning format that provides detail which will not be noticed on smaller screens. This is not to say, however, that 1080p/50 should not be used for programme production, where headroom could be an advantage – but this is the subject of another study.

This choice of the 720p/50 format, rather than 1080p/50, with an advanced compression system would decrease the risk of compression artefacts for practical bitrates. If we choose the lower of the two scanning formats, for a given delivery bitrate, we have a higher chance of providing artefact-free delivery.

A demonstration, conducted by EBU at IBC 2006, was not intended to be a formal scientific subjective evaluation of three HDTV formats, but rather a first-hand look at the qualitative differences in the formats, in as fair and controlled feasible environment.

In the presentation of uncompressed sequences, the delegates reported difficulties in seeing difference between the three formats – even at a viewing distance of 3h. But when the compressed images were shown, the viewers did notice differences in the visibility of compression artefacts. Depending on the viewing distance and scene content, the artefacts became visible to a greater or lesser extent and, with few exceptions, the following were reported:

i) The 720p/50 format showed better image quality than the 1080i/25 format for all sequences and for all bitrates;

ii) With decreasing bitrate in the compressed domain, the difference between the 720p/50 and 1080i/25 format became more marked;

iii) The 1080p/50 format was rated equal or better than 720p/50 for the higher bitrates. However, 720p/50 was rated better than 1080p/50 at the lower bitrates.

Annex 5 - Part C
Status of HDTV Delivery Technology

5.C.1 System considerations

5.C.1.1 HD scanning formats

The EBU has identified and specified, in EBU document Tech 3299 (ITU-R Rec. BT.709-5), **four HDTV production formats**: 720p/50, 1080p/25, 1080i/25, and 1080p/50. The 1080i/25 and the 720p/50 formats can also be used for broadcasting, or other forms of secondary distribution, whereas 1080p/25 is currently a production format only. However, for distribution, 1080p/25 can either be mapped into 1080i/25 as 1080psf/25 (**p**rogressive **s**egmented **f**rame, psf) or converted to 720p/50 by spatial down conversion combined with frame repetition.

The 1080p/50 is termed a “3rd generation” HDTV format, which some broadcasters believe may be used in future both for production and distribution purposes.

EBU studies suggest that, if the final quality seen by the modern HDTV viewer is taken into account, the most “quality-efficient” broadcast format of these four, seen on current HDTV consumer displays, is the 720p/50 format. The 1080p/50 is quality-efficient and can be compressed to bitrates comparable to 1080i/25. No technical advantages have been identified to date for the 1080i/25 format in the current broadcast environment, though there were advantages in the past in the all-CRT-based display environment.

Almost all HDTV displays sold in Europe today are flat-panel matrix displays, requiring incoming interlaced TV signals to be deinterlaced. The progressive format is thus the natural match to current HDTV displaysSome broadcasters in Europe are however choosing the production format 1080i/25 for other than technical reasons. This may be when, for example, older legacy equipment only supports 1080i/25, or when productions are commissioned in, or the customer may require, 1080i/25. Both are understandable reasons. *But it is now technically understood that the interlaced footprint in the HDTV signal cannot be removed with standards converters*. Consequently a chain with a progressive signal generated from an interlaced source will always have a potentially impaired quality compared to a full progressive chain.

As a rule of thumb, for interlaced production, it is better to use one high quality professional de-interlacer at the playout point, rather than placing the burden of de-interlacing on the many (and less effective) consumer devices in the home. An additional advantage is that broadcast encoders can operate moderately more efficiently in terms of bitrate requirements with progressive signals derived from interlaced than with interlaced HDTV.

EBU tests suggest that, all other elements being equal, the advantage for 720p/50 broadcasting applies whether the viewer's display is one of the widespread Wide-XGA-panels (1366x768 pixel, also called HD-Ready) or a newer panel with 1920x1080 pixel (HD Ready 1080p), up to a diagonal size of about 52 inch. However taking into account that average screen size predicted for year 2015 will be 60 inch this suggestion may not be future-proof, therefore 1080p delivery would be better solution for the nearest future.

HDTV broadcast encoder manufacturers usually provide optional signal processing functionalities which process the baseband input video signal. This normally includes selectable input filters that reduce the horizontal resolution of the video signals, in order to reduce the required bitrate in distribution, but with some quality trade-off.

Often this horizontal down-filtering is expressed as the number of pixels per line. Having lower horizontal resolution reduces the “criticality” of the scene (a function of the entropy of the picture, which relates to how difficult the picture is to compress without artifacts) and thus makes compression easier. If a scene shows visible compression artefacts such as “blocking”, lowering the horizontal resolution can reduce these, though the sharpness potential of the image falls also.

It is worth noting that recent formats from Sony (XDCAMHD 422) and Panasonic (AVC-I) and GVG/Thomson (Infinity J2K) do not use horizontal down-sampling for either 1080i/25 or 720p/50.

The HDTV baseband environment can be seen as comprising a number of quality format/levels, given that the compression system and bitrate are chosen to transparently deliver the original signal.

Though it is by no means a complete indicator of quality, a major indicator of quality of a moving picture system is its luminance-sampling rate. This is used below to classify scanning formats. There are several factors in addition to horizontal resolution that relate to subjectively perceived picture quality, so the luminance sampling rate should not be taken as a singular or linear measure of potential quality:

Scanning raster Luminance sampling Rate

1920x1080p/50 148.5 MHz

1920x1080i/25 74.25 MHz

1920x1080p/25 74.25 MHz

1280x720p/50 74.25 MHz

Equivalent luminance sampling rate with subsampling

1440x1080i/25 54 MHz

960x720p/50 54 MHz

1280x1080i/25 48 MHz

960x1080i/25 36 MHz

The lower the level above that is used, the lower the bitrate needed to produce “artefact free” images, for a given scanning algorithm, but also the lower the potential detail in the picture - which is important for the HDTV experience.

SDTV quality signals (720x576i/25, 13.5 MHz luminance sampling rate) can be “up-converted” to any of the formats by the broadcaster prior to broadcasting. The quality available to the viewer in this case can be better that the quality obtained from up-conversion in the viewer's HDTV receiver, and may be improved in quality compared to normally seen SDTV - but is not “HDTV. This can become even more apparent to the viewer if he has the possibility of ”zapping” between SD-up-converted and native HDTV channels.

To avoid double up-conversion, once in the studio and once in the receiver, if an HDTV format is broadcast, it is best if 576i/25 source material is converted only once to 720p/50, using the best possible converter in the studio.

The 1080p/50 format will provide higher quality headroom for programme production, and will make a major contribution to programme production in the years ahead, when 1080p/50 production equipment becomes readily available. Today, however, no complete IT-based studio infrastructure is available yet for this format, but TV production manufacturers will fill in this temporary gap in the next couple of years.

The 1080p/25 format is an excellent format for programme production where motion portrayal is not critical, as is often the case with drama (movie-look type programmes). This format fits into a 1080i/25 delivery channel as segmented frames (1080psf/25), and can provide very high picture quality for viewers with 1920x1080 displays (given that there is no overscan, but one by one pixel mapping, though which is not very often the case today), and a modest quality advantage for viewers with WideXGA (1366x768) displays.

There may be a case for using any or all of the four formats, 1080p/50, 720p/50, 1080p/25,and 1080i/25 for programme production, and one or combination of the formats 1080p/50, 1080i/25 and 720p/50 for distribution. Broadcasters need to make informed decisions on formats, rather than decisions based solely on the advice of equipment manfacturers, who may be influenced by their own product line availability.

To respond to Members' needs, the EBU has asked production equipment manufacturers to make production equipment which is “agile”, and can support any of the three 74.25 MHz formats. If possible, the equipment should also support the 1080p/50 format (EBU R115). The information available at Spring 2008 is that current new generation mainstream HD production equipment made by most or all manufacturers can support any of the 74.25 MHz formats.

In 2005 the consumer equipment manufacturers association, EICTA, supported and encouraged by the EBU, agreed labels that can be used for HDTV displays and for HDTV receivers. These are the “HD-ready”, and “HDTV 1080” labels. These labels mean that receivers and displays are able to interpret and display the 720p/50 and the 1080i/25 format, as well as SDTV. Displays with the highest market penetration today are compliant with the “HD-Ready” or “HD-Ready-1080p”/” HDTV-1080p” specification of EICTA (see www.eicta.org/ for more details of these and other labels) with market share of large screen “HDTV-1080p” steadily growing.

Several manufacturers are already making available 1920x1080 displays. Until recently, they have attached one of the many proprietary labels that are not clearly defined. However their meaning for the public was limited to indicating that those displays use a native 1920x1080 panel. It is neither an indicator of one-to-one pixel mapping (i.e. no overscan), nor of the signal formats accepted (e.g. 1080p24/25/50/60 for Blu-Ray) at its interfaces. These non-specified labels confused consumers and the industry, and should be avoided. Fortunately, in Autumn 2007 EICTA agreed new and defined labels for 1080p displays (“HD-Ready 1080p”) and for integrated receiver-displays (“HDTV - 1080p”). This is a welcome move, and these labels should supersede the earlier labels.

Whilst the EICTA/Digital Europe HD-ready logo had found widespread acceptance as a guarantee that a TV set would display an HD signal when the broadcasts started, the next step - the HD-ready 1080p logo – appears not to have achieved the same acceptance until second quarter of 2009, which is rather unfortunate. Whilst a manufacturer’s own “Full-HD” logo indicates that the display has indeed got 1080 lines of pixels, it does not go as far as to guarantee that the TV will be compatible with 1080p50 signals from a set-top box or 1080p60 from games machine.

EBU has produced publicly available EBU Tech 3307 “Service requirements for Free-to-Air High definition Receivers” in June 2005. and EBU Tech 3333 “HDTV receiver requirements’ publicly available at www.ebu.ch.

Broadcasters can broadcast either 720p/50 or 1080i/25, or the horizontally downsampled versions of them, as well as SDTV, in the knowledge that all HDTV ready receivers will be able to decode and display them (provided any conditions needed for copy protection and conditional access needed have been met by the viewer). Future-proof option of broadcasting 1080p/50 should also be considered.

It is reasonable for broadcasters to inform their viewers about the quality they have provided in their services. This is a sensitive issue, because many broadcasts today use "sub-sampling" prior to broadcasting, to allow a lower delivery bitrate at the expense of some loss of detail in the picture***. Strictly speaking, services that are not based on a 74.25 MHz luminance sample rate should not technically be labelled as "HDTV".***

5.C.2 Distribution options

Broadcasters have to decide which delivery media to use for their HDTV services.

5.C.2.1 Broadband

The linear/non-linear medium of broadband (both wired and wireless) is available in some parts of Europe. However it should be noted that high-quality (unimpaired) HDTV-services need high data rates that can currently only be met by VDSL- technology. The more widespread ADSL2+ technology can be used, but with some drawbacks in quality and Quality of Service (QoS), related to error transmission time.

FTTH (Fibre to the Home) networks are being deployed in many countries providing a much higher data rate (100 Mbit/s) into the viewers home, using IP protocol. These services can provide 'transparent' quality for HDTV, provided the networks are managed to avoid packet loss for video services.

Broadband networks usually offer a certain bitrate that is not so large compared with digital satellite, terrestrial, and cable capacities. In addition, zapping times and other quality of service parameters can be dependent on the number of broadband streams simultaneously watched by the viewers. Only few European broadband networks today have the capacity to deliver a single channel of HDTV without impairment - that is with the bitrates of 12 Mbit/s or higher needed.

It is possible to deliver HDTV on the Internet by downloading or streaming. Peer-to-peer networks could deliver such services, but work remains to be done to establish the practicality of doing so.

Introducing HDTV in the terrestrial frequency bands is less straightforward, mainly because terrestrial radio frequency spectrum is scarce resource.

5.C.2.3 Satellite delivery

The digital satellite transponder is essentially a container that can carry digital signals of any form, and there is considerable airwave capacity available in DTH bands. Satellites have generally adequate data capacities for HDTV channels, though current satellite bands are filling up.

The DVB-S2 digital multiplex capacity will be typically about 50 Mbit/s. If this is used as a single statistical multiplex of HDTV services with diverse types of content, with mature encoders, the multiplex should be able to accommodate three to five HDTV MPEG-4 AVC channels.

5.C.2.4 Terrestrial delivery

As a rule of the thumb, frequency planning for the digital terrestrial television environment is based on using the same channel widths that are used today for analogue television broadcasting. This means that any digital terrestrial television (DTTV) service, including HDTV terrestrial services, will be based on conventional radio frequency TV channels, with the consequent limitation on the size of digital multiplexes.

The DVB-T digital terrestrial television system (DTTV) is essentially a "container" with a capacity of between 12 Mbit/s and 24 Mbit/s, depending on the error protection level and modulation scheme used, for a 7/8 MHz (Band III) or 8 MHz (Bands IV and V) channel.

Work was accomplished by the DVB Project on a new digital terrestrial TV broadcasting format, DVB-T2. The draft specification of this is freely available on the DVB website. DVB-T2 offers, in its first profile, a 50% gain in channel capacity compared to DVB-T. Though there are many parameters affecting bitrate capacity, a typical maximum channel capacity for DVB-T2 may be 36 Mbit/s. DVB-T2 receivers however will not be available before 2010.

5.C.3 Accommodation of HDTV in the ITU RRC-06 (GE-06 Agreement and Plan)

Introduction

The purpose of this Section is to assess the potential of the GE06 Plan to accommodate HDTV services. In a recent study carried out for the EBU Technical Committee it is considered that in the future all TV programmes will be in HD quality and that a minimum of 20 to 25 HDTV programmes will need to be provided on the terrestrial platform in order to make it attractive for the viewers.

The GE06 digital broadcasting plan allows for implementation of HDTV services, i.e. using DVB-T. However, not all DVB-T plan entries offer the same opportunity for HDTV, primarily because of different Reference Planning Configurations (RPCs) or system variants used to establish the GE06 Plan. Nevertheless, the GE06 Plan permits a significant degree of flexibility in the implementation of transmission networks that may be used in favour of HDTV.

By using advanced transmission systems, such as DVB-T2, it is possible to provide a higher transmission capacity than DVB-T without changes to the GE06 Plan. It is worth noting that the GE06 Agreement allows only DVB-T and T-DAB entries to be recorded in the Plan. However, other digital television systems, such as DVB-H and DVB-T2 can be implemented using the ‘envelope concept‘.

Data rate capacity required to deliver HDTV

One element of choice for HDTV broadcasting (or for HDTV delivery by other means) will be the data rate used for delivering the compressed HDTV video signal. This is a critical factor that affects both the quality the viewer experiences as well as the transmission costs.

The digital transmission capacity needed to deliver HDTV depends on a number of factors, such as:

- The type of compression used: legacy MPEG-2 or ITU-T H.264/AVC (MPEG-4 Part 10) also referred as MPEG-4.
- The HDTV scanning format used.
- The degree to which picture impairments are acceptable.
- Whether the compression has to be done as the programme unfolds –“on the fly”- or not.
- There may or may not be time for several passes through the encoder for quality optimization scene-by-scene. At least some broadcast material will always demand “real time” encoding because the material is live.
- Whether the HDTV signal is part of a “statistical multiplex”.
- The performance of the particular manufacturer's encoding equipment.
- The type and size of the display and viewing distance at home.
- Predominant type of content.

All European broadcasters that have to date announced future plans to broadcast HDTV on the terrestrial platform will use MPEG-4 compression.

The EBU has identified and specified4 four HDTV production formats: 720p/50, 1080p/25, 1080i/25, and 1080p/50. The 1080i/25 and the 720p/50 formats can also be used for broadcasting, or other forms of secondary distribution, whereas 1080p/25 is currently a production format only. The 1080p/50 is defined as “3rd generation” HDTV format, which may be used in future both for production and distribution.

Recent EBU tests of stand-alone MPEG-4 encoders of different vendors have suggested the following minimum fixed bitrates in order achieve an HDTV image quality providing a significantly better quality perception compared to good quality SDTV of 6 Mbit/s MPEG-2 for a wide range, including critical content:

- For the 1080i/25 HDTV format and horizontal sub-sampling to 1440 samples a minimum bitrate of 12 Mbit/s is recommended,
- For the 1080i/25 HDTV format and no horizontal sub-sampling a minimum bitrate of 12 - 14 Mbit/s is recommended,

- For the 720p/50 HDTV format and no horizontal sub-sampling a minimum bitrate of 10 Mbit/s is recommended.

The choice of bitrate for HDTV needs to take into account a number of conflicting factors, and there will be a need for trade-off of advantages and disadvantages.

For various reasons, administrations or broadcasters may decide to launch HD at a level of quality beneath the above recommendations. These reasons may be due to strategic decision, or the requirement to respect a given time schedule. Whilst the quality of such HD services may be less than recommended several broadcasters consider that they are providing or will provide a significantly better offering than SD. Nevertheless, it should not prevent a broadcaster to look for further improvements of the quality as they become available (more spectrum, better compression, statistical multiplexing and so on...).

Whatever bit rate is employed, there will always be less risk of compression artefacts if 720p/50 is used rather than 1080i/25, and thus there will be advantages in using 720p/50 for terrestrial HDTV broadcasting, until the 1080p/50 standard eventually becomes available (EBU Recommendation R 124).

The bit rate used for current HDTV services is constrained by commercially available encoder performance, which is constantly evolving (moving target).

In practice a range of bitrates is currently used for HDTV broadcasting, including, for example, about 13 Mbit/s by the SRG for their 720p/50 service in Switzerland. In Germany, since July 2008, ARTE has transmitted a 720p/50 satellite service with a video data rate of 12 Mbit/s. In Belgium, HDTV services are available in cable and over IP, 720p/50 and 1080i/25, depending on the programme, and with a bit rate of about 9 Mbit/s.

In France TF1, France 2, Canal+, ARTE and M6 are offering terrestrial HDTV services in the 720p/50 and 1080i/25 format. One HD multiplex uses 64 QAM ¾ GI 1/8 over SFN with 3 HD programmes in the statistical multiplex with an average video bit rate of 7.3 Mbit/s per programme.

MPEG-4 advanced video coding transmissions will benefit from statistical multiplexing. In a large statistical multiplex, with mature encoders, future HD services may be able to operate with an average bit rate of about 8-10 Mbit/s. In a standalone service, up to 16 Mbit/s will be needed, depending on the development of encoders in the future. In a small statistical multiplex, the bit rate needed will lie between the said two values.

Finally, when calculating the overall bitrate budget for an HDTV service, additional capacity needs to be added to the video bitrate for 5.1 surround sound (about 0.5 Mbit/s with the DD system and 0.25 with DD+ or HE-AAC) and about 2 Mbits/s for interactive multimedia services (MHP, OpenTV, MHEG).

Features of the GE-06 Plan

The GE-06 Plan covers the frequency band 174 - 230 MHz (Band III - arranged into seven or eight channels with 8 or 7 MHz bandwidth, respectively, depending on the country,) and the frequency band 470 - 862 MHz (Bands IV/V - subdivided into 49 channels, each with 8 MHz bandwidth).

Whilst large number of combinations of DVB-T system variants and the reception modes (fixed, portable and mobile reception) are possible, their use would make the frequency planning extremely complicated. Furthermore, not all of these combinations are used in practice.

In order to simplify the Conference planning process a limited number of Reference Planning Configurations (RPCs) was defined representing, in an approximate way, the most common types of coverage. As a result, for each GE06 Plan entry an associated RPC (mainly as allotments), or a chosen combination of system variant and reception modes, are recorded in the Plan. In the implementation phase, broadcasters or delivery network operators have the freedom to choose a system variant that best fits the real coverage requirements, while taking account of the recorded RPC of the corresponding digital entry in the Plan.

The three following RPCs have been defined for DVB-T:

- RPC1 - for fixed roof-level reception
- RPC2 - for portable outdoor, lower coverage quality portable indoor, or mobile reception
- RPC3 - for higher coverage quality for portable indoor reception

Some examples of typical implementation parameters corresponding to these three RPCs are shown in the table below. Other system variants may be implemented under certain conditions.

Reference planning configuration	RPC1	RPC2					RPC3
Reception mode	Fixed	Portable outdoor		Mobile		Portable indoor	Portable indoor
Modulation	64-QAM	16-QAM	64-QAM	QPSK	16-QAM	16-QAM	16-QAM
Code rate	3/4	2/3	2/3	2/3	½	2/3	2/3
Location probability for planning	95%	95%	95%	99%	99%	70%	95%
Max. net bit rate* (Mbit/s)	27.14	16.09	24.13	8.04	12.06	16.09	16.09

* Source: EBU BPN005 - Terrestrial Digital Television: Planning and Implementation Considerations,

Third issue, Summer 2001

It is not obvious from GE-06 how the Plan entries will be used in practice, since national objectives for DTTV are different across the 120 countries of the GE-06 Plan. The total capacity available in the GE-06 Plan is often expressed in the number of multiplexes ('layers') that could be provided over the whole national territory. One layer represents a set of channels that can be used to provide one full, or partial, nationwide coverage.

For most countries this is equivalent to:

- three T-DAB layers in Band III,
- one DVB-T layer in Band III, and
- seven to eight DVB-T layers in Bands IV/V.

It is up to the national administrations to decide how this capacity will be used. Some of the Plan entries are likely to be used to provide nationwide coverage while the other entries will be used for regional or local coverage.

The number of multiplexes that can be achieved in practice sometimes exceeds the capacity that is theoretically available in the GE-06 Plan. In most cases this will be at the expense of accepting higher levels of interference that may result in reduced coverage or lower quality of service. Moreover, variations in the overall coverage that can be achieved by a given country arise due to the different situations that occur within the area of this Plan; for example geographical size, proximity and number of neighbouring countries, type of reception mode adopted (fixed or portable).

For the purpose of this Report the theoretical capacity available in the GE-06 Plan will be used.

5.C.4 Assumptions on the technology evolution

There are important developments taking place that would provide for a significant increase in the transmission capacity on the terrestrial platform. These relate to improvements in coding (compression) and transmission system as follows:

• **MPEG-4** is an improved video and audio coding compression standard. This is expected to operate at up to double the efficiency of the coding standard MPEG-2 that is currently used for most of the digital terrestrial transmissions. This means that a DTTV multiplex could carry up to twice as many services using MPEG-4 as can currently be achieved using MPEG-2, whilst maintaining similar picture quality.

• **DVB-T2** is a new transmission standard. Early estimates of performance of the baseline specification suggest 30 to 50% bitrate capacity gain for a typical application for the same reception conditions.

It has been estimated that the introduction of these two innovations could, if combined, increase the capacity of a multiplex by up to 160% for fixed reception although some experts consider 100% to be a more realistic estimate. It is also assumed that the capacity gain in the case of portable or mobile reception will be similar to that of fixed reception.

Furthermore, as a trade off, implementation of new DTTV systems such as DVB-T2 may:

• require different approaches concerning network planning and may also have an impact on the frequency planning. In particular, if GE06 Plan entries are to be used for DVB-T2 instead of DVB-T the conditions for such substitution need to be determined and the implications in terms of interference, protection requirements and coverage parameters have to be investigated.

• induce extra cost for the broadcaster - transmitter, aerial if multiple input single output antennas (MISO), and new set up boxes and HDTV receivers availability for the viewers which should be taken into account at the time of the considered introduction of DVB-T2 but dully taking into account other available digital terrestrial television platforms.

5.C.5 Conclusions

An entry to GE-06 Plan is submitted and implemented as one DVB-T multiplex transmitted over a corresponding coverage area. This applies to both assignments and allotments. Allotments are normally converted into a single assignment or a set of assignments that operate as an SFN.

A DVB-T multiplex is essentially a "container" with a given bitrate capacity, which in practice ranges between 8 Mbit/s (QPSK, 2/3) and 27 Mbit/s (64 QAM, 3/4). Whilst the choice of the system variant is in some cases constrained by the RPC recorded in the Plan, there is the possibility for the Plan to be modified to include a different system variant.

In principle, the container (multiplex) can be used to deliver any picture quality, including HDTV providing that the services fit into the available channel capacity and are receivable at an adequate bit error rate.

One HD programme currently requires a fixed bit rate of 10-20 Mbit/s depending on the format and compression method used (e.g. MPEG-2 or MPEG-4). If statistical multiplex is applied an average bit rate of 7-8 Mbit/s per programme can be achieved (e.g. if 3 HD services are multiplexed together in a DVB-T multiplex with around 24 Mbit/s). Careful design of the production chain and high quality MPEG-4 encoders in combination with statistical multiplexing and horizontal sub-sampling will allow that these bitrates provide perceptible improvements over state-of-the-art MPEG-2 based SDTV services on DTTV. Consequently, one GE-06-based DTTV multiplex can theoretically carry one to three HD programmes for fixed reception and maximum of one or two HD programme for the more robust system variants that allow for portable or mobile reception. Some system variants do not have sufficient capacity for HDTV.

In the future, with the expected future improvements of video coding, it is assumed that HD fixed bit rate requirements will be reduced to 8-10 Mbit/s per programme. There will also be advances in the transmission system such as DVB-T2. The GE-06 Agreement allows for implementation of DVB-T2 *under the envelope concept*; i.e. provided that it does not cause more interference nor require higher protection that the original Plan entry. This may restrict the choice of DVB-T2 system variants available for such implementation and will need further investigation.

By combining the expected advances in the transmission systems and using statistical multiplexing it should be possible to aggregate up to 4 or 5 HDTV programmes per multiplex for fixed reception, or 2 to 3 HDTV programmes in a multiplex for portable or mobile reception.

This leads to the conclusion that the maximum capacity currently available in the GE-06 Plan in terms of number of programmes is as follows:

	Fixed Reception		Portable Reception	
	UHF Bands IV/V	**VHF Band III**	**UHF Bands IV/V**	**VHF Band III**
DVB-T	7-24	1-3	7-16	1-2
DVB-T2	21-40	4-5	14-24	2-3

The figures in the table above are based on the following assumptions:

- most countries have 7-8 layers in UHF and 1 layer in VHF in the GE-06 Plan,
- all DVB-T Plan entries will be used to provide HDTV services, and
- the performance MPEG-4 encoders, which are continuously evolving (moving target), are sufficiently advanced by the time of DVB-T2 implementation.

It should be understood that these conditions may not always be applicable in practice. The above-mentioned maximum bitrates for DVB-T can only be achieved with MFNs or SFNs using short guard intervals, otherwise the actual net bitrates are less than the stated above.

It should be noted that many European countries may not be able to launch a full HDTV offering on the terrestrial platform until they and their neighbours have completed analogue switch-off.

Mr. R. Brugger and Ms. A. Gbenga-llori, IRT, Munich, Germany have published the outcome of their study “Spectrum Usage and requirements for future terrestrial broadcasting applications” in the EBU Technical Review, 2009 Q4. There-in, they have assumed the HDTV as future standard for all TV applications and they have assessed the number of TV programmes that could be accommodated in given multiplex when applying both the MPEG-4 source coding techniques and the DVB-T2 channel coding techniques. Based on those assumptions and taking into account latest status-quo of technology development, they have investigated the possibilities available within GE-06 Agreement and Plan as well as the potential of digital terrestrial television to provide a competitive platform for future broadcasting applications.

The concise up to date information in this article [Hyperlink A] may provide a realistic framework for conceptual elaboration of strategy, policy and plans for the transition to DTTV broadcasting and deserves thourough consideration and analysis not only by the TV Broadcasters but also by competent Regulatory and Policy Making Authorities.

5.C.6 Licence Fees for MPEG-4/AVC

A factor affecting decisions on the use of technologies is the licensing costs of using them. Broadcasters expressed concern about these charges, and MPEG-LA also offered the option of a one-time fee of $2500 per professional encoder. In 2008, there are two options for free to air broadcasters:

- one payment of $2,500 per encoder
- Payment of $10,000 each year for any number of encoders per legal entity.

The less expensive option depends on the way the individual broadcaster operates.

5.C.7 Interactivity services and Teletext

Broadcasters may also want to add interactivity to their HD broadcast services.

Teletext already allows for limited local interactivity (with SDTV resolution only), whereas the DVB developed system, the Multimedia Home Platform MHP (and other systems) can provide the full range of interactive content (declarative and procedural). The MHEG API used in the UK currently provides for declarative content.

The MHP 1.1.3 specification has been extended to support HDTV, i.e. the resolutions of 1280x720 and 960x540 as mandatory formats, and 1920x1080 as an optional format in addition to an SD resolution of 720x576.

Both mandatory resolutions of 1280x720 and 960x540 are 'exclusive', which means that applications can only use one of these resolutions at a given time. In most cases, a broadcaster will need to align the resolution of the HD MHP graphics plane with the resolution of the video content. Where several applications share a graphics plane, these need to agree on the same resolution.

If unbound applications provided by a network operator are active at the same time as applications provided by a broadcaster, the parties need to agree on a graphics resolution that is commonly used by their applications.

At the current time however, the EBU Technical Committee has withdrawn its recommendation for MHP because of lack of information on licensing, and is developing requirements for future systems.

5.C.8 Dynamic switching of HD and SD resolutions

The display (or other downstream device) following the receiver, whether connected through analogue or digital (HDMI) interfaces, needs to follow resolution changes without picture break up, frame roll or freezing, and without on-screen display indications, unless a fixed output format is configured at the receiver output. The use of such fixed output format is less advantageous for overall signal quality.

Dynamic switching between SD and HD

The new DVB guidelines for receiver implementation, ETSI TS 101 154, identify four separate categories of receivers in the 50 Hz world:

- Receivers based on MPEG-2 and supporting SDTV,
- Receivers based on MPEG-2 and supporting HDTV,
- Receivers based on MPEG-4 H.264/AVC and supporting SDTV
- Receivers based on MPEG-4 H.264/AVC and supporting HDTV

These categories are not mandatory backwards compatible, and at least in principle, receivers could be made that are capable of decoding MPEG-4/AVC in HDTV, but do not support either SDTV, or MPEG-2 services in either resolution. However, most receivers in free-to-air markets will support both HD and SD resolutions, and often MPEG-4/AVC and MPEG-2 video coding. A requirement to support more than one of these categories should be specified in receiver guidelines.

Where a receiver supports more than one category, the broadcaster might wish to dynamically switch between an HDTV and SDTV event by event in order to optimize the use of a broadcast channel. Receivers should follow such changes without any action by the user, without any onscreen indication, and with a minimum of service interruption comparable to a channel change.

Since such near-seamless dynamic switching is not explicitly specified by DVB, a broadcaster who wishes to do so should make this an explicit requirement, and might also decide to provide test signals on air to check this feature. This approach would help to establish a receiver population supporting all these operational modes, even if such features are not used from the start of any HD broadcast services.

Dynamic switching of HD resolution and HD formats

In the same way as switching between HD and SD resolutions, a broadcaster might wish to dynamically change the horizontal resolution, e.g. between 1920 and 1440 pixels, for a give vertical resolution, or might wish to change between 1080i and 720p formats. Such switching could help to avoid cascaded conversion processes in a broadcast chain.

In the same way as for dynamic switching between SD and HD, it is recommended that prior to regular services using this feature, test signals are provided on air, and inclusion of such features in the related receiver specifications. Further studies are required to cope with the 1080p option.

Dynamic switching of channels and transponders

It may be useful for broadcasters to be able to provide HD versions of programmes on a different channel to SDTV versions, and to trigger set top boxes to switch to HD versions of programmes when they are available. This approach is used by TPS in France, and uses signalling in the DVB-SI, in “private data” to signal the existence of an HDTV version of a programme, and its location (transponder, multiplex, SI). If such a feature was valuable to several broadcasters, a standard could be developed.

Signalling of aspect ratio

MPEG-4/AVC signals include the “pixel” aspect ratio as an optional parameter in the bit-stream, whereas for MPEG-2 signals, the aspect ratio is mandatory information.

At the time of writing this report, not all AVC encoders include this optional information, and there is also a minor inconsistency between the ISO/IEC MPEG-4/AVC specification and the corresponding DVB document.

However it is recommended that all professional broadcast encoders should include this information in the broadcast stream..

5.C.9 Broadcast issues

5.C.9.1 Encoder performance

Encoders for MPEG-4 H.264/AVC have been developed by several established broadcast equipment manufacturers, but also by manufacturers generally known for Internet applications, or from the merging IPTV market.

For head-end implementation, most encoders already provide both DVB-ASI and IP/Ethernet interfaces, as typical interfaces for these areas.

Current quality of H.264 compared to MPEG-2

The quality of MPEG-4 H.264/AVC encoders has improved significantly in recent years. The results of the evaluation are given in separate reports available for each manufacturer, to EBU members only.

Preliminary conclusions on encoder quality

The following initial conclusions can be drawn from this evaluation:

- Coding efficiency has significantly improved. Practical broadcast implementations of MPEG-4 H.264/AVC now show a clear advantage over established MPEG-2 encoders.
- Some implementations of MPEG-4 H.264/AVC encoders now allow a saving of about 40-50% bitrate (depending on content criticality) compared to MPEG-2.
- 1080i/25 is generally more difficult to compress than 720p/50. The advantage of 720p/50 over 1080i/25 varies for different implementations. Current, but ongoing, investigations indicate about 20% bitrate savings for critical content with 720p/50.

5.C.9.2 Delay issues between audio and video “lipsync”

In HDTV systems using sophisticated compression and scaling, the major sound vision synchronisation issue is the extent to which the sound runs ahead of the vision due to the image processing, which causes a delay, which in turn can be much greater that the delay caused by the audio processing.

The human senses are much more sensitive to sound ahead of the picture than to sound behind the picture, because having sound arriving later than the image is quite normal when we converse with people who are far away. Unfortunately, sound running ahead of the image, to which we are particularly sensitive, is the usual form of lack of synchronisation in HDTV broadcasting.

The situation is complex because the delay in the display itself can depend on whether the incoming picture is interlaced or progressively scanned, because of the need to deinterlace the interlaced image in the display.

The threshold of perception of sound running ahead of the picture in critical conditions is very small - about 10ms, and the threshold for sound running after the picture is about 20ms. In normal circumstances however it is considered that for SDTV these requirements can be relaxed to 40ms and 60ms for the end-to-end chain (EBU R37).

To apportion this to different parts of the broadcast chain is somewhat arbitrary, but ideally, the delay should be arranged in the encoder/decoder combination to be less than 5ms, to allow maximum freedom for delay in production and home display.

5.C.9.3 Quality requirements for broadcasting

Bitrates should be chosen such that there are acceptable (just perceptible or imperceptible, for virtually all average programmes) compression artefacts at 3H viewing distance, on scenes which are “critical for advanced compression systems but not unduly so”, on a given target display (up to 50”). This means using scenes that have high entropy (scenes full of non identical detail and non uniform movement) but which could still be conceivably part of a normal programme.

For an HDTV service to have a public value, it is necessary to provide and maintain high quality, and the presence of artefacts must not diminish the value of the high definition. The service must be essentially artefact free, in order to provide the added value compared to an SDTV service.

The bitrate needed depends on many factors, explained earlier.

5.C.9.4 Receiver Content Protection

Information on the current Content protection options is given in the Appendix below.

5.C.9.5 General conclusions on HDTV delivery

In principle, the highest quality for the viewer will result if the highest quality is used for programme production, and the most efficient format used for compression for broadcasting, bearing in mind viewer’s display capabilities.

The highest quality HDTV today can be provided for normal viewers using display sizes up to about 50 inch, if programme production is in the 1920x1080p/50 format, and broadcasting is in the 1280x720p/50 format.

If 1920x1080p/50 format production is not available (as is the case today), the highest viewer picture quality will be achieved for scenes with motion critical content originating from 1280x720p/50 programme production and by1280x720p/50 delivery. This will deliver the best quality for “events” HDTV television, and the best trade-off between bitrate required and quality delivered to households.

If 1920x1080p/50 format production is not available, and the programme content has very little movement (i.e. with movies), than the highest potential viewer quality will be achieved for viewers with 1920x1080p/25 production and 1920x1080psf/25 delivery. This format will deliver the best quality for “drama”.

If 1440 or 1920x1080i/25 programme production is used, conversion to 720p/50 for broadcasting will not significantly improve the picture quality, because the efficiency gains of progressive scanning for compression will not be available, although professional standards converters can improve quality. The viewed picture may be slightly better because of the improved sophistication of the interlace-to-progressive conversion. It is better to use professional, high quality interlaced to-progressive converters at the broadcaster’s premises than to place the de-interlacing task on consumer displays or set-top boxes.

5.C.10 Appendix: Digital HDTV broadcast security elements

The current situation suggests that EBU members have **different circumstances and different needs** for HDTV broadcast security. A number of different scenarios will therefore need to exist among EBU members.

- A 'common EBU position' may amount to an acknowledgment that different scenarios exist, which may each suite different members best, depending on their local circumstances
- There are five different scenarios in use by different broadcasters in different countries.

The elements determining broadcast security

There are two main elements of the broadcasting path to consider:

- the signal on the broadcast path **from the transmitter (e.g. via satellite) to the receiver** in the home, which is usually a set top box.
- the signal on the path in the home **from the set top box to the display**.

The signals in each case can be "in-the-clear" or "scrambled". If the signal is "scrambled" the picture will not be viewable unless it is "descrambled".

For the first element of the broadcasting path, e.g. from a satellite to the receiver in the home, "**geolocation**" (limiting coverage to certain geographical areas) may be applied to limit coverage.

Broadcast coverage areas can, in principle, be limited by two means:

- The first may be called '**physical geolocation**'. In this case the coverage beam or a combination of the coverage beam and the error correction system used on the satellite delivery path are arranged to ensure that only viewers in a given area can watch the broadcast. This may or may not be possible depending on factors such as which satellite beams are available. This is done, for example, by the BBC and ITV in the UK to constrain coverage of their digital satellite services to the United Kingdom.
- The second may be called '**electronic geolocation**'. In this case, the broadcast signal is scrambled and is only available to those who have a receiver that accepts smart cards, and have a particular smart card. This is done, for example, for SDTV services by the SRG in Switzerland, who provide the necessary smart card only to those who have paid the annual broadcast license, and are normally resident in Switzerland. There are scrambling methods available, such as the DVB algorithm, but there is no EBU recommended scrambling method specifically for this application.

The reason geolocation is applied to broadcasting is usually because rights have not been obtained for viewers outside a constrained area.

For the second element of the broadcasting path, the path from the set top box to the display, "**content protection**" may be applied to prevent copying and redistribution of the signal.

If simply signalling that the material should not be copied is not enough, the signal on the link can be scrambled (though with a new system which is separate from that used on the broadcast path). The signal will be viewable on the display if it is an "authorized" display (subject to authentication or revocation between STB and Display), because it will contain the descrambler. There is a standardized method of scrambling and descrambling on this link called '**HDCP**' (High Bandwidth Digital Content Protection).

The HDCP scrambling can be set to be 'on' or 'off' by default, which will be the status of the equipped devices when purchased. It is possible in principle to switch either at any time, or per content. This requires, however, that broadcasters insert a flag in their signal to activate or deactivate the appropriate mode, respectful of the original default mode. This flag however requires a particular protected transport that is usually not available for free-to-air FTA broadcasts.

The DVB Project has developed a signalling system that can be used to switch the HDCP scrambling on and off. This DVB signalling is intended for use in general for Content Protection and Copy Management (DVB-CPCM). It contains a flag called "Do Not Scramble" that could be used to control HDCP. This signalling could be implemented and used before consumer electronic product implement the DVB-CPCM solution in integrated form as a whole.

The total broadcast security system is defined by the **combination of methods used on the two parts of the signal path**. There is a link between the two elements to the extent that security may need to be balanced in both parts - both high and both low. However, there may be circumstances when this does not apply.

Scenario 1: Free to Air Scrambled (FTA/S) with HDCP default set to "on" in the set top box or receiver

1.1 The digital HDTV signal over the broadcast path is scrambled. The purpose is not to enable payment systems, it is usually to ensure that only viewers in given geographical areas are able to watch the programmes ("geolocation") when and if viewing rights restrictions call for it.

1.2 The digital HDTV signals can only be received on "authorized" receivers, in the sense that the receivers conform to a specification that includes a descrambling process and the receiver needs a smart card.

1.3 Part of the descrambler is included in a smart card that needs to be inserted into the receiver. Smart cards can be available at no cost to the user at the point of sale of the receiver or in some other convenient way, but only in geographically authorized locations.

They could be made available subject to proof of payment of a TV license.

1.4 There are several elements of additional costs associated with this scenario, compared to a free to air unscrambled scenario. The set top boxes need additional complexity and they will cost more. The smart cards have to be made and provided. Broadcasters have an additional burden associated with the scrambling process.

1.5 The burden of the additional costs to be born by the viewer can be light to the extent than volume production of receivers inevitably reduces the cost of features in a receiver. The cost of the set top box is determined more by the volume made than by the cost of the components in it.

1.6 The burden of the costs to be born by the broadcaster in the arrangements for the smart card is large if born by a single broadcaster, and could have a significant impact. The burden of costs would be reduced if born collectively by a group of broadcasters. A smart card system has been in operation in Japan and the cost of management of the smart card has proved to be higher than anticipated revocation is per device and not per content. This is one of the drawbacks of HDCP "on" by default.

1.7 The scrambling between the set top box and the display is set to "on" unless otherwise instructed. Authorized displays (e.g. those which have the "HD ready'"label) are able to descramble the signal and display it. Older displays which do not have an HDCP-descrambler built in (and thus no HD-ready label) are not able to display the digital signal, but may be able to see a marginally inferior analogue HDTV picture.

1.8 Programmes that need to be scrambled for "geolocation" reasons are likely also to be subject to restrictions on copying and transfer to other media such as Internet. Once the obligation of distributing content within a geographical area has been fulfilled there may however be no reason why content could not remain in the clear after acquisition within the home.

1.9 If broadcasters use HDCP actively this will mean they have the responsibility of distributing the 'black list' of devices which should not be served because they are known to allow piracy in some way - the so-called "revocation list". Furthermore, if a device is on the revocation list because of its insertion by a Pay TV operator, the same revocation will apply to free to air services, whatever the public service mission of the operator of the free to air services.

Scenario 2: Free to Air Unscrambled (FTA) with HDCP default set to "off"

2.1 The digital HDTV signal over the broadcast path is in the clear. Other means of physical geolocation may be used.

2.2 The digital HDTV signals can be received on any receiver, and no smart card is needed.

2.3 Old HDTV and new HD-ready displays are able to view the digital HDTV signal.

2.4 Given that a signalling system is standardized in the DVB family of standards, and that receivers recognize it, it will be possible for the broadcaster to switch the HDCP scrambling off remotely. This could be important if there are set top boxes on the market which have HDCP enabled by default and if manufacturers are obliged to implement HDCP devices with this switching function.

2.5 This configuration prevents revocation from impeding reception.

Scenario 3: Free to Air Unscrambled (FTA) with HDCP default set to "on"

3.1 The digital HDTV signal over the broadcast path is in the clear. Other means of physical geolocation may be used.

3.2 The digital HDTV signals can be received on any receiver, and no smart card is needed.

3.3 The scrambling between the set top box and the display is set to "on" unless otherwise instructed. Authorized displays, those that have the "HD ready" label and thus have an HDCP descrambler, are able to descramble the signal and show it to the viewer. Other devices that are not authorized cannot. This acts as a deterrent to the redistribution of the programme. Older displays which do not have the HD-ready label are not able to display the digital HDTV signals, but may be able to see a marginally inferior analogue HDTV signal, although the trend is to abandon such analogue interfaces on the mid to long term.

3.4 If all devices are HDCP compatible, free-to-air programmes would flow transparently to the display. If the device is shared with other service providers such as Pay TV broadcasters with stronger security constraints, and if Pay TV broadcasters were required by content providers to revoke certain devices, the screen would go also black for FTA content as HDCP scrambling 'on' if this is required for some content by the owners.

Scenario 4: PayTV Scrambled with HDCP default set to "on"

This is the most likely scenario for Pay TV services.

As mentioned above, the use of revocation per device may have repercussions for the reception of FTA content.

Scenario 5: PayTV Scrambled with HDCP default set to "off"

This is the second scenario for Pay TV services. The digital HDTV signal over the broadcast path is scrambled but the default setting of HDCP scrambling between the set top box and the display is set to "off".

Pay TV services use their proprietary scrambling systems on the broadcast path to switch HDCP scrambling "on" if this is required for some content by the owners.

Current situation in Europe

Available information obtained suggests that:

France Television believes that Scenario 1 is necessary for the French environment, including public service broadcasting. The dominant factor is the critical need for content that is only available if there is guaranteed geolocation and copy control.

ARD, ZDF, and SRG believe that Scenario 2 is necessary for their environments in Switzerland and Germany. The dominant factor is the national policy for public service broadcasting to be in clear.

The BBC and ITV believe that Scenario 3 is necessary for the UK environment. The dominant factor is a combination of the national policy for public service broadcasting to be in clear, coupled with the wish to take some steps to deter redistribution of content. Though not "watertight" measures, they would act as a deterrent to unauthorized redistribution.

Scenario 5 is used by Premiere for Pay TV services, and 4 is used by Sky Italia and Sky UK for Pay TV services, and by Canal plus/TPS for Pay TV services. The reason for the different approaches has not been established.

Annex 6

European Commission Launches Public Consultation on Digital Dividend

On July 10, 2009 the European Commission published for public consultation until September 4, 2009 a document on *"transforming the digital opportunity into social benefits and economic growth in Europe"*.

The consultation is aimed at collecting views from all interested stakeholders on the use of the digital dividend radio spectrum released from the transition from analogue to digital terrestrial television (DTT).

The Commission intends to adopt a communication on the digital dividend, including an official proposal for an EU policy roadmap, to be submitted to the European Parliament and Council in autumn 2009.

The Commission also identifies two urgent measures to facilitate the process of making the UHF 790-862 MHz band ('800 MHz band') available on a technology and service neutral basis as quickly as possible within a harmonised technical framework.

A. Background

The policy debate on the use of the digital dividend dates back to 2005 when a commission communication set January 1, 2012 as the recommended deadline for the EU-wide transition to DTT (see EU Media Tracker 11).

In its 2007 communication on *"reaping the full benefits of the digital dividend in Europe: a common approach to the use of the spectrum released by the digital switchover"* the Commission proposed an approach based on different 'clusters' in the UHF band (470-872 MHz) which would be subject to different degrees of spectrum management coordination at the EU level. These clusters would be the sub-bands for: digital terrestrial broadcasting; mobile multimedia (including mobile TV); and fixed wireless/mobile broadband (see EU Media Tracker 12).

A number of follow-up initiatives were then promoted by the Commission to further analyse the economic, technical and policy implications of the proposed approach, including:

- launch of a comprehensive study assessing the economic and social impact of the different uses of the digital dividend and the potential benefits resulting from EU coordination;
- technical studies under the auspices of the European Conference of Postal and Telecommunications Administrations (CEPT) to identify technical solutions to interference challenges; and
- extensive consultations with main stakeholders.

Consensus on the approach and a call for swift action on the digital dividend also came from the Radio Spectrum Working Group (RSWG) and the European Regulators Group (ERG) in May 2009 (see EU Media Flash 31/2009).

NB. For an overview on the analogue switch-off dates and the use of the digital dividend in the EU Member States, see Table 18 in the WE Telecom Cross-Country Analysis and Table 15 in the CEE Telecom Cross-Country Analysis, and Table 2 in the WE Media Cross-Country Analysis.

B. EU roadmap for mid- and long-term action

Considering the broad consensus on the need for a harmonised approach to the digital dividend, the Commission suggests the envisaged coordination could be achieved by agreeing on a shared EU roadmap which would define the process and milestones for implementing a set of strategic actions at the EU level.

In practical terms, the roadmap could be incorporated into the wider multi-annual spectrum action programme to be adopted by the European Parliament and Council in early 2010, as foreseen in the reformed regulatory framework for electronic communications (see EU Telecoms Tracker 1).

A summary of the main actions under consideration is presented in the table below.

Objective	Proposed measures
1. Improve consumers' experience by ensuring high quality standards for DTT receivers across Europe	• Ensure availability of compression standards of defined minimum efficiency (at least as the MPEG-4) on all DTT receivers sold after Jan. 1, 2012. • Set standards for the ability of DTT receivers to resist interference.
2. Increase the size of the digital dividend by spectrum efficiency gains	• Foster collaboration between Member States to share future broadcasting network deployment plans (e.g. migration to MPEG-4 or DVB-T2) in order to increase efficiency. • Encourage the deployment of Single Frequency Networks (SFN). NB In short, DTT networks can be implemented by using Multi Frequency Network (MFN) technology, SFN or a mix of these two technologies. On SFN all transmitters of the network use of the same frequency channel to provide a common coverage for same content. On MFN each transmitter uses different frequency channel and has its own coverage area to carry either same or different content. • Support research on *"frequency agile mobile communications systems"*. (The consultation document does not specify in clear terms what this would mean in practice).
3. Make the 800 MHz band swiftly available under harmonised technical conditions	• Accelerate the switchover process in all Member States. • Make concrete steps towards EU-level technical harmonisation. NB For more details see C.2. below.
4. Adopt a common position on the use of *"white spaces"*	Invite Member States to cooperate with the Commission to assess the possibility to open up the *"white spaces"* (i.e. the unused spectrum between broadcasting coverage areas) in their respective countries.

5. Ensure continuity and development of wireless microphone applications	Develop a migration path for current secondary users of UHF spectrum, with possible mandate to be given to CEPT. NB The issue of wireless microphones has recently arisen e.g. in Germany where users were protesting against the proposals to make the 790-862 MHz band available for wireless broadband services (see Big Five Update June 2009).
6. Facilitate cross-border coordination with non-EU countries	Assist Member States in their negotiations with non-EU neighbouring countries.
7. Address future challenges	Establish mechanism to monitor external developments affecting the roadmap.

Printed in Switzerland
Geneva, 2010

Photo credits: ITU Photo Library